

The Python Library Reference

發  3.11.8

Guido van Rossum and the Python development team

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Python Software Foundation
Email: docs@python.org

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[reference-index](#) 說明 Python 這門語言確切的文法及語意，而這份函式庫參考手冊則是說明隨著 Python 一起發行的標準函式庫，除此之外，其內容也包含一些時常出現在 Python 發行版本中的非必要套件。

Python 的標準函式庫是非常龐大的，其提供了如下所述極多且涵蓋用途極廣的許多模組。包含一些用 C 語言撰寫，可以操作像是檔案讀寫等系統相關功能的內建模組，當然也有用 Python 撰寫，使用標準解法解決許多常見問題的模組。其中有些模組則是特別針對 Python 的可移植性去設計的，因此特地將一些平台特殊相依性的功能抽象化成可跨平台的 API。

Python 的 Windows 安裝檔基本上包含整個標準函式庫，且通常也包含許多附加的組件；而在類 Unix 作業系統方面，Python 通常是以一系列的套件被安裝，因此對於某些或全部的可選組件，可能都必須使用該作業系統提供的套件管理工具來安裝。

在標準函式庫之外，還有成千上萬且不斷增加的組件（從個別的程式、模組、套件到完整的應用程式開發框架），可以從 [Python 套件索引 \(Python Package Index\)](#) 中取得。

簡介

「Python 函式庫」包含了許多不同的部分。

函式庫中包括被視爲程式語言「核心」部分的資料型態，像是數字 (number) 或是串列 (list)。對於這些型別，Python 核心對這些字面值 (literal) 的形式做定義，對它們的語意制定了一些限制，但在此同時不把文字對應的語意完全定義。(另一方面，Python 在語法面上有確實的定義，例如拼字或是運算元次序)

Python 函式庫也囊括了建置函式與例外處理——這些物件都可以不用透過 `import` 陳述式來引入 Python 程式中就能使用。函式庫中有部份是被 Python 核心所定義的，但在這僅解釋最核心的語意部分。

整個函式庫中包含了許多模組，有許多方法可以從函式庫中取用這些模組。有些模組是以 C 語言撰寫並建置於 Python 編譯器之中，其他的是由 Python 撰寫以源碼的方式 (source form) 引入。有些模組提供的功能是專屬於 Python 的，像是把 stack trace 印出來；有些則是針對特定作業系統，去試著存取特定硬體；還有些提供對特定應用的功能與操作介面，像是 World Wide Web。模組的使用情況會因機器與 Python 的版本而不同，部分模組是開放所有版本以及 Port 的 Python 來使用的，但有些會因系統支援或需求在某些版本或系統下無法使用，甚至有些僅限在特定的設定環境下才能使用。

這個手冊會「深入淺出」地介紹 Python 函式庫。它會先介紹一些建置函式、資料型態、和一些例外處理，再來一章章的主題式介紹相關模組。

這代表如果你從這個手冊的最開始讀起，在感到無聊時跳到下一個章節，你仍然可以得到一個對 Python 函式庫所支援的模組與其合理應用的概觀。當然，你不必像是在讀一本小說一樣讀這本手冊——你可以快速瀏覽目錄（在手冊的最前頭）、或是你可以利用最後面的索引來查詢特定的函式或模組。最後，如果你享受讀一些隨機的主題，你可以選擇一個隨機的數字開始閱讀（見 `random` 模組）。不管你想要以什麼順序來讀這個手冊，建置函式會是一個很好的入門，因手冊中其他章節都預設你已經對這個章節有一定的熟悉程度。

讓我們開始吧！

1.1 可用性之釋

- 如果出現「適用： Unix」釋，則代表該函式普遍存在於 Unix 系統中，但這不保證其存在於某特定作業系統。
- 如果釋有分釋的話，有標明「適用： Unix」釋的所有函式也都於 macOS 上支援，因其建於 Unix 核心之上。
- If an availability note contains both a minimum Kernel version and a minimum libc version, then both conditions must hold. For example a feature with note *Availability: Linux >= 3.17 with glibc >= 2.27* requires both Linux 3.17 or newer and glibc 2.27 or newer.

1.1.1 WebAssembly 平台

The WebAssembly platforms `wasm32-emscripten` (Emscripten) and `wasm32-wasi` (WASI) provide a subset of POSIX APIs. WebAssembly runtimes and browsers are sandboxed and have limited access to the host and external resources. Any Python standard library module that uses processes, threading, networking, signals, or other forms of inter-process communication (IPC), is either not available or may not work as on other Unix-like systems. File I/O, file system, and Unix permission-related functions are restricted, too. Emscripten does not permit blocking I/O. Other blocking operations like `sleep()` block the browser event loop.

The properties and behavior of Python on WebAssembly platforms depend on the Emscripten-SDK or WASI-SDK version, WASM runtimes (browser, NodeJS, `wasmtime`), and Python build time flags. WebAssembly, Emscripten, and WASI are evolving standards; some features like networking may be supported in the future.

For Python in the browser, users should consider `Pyodide` or `PyScript`. `PyScript` is built on top of `Pyodide`, which itself is built on top of CPython and Emscripten. `Pyodide` provides access to browsers' JavaScript and DOM APIs as well as limited networking capabilities with JavaScript's `XMLHttpRequest` and `Fetch` APIs.

- Process-related APIs are not available or always fail with an error. That includes APIs that spawn new processes (`fork()`, `execve()`), wait for processes (`waitpid()`), send signals (`kill()`), or otherwise interact with processes. The `subprocess` is importable but does not work.
- The `socket` module is available, but is limited and behaves differently from other platforms. On Emscripten, sockets are always non-blocking and require additional JavaScript code and helpers on the server to proxy TCP through WebSockets; see [Emscripten Networking](#) for more information. WASI snapshot preview 1 only permits sockets from an existing file descriptor.
- Some functions are stubs that either don't do anything and always return hardcoded values.
- Functions related to file descriptors, file permissions, file ownership, and links are limited and don't support some operations. For example, WASI does not permit symlinks with absolute file names.

建立函式

Python 直譯器有建立多個可隨時使用的函式和型。以下按照英文字母排序列出。

F 建函式

A

`abs()`
`aiter()`
`all()`
`anext()`
`any()`
`ascii()`

B

`bin()`
`bool()`
`breakpoint()`
`bytearray()`
`bytes()`

C

`callable()`
`chr()`
`classmethod()`
`compile()`
`complex()`

D

`delattr()`
`dict()`
`dir()`
`divmod()`

E

`enumerate()`
`eval()`
`exec()`

F

`filter()`
`float()`
`format()`
`frozenset()`

G

`getattr()`
`globals()`

H

`hasattr()`
`hash()`
`help()`
`hex()`

I

`id()`
`input()`
`int()`
`isinstance()`
`issubclass()`
`iter()`

L

`len()`
`list()`
`locals()`

M

`map()`
`max()`
`memoryview()`
`min()`

N

`next()`

O

`object()`
`oct()`
`open()`
`ord()`

P

`pow()`
`print()`
`property()`

R

`range()`
`repr()`
`reversed()`
`round()`

S

`set()`
`setattr()`
`slice()`
`sorted()`
`staticmethod()`
`str()`
`sum()`
`super()`

T

`tuple()`
`type()`

V

`vars()`

Z

`zip()`

`__import__()`

abs(x)

Return the absolute value of a number. The argument may be an integer, a floating point number, or an object implementing `__abs__()`. If the argument is a complex number, its magnitude is returned.

aiter(async_iterable)

Return an *asynchronous iterator* for an *asynchronous iterable*. Equivalent to calling `x.__aiter__()`.

Note: Unlike `iter()`, `aiter()` has no 2-argument variant.

在 3.10 版新加入。

all(iterable)

如果 *iterable* 的所有元素皆 F 真（或 *iterable* F 空）則回傳 True。等價於：

```
def all(iterable):
    for element in iterable:
        if not element:
            return False
    return True
```

awaitable anext(async_iterator)

awaitable anext (*async_iterator*, *default*)

When awaited, return the next item from the given *asynchronous iterator*, or *default* if given and the iterator is exhausted.

This is the async variant of the *next()* builtin, and behaves similarly.

This calls the `__anext__()` method of *async_iterator*, returning an *awaitable*. Awaiting this returns the next value of the iterator. If *default* is given, it is returned if the iterator is exhausted, otherwise *StopAsyncIteration* is raised.

在 3.10 版新加入。

any (*iterable*)

如果 *iterable* 的任一元素為真，回傳 True。如果 *iterable* 是空的，則回傳 False。等價於：

```
def any(iterable):
    for element in iterable:
        if element:
            return True
    return False
```

ascii (*object*)

就像函式 *repr()*，回傳一個表示物件的字串，但是 *repr()* 回傳的字串中非 ASCII 編碼的字元會被跳 (escape)，像是 \x、\u 和 \U。這個函式生成的字串和 Python 2 的 *repr()* 回傳的結果相似。

bin (*x*)

將一個整數轉變為一個前綴 "0b" 的二進位制字串。結果是一個有效的 Python 運算式。如果 *x* 不是 Python 的 *int* 物件，那它需要定義 `__index__()` method 回傳一個整數。舉例來：

```
>>> bin(3)
'0b11'
>>> bin(-10)
'-0b1010'
```

如果不一定需要 "0b" 前綴，還可以使用如下的方法。

```
>>> format(14, '#b'), format(14, 'b')
('0b1110', '1110')
>>> f'{14:#b}', f'{14:b}'
('0b1110', '1110')
```

可參考 *format()* 獲取更多資訊。

class bool (*x=False*)

回傳一個布林值，即 True 或者 False。*x* 使用標準的真值測試程序來轉。如果 *x* 為假或者被省略，則回傳 False；其他情況回傳 True。*bool* class (類) 是 *int* 的 subclass (子類) (參見 *Numeric Types --- int, float, complex*)，其他 class 不能繼承自它。它只有 False 和 True 兩個實例 (參見 *Boolean Values*)。

在 3.7 版的變更: *x* is now a positional-only parameter.

breakpoint (**args, **kws*)

This function drops you into the debugger at the call site. Specifically, it calls *sys.breakpointhook()*, passing *args* and *kws* straight through. By default, *sys.breakpointhook()* calls *pdb.set_trace()* expecting no arguments. In this case, it is purely a convenience function so you don't have to explicitly import *pdb* or type as much code to enter the debugger. However, *sys.breakpointhook()* can be set to some other function and *breakpoint()* will automatically call that, allowing you to drop into the debugger of choice. If *sys.breakpointhook()* is not accessible, this function will raise *RuntimeError*.

By default, the behavior of *breakpoint()* can be changed with the PYTHONBREAKPOINT environment variable. See *sys.breakpointhook()* for usage details.

Note that this is not guaranteed if *sys.breakpointhook()* has been replaced.

引發一個附帶引數 `breakpointhook` 的稽核事件 `builtins.breakpoint`。

在 3.7 版新加入。

class bytearray (*source=b*)

class bytearray (*source, encoding*)

class bytearray (*source, encoding, errors*)

回傳一個新的 `bytes` 陣列。`bytearray` class 是一個可變的整數序列，包含範圍 $0 \leq x < 256$ 的整數。它有可變序列大部分常見的 `method`（如在 *Mutable Sequence Types* 中所述），同時也有 `bytes` 型 F 大部分的 `method`，參見 *Bytes and Bytearray Operations*。

選擇性參數 *source* 可以被用來以不同的方式初始化陣列：

- 如果是一個 *string*，你必須提供 *encoding* 參數（以及選擇性地提供 *errors*）；`bytearray()` 會使用 `str.encode()` `method` 來將 `string` 轉變成 `bytes`。
- 如果是一個 *integer*，陣列則會有該數值的長度，F 以 `null bytes` 來當作初始值。
- 如果是一個符合 `buffer` 介面的物件，該物件的唯讀 `buffer` 會被用來初始化 `bytes` 陣列。
- 如果是一個 *iterable*，它的元素必須是範圍 $0 \leq x < 256$ 的整數，F 且會被用作陣列的初始值。

如果 F 有引數，則建立長度 F 0 的陣列。

可參考 *Binary Sequence Types --- bytes, bytearray, memoryview* 和 *Bytearray Objects*。

class bytes (*source=b*)

class bytes (*source, encoding*)

class bytes (*source, encoding, errors*)

回傳一個新的“`bytes`”物件，會是一個元素是範圍 $0 \leq x < 256$ 整數的不可變序列。`bytes` 是 `bytearray` 的不可變版本——它的同樣具備不改變物件的 `method`，也有相同的索引和切片操作。

因此，建構函式的引數和 `bytearray()` 相同。

`Bytes` 物件還可以用文字建立，參見 `strings`。

可參考 *Binary Sequence Types --- bytes, bytearray, memoryview*、*Bytes Objects* 和 *Bytes and Bytearray Operations*。

callable (*object*)

Return `True` if the *object* argument appears callable, `False` if not. If this returns `True`, it is still possible that a call fails, but if it is `False`, calling *object* will never succeed. Note that classes are callable (calling a class returns a new instance); instances are callable if their class has a `__call__()` `method`.

在 3.2 版新加入：這個函式一開始在 Python 3.0 被移除，但在 Python 3.2 又被重新加入。

chr (*i*)

回傳代表字元之 Unicode 編碼位置 F 整數 *i* 的字串。例如，`chr(97)` 回傳字串 `'a'`，而 `chr(8364)` 回傳字串 `'€'`。這是 `ord()` 的逆函式。

引數的有效範圍是 0 到 1,114,111（16 進制表示 F 0x10FFFF）。如果 *i* 超過這個範圍，會觸發 `ValueError`。

@classmethod

把一個 `method` 封裝成 `class method`（類 F 方法）。

一個 `class method` 把自己的 `class` 作 F 第一個引數，就像一個實例 `method` 把實例自己作 F 第一個引數。請用以下慣例來宣告 `class method`：

```
class C:
    @classmethod
    def f(cls, arg1, arg2): ...
```

@classmethod 語法是一個函式 *decorator* — 參見 `function` 中關於函式定義的詳細介紹。

一個 class method 可以在 class (如 `C.f()`) 或實例 (如 `C().f()`) 上呼叫。實例除了它的 class 資訊, 其他都會被忽略。如果一個 class method 在 subclass 上呼叫, subclass 會作第一個引數傳入。

Class method 和 C++ 與 Java 的 static method 是有區別的。如果你想了解 static method, 請看本節的 `staticmethod()`。關於 class method 的更多資訊, 請參考 `types`。

在 3.9 版的變更: Class methods can now wrap other *descriptors* such as `property()`。

在 3.10 版的變更: Class methods now inherit the method attributes (`__module__`, `__name__`, `__qualname__`, `__doc__` and `__annotations__`) and have a new `__wrapped__` attribute。

在 3.11 版的變更: Class methods can no longer wrap other *descriptors* such as `property()`。

compile (*source*, *filename*, *mode*, *flags*=0, *dont_inherit*=False, *optimize*=-1)

將 *source* 編譯成程式碼或 AST 物件。程式碼物件可以被 `exec()` 或 `eval()` 執行。*source* 可以是一般的字串、bytes 字串、或者 AST 物件。參見 `ast` module (模組) 的文件了解如何使用 AST 物件。

filename 引數必須是程式碼的檔名; 如果程式碼不是從檔案中讀取, 可以傳入一些可辨識的值 (經常會使用 `'<string>'` 來替代)。

mode 引數指定了編譯程式碼時必須用的模式。如果 *source* 是一系列的陳述式, 可以是 `'exec'`; 如果是單一運算式, 可以是 `'eval'`; 如果是單個互動式陳述式, 可以是 `'single'` (在最後一種情況下, 如果運算式執行結果不是 None 則會被印出來)。

The optional arguments *flags* and *dont_inherit* control which *compiler options* should be activated and which future features should be allowed. If neither is present (or both are zero) the code is compiled with the same flags that affect the code that is calling `compile()`. If the *flags* argument is given and *dont_inherit* is not (or is zero) then the compiler options and the future statements specified by the *flags* argument are used in addition to those that would be used anyway. If *dont_inherit* is a non-zero integer then the *flags* argument is it -- the flags (future features and compiler options) in the surrounding code are ignored.

編譯器選項和 future 陳述式使用 bits 來表示, 可以一起被位元操作 OR 來表示多個選項。需要被具體定義特徵的位元域可以透過 `__future__` module 中 `_Feature` 實例中的 `compiler_flag` 屬性來獲得。編譯器旗標可以在 `ast` module 中搜尋有 `PyCF_` 前綴的名稱。

引數 *optimize* 用來指定編譯器的最佳化級別; 預設值 -1 選擇與直譯器的 -O 選項相同的最佳化級別。其他級別 0 (有最佳化; `__debug__` 為真值)、1 (assert 被排除, `__debug__` 為假值) 或 2 (文件字串也被排除)。

如果編譯的原始碼無效, 此函式會觸發 `SyntaxError`, 如果原始碼包含 null bytes, 則會觸發 `ValueError`。

如果您想解析 Python 程式碼為 AST 運算式, 請參見 `ast.parse()`。

引發一個附帶引數 *source*、*filename* 的稽核事件 `compile`。

備註: 在 `'single'` 或 `'eval'` 模式編譯多行程式碼時, 輸入必須以至少一個行符號結尾。這使 `code` module 更容易檢測陳述式的完整性。

警告: 如果編譯足夠大或者足夠雜的字串成 AST 物件時, Python 直譯器會因 Python AST 編譯器的 stack 深度限制而崩潰。

在 3.2 版的變更: 允許使用 Windows 和 Mac 的行符號。在 `'exec'` 模式不需要以行符號結尾。增加了 *optimize* 參數。

在 3.5 版的變更: 在之前的版本, *source* 中包含 null bytes 會觸發 `TypeError` 異常。

在 3.8 版新加入: `ast.PyCF_ALLOW_TOP_LEVEL_AWAIT` can now be passed in flags to enable support for top-level await, async for, and async with.

class complex (*real*=0, *imag*=0)

class complex (*string*)

回傳值 $real + imag*1j$ 的 `complex` 數，或將字串、數字轉 `complex` 數。如果第一個引數是字串，則它被視為一個 `complex` 數，且函式呼叫時不得有第二個引數。第二個引數對不能是字串。每個引數都可以是任意的數值型（包括 `complex` 數）。如果省略了 *imag*，則預設值為零，建構函式會像 `int` 和 `float` 一樣進行數值轉。如果兩個引數都省略，則回傳 `0j`。

對於一般的 Python 物件 `x`，`complex(x)` 指派給 `x.__complex__()`。如果未定義 `__complex__()` 則會回退使用 `__float__()`。如果未定義 `__float__()` 則會回退使用 `__index__()`。

備註：當轉自一字串時，字串在 `+` 或 `-` 運算子的周圍必須不能有空格。例如 `complex('1+2j')` 是有效的，但 `complex('1 + 2j')` 會觸發 `ValueError`。

`complex` 數型在 *Numeric Types --- int, float, complex* 中有相關描述。

在 3.6 版的變更：可以使用底將程式碼文字中的數字進行分組。

在 3.8 版的變更：Falls back to `__index__()` if `__complex__()` and `__float__()` are not defined.

delattr (*object*, *name*)

這是 `setattr()` 相關的函式。引數是一個物件和一個字串，該字串必須是物件中某個屬性名稱。如果物件允許，該函式將除指定的屬性。例如 `delattr(x, 'foobar')` 等價於 `del x.foobar`。*name* 不必是個 Python 識別符 (identifier) (請見 `setattr()`)。

class dict (***kwarg*)

class dict (*mapping*, ***kwarg*)

class dict (*iterable*, ***kwarg*)

建立一個新的 dictionary (字典)。`dict` 物件是一個 dictionary class。參見 `dict` 和 *Mapping Types --- dict* 來解這個 class。

其他容器型，請參見建的 `list`、`set` 和 `tuple` class，以及 `collections` module。

dir()

dir (*object*)

如果有引數，則回傳當前本地作用域中的名稱列表。如果有引數，它會嘗試回傳該物件的有效屬性列表。

If the object has a method named `__dir__()`, this method will be called and must return the list of attributes. This allows objects that implement a custom `__getattr__()` or `__getattribute__()` function to customize the way `dir()` reports their attributes.

If the object does not provide `__dir__()`, the function tries its best to gather information from the object's `__dict__` attribute, if defined, and from its type object. The resulting list is not necessarily complete and may be inaccurate when the object has a custom `__getattr__()`.

預設的 `dir()` 機制對不同型的物件有不同行，它會試圖回傳最相關而非最完整的資訊：

- 如果物件是 module 物件，則列表包含 module 的屬性名稱。
- 如果物件是型或 class 物件，則列表包含它們的屬性名稱，且遞查詢其基礎的所有屬性。
- 否則，包含物件的屬性名稱列表、它的 class 屬性名稱，且遞查詢它的 class 的所有基礎 class 的屬性。

回傳的列表按字母表排序，例如：

```
>>> import struct
>>> dir()      # show the names in the module namespace
['__builtins__', '__name__', 'struct']
>>> dir(struct)  # show the names in the struct module
['Struct', '__all__', '__builtins__', '__cached__', '__doc__', '__file__',
 '__initializing__', '__loader__', '__name__', '__package__',
```

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```

'_clearcache', 'calcsz', 'error', 'pack', 'pack_into',
'unpack', 'unpack_from']
>>> class Shape:
...     def __dir__(self):
...         return ['area', 'perimeter', 'location']
>>> s = Shape()
>>> dir(s)
['area', 'location', 'perimeter']

```

備註：因`dir()`主要是為了便於在互動式提示字元時使用，所以它會試圖回傳人們感興趣的名稱集合，而不是試圖保證結果的嚴格性或一致性，它具體的行爲也可能在不同版本之間改變。例如，當引數是一個 class 時，metaclass 的屬性不包含在結果列表中。

`divmod(a, b)`

它將兩個（非零）數字作引數，在執行整數除法時回傳一對商和余數。對於混合運算元型，適用二進位算術運算子的規則。對於整數，運算結果和 $(a // b, a \% b)$ 一致。對於浮點數，運算結果是 $(q, a \% b)$ ， q 通常是 $\text{math.floor}(a / b)$ 但可能會比 1 小。在任何情況下， $q * b + a \% b$ 和 a 基本相等，如果 $a \% b$ 非零，則它的符號和 b 一樣，且 $0 \leq \text{abs}(a \% b) < \text{abs}(b)$ 。

`enumerate(iterable, start=0)`

回傳一個列舉 (enumerate) 物件。*iterable* 必須是一個序列、*iterator* 或其他支援迭代的物件。`enumerate()` 回傳之 *iterator* 的 `__next__()` method 回傳一個 tuple (元組)，它包含一個計數值（從 *start* 開始，預設 0）和通過迭代 *iterable* 獲得的值。

```

>>> seasons = ['Spring', 'Summer', 'Fall', 'Winter']
>>> list(enumerate(seasons))
[(0, 'Spring'), (1, 'Summer'), (2, 'Fall'), (3, 'Winter')]
>>> list(enumerate(seasons, start=1))
[(1, 'Spring'), (2, 'Summer'), (3, 'Fall'), (4, 'Winter')]

```

等價於：

```

def enumerate(iterable, start=0):
    n = start
    for elem in iterable:
        yield n, elem
        n += 1

```

`eval(expression, globals=None, locals=None)`

引數是一個字串，以及選擇性的 *globals* 和 *locals*。如果有提供選擇性引數，*globals* 必須是一個 dictionary。*locals* 可以是任何映射 (mapping) 物件。

expression 引數被剖析執行成 Python 運算式（技術上而言，是條件列表），*globals* 和 *locals* dictionaries 分別用作全域性和本地命名空間。如果 *globals* dictionary 存在但缺少 `__builtins__` 的鍵值，那 *expression* 被剖析之前，將該鍵插入對 `builtins` module dictionary 的引用。這一來，在將 `__builtins__` 傳入 `eval()` 之前，你可以透過將它插入 *globals* 來控制你需要哪些函式。如果 *locals* 被省略，那它的預設值是 *globals* dictionary。如果兩個 dictionary 變數都被省略，則在 `eval()` 被呼叫的環境中執行運算式。請注意，`eval()` 在封閉環境中無法存取巢狀域 (non-locals)。

The return value is the result of the evaluated expression. Syntax errors are reported as exceptions. Example:

```

>>> x = 1
>>> eval('x+1')
2

```

這個函式也可以用來執行任意程式碼物件（如被 `compile()` 建立的那些）。這種情況下，傳入的引數是程式碼物件而不是字串。如果編譯該物件時的 *mode* 引數是 `'exec'`，那 `eval()` 回傳值 `None`。

提示：`exec()` 函式支援動態執行陳述式。`globals()` 和 `locals()` 函式分別回傳當前的全域性和局部性 dictionary，它們對於將引數傳遞給 `eval()` 或 `exec()` 可能會方便許多。

If the given source is a string, then leading and trailing spaces and tabs are stripped.

另外可以參閱 `ast.literal_eval()`，該函式可以安全執行僅包含文字的運算式字串。

引發一個附帶引數 `code_object` 的稽核事件 `exec`。

exec (*object*, *globals*=None, *locals*=None, /, *, *closure*=None)

這個函式支援動態執行 Python 程式碼。*object* 必須是字串或者程式碼物件。如果是字串，那麼該字串將被剖析一系列 Python 陳述式執行（除非發生語法錯誤）。¹ 如果是程式碼物件，它將被直接執行。無論哪種情況，被執行的程式碼都需要和檔案輸入一樣是有效的（可參考手冊中關於 `file-input` 的章節）。請注意，即使在傳遞給 `exec()` 函式的程式碼的上下文中，`nonlocal`、`yield` 和 `return` 陳述式也不能在函式之外使用。該函式回傳值是 `None`。

無論哪種情況，如果省略了選擇性引數，程式碼將在當前作用域執行。如果只提供了 *globals* 引數，就必須是 dictionary 型，而且會被用作全域性和本地變數。如果同時提供了 *globals* 和 *locals* 引數，它們分別被用作全域性和本地變數。如果提供了 *locals* 引數，則它可以是任何映射物件。請記住，在 `module` 層級中全域性和本地變數是相同的 dictionary。如果 `exec` 有兩個不同的 *globals* 和 *locals* 物件，程式碼就像嵌入在 `class` 定義中一樣執行。

如果 *globals* dictionary 不包含 `__builtins__` 鍵值，則將該鍵插入對 `builtins` module dictionary 的引用。因此，在將執行的程式碼傳遞給 `exec()` 之前，可以通過將自己的 `__builtins__` dictionary 插入到 *globals* 中來控制可以使用哪些 `builtins` 程式碼。

The *closure* argument specifies a closure--a tuple of cellvars. It's only valid when the *object* is a code object containing free variables. The length of the tuple must exactly match the number of free variables referenced by the code object.

引發一個附帶引數 `code_object` 的稽核事件 `exec`。

備註： `globals()` 和 `locals()` 函式各自回傳當前的全域性和本地 dictionary，因此可以將它們傳遞給 `exec()` 的第二個和第三個引數。

備註： 預設情況下，*locals* 的行如下面 `locals()` 函式描述的一樣：不要試圖改變預設的 *locals* dictionary。如果您想在 `exec()` 函式回傳時知道程式碼對 *locals* 的變動，請明確地傳遞 *locals* dictionary。

在 3.11 版的變更：增加了 *closure* 參數。

filter (*function*, *iterable*)

用 *iterable* 中函式 *function* 為 `True` 的那些元素，構建一個新的 iterator。*iterable* 可以是一個序列、一個支援 `iter()` 的容器、或一個 iterator。如果 *function* 是 `None`，則會假設它是一個等函式，即 *iterable* 中所有假值元素會被移除。

請注意，`filter(function, iterable)` 相當於一個生成器運算式，當 *function* 不是 `None` 的時候 `(item for item in iterable if function(item))`；*function* 是 `None` 的時候 `(item for item in iterable if item)`。

請參閱 `itertools.filterfalse()`，只有 *function* 為 `false` 時才選取 *iterable* 中元素的互補函式。

class float (*x*=0.0)

回傳從數字或字串 *x* 生成的浮點數。

如果引數是字串，則它必須是包含十進位制數字的字串，字串前面可以有符號，之前也可以有空格。選擇性的符號有 '+' 和 '-'；'+' 對建立的值有影響。引數也可以是 NaN（非數字）或正負無窮大的字串。確切地說，除去首尾的空格後，輸入必須遵循以下語法中 `floatvalue` 的生成規則：

¹ 剖析器只接受 Unix 風格的行結束符。如果您從檔案中讀取程式碼，請確保用行符轉模式轉 Windows 或 Mac 風格的行符。


```

sign          ::= "+" | "-"
infinity      ::= "Infinity" | "inf"
nan           ::= "nan"
digit         ::= <a Unicode decimal digit, i.e. characters in Unicode general category
digitpart     ::= digit (["_"] digit)*
number        ::= [digitpart] "." digitpart | digitpart ["."]
exponent      ::= ("e" | "E") ["+" | "-"] digitpart
floatnumber   ::= number [exponent]
floatvalue    ::= [sign] (floatnumber | infinity | nan)

```

Case is not significant, so, for example, "inf", "Inf", "INFINITY", and "iNfINity" are all acceptable spellings for positive infinity.

否則，如果引數是整數或浮點數，則回傳具有相同值（在 Python 浮點精度範圍 F）的浮點數。如果引數在 Python 浮點精度範圍外，則會觸發 *OverflowError*。

對於一般的 Python 物件 *x*，`float(x)` 指派給 `x.__float__()`。如果未定義 `__float__()` 則回退使用 `__index__()`。

如果 F 有引數，則回傳 0.0。

例如：

```

>>> float('+1.23')
1.23
>>> float(' -12345\n')
-12345.0
>>> float('1e-003')
0.001
>>> float('+1E6')
1000000.0
>>> float('-Infinity')
-inf

```

Numeric Types --- int, float, complex 描述了浮點數型 F。

在 3.6 版的變更：可以使用底 F 將程式碼文字中的數字進行分組。

在 3.7 版的變更：*x* is now a positional-only parameter.

在 3.8 版的變更：Falls back to `__index__()` if `__float__()` is not defined.

format (*value*, *format_spec*="")

將 *value* 轉 F F *format_spec* 控制的“格式化”表示。*format_spec* 的解釋取 F 於 *value* 引數的型 F，但是大多數 F 建型 F 使用標準格式化語法：*Format Specification Mini-Language*。

預設的 *format_spec* 是一個空字串，它通常和呼叫 `str(value)` 的效果相同。

A call to `format(value, format_spec)` is translated to `type(value).__format__(value, format_spec)` which bypasses the instance dictionary when searching for the value's `__format__()` method. A *TypeError* exception is raised if the method search reaches *object* and the *format_spec* is non-empty, or if either the *format_spec* or the return value are not strings.

在 3.4 版的變更：當 *format_spec* 不是空字串時，`object().__format__(format_spec)` 會觸發 *TypeError*。

class frozenset (*iterable*=set())

回傳一個新的 *frozenset* 物件，它包含選擇性引數 *iterable* 中的元素。*frozenset* 是一個 F 建的 class。有關此 class 的文件，請參 F *frozenset* 和 *Set Types --- set, frozenset*。

請參 F F 建的 *set*、*list*、*tuple* 和 *dict* class，以及 *collections* module 來了解其它的容器。

getattr (*object*, *name*)

getattr (*object, name, default*)

回傳 *object* 之具名屬性的值。*name* 必須是字串。如果該字串是物件屬性之一的名稱，則回傳該屬性的值。例如，`getattr(x, 'foobar')` 等同於 `x.foobar`。如果指定的屬性不存在，且提供了 *default* 值，則回傳其值，否則觸發 `AttributeError`。*name* 不必是個 Python 識符 (identifier) (請見 `setattr()`)。

備註： Since private name mangling happens at compilation time, one must manually mangle a private attribute's (attributes with two leading underscores) name in order to retrieve it with `getattr()`.

globals ()

回傳代表當前 module 命名空間的 dictionary。對於在函式中的程式碼來，這在定義函式時設定且不論該函式是在何處呼叫都會保持相同。

hasattr (*object, name*)

該引數是一個物件和一個字串。如果字串是物件屬性之一的名稱，則回傳 `True`，否則回傳 `False`。(此功能是通過呼叫 `getattr(object, name)` 看是否有 `AttributeError` 來實現的。)

hash (*object*)

回傳該物件的雜值 (如果它有的話)。雜值是整數。它們在 dictionary 查詢元素時用來快速比較 dictionary 的鍵。相同大小的數字數值有相同的雜值 (即使它們型不同，如 1 和 1.0)。

備註： For objects with custom `__hash__()` methods, note that `hash()` truncates the return value based on the bit width of the host machine.

help ()**help** (*request*)

互動式的幫助系統 (此函式主要以互動式使用)。如果有引數，直譯器控制臺會啟動互動式幫助系統。如果引數是一個字串，則在 module、函式、class、method、關鍵字或文件主題中搜索該字串，在控制台上列印幫助資訊。如果引數是其他任意物件，則會生成該物件的幫助頁。

Note that if a slash (/) appears in the parameter list of a function when invoking `help()`, it means that the parameters prior to the slash are positional-only. For more info, see the FAQ entry on positional-only parameters.

該函式透過 `site` module 加入到互動命名空間。

在 3.4 版的變更: 變更至 `pydoc` 和 `inspect` 使得可呼叫物件的簽名信息 (signature) 更加全面和一致。

hex (*x*)

將整數轉以 "0x" 前綴的小寫十六進位制字串。如果 *x* 不是 Python `int` 物件，則必須定義一個 `__index__()` method 且回傳一個整數。舉例來：

```
>>> hex(255)
'0xff'
>>> hex(-42)
'-0x2a'
```

如果要將整數轉大寫或小寫的十六進位制字串，可選擇有無 "0x" 前綴，則可以使用如下方法：

```
>>> '%#x' % 255, '%x' % 255, '%X' % 255
('0xff', 'ff', 'FF')
>>> format(255, '#x'), format(255, 'x'), format(255, 'X')
('0xff', 'ff', 'FF')
>>> f'{255:#x}', f'{255:x}', f'{255:X}'
('0xff', 'ff', 'FF')
```

可參考 `format()` 獲取更多資訊。

另請參 `int()` 將十六進位制字串轉以 16 基數的整數。

備註：如果要獲取浮點數的十六進位制字串形式，請使用 `float.hex()` method。

`id(object)`

回傳物件的“標識值”。該值是一個整數，在此物件的生命期中保證是唯一且固定的。兩個生命期不重疊的物件可能具有相同的 `id()` 值。

CPython 實作細節： This is the address of the object in memory.

引發一個附帶引數 `id` 的稽核事件 `builtins.id`。

`input()`

`input(prompt)`

如果有提供 `prompt` 引數，則將其寫入標準輸出，末尾不帶換行符。接下來，該函式從輸入中讀取一行，將其轉為字串（去除末尾的換行符）回傳。當讀取到 EOF 時，則觸發 `EOFError`。例如：

```
>>> s = input('--> ')
--> Monty Python's Flying Circus
>>> s
"Monty Python's Flying Circus"
```

如果載入了 `readline` module，`input()` 將使用它來提供複雜的行編輯和歷史記憶功能。

引發一個附帶引數 `prompt` 的稽核事件 `builtins.input`。

引發一個附帶引數 `result` 的稽核事件 `builtins.input/result`。

`class int(x=0)`

`class int(x, base=10)`

回傳一個使用數字或字串 `x` 建構的整數物件，或者在沒有引數時回傳 0。如果 `x` 定義了 `__int__()`，`int(x)` 回傳 `x.__int__()`。如果 `x` 定義了 `__index__()` 則回傳 `x.__index__()`。如果 `x` 定義了 `__trunc__()` 則回傳 `x.__trunc__()`。對於浮點數則向零舍入。

如果 `x` 不是數字或如果有給定 `base`，則 `x` 必須是個字串、`bytes` 或 `bytearray` 實例，表示基數 (radix) `base` 中的整數。可選地，字串之前可以有 + 或 -（中間有空白）、可有個前導的零、也可被空白包圍、或在數字間有單一底線。

一個 `n` 進制的整數字串，包含各個代表 0 到 `n-1` 的數字，0-9 可以用任何 Unicode 十進制數字表示，10-35 可以用 a 到 z（或 A 到 Z）表示。預設的 `base` 是 10。允許的進位制有 0、2-36。2、8、16 進位的字串可以在程式碼中用 `0b/0B`、`0o/0O`、`0x/0X` 前綴來表示，如同程式碼中的整數文字。進位制 0 的字串將以和程式碼整數字面值 (integer literal in code) 類似的方式來直譯，最後由前綴固定的結果會是 2、8、10、16 進制中的一個，所以 `int('010', 0)` 是非法的，但 `int('010')` 和 `int('010', 8)` 是有效的。

整數型定義請參 [Numeric Types --- int, float, complex](#)。

在 3.4 版的變更：如果 `base` 不是 `int` 的實例，但 `base` 物件有 `base.__index__` method，則會呼叫該 method 來獲取此進位制整數。以前的版本使用 `base.__int__` 而不是 `base.__index__`。

在 3.6 版的變更：可以使用底線將程式碼文字中的數字進行分組。

在 3.7 版的變更：`x` is now a positional-only parameter.

在 3.8 版的變更：Falls back to `__index__()` if `__int__()` is not defined.

在 3.11 版的變更：The delegation to `__trunc__()` is deprecated.

在 3.11 版的變更：`int` string inputs and string representations can be limited to help avoid denial of service attacks. A `ValueError` is raised when the limit is exceeded while converting a string `x` to an `int` or when converting an `int` into a string would exceed the limit. See the [integer string conversion length limitation](#) documentation.

isinstance (*object*, *classinfo*)

如果 *object* 引數是 *classinfo* 引數的實例，或者是（直接、間接或 *virtual*）subclass 的實例，則回傳 True。如果 *object* 不是給定型 *classinfo* 的物件，函式始終回傳 False。如果 *classinfo* 是包含物件型 *classinfo* 的 tuple（或多個遞 *classinfo* tuple）或一個包含多種型 *classinfo* 的 *Union Type*，若 *object* 是其中的任何一個物件的實例則回傳 True。如果 *classinfo* 既不是型 *classinfo*，也不是型 *classinfo* tuple 或型 *classinfo* 的遞 *classinfo* tuple，那 *classinfo* 會觸發 *TypeError* 異常。若是先前檢查已經成功，*TypeError* 可能不會再因 *classinfo* 不合格的型 *classinfo* 而被引發。

在 3.10 版的變更: *classinfo* 可以是一個 *Union Type*。

issubclass (*class*, *classinfo*)

如果 *class* 是 *classinfo* 的 subclass（直接、間接或 *virtual*），則回傳 True。*classinfo* 可以是 class 物件的 tuple（或遞 *classinfo* 地其他類似 tuple）或是一個 *Union Type*，此時若 *class* 是 *classinfo* 中任一元素的 subclass 時則回傳 True。其他情況，會觸發 *TypeError*。

在 3.10 版的變更: *classinfo* 可以是一個 *Union Type*。

iter (*object*)**iter** (*object*, *sentinel*)

Return an *iterator* object. The first argument is interpreted very differently depending on the presence of the second argument. Without a second argument, *object* must be a collection object which supports the *iterable* protocol (the `__iter__()` method), or it must support the sequence protocol (the `__getitem__()` method with integer arguments starting at 0). If it does not support either of those protocols, *TypeError* is raised. If the second argument, *sentinel*, is given, then *object* must be a callable object. The iterator created in this case will call *object* with no arguments for each call to its `__next__()` method; if the value returned is equal to *sentinel*, *StopIteration* will be raised, otherwise the value will be returned.

另請參閱 *Iterator Types*。

One useful application of the second form of *iter()* is to build a block-reader. For example, reading fixed-width blocks from a binary database file until the end of file is reached:

```
from functools import partial
with open('mydata.db', 'rb') as f:
    for block in iter(partial(f.read, 64), b''):
        process_block(block)
```

len (*s*)

回傳物件的長度（元素個數）。引數可以是序列（如 string、bytes、tuple、list 或 range）或集合（如 dictionary、set 或 frozen set）。

CPython 實作細節： `len` raises *OverflowError* on lengths larger than `sys.maxsize`, such as `range(2 ** 100)`.

class list**class list** (*iterable*)

除了是函式，*list* 也是可變序列型 *list*，詳情請參閱 *List (串列)* 和 *Sequence Types --- list, tuple, range*。

locals ()

更新 *locals* 回傳表示當前本地符號表的 dictionary。在函式區塊而不是 class 區塊中呼叫 *locals()* 時會回傳自由變數。請注意，在 module 階層中，*locals()* 和 *globals()* 是相同的 dictionary。

備註： 此 dictionary 的內容不應該被更動；更改可能不會影響直譯器使用的本地變數或自由變數的值。

map (*function*, *iterable*, **iterables*)

產生一個將 *function* 應用於 *iterable* 中所有元素，收集回傳結果的 iterator。如果傳遞了額外的 *iterables* 引數，*function* 必須接受相同個數的引數，應用於所有 *iterables* 中同時獲取的元素。當有多個 *iterables* 時，最短的 *iterable* 耗盡時 iterator 也會結束。如果函式的輸入已經是 tuple 的引數，請參閱 *itertools.starmap()*。

max (*iterable*, *, *key=None*)

max (iterable, *, default, key=None)

max (arg1, arg2, *args, key=None)

回傳 iterable 中最大的元素，或者回傳兩個及以上引數中最大的。

如果只提供了一個位置引數，它必須是個 *iterable*，iterable 中最大的元素會被回傳。如果提供了兩個或以上的位置引數，則回傳最大的位置引數。

這個函式有兩個選擇性僅限關鍵字的引數。key 引數指定一個只有一個引數的排序函式，如同 `list.sort()` 使用方式。default 引數是當 iterable 空時回傳的值。如果 iterable 空，且 有提供 default，則會觸發 *ValueError*。

如果有多個最大元素，則此函式將回傳第一個找到的。這和其他穩定排序工具如 `sorted(iterable, key=keyfunc, reverse=True)[0]` 和 `heapq.nlargest(1, iterable, key=keyfunc)` 一致。

在 3.4 版的變更: Added the *default* keyword-only parameter.

在 3.8 版的變更: The *key* can be None.

class memoryview (object)

回傳由給定的引數建立之“memory view”物件。有關詳細資訊，請參 [Memory Views](#)。

min (iterable, *, key=None)

min (iterable, *, default, key=None)

min (arg1, arg2, *args, key=None)

回傳 iterable 中最小的元素，或者回傳兩個及以上引數中最小的。

如果只提供了一個位置引數，它必須是個 *iterable*，iterable 中最小的元素會被回傳。如果提供了兩個或以上的位置引數，則回傳最小的位置引數。

這個函式有兩個選擇性僅限關鍵字的引數。key 引數指定一個只有一個引數的排序函式，如同 `list.sort()` 使用方式。default 引數是當 iterable 空時回傳的值。如果 iterable 空，且 有提供 default，則會觸發 *ValueError*。

如果有多個最小元素，則此函式將回傳第一個找到的。這和其他穩定排序工具如 `sorted(iterable, key=keyfunc)[0]` 和 `heapq.nsmallest(1, iterable, key=keyfunc)` 一致。

在 3.4 版的變更: Added the *default* keyword-only parameter.

在 3.8 版的變更: The *key* can be None.

next (iterator)

next (iterator, default)

通過呼叫 *iterator* 的 `__next__()` method 獲取下一個元素。如果 iterator 耗盡，則回傳給定的預設值 default，如果 有預設值則觸發 *StopIteration*。

class object

回傳一個 有特徵的新物件。object 是所有 class 的基礎，它具有所有 Python class 實例的通用 method。這個函式不接受任何引數。

備註: 由於 object 有 `__dict__`，因此無法將任意屬性賦給 object class 的實例。

oct (x)

將一個整數轉變一個前綴“0o”的八進位制字串。回傳結果是一個有效的 Python 運算式。如果 x 不是 Python 的 *int* 物件，那它需要定義 `__index__()` method 回傳一個整數。舉例來:

```
>>> oct(8)
'0o10'
>>> oct(-56)
'-0o70'
```


如果要將整數轉成八進位制字串，不論是否具備“0o”前綴，都可以使用下面的方法。

```
>>> '%#o' % 10, '%o' % 10
('0o12', '12')
>>> format(10, '#o'), format(10, 'o')
('0o12', '12')
>>> f'{10:#o}', f'{10:o}'
('0o12', '12')
```

可參考 `format()` 獲取更多資訊。

open (*file*, *mode='r'*, *buffering=-1*, *encoding=None*, *errors=None*, *newline=None*, *closefd=True*, *opener=None*)

開 `file` 回傳對應的 `file object`。如果該檔案不能開，則觸發 `OSError`。關於使用此函式的更多方法請參 `tut-files`。

file 是一個 *path-like object*，是將被開之檔案的路徑（對路徑或者當前工作目錄的相當路徑），或是被封裝的整數檔案描述器（file descriptor）。（如果有提供檔案描述器，它會隨著回傳的 I/O 物件關閉而關閉，除非 *closefd* 被設 `False`。）

mode 是一個選擇性字串，用於指定開檔案的模式。預設值是 `'r'`，這意味著它以文字模式開讀取。其他常見模式有：寫入 `'w'`（會舍去已經存在的檔案）、唯一性創建 `'x'`、追加寫入 `'a'`（在一些 Unix 系統上，無論當前的檔案指標在什麼位置，所有寫入都會追加到檔案末尾）。在文字模式，如果有指定 *encoding*，則根據電腦平臺來定使用的編碼：呼叫 `locale.getencoding()` 來獲取當前的本地編碼。（要讀取和寫入原始 bytes，請使用二進位制模式且不要指定 *encoding*。）可用的模式有：

字元	意義
<code>'r'</code>	讀取（預設）
<code>'w'</code>	open for writing, truncating the file first
<code>'x'</code>	唯一性創建，如果文件已存在則會失敗
<code>'a'</code>	寫入，如果文件存在則在末尾追加寫入內容
<code>'b'</code>	binary mode（二進位模式）
<code>'t'</code>	文字模式（預設）
<code>'+'</code>	更新（讀取和寫入）

預設的模式是 `'r'`（開讀取文字，同 `'rt'`）。對於二進位制寫入，`'w+b'` 模式開把檔案內容變成 0 bytes，`'r+b'` 則不會舍去原始內容。

As mentioned in the 總覽, Python distinguishes between binary and text I/O. Files opened in binary mode (including `'b'` in the *mode* argument) return contents as *bytes* objects without any decoding. In text mode (the default, or when `'t'` is included in the *mode* argument), the contents of the file are returned as *str*, the bytes having been first decoded using a platform-dependent encoding or using the specified *encoding* if given.

備註： Python doesn't depend on the underlying operating system's notion of text files; all the processing is done by Python itself, and is therefore platform-independent.

buffering is an optional integer used to set the buffering policy. Pass 0 to switch buffering off (only allowed in binary mode), 1 to select line buffering (only usable when writing in text mode), and an integer > 1 to indicate the size in bytes of a fixed-size chunk buffer. Note that specifying a buffer size this way applies for binary buffered I/O, but `TextIOWrapper` (i.e., files opened with *mode='r+'*) would have another buffering. To disable buffering in `TextIOWrapper`, consider using the `write_through` flag for `io.TextIOWrapper.reconfigure()`. When no *buffering* argument is given, the default buffering policy works as follows:

- Binary files are buffered in fixed-size chunks; the size of the buffer is chosen using a heuristic trying to determine the underlying device's "block size" and falling back on `io.DEFAULT_BUFFER_SIZE`. On many systems, the buffer will typically be 4096 or 8192 bytes long.

- "Interactive" text files (files for which `isatty()` returns `True`) use line buffering. Other text files use the policy described above for binary files.

encoding is the name of the encoding used to decode or encode the file. This should only be used in text mode. The default encoding is platform dependent (whatever `locale.getencoding()` returns), but any *text encoding* supported by Python can be used. See the `codecs` module for the list of supported encodings.

errors is an optional string that specifies how encoding and decoding errors are to be handled—this cannot be used in binary mode. A variety of standard error handlers are available (listed under *Error Handlers*), though any error handling name that has been registered with `codecs.register_error()` is also valid. The standard names include:

- `'strict'` to raise a `ValueError` exception if there is an encoding error. The default value of `None` has the same effect.
- `'ignore'` ignores errors. Note that ignoring encoding errors can lead to data loss.
- `'replace'` causes a replacement marker (such as `'?'`) to be inserted where there is malformed data.
- `'surrogateescape'` will represent any incorrect bytes as low surrogate code units ranging from `U+DC80` to `U+DCFF`. These surrogate code units will then be turned back into the same bytes when the `surrogateescape` error handler is used when writing data. This is useful for processing files in an unknown encoding.
- `'xmlcharrefreplace'` is only supported when writing to a file. Characters not supported by the encoding are replaced with the appropriate XML character reference `&#nnn;`.
- `'backslashreplace'` replaces malformed data by Python's backslashed escape sequences.
- `'namereplace'` (also only supported when writing) replaces unsupported characters with `\N{...}` escape sequences.

newline determines how to parse newline characters from the stream. It can be `None`, `' '`, `'\n'`, `'\r'`, and `'\r\n'`. It works as follows:

- When reading input from the stream, if *newline* is `None`, universal newlines mode is enabled. Lines in the input can end in `'\n'`, `'\r'`, or `'\r\n'`, and these are translated into `'\n'` before being returned to the caller. If it is `' '`, universal newlines mode is enabled, but line endings are returned to the caller untranslated. If it has any of the other legal values, input lines are only terminated by the given string, and the line ending is returned to the caller untranslated.
- When writing output to the stream, if *newline* is `None`, any `'\n'` characters written are translated to the system default line separator, `os.linesep`. If *newline* is `' '` or `'\n'`, no translation takes place. If *newline* is any of the other legal values, any `'\n'` characters written are translated to the given string.

If *closefd* is `False` and a file descriptor rather than a filename was given, the underlying file descriptor will be kept open when the file is closed. If a filename is given *closefd* must be `True` (the default); otherwise, an error will be raised.

A custom opener can be used by passing a callable as *opener*. The underlying file descriptor for the file object is then obtained by calling *opener* with (*file*, *flags*). *opener* must return an open file descriptor (passing `os.open` as *opener* results in functionality similar to passing `None`).

新建立的檔案是不可繼承的。

下面的範例使用 `os.open()` 函式回傳值當作 *dir_fd* 的參數，從給定的目錄中用相對路徑開檔案：

```
>>> import os
>>> dir_fd = os.open('somedir', os.O_RDONLY)
>>> def opener(path, flags):
...     return os.open(path, flags, dir_fd=dir_fd)
...
>>> with open('spamspam.txt', 'w', opener=opener) as f:
...     print('This will be written to somedir/spamspam.txt', file=f)
...
>>> os.close(dir_fd) # don't leak a file descriptor
```

The type of *file object* returned by the `open()` function depends on the mode. When `open()` is used to open a file in a text mode ('w', 'r', 'wt', 'rt', etc.), it returns a subclass of `io.TextIOBase` (specifically `io.TextIOWrapper`). When used to open a file in a binary mode with buffering, the returned class is a subclass of `io.BufferedIOBase`. The exact class varies: in read binary mode, it returns an `io.BufferedReader`; in write binary and append binary modes, it returns an `io.BufferedWriter`, and in read/write mode, it returns an `io.BufferedRandom`. When buffering is disabled, the raw stream, a subclass of `io.RawIOBase`, `io.FileIO`, is returned.

另請參閱檔案操作模組，例如 `fileinput`、`io` (定義了 `open()` 的 module)、`os`、`os.path`、`tempfile` 以及 `shutil`。

引發一個附帶引數 `file`、`mode`、`flags` 的稽核事件 `open`。

The `mode` and `flags` arguments may have been modified or inferred from the original call.

在 3.3 版的變更：

- 增加了 `opener` 參數。
- 增加了 'x' 模式。
- 過去觸發的 `IOError`，現在是 `OSError` 的別名。
- 如果檔案已存在但使用了唯一性建立模式 ('x')，現在會觸發 `FileExistsError`。

在 3.4 版的變更：

- 檔案在當前版本開始禁止繼承。

在 3.5 版的變更：

- 如果系統呼叫被中斷，但訊號處理程序沒有觸發例外，此函式現在會重試系統呼叫，而不是觸發 `InterruptedError` (原因詳見 [PEP 475](#))。
- 增加了 'namereplace' 錯誤處理程式。

在 3.6 版的變更：

- 增加對實現了 `os.PathLike` 物件的支援。
- 在 Windows 上，開啟一個控制臺緩衝區可能會回傳 `io.RawIOBase` 的 subclass，而不是 `io.FileIO`。

在 3.11 版的變更：'U' 模式被移除。

ord(c)

對於代表單個 Unicode 字元的字串，回傳代表它 Unicode 編碼位置的整數。例如 `ord('a')` 回傳整數 97、`ord('€')` (歐元符號) 回傳 8364。這是 `chr()` 的逆函式。

pow(base, exp, mod=None)

回傳 `base` 的 `exp` 次方；如果 `mod` 存在，則回傳 `base` 的 `exp` 次方對 `mod` 取余數 (比直接呼叫 `pow(base, exp) % mod` 計算更高效)。兩個引數形式的 `pow(exp, exp)` 等價於次方運算子：`base**exp`。

The arguments must have numeric types. With mixed operand types, the coercion rules for binary arithmetic operators apply. For `int` operands, the result has the same type as the operands (after coercion) unless the second argument is negative; in that case, all arguments are converted to float and a float result is delivered. For example, `pow(10, 2)` returns 100, but `pow(10, -2)` returns 0.01. For a negative base of type `int` or `float` and a non-integral exponent, a complex result is delivered. For example, `pow(-9, 0.5)` returns a value close to 3j.

For `int` operands `base` and `exp`, if `mod` is present, `mod` must also be of integer type and `mod` must be nonzero. If `mod` is present and `exp` is negative, `base` must be relatively prime to `mod`. In that case, `pow(inv_base, -exp, mod)` is returned, where `inv_base` is an inverse to `base` modulo `mod`.

Here's an example of computing an inverse for 38 modulo 97:


```
>>> pow(38, -1, mod=97)
23
>>> 23 * 38 % 97 == 1
True
```

在 3.8 版的變更: For `int` operands, the three-argument form of `pow` now allows the second argument to be negative, permitting computation of modular inverses.

在 3.8 版的變更: Allow keyword arguments. Formerly, only positional arguments were supported.

print (*objects, sep=' ', end='\n', file=None, flush=False)

Print *objects* to the text stream *file*, separated by *sep* and followed by *end*. *sep*, *end*, *file*, and *flush*, if present, must be given as keyword arguments.

All non-keyword arguments are converted to strings like `str()` does and written to the stream, separated by *sep* and followed by *end*. Both *sep* and *end* must be strings; they can also be `None`, which means to use the default values. If no *objects* are given, `print()` will just write *end*.

The *file* argument must be an object with a `write(string)` method; if it is not present or `None`, `sys.stdout` will be used. Since printed arguments are converted to text strings, `print()` cannot be used with binary mode file objects. For these, use `file.write(...)` instead.

Output buffering is usually determined by *file*. However, if *flush* is true, the stream is forcibly flushed.

在 3.3 版的變更: 增加了 *flush* 關鍵字引數。

class property (fget=None, fset=None, fdel=None, doc=None)

回傳 property 屬性。

fget is a function for getting an attribute value. *fset* is a function for setting an attribute value. *fdel* is a function for deleting an attribute value. And *doc* creates a docstring for the attribute.

A typical use is to define a managed attribute `x`:

```
class C:
    def __init__(self):
        self._x = None

    def getx(self):
        return self._x

    def setx(self, value):
        self._x = value

    def delx(self):
        del self._x

x = property(getx, setx, delx, "I'm the 'x' property.")
```

If *c* is an instance of *C*, `c.x` will invoke the getter, `c.x = value` will invoke the setter, and `del c.x` the deleter.

If given, *doc* will be the docstring of the property attribute. Otherwise, the property will copy *fget*'s docstring (if it exists). This makes it possible to create read-only properties easily using `property()` as a *decorator*:

```
class Parrot:
    def __init__(self):
        self._voltage = 100000

    @property
    def voltage(self):
        """Get the current voltage."""
        return self._voltage
```

The `@property` decorator turns the `voltage()` method into a "getter" for a read-only attribute with the same name, and it sets the docstring for `voltage` to "Get the current voltage."

@getter

@setter

@deleter

A property object has `getter`, `setter`, and `deleter` methods usable as decorators that create a copy of the property with the corresponding accessor function set to the decorated function. This is best explained with an example:

```
class C:
    def __init__(self):
        self._x = None

    @property
    def x(self):
        """I'm the 'x' property."""
        return self._x

    @x.setter
    def x(self, value):
        self._x = value

    @x.deleter
    def x(self):
        del self._x
```

This code is exactly equivalent to the first example. Be sure to give the additional functions the same name as the original property (`x` in this case.)

The returned property object also has the attributes `fget`, `fset`, and `fdel` corresponding to the constructor arguments.

在 3.5 版的變更: The docstrings of property objects are now writeable.

class range (*stop*)

class range (*start, stop, step=1*)

Rather than being a function, *range* is actually an immutable sequence type, as documented in [Ranges](#) and [Sequence Types --- list, tuple, range](#).

repr (*object*)

Return a string containing a printable representation of an object. For many types, this function makes an attempt to return a string that would yield an object with the same value when passed to `eval()`; otherwise, the representation is a string enclosed in angle brackets that contains the name of the type of the object together with additional information often including the name and address of the object. A class can control what this function returns for its instances by defining a `__repr__()` method. If `sys.displayhook()` is not accessible, this function will raise `RuntimeError`.

This class has a custom representation that can be evaluated:

```
class Person:
    def __init__(self, name, age):
        self.name = name
        self.age = age

    def __repr__(self):
        return f"Person('{self.name}', {self.age})"
```

reversed (*seq*)

Return a reverse *iterator*. *seq* must be an object which has a `__reversed__()` method or supports the se-

quence protocol (the `__len__()` method and the `__getitem__()` method with integer arguments starting at 0).

round (*number*, *ndigits=None*)

Return *number* rounded to *ndigits* precision after the decimal point. If *ndigits* is omitted or is `None`, it returns the nearest integer to its input.

For the built-in types supporting `round()`, values are rounded to the closest multiple of 10 to the power minus *ndigits*; if two multiples are equally close, rounding is done toward the even choice (so, for example, both `round(0.5)` and `round(-0.5)` are 0, and `round(1.5)` is 2). Any integer value is valid for *ndigits* (positive, zero, or negative). The return value is an integer if *ndigits* is omitted or `None`. Otherwise, the return value has the same type as *number*.

For a general Python object *number*, `round` delegates to `number.__round__`.

備F: The behavior of `round()` for floats can be surprising: for example, `round(2.675, 2)` gives `2.67` instead of the expected `2.68`. This is not a bug: it's a result of the fact that most decimal fractions can't be represented exactly as a float. See `tut-fp-issues` for more information.

class set

class set (*iterable*)

Return a new `set` object, optionally with elements taken from *iterable*. `set` is a built-in class. See `set` and `Set Types --- set, frozenset` for documentation about this class.

For other containers see the built-in `frozenset`, `list`, `tuple`, and `dict` classes, as well as the `collections` module.

setattr (*object*, *name*, *value*)

This is the counterpart of `getattr()`. The arguments are an object, a string, and an arbitrary value. The string may name an existing attribute or a new attribute. The function assigns the value to the attribute, provided the object allows it. For example, `setattr(x, 'foobar', 123)` is equivalent to `x.foobar = 123`.

name need not be a Python identifier as defined in `identifiers` unless the object chooses to enforce that, for example in a custom `__getattribute__()` or via `__slots__`. An attribute whose name is not an identifier will not be accessible using the dot notation, but is accessible through `getattr()` etc..

備F: Since private name mangling happens at compilation time, one must manually mangle a private attribute's (attributes with two leading underscores) name in order to set it with `setattr()`.

class slice (*stop*)

class slice (*start*, *stop*, *step=None*)

Return a `slice` object representing the set of indices specified by `range(start, stop, step)`. The *start* and *step* arguments default to `None`.

start

stop

step

Slice objects have read-only data attributes `start`, `stop`, and `step` which merely return the argument values (or their default). They have no other explicit functionality; however, they are used by NumPy and other third-party packages.

Slice objects are also generated when extended indexing syntax is used. For example: `a[start:stop:step]` or `a[start:stop, i]`. See `itertools.islice()` for an alternate version that returns an `iterator`.

sorted (*iterable*, /, *, *key=None*, *reverse=False*)

Return a new sorted list from the items in *iterable*.

有兩個選擇性引數，只能使用關鍵字引數來指定。

key specifies a function of one argument that is used to extract a comparison key from each element in *iterable* (for example, *key=str.lower*). The default value is `None` (compare the elements directly).

reverse is a boolean value. If set to `True`, then the list elements are sorted as if each comparison were reversed.

Use `functools.cmp_to_key()` to convert an old-style *cmp* function to a *key* function.

The built-in `sorted()` function is guaranteed to be stable. A sort is stable if it guarantees not to change the relative order of elements that compare equal --- this is helpful for sorting in multiple passes (for example, sort by department, then by salary grade).

The sort algorithm uses only `<` comparisons between items. While defining an `__lt__()` method will suffice for sorting, **PEP 8** recommends that all six rich comparisons be implemented. This will help avoid bugs when using the same data with other ordering tools such as `max()` that rely on a different underlying method. Implementing all six comparisons also helps avoid confusion for mixed type comparisons which can call reflected the `__gt__()` method.

For sorting examples and a brief sorting tutorial, see [sortinghowto](#).

@staticmethod

Transform a method into a static method.

A static method does not receive an implicit first argument. To declare a static method, use this idiom:

```
class C:
    @staticmethod
    def f(arg1, arg2, argN): ...
```

@staticmethod 語法是一個函式 *decorator* - 參見 [function](#) 中的詳細介紹。

A static method can be called either on the class (such as `C.f()`) or on an instance (such as `C().f()`). Moreover, they can be called as regular functions (such as `f()`).

Static methods in Python are similar to those found in Java or C++. Also, see `classmethod()` for a variant that is useful for creating alternate class constructors.

Like all decorators, it is also possible to call `staticmethod` as a regular function and do something with its result. This is needed in some cases where you need a reference to a function from a class body and you want to avoid the automatic transformation to instance method. For these cases, use this idiom:

```
def regular_function():
    ...

class C:
    method = staticmethod(regular_function)
```

關於 static method 的更多資訊，請參考 [types](#)。

在 3.10 版的變更: Static methods now inherit the method attributes (`__module__`, `__name__`, `__qualname__`, `__doc__` and `__annotations__`), have a new `__wrapped__` attribute, and are now callable as regular functions.

class str (*object=""*)

class str (*object=b''*, *encoding='utf-8'*, *errors='strict'*)

Return a *str* version of *object*. See `str()` for details.

`str` is the built-in string *class*. For general information about strings, see [Text Sequence Type --- str](#).

sum (*iterable*, /, *start*=0)

Sums *start* and the items of an *iterable* from left to right and returns the total. The *iterable*'s items are normally numbers, and the start value is not allowed to be a string.

For some use cases, there are good alternatives to `sum()`. The preferred, fast way to concatenate a sequence of strings is by calling `' '.join(sequence)`. To add floating point values with extended precision, see `math.fsum()`. To concatenate a series of iterables, consider using `itertools.chain()`.

在 3.8 版的變更: *start* 參數可被指定 F 關鍵字引數。

class super

class super (*type*, *object_or_type*=None)

Return a proxy object that delegates method calls to a parent or sibling class of *type*. This is useful for accessing inherited methods that have been overridden in a class.

The *object_or_type* determines the *method resolution order* to be searched. The search starts from the class right after the *type*.

For example, if `__mro__` of *object_or_type* is D -> B -> C -> A -> object and the value of *type* is B, then `super()` searches C -> A -> object.

The `__mro__` attribute of the *object_or_type* lists the method resolution search order used by both `getattr()` and `super()`. The attribute is dynamic and can change whenever the inheritance hierarchy is updated.

If the second argument is omitted, the super object returned is unbound. If the second argument is an object, `isinstance(obj, type)` must be true. If the second argument is a type, `issubclass(type2, type)` must be true (this is useful for classmethods).

There are two typical use cases for *super*. In a class hierarchy with single inheritance, *super* can be used to refer to parent classes without naming them explicitly, thus making the code more maintainable. This use closely parallels the use of *super* in other programming languages.

The second use case is to support cooperative multiple inheritance in a dynamic execution environment. This use case is unique to Python and is not found in statically compiled languages or languages that only support single inheritance. This makes it possible to implement "diamond diagrams" where multiple base classes implement the same method. Good design dictates that such implementations have the same calling signature in every case (because the order of calls is determined at runtime, because that order adapts to changes in the class hierarchy, and because that order can include sibling classes that are unknown prior to runtime).

For both use cases, a typical superclass call looks like this:

```
class C(B):
    def method(self, arg):
        super().method(arg)      # This does the same thing as:
                                # super(C, self).method(arg)
```

In addition to method lookups, `super()` also works for attribute lookups. One possible use case for this is calling *descriptors* in a parent or sibling class.

Note that `super()` is implemented as part of the binding process for explicit dotted attribute lookups such as `super().__getitem__(name)`. It does so by implementing its own `__getattribute__()` method for searching classes in a predictable order that supports cooperative multiple inheritance. Accordingly, `super()` is undefined for implicit lookups using statements or operators such as `super()[name]`.

Also note that, aside from the zero argument form, `super()` is not limited to use inside methods. The two argument form specifies the arguments exactly and makes the appropriate references. The zero argument form only works inside a class definition, as the compiler fills in the necessary details to correctly retrieve the class being defined, as well as accessing the current instance for ordinary methods.

For practical suggestions on how to design cooperative classes using `super()`, see [guide to using super\(\)](#).

class tuple

class tuple (*iterable*)

Rather than being a function, *tuple* is actually an immutable sequence type, as documented in *Tuples* and *Sequence Types* --- *list*, *tuple*, *range*.

class type (*object*)

class type (*name*, *bases*, *dict*, ***kwargs*)

With one argument, return the type of an *object*. The return value is a type object and generally the same object as returned by *object.__class__*.

The *isinstance()* built-in function is recommended for testing the type of an object, because it takes subclasses into account.

With three arguments, return a new type object. This is essentially a dynamic form of the *class* statement. The *name* string is the class name and becomes the *__name__* attribute. The *bases* tuple contains the base classes and becomes the *__bases__* attribute; if empty, *object*, the ultimate base of all classes, is added. The *dict* dictionary contains attribute and method definitions for the class body; it may be copied or wrapped before becoming the *__dict__* attribute. The following two statements create identical *type* objects:

```
>>> class X:
...     a = 1
...
>>> X = type('X', (), dict(a=1))
```

另請參 F *Type Objects*.

Keyword arguments provided to the three argument form are passed to the appropriate metaclass machinery (usually *__init_subclass__()*) in the same way that keywords in a class definition (besides *metaclass*) would.

另請參 F *class-customization*.

在 3.6 版的變更: Subclasses of *type* which don't override *type.__new__* may no longer use the one-argument form to get the type of an object.

vars()

vars (*object*)

Return the *__dict__* attribute for a module, class, instance, or any other object with a *__dict__* attribute.

Objects such as modules and instances have an updateable *__dict__* attribute; however, other objects may have write restrictions on their *__dict__* attributes (for example, classes use a *types.MappingProxyType* to prevent direct dictionary updates).

Without an argument, *vars()* acts like *locals()*. Note, the locals dictionary is only useful for reads since updates to the locals dictionary are ignored.

A *TypeError* exception is raised if an object is specified but it doesn't have a *__dict__* attribute (for example, if its class defines the *__slots__* attribute).

zip (**iterables*, *strict=False*)

Iterate over several iterables in parallel, producing tuples with an item from each one.

例如:

```
>>> for item in zip([1, 2, 3], ['sugar', 'spice', 'everything nice']):
...     print(item)
...
(1, 'sugar')
(2, 'spice')
(3, 'everything nice')
```

More formally: *zip()* returns an iterator of tuples, where the *i*-th tuple contains the *i*-th element from each of the argument iterables.

Another way to think of *zip()* is that it turns rows into columns, and columns into rows. This is similar to *transposing a matrix*.

`zip()` is lazy: The elements won't be processed until the iterable is iterated on, e.g. by a `for` loop or by wrapping in a `list`.

One thing to consider is that the iterables passed to `zip()` could have different lengths; sometimes by design, and sometimes because of a bug in the code that prepared these iterables. Python offers three different approaches to dealing with this issue:

- By default, `zip()` stops when the shortest iterable is exhausted. It will ignore the remaining items in the longer iterables, cutting off the result to the length of the shortest iterable:

```
>>> list(zip(range(3), ['fee', 'fi', 'fo', 'fum']))
[(0, 'fee'), (1, 'fi'), (2, 'fo')]
```

- `zip()` is often used in cases where the iterables are assumed to be of equal length. In such cases, it's recommended to use the `strict=True` option. Its output is the same as regular `zip()`:

```
>>> list(zip(('a', 'b', 'c'), (1, 2, 3), strict=True))
[('a', 1), ('b', 2), ('c', 3)]
```

Unlike the default behavior, it raises a `ValueError` if one iterable is exhausted before the others:

```
>>> for item in zip(range(3), ['fee', 'fi', 'fo', 'fum'], strict=True):
...     print(item)
...
(0, 'fee')
(1, 'fi')
(2, 'fo')
Traceback (most recent call last):
...
ValueError: zip() argument 2 is longer than argument 1
```

Without the `strict=True` argument, any bug that results in iterables of different lengths will be silenced, possibly manifesting as a hard-to-find bug in another part of the program.

- Shorter iterables can be padded with a constant value to make all the iterables have the same length. This is done by `itertools.zip_longest()`.

Edge cases: With a single iterable argument, `zip()` returns an iterator of 1-tuples. With no arguments, it returns an empty iterator.

Tips and tricks:

- The left-to-right evaluation order of the iterables is guaranteed. This makes possible an idiom for clustering a data series into `n`-length groups using `zip(*[iter(s)]*n, strict=True)`. This repeats the *same* iterator `n` times so that each output tuple has the result of `n` calls to the iterator. This has the effect of dividing the input into `n`-length chunks.
- `zip()` in conjunction with the `*` operator can be used to unzip a list:

```
>>> x = [1, 2, 3]
>>> y = [4, 5, 6]
>>> list(zip(x, y))
[(1, 4), (2, 5), (3, 6)]
>>> x2, y2 = zip(*zip(x, y))
>>> x == list(x2) and y == list(y2)
True
```

在 3.10 版的變更: 增加了 `strict` 引數。

`__import__` (*name*, *globals=None*, *locals=None*, *fromlist=()*, *level=0*)

備F: This is an advanced function that is not needed in everyday Python programming, unlike `importlib.import_module()`.

This function is invoked by the `import` statement. It can be replaced (by importing the `builtins` module and assigning to `builtins.__import__`) in order to change semantics of the `import` statement, but doing so is **strongly** discouraged as it is usually simpler to use import hooks (see [PEP 302](#)) to attain the same goals and does not cause issues with code which assumes the default import implementation is in use. Direct use of `__import__()` is also discouraged in favor of `importlib.import_module()`.

The function imports the module *name*, potentially using the given *globals* and *locals* to determine how to interpret the name in a package context. The *fromlist* gives the names of objects or submodules that should be imported from the module given by *name*. The standard implementation does not use its *locals* argument at all and uses its *globals* only to determine the package context of the `import` statement.

level specifies whether to use absolute or relative imports. 0 (the default) means only perform absolute imports. Positive values for *level* indicate the number of parent directories to search relative to the directory of the module calling `__import__()` (see [PEP 328](#) for the details).

When the *name* variable is of the form `package.module`, normally, the top-level package (the name up till the first dot) is returned, *not* the module named by *name*. However, when a non-empty *fromlist* argument is given, the module named by *name* is returned.

For example, the statement `import spam` results in bytecode resembling the following code:

```
spam = __import__('spam', globals(), locals(), [], 0)
```

The statement `import spam.ham` results in this call:

```
spam = __import__('spam.ham', globals(), locals(), [], 0)
```

Note how `__import__()` returns the toplevel module here because this is the object that is bound to a name by the `import` statement.

On the other hand, the statement `from spam.ham import eggs, sausage as saus` results in

```
_temp = __import__('spam.ham', globals(), locals(), ['eggs', 'sausage'], 0)
eggs = _temp.eggs
saus = _temp.sausage
```

Here, the `spam.ham` module is returned from `__import__()`. From this object, the names to import are retrieved and assigned to their respective names.

If you simply want to import a module (potentially within a package) by name, use `importlib.import_module()`.

在 3.3 版的變更: Negative values for *level* are no longer supported (which also changes the default value to 0).

在 3.9 版的變更: When the command line options `-E` or `-I` are being used, the environment variable `PYTHONCASEOK` is now ignored.

解

☐ 建常數

有一小部分的常數存在於☐建命名空間中。他們是：

False

在`bool`型☐中的 `false` 值。對於 `False` 的賦值是不合法的，☐且會☐出 `SyntaxError`。

True

在`bool`型☐中的 `true` 值。對於 `True` 的賦值是不合法的，☐且會☐出 `SyntaxError`。

None

An object frequently used to represent the absence of a value, as when default arguments are not passed to a function. Assignments to `None` are illegal and raise a `SyntaxError`. `None` is the sole instance of the `NoneType` type.

NotImplemented

A special value which should be returned by the binary special methods (e.g. `__eq__()`, `__lt__()`, `__add__()`, `__rsub__()`, etc.) to indicate that the operation is not implemented with respect to the other type; may be returned by the in-place binary special methods (e.g. `__imul__()`, `__iand__()`, etc.) for the same purpose. It should not be evaluated in a boolean context. `NotImplemented` is the sole instance of the `types.NotImplementedType` type.

備☐： When a binary (or in-place) method returns `NotImplemented` the interpreter will try the reflected operation on the other type (or some other fallback, depending on the operator). If all attempts return `NotImplemented`, the interpreter will raise an appropriate exception. Incorrectly returning `NotImplemented` will result in a misleading error message or the `NotImplemented` value being returned to Python code.

請參見實作算術操作 以找到更多範例。

備☐： `NotImplementedError` and `NotImplemented` are not interchangeable, even though they have similar names and purposes. See `NotImplementedError` for details on when to use it.

在 3.9 版的變更: Evaluating `NotImplemented` in a boolean context is deprecated. While it currently evaluates as true, it will emit a `DeprecationWarning`. It will raise a `TypeError` in a future version of Python.

Ellipsis

與「節號」... 字面相同。一特殊值，大多用於結合使用者定義資料型的延伸切片語法 (extended slicing syntax)。Ellipsis 是型 `types.EllipsisType` 的唯一實例。

__debug__

如果 Python 有被以 `-O` 選項啟動，則此常數 `true`。請參見 `assert` 陳述式。

備註: `None`, `False`, `True`, 以及 `__debug__` 都是不能被重新賦值的 (任何對它們的賦值，即使是屬性的名稱，也會出 `SyntaxError`)。因此，它們可以被視為「真正的」常數。

3.1 由 site module (模組) 所添增的常數

`site` module (模組) (在啟動期間自動 import，除非有給予 `-S` 指令行選項) 會添增一些常數到建命名空間 (built-in namespace) 中。它們在互動式直譯器中是很有幫助的，但不應該在程式 (programs) 中被使用。

quit (`code=None`)

exit (`code=None`)

當印出物件時，會印出一個訊息: "Use quit() or Ctrl-D (i.e. EOF) to exit"。當被呼叫時，則會出 `SystemExit` 帶有指定的返回碼 (exit code)。

copyright

credits

當印出或是呼叫此物件時，分會印出版權與致謝的文字。

license

當印出此物件時，會印出訊息 "Type license() to see the full license text"。當被呼叫時，則會以分頁形式印出完整的許可證文字 (一次一整個畫面)。

變型

以下章節描述了直譯器中內建的標準型。

主要變型數字、序列、映射、class (類)、實例和例外。

有些集合類是 `mutable` (可變的)。那些用於原地 (`in-place`) 加入、移除或重新排列其成員且不回傳特定項的 `method` (方法)，也只會回傳 `None` 而非集合實例自己。

某些操作已被多種物件型支援；特別是實務上所有物件都已經可以做相等性比較、真值檢測及被轉成字串 (使用 `repr()` 函式或稍有差別的 `str()` 函式)，後者當物件傳入 `print()` 函式印出時在背後被調用的函式。

4.1 真值檢測

任何物件都可以進行檢測以判斷是否真值，以便在 `if` 或 `while` 條件中使用，或是作如下所述 `boolean` (布林) 運算之運算元所用。

By default, an object is considered true unless its class defines either a `__bool__()` method that returns `False` or a `__len__()` method that returns zero, when called with the object.¹ Here are most of the built-in objects considered false:

- 定義 `false` 之常數: `None` 與 `False`
- 任何數值型的零: `0`、`0.0`、`0j`、`Decimal(0)`、`Fraction(0, 1)`
- 空的序列和集合: `''`、`()`、`[]`、`{}`、`set()`、`range(0)`

除非另有特別說明，生成 `boolean` 結果的操作或建函式都會回傳 `0` 或 `False` 作假值、`1` 或 `True` 作真值。(重要例外: `boolean` 運算 `or` 和 `and` 回傳的是其中一個運算元。)

¹ Additional information on these special methods may be found in the Python Reference Manual (customization).

4.2 Boolean Operations --- and, or, not

These are the Boolean operations, ordered by ascending priority:

Operation	結果	解
<code>x or y</code>	if <i>x</i> is true, then <i>x</i> , else <i>y</i>	(1)
<code>x and y</code>	if <i>x</i> is false, then <i>x</i> , else <i>y</i>	(2)
<code>not x</code>	if <i>x</i> is false, then <code>True</code> , else <code>False</code>	(3)

解:

- (1) This is a short-circuit operator, so it only evaluates the second argument if the first one is false.
- (2) This is a short-circuit operator, so it only evaluates the second argument if the first one is true.
- (3) `not` has a lower priority than non-Boolean operators, so `not a == b` is interpreted as `not (a == b)`, and `a == not b` is a syntax error.

4.3 Comparisons

There are eight comparison operations in Python. They all have the same priority (which is higher than that of the Boolean operations). Comparisons can be chained arbitrarily; for example, `x < y <= z` is equivalent to `x < y` and `y <= z`, except that *y* is evaluated only once (but in both cases *z* is not evaluated at all when `x < y` is found to be false).

This table summarizes the comparison operations:

Operation	Meaning
<code><</code>	strictly less than
<code><=</code>	less than or equal
<code>></code>	strictly greater than
<code>>=</code>	greater than or equal
<code>==</code>	equal
<code>!=</code>	not equal
<code>is</code>	object identity
<code>is not</code>	negated object identity

Objects of different types, except different numeric types, never compare equal. The `==` operator is always defined but for some object types (for example, class objects) is equivalent to `is`. The `<`, `<=`, `>` and `>=` operators are only defined where they make sense; for example, they raise a `TypeError` exception when one of the arguments is a complex number.

Non-identical instances of a class normally compare as non-equal unless the class defines the `__eq__()` method.

Instances of a class cannot be ordered with respect to other instances of the same class, or other types of object, unless the class defines enough of the methods `__lt__()`, `__le__()`, `__gt__()`, and `__ge__()` (in general, `__lt__()` and `__eq__()` are sufficient, if you want the conventional meanings of the comparison operators).

The behavior of the `is` and `is not` operators cannot be customized; also they can be applied to any two objects and never raise an exception.

Two more operations with the same syntactic priority, `in` and `not in`, are supported by types that are *iterable* or implement the `__contains__()` method.

4.4 Numeric Types --- int, float, complex

There are three distinct numeric types: *integers*, *floating point numbers*, and *complex numbers*. In addition, Booleans are a subtype of integers. Integers have unlimited precision. Floating point numbers are usually implemented using `double` in C; information about the precision and internal representation of floating point numbers for the machine on which your program is running is available in `sys.float_info`. Complex numbers have a real and imaginary part, which are each a floating point number. To extract these parts from a complex number `z`, use `z.real` and `z.imag`. (The standard library includes the additional numeric types `fractions.Fraction`, for rationals, and `decimal.Decimal`, for floating-point numbers with user-definable precision.)

Numbers are created by numeric literals or as the result of built-in functions and operators. Unadorned integer literals (including hex, octal and binary numbers) yield integers. Numeric literals containing a decimal point or an exponent sign yield floating point numbers. Appending `'j'` or `'J'` to a numeric literal yields an imaginary number (a complex number with a zero real part) which you can add to an integer or float to get a complex number with real and imaginary parts.

Python fully supports mixed arithmetic: when a binary arithmetic operator has operands of different numeric types, the operand with the "narrower" type is widened to that of the other, where integer is narrower than floating point, which is narrower than complex. A comparison between numbers of different types behaves as though the exact values of those numbers were being compared.²

The constructors `int()`, `float()`, and `complex()` can be used to produce numbers of a specific type.

All numeric types (except complex) support the following operations (for priorities of the operations, see operator-summary):

Operation	結果	解 F	Full documentation
<code>x + y</code>	sum of <i>x</i> and <i>y</i>		
<code>x - y</code>	difference of <i>x</i> and <i>y</i>		
<code>x * y</code>	product of <i>x</i> and <i>y</i>		
<code>x / y</code>	quotient of <i>x</i> and <i>y</i>		
<code>x // y</code>	floored quotient of <i>x</i> and <i>y</i>	(1)(2)	
<code>x % y</code>	remainder of <i>x</i> / <i>y</i>	(2)	
<code>-x</code>	<i>x</i> negated		
<code>+x</code>	<i>x</i> unchanged		
<code>abs(x)</code>	absolute value or magnitude of <i>x</i>		<code>abs()</code>
<code>int(x)</code>	<i>x</i> converted to integer	(3)(6)	<code>int()</code>
<code>float(x)</code>	<i>x</i> converted to floating point	(4)(6)	<code>float()</code>
<code>complex(re, im)</code>	a complex number with real part <i>re</i> , imaginary part <i>im</i> . <i>im</i> defaults to zero.	(6)	<code>complex()</code>
<code>c.conjugate()</code>	conjugate of the complex number <i>c</i>		
<code>divmod(x, y)</code>	the pair (<i>x</i> // <i>y</i> , <i>x</i> % <i>y</i>)	(2)	<code>divmod()</code>
<code>pow(x, y)</code>	<i>x</i> to the power <i>y</i>	(5)	<code>pow()</code>
<code>x ** y</code>	<i>x</i> to the power <i>y</i>	(5)	

解 F:

- (1) Also referred to as integer division. For operands of type `int`, the result has type `int`. For operands of type `float`, the result has type `float`. In general, the result is a whole integer, though the result's type is not necessarily `int`. The result is always rounded towards minus infinity: `1//2` is 0, `(-1)//2` is -1, `1//(-2)` is -1, and `(-1)//(-2)` is 0.
- (2) Not for complex numbers. Instead convert to floats using `abs()` if appropriate.
- (3) Conversion from `float` to `int` truncates, discarding the fractional part. See functions `math.floor()` and `math.ceil()` for alternative conversions.

² As a consequence, the list `[1, 2]` is considered equal to `[1.0, 2.0]`, and similarly for tuples.

- (4) float also accepts the strings "nan" and "inf" with an optional prefix "+" or "-" for Not a Number (NaN) and positive or negative infinity.
- (5) Python defines `pow(0, 0)` and `0 ** 0` to be 1, as is common for programming languages.
- (6) The numeric literals accepted include the digits 0 to 9 or any Unicode equivalent (code points with the `Nd` property).

See <https://www.unicode.org/Public/14.0.0/ucd/extracted/DerivedNumericType.txt> for a complete list of code points with the `Nd` property.

All `numbers.Real` types (`int` and `float`) also include the following operations:

Operation	結果
<code>math.trunc(x)</code>	<code>x</code> truncated to <i>Integral</i>
<code>round(x[, n])</code>	<code>x</code> rounded to <code>n</code> digits, rounding half to even. If <code>n</code> is omitted, it defaults to 0.
<code>math.floor(x)</code>	the greatest <i>Integral</i> $\leq x$
<code>math.ceil(x)</code>	the least <i>Integral</i> $\geq x$

For additional numeric operations see the `math` and `cmath` modules.

4.4.1 Bitwise Operations on Integer Types

Bitwise operations only make sense for integers. The result of bitwise operations is calculated as though carried out in two's complement with an infinite number of sign bits.

The priorities of the binary bitwise operations are all lower than the numeric operations and higher than the comparisons; the unary operation `~` has the same priority as the other unary numeric operations (`+` and `-`).

This table lists the bitwise operations sorted in ascending priority:

Operation	結果	解 F
<code>x y</code>	bitwise <i>or</i> of <code>x</code> and <code>y</code>	(4)
<code>x ^ y</code>	bitwise <i>exclusive or</i> of <code>x</code> and <code>y</code>	(4)
<code>x & y</code>	bitwise <i>and</i> of <code>x</code> and <code>y</code>	(4)
<code>x << n</code>	<code>x</code> shifted left by <code>n</code> bits	(1)(2)
<code>x >> n</code>	<code>x</code> shifted right by <code>n</code> bits	(1)(3)
<code>~x</code>	the bits of <code>x</code> inverted	

解 F:

- (1) Negative shift counts are illegal and cause a `ValueError` to be raised.
- (2) A left shift by `n` bits is equivalent to multiplication by `pow(2, n)`.
- (3) A right shift by `n` bits is equivalent to floor division by `pow(2, n)`.
- (4) Performing these calculations with at least one extra sign extension bit in a finite two's complement representation (a working bit-width of `1 + max(x.bit_length(), y.bit_length())` or more) is sufficient to get the same result as if there were an infinite number of sign bits.

4.4.2 Additional Methods on Integer Types

The `int` type implements the `numbers.Integral abstract base class`. In addition, it provides a few more methods:

`int.bit_length()`

Return the number of bits necessary to represent an integer in binary, excluding the sign and leading zeros:

```
>>> n = -37
>>> bin(n)
'-0b100101'
>>> n.bit_length()
6
```

More precisely, if `x` is nonzero, then `x.bit_length()` is the unique positive integer `k` such that $2^{k-1} \leq \text{abs}(x) < 2^k$. Equivalently, when `abs(x)` is small enough to have a correctly rounded logarithm, then `k = 1 + int(log(abs(x), 2))`. If `x` is zero, then `x.bit_length()` returns 0.

等價於:

```
def bit_length(self):
    s = bin(self)          # binary representation: bin(-37) --> '-0b100101'
    s = s.lstrip('-0b')    # remove leading zeros and minus sign
    return len(s)          # len('100101') --> 6
```

在 3.1 版新加入.

`int.bit_count()`

Return the number of ones in the binary representation of the absolute value of the integer. This is also known as the population count. Example:

```
>>> n = 19
>>> bin(n)
'0b10011'
>>> n.bit_count()
3
>>> (-n).bit_count()
3
```

等價於:

```
def bit_count(self):
    return bin(self).count("1")
```

在 3.10 版新加入.

`int.to_bytes(length=1, byteorder='big', *, signed=False)`

Return an array of bytes representing an integer.

```
>>> (1024).to_bytes(2, byteorder='big')
b'\x04\x00'
>>> (1024).to_bytes(10, byteorder='big')
b'\x00\x00\x00\x00\x00\x00\x00\x00\x04\x00'
>>> (-1024).to_bytes(10, byteorder='big', signed=True)
b'\xff\xff\xff\xff\xff\xff\xff\xff\xfc\x00'
>>> x = 1000
>>> x.to_bytes((x.bit_length() + 7) // 8, byteorder='little')
b'\xe8\x03'
```

The integer is represented using `length` bytes, and defaults to 1. An `OverflowError` is raised if the integer is not representable with the given number of bytes.

The *byteorder* argument determines the byte order used to represent the integer, and defaults to "big". If *byteorder* is "big", the most significant byte is at the beginning of the byte array. If *byteorder* is "little", the most significant byte is at the end of the byte array.

The *signed* argument determines whether two's complement is used to represent the integer. If *signed* is `False` and a negative integer is given, an *OverflowError* is raised. The default value for *signed* is `False`.

The default values can be used to conveniently turn an integer into a single byte object:

```
>>> (65).to_bytes()
b'A'
```

However, when using the default arguments, don't try to convert a value greater than 255 or you'll get an *OverflowError*.

等價於：

```
def to_bytes(n, length=1, byteorder='big', signed=False):
    if byteorder == 'little':
        order = range(length)
    elif byteorder == 'big':
        order = reversed(range(length))
    else:
        raise ValueError("byteorder must be either 'little' or 'big'")
    return bytes((n >> i*8) & 0xff for i in order)
```

在 3.2 版新加入.

在 3.11 版的變更: Added default argument values for *length* and *byteorder*.

classmethod `int.from_bytes(bytes, byteorder='big', *, signed=False)`

Return the integer represented by the given array of bytes.

```
>>> int.from_bytes(b'\x00\x10', byteorder='big')
16
>>> int.from_bytes(b'\x00\x10', byteorder='little')
4096
>>> int.from_bytes(b'\xfc\x00', byteorder='big', signed=True)
-1024
>>> int.from_bytes(b'\xfc\x00', byteorder='big', signed=False)
64512
>>> int.from_bytes([255, 0, 0], byteorder='big')
16711680
```

The argument *bytes* must either be a *bytes-like object* or an iterable producing bytes.

The *byteorder* argument determines the byte order used to represent the integer, and defaults to "big". If *byteorder* is "big", the most significant byte is at the beginning of the byte array. If *byteorder* is "little", the most significant byte is at the end of the byte array. To request the native byte order of the host system, use `sys.byteorder` as the byte order value.

The *signed* argument indicates whether two's complement is used to represent the integer.

等價於：

```
def from_bytes(bytes, byteorder='big', signed=False):
    if byteorder == 'little':
        little_ordered = list(bytes)
    elif byteorder == 'big':
        little_ordered = list(reversed(bytes))
    else:
        raise ValueError("byteorder must be either 'little' or 'big'")
```

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```

n = sum(b << i*8 for i, b in enumerate(little_ordered))
if signed and little_ordered and (little_ordered[-1] & 0x80):
    n -= 1 << 8*len(little_ordered)

return n

```

在 3.2 版新加入。

在 3.11 版的變更: Added default argument value for byteorder.

`int.as_integer_ratio()`

Return a pair of integers whose ratio is exactly equal to the original integer and with a positive denominator. The integer ratio of integers (whole numbers) is always the integer as the numerator and 1 as the denominator.

在 3.8 版新加入。

4.4.3 Additional Methods on Float

The float type implements the *numbers.Real abstract base class*. float also has the following additional methods.

`float.as_integer_ratio()`

Return a pair of integers whose ratio is exactly equal to the original float and with a positive denominator. Raises *OverflowError* on infinities and a *ValueError* on NaNs.

`float.is_integer()`

Return True if the float instance is finite with integral value, and False otherwise:

```

>>> (-2.0).is_integer()
True
>>> (3.2).is_integer()
False

```

Two methods support conversion to and from hexadecimal strings. Since Python's floats are stored internally as binary numbers, converting a float to or from a *decimal* string usually involves a small rounding error. In contrast, hexadecimal strings allow exact representation and specification of floating-point numbers. This can be useful when debugging, and in numerical work.

`float.hex()`

Return a representation of a floating-point number as a hexadecimal string. For finite floating-point numbers, this representation will always include a leading 0x and a trailing p and exponent.

classmethod `float.fromhex(s)`

Class method to return the float represented by a hexadecimal string *s*. The string *s* may have leading and trailing whitespace.

Note that `float.hex()` is an instance method, while `float.fromhex()` is a class method.

A hexadecimal string takes the form:

```
[sign] ['0x'] integer ['.' fraction] ['p' exponent]
```

where the optional sign may be either + or -, integer and fraction are strings of hexadecimal digits, and exponent is a decimal integer with an optional leading sign. Case is not significant, and there must be at least one hexadecimal digit in either the integer or the fraction. This syntax is similar to the syntax specified in section 6.4.4.2 of the C99 standard, and also to the syntax used in Java 1.5 onwards. In particular, the output of `float.hex()` is usable as a hexadecimal floating-point literal in C or Java code, and hexadecimal strings produced by C's %a format character or Java's Double.toHexString are accepted by `float.fromhex()`.

Note that the exponent is written in decimal rather than hexadecimal, and that it gives the power of 2 by which to multiply the coefficient. For example, the hexadecimal string `0x3.a7p10` represents the floating-point number $(3 + 10./16 + 7./16**2) * 2.0**10$, or `3740.0`:

```
>>> float.fromhex('0x3.a7p10')
3740.0
```

Applying the reverse conversion to `3740.0` gives a different hexadecimal string representing the same number:

```
>>> float.hex(3740.0)
'0x1.d380000000000p+11'
```

4.4.4 Hashing of numeric types

For numbers x and y , possibly of different types, it's a requirement that `hash(x) == hash(y)` whenever `x == y` (see the `__hash__()` method documentation for more details). For ease of implementation and efficiency across a variety of numeric types (including `int`, `float`, `decimal.Decimal` and `fractions.Fraction`) Python's hash for numeric types is based on a single mathematical function that's defined for any rational number, and hence applies to all instances of `int` and `fractions.Fraction`, and all finite instances of `float` and `decimal.Decimal`. Essentially, this function is given by reduction modulo P for a fixed prime P . The value of P is made available to Python as the `modulus` attribute of `sys.hash_info`.

CPython 實作細節： Currently, the prime used is $P = 2^{31} - 1$ on machines with 32-bit C longs and $P = 2^{61} - 1$ on machines with 64-bit C longs.

Here are the rules in detail:

- If $x = m / n$ is a nonnegative rational number and n is not divisible by P , define `hash(x)` as $m * \text{invmod}(n, P) \% P$, where `invmod(n, P)` gives the inverse of n modulo P .
- If $x = m / n$ is a nonnegative rational number and n is divisible by P (but m is not) then n has no inverse modulo P and the rule above doesn't apply; in this case define `hash(x)` to be the constant value `sys.hash_info.inf`.
- If $x = m / n$ is a negative rational number define `hash(x)` as `-hash(-x)`. If the resulting hash is `-1`, replace it with `-2`.
- The particular values `sys.hash_info.inf` and `-sys.hash_info.inf` are used as hash values for positive infinity or negative infinity (respectively).
- For a `complex` number z , the hash values of the real and imaginary parts are combined by computing `hash(z.real) + sys.hash_info.imag * hash(z.imag)`, reduced modulo $2^{**} \text{sys.hash_info.width}$ so that it lies in range $(-2^{**}(\text{sys.hash_info.width} - 1), 2^{**}(\text{sys.hash_info.width} - 1))$. Again, if the result is `-1`, it's replaced with `-2`.

To clarify the above rules, here's some example Python code, equivalent to the built-in hash, for computing the hash of a rational number, `float`, or `complex`:

```
import sys, math

def hash_fraction(m, n):
    """Compute the hash of a rational number m / n.

    Assumes m and n are integers, with n positive.
    Equivalent to hash(fractions.Fraction(m, n)).

    """
    P = sys.hash_info.modulus
    # Remove common factors of P. (Unnecessary if m and n already coprime.)
    while m % P == n % P == 0:
        m, n = m // P, n // P
```

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```

if n % P == 0:
    hash_value = sys.hash_info.inf
else:
    # Fermat's Little Theorem: pow(n, P-1, P) is 1, so
    # pow(n, P-2, P) gives the inverse of n modulo P.
    hash_value = (abs(m) % P) * pow(n, P - 2, P) % P
if m < 0:
    hash_value = -hash_value
if hash_value == -1:
    hash_value = -2
return hash_value

def hash_float(x):
    """Compute the hash of a float x."""

    if math.isnan(x):
        return object.__hash__(x)
    elif math.isinf(x):
        return sys.hash_info.inf if x > 0 else -sys.hash_info.inf
    else:
        return hash_fraction(*x.as_integer_ratio())

def hash_complex(z):
    """Compute the hash of a complex number z."""

    hash_value = hash_float(z.real) + sys.hash_info.imag * hash_float(z.imag)
    # do a signed reduction modulo 2**sys.hash_info.width
    M = 2**(sys.hash_info.width - 1)
    hash_value = (hash_value & (M - 1)) - (hash_value & M)
    if hash_value == -1:
        hash_value = -2
    return hash_value

```

4.5 Iterator Types

Python supports a concept of iteration over containers. This is implemented using two distinct methods; these are used to allow user-defined classes to support iteration. Sequences, described below in more detail, always support the iteration methods.

One method needs to be defined for container objects to provide *iterable* support:

`container.__iter__()`

Return an *iterator* object. The object is required to support the iterator protocol described below. If a container supports different types of iteration, additional methods can be provided to specifically request iterators for those iteration types. (An example of an object supporting multiple forms of iteration would be a tree structure which supports both breadth-first and depth-first traversal.) This method corresponds to the `tp_iter` slot of the type structure for Python objects in the Python/C API.

The iterator objects themselves are required to support the following two methods, which together form the *iterator protocol*:

`iterator.__iter__()`

Return the *iterator* object itself. This is required to allow both containers and iterators to be used with the `for` and `in` statements. This method corresponds to the `tp_iter` slot of the type structure for Python objects in the Python/C API.

`iterator.__next__()`

Return the next item from the *iterator*. If there are no further items, raise the *StopIteration* exception.

This method corresponds to the `tp_iternext` slot of the type structure for Python objects in the Python/C API.

Python defines several iterator objects to support iteration over general and specific sequence types, dictionaries, and other more specialized forms. The specific types are not important beyond their implementation of the iterator protocol.

Once an iterator's `__next__()` method raises `StopIteration`, it must continue to do so on subsequent calls. Implementations that do not obey this property are deemed broken.

4.5.1 Generator Types

Python's *generators* provide a convenient way to implement the iterator protocol. If a container object's `__iter__()` method is implemented as a generator, it will automatically return an iterator object (technically, a generator object) supplying the `__iter__()` and `__next__()` methods. More information about generators can be found in the documentation for the yield expression.

4.6 Sequence Types --- list, tuple, range

There are three basic sequence types: lists, tuples, and range objects. Additional sequence types tailored for processing of *binary data* and *text strings* are described in dedicated sections.

4.6.1 Common Sequence Operations

The operations in the following table are supported by most sequence types, both mutable and immutable. The `collections.abc.Sequence` ABC is provided to make it easier to correctly implement these operations on custom sequence types.

This table lists the sequence operations sorted in ascending priority. In the table, *s* and *t* are sequences of the same type, *n*, *i*, *j* and *k* are integers and *x* is an arbitrary object that meets any type and value restrictions imposed by *s*.

The `in` and `not in` operations have the same priorities as the comparison operations. The `+` (concatenation) and `*` (repetition) operations have the same priority as the corresponding numeric operations.³

Operation	結果	解 F
<code>x in s</code>	True if an item of <i>s</i> is equal to <i>x</i> , else False	(1)
<code>x not in s</code>	False if an item of <i>s</i> is equal to <i>x</i> , else True	(1)
<code>s + t</code>	the concatenation of <i>s</i> and <i>t</i>	(6)(7)
<code>s * n</code> 或 <code>n * s</code>	equivalent to adding <i>s</i> to itself <i>n</i> times	(2)(7)
<code>s[i]</code>	<i>i</i> th item of <i>s</i> , origin 0	(3)
<code>s[i:j]</code>	slice of <i>s</i> from <i>i</i> to <i>j</i>	(3)(4)
<code>s[i:j:k]</code>	slice of <i>s</i> from <i>i</i> to <i>j</i> with step <i>k</i>	(3)(5)
<code>len(s)</code>	length of <i>s</i>	
<code>min(s)</code>	smallest item of <i>s</i>	
<code>max(s)</code>	largest item of <i>s</i>	
<code>s.index(x[, i[, j]])</code>	index of the first occurrence of <i>x</i> in <i>s</i> (at or after index <i>i</i> and before index <i>j</i>)	(8)
<code>s.count(x)</code>	total number of occurrences of <i>x</i> in <i>s</i>	

Sequences of the same type also support comparisons. In particular, tuples and lists are compared lexicographically by comparing corresponding elements. This means that to compare equal, every element must compare equal and the two sequences must be of the same type and have the same length. (For full details see comparisons in the language reference.)

³ They must have since the parser can't tell the type of the operands.

Forward and reversed iterators over mutable sequences access values using an index. That index will continue to march forward (or backward) even if the underlying sequence is mutated. The iterator terminates only when an *IndexError* or a *StopIteration* is encountered (or when the index drops below zero).

解:

- (1) While the `in` and `not in` operations are used only for simple containment testing in the general case, some specialised sequences (such as *str*, *bytes* and *bytearray*) also use them for subsequence testing:

```
>>> "gg" in "eggs"
True
```

- (2) Values of *n* less than 0 are treated as 0 (which yields an empty sequence of the same type as *s*). Note that items in the sequence *s* are not copied; they are referenced multiple times. This often haunts new Python programmers; consider:

```
>>> lists = [[]] * 3
>>> lists
[[], [], []]
>>> lists[0].append(3)
>>> lists
[[3], [3], [3]]
```

What has happened is that `[[]]` is a one-element list containing an empty list, so all three elements of `[[]] * 3` are references to this single empty list. Modifying any of the elements of `lists` modifies this single list. You can create a list of different lists this way:

```
>>> lists = [[] for i in range(3)]
>>> lists[0].append(3)
>>> lists[1].append(5)
>>> lists[2].append(7)
>>> lists
[[3], [5], [7]]
```

Further explanation is available in the FAQ entry [faq-multidimensional-list](#).

- (3) If *i* or *j* is negative, the index is relative to the end of sequence *s*: `len(s) + i` or `len(s) + j` is substituted. But note that `-0` is still 0.
- (4) The slice of *s* from *i* to *j* is defined as the sequence of items with index *k* such that `i <= k < j`. If *i* or *j* is greater than `len(s)`, use `len(s)`. If *i* is omitted or `None`, use 0. If *j* is omitted or `None`, use `len(s)`. If *i* is greater than or equal to *j*, the slice is empty.
- (5) The slice of *s* from *i* to *j* with step *k* is defined as the sequence of items with index `x = i + n*k` such that `0 <= n < (j-i)/k`. In other words, the indices are *i*, *i+k*, *i+2*k*, *i+3*k* and so on, stopping when *j* is reached (but never including *j*). When *k* is positive, *i* and *j* are reduced to `len(s)` if they are greater. When *k* is negative, *i* and *j* are reduced to `len(s) - 1` if they are greater. If *i* or *j* are omitted or `None`, they become "end" values (which end depends on the sign of *k*). Note, *k* cannot be zero. If *k* is `None`, it is treated like 1.
- (6) Concatenating immutable sequences always results in a new object. This means that building up a sequence by repeated concatenation will have a quadratic runtime cost in the total sequence length. To get a linear runtime cost, you must switch to one of the alternatives below:
 - if concatenating *str* objects, you can build a list and use `str.join()` at the end or else write to an `io.StringIO` instance and retrieve its value when complete
 - if concatenating *bytes* objects, you can similarly use `bytes.join()` or `io.BytesIO`, or you can do in-place concatenation with a *bytearray* object. *bytearray* objects are mutable and have an efficient overallocation mechanism
 - if concatenating *tuple* objects, extend a *list* instead
 - for other types, investigate the relevant class documentation

- (7) Some sequence types (such as `range`) only support item sequences that follow specific patterns, and hence don't support sequence concatenation or repetition.
- (8) `index` raises `ValueError` when `x` is not found in `s`. Not all implementations support passing the additional arguments `i` and `j`. These arguments allow efficient searching of subsections of the sequence. Passing the extra arguments is roughly equivalent to using `s[i:j].index(x)`, only without copying any data and with the returned index being relative to the start of the sequence rather than the start of the slice.

4.6.2 Immutable Sequence Types

The only operation that immutable sequence types generally implement that is not also implemented by mutable sequence types is support for the `hash()` built-in.

This support allows immutable sequences, such as `tuple` instances, to be used as `dict` keys and stored in `set` and `frozenset` instances.

Attempting to hash an immutable sequence that contains unhashable values will result in `TypeError`.

4.6.3 Mutable Sequence Types

The operations in the following table are defined on mutable sequence types. The `collections.abc.MutableSequence` ABC is provided to make it easier to correctly implement these operations on custom sequence types.

In the table `s` is an instance of a mutable sequence type, `t` is any iterable object and `x` is an arbitrary object that meets any type and value restrictions imposed by `s` (for example, `bytearray` only accepts integers that meet the value restriction `0 <= x <= 255`).

Operation	結果	解
<code>s[i] = x</code>	item <code>i</code> of <code>s</code> is replaced by <code>x</code>	
<code>s[i:j] = t</code>	slice of <code>s</code> from <code>i</code> to <code>j</code> is replaced by the contents of the iterable <code>t</code>	
<code>del s[i:j]</code>	same as <code>s[i:j] = []</code>	
<code>s[i:j:k] = t</code>	the elements of <code>s[i:j:k]</code> are replaced by those of <code>t</code>	(1)
<code>del s[i:j:k]</code>	removes the elements of <code>s[i:j:k]</code> from the list	
<code>s.append(x)</code>	appends <code>x</code> to the end of the sequence (same as <code>s[len(s):len(s)] = [x]</code>)	
<code>s.clear()</code>	removes all items from <code>s</code> (same as <code>del s[:]</code>)	(5)
<code>s.copy()</code>	creates a shallow copy of <code>s</code> (same as <code>s[:]</code>)	(5)
<code>s.extend(t)</code> 或 <code>s += t</code>	extends <code>s</code> with the contents of <code>t</code> (for the most part the same as <code>s[len(s):len(s)] = t</code>)	
<code>s *= n</code>	updates <code>s</code> with its contents repeated <code>n</code> times	(6)
<code>s.insert(i, x)</code>	inserts <code>x</code> into <code>s</code> at the index given by <code>i</code> (same as <code>s[i:i] = [x]</code>)	
<code>s.pop()</code> 或 <code>s.pop(i)</code>	retrieves the item at <code>i</code> and also removes it from <code>s</code>	(2)
<code>s.remove(x)</code>	remove the first item from <code>s</code> where <code>s[i]</code> is equal to <code>x</code>	(3)
<code>s.reverse()</code>	reverses the items of <code>s</code> in place	(4)

解:

- (1) `t` must have the same length as the slice it is replacing.
- (2) The optional argument `i` defaults to `-1`, so that by default the last item is removed and returned.
- (3) `remove()` raises `ValueError` when `x` is not found in `s`.
- (4) The `reverse()` method modifies the sequence in place for economy of space when reversing a large sequence. To remind users that it operates by side effect, it does not return the reversed sequence.

- (5) `clear()` and `copy()` are included for consistency with the interfaces of mutable containers that don't support slicing operations (such as `dict` and `set`). `copy()` is not part of the `collections.abc.MutableSequence` ABC, but most concrete mutable sequence classes provide it.

在 3.3 版新加入: `clear()` and `copy()` methods.

- (6) The value `n` is an integer, or an object implementing `__index__()`. Zero and negative values of `n` clear the sequence. Items in the sequence are not copied; they are referenced multiple times, as explained for `s * n` under *Common Sequence Operations*.

4.6.4 List (串列)

Lists are mutable sequences, typically used to store collections of homogeneous items (where the precise degree of similarity will vary by application).

class `list` (`[iterable]`)

Lists may be constructed in several ways:

- Using a pair of square brackets to denote the empty list: `[]`
- Using square brackets, separating items with commas: `[a], [a, b, c]`
- Using a list comprehension: `[x for x in iterable]`
- Using the type constructor: `list()` or `list(iterable)`

The constructor builds a list whose items are the same and in the same order as *iterable*'s items. *iterable* may be either a sequence, a container that supports iteration, or an iterator object. If *iterable* is already a list, a copy is made and returned, similar to `iterable[:]`. For example, `list('abc')` returns `['a', 'b', 'c']` and `list((1, 2, 3))` returns `[1, 2, 3]`. If no argument is given, the constructor creates a new empty list, `[]`.

Many other operations also produce lists, including the `sorted()` built-in.

Lists implement all of the *common* and *mutable* sequence operations. Lists also provide the following additional method:

sort (`*`, `key=None`, `reverse=False`)

This method sorts the list in place, using only `<` comparisons between items. Exceptions are not suppressed - if any comparison operations fail, the entire sort operation will fail (and the list will likely be left in a partially modified state).

`sort()` accepts two arguments that can only be passed by keyword (*keyword-only arguments*):

key specifies a function of one argument that is used to extract a comparison key from each list element (for example, `key=str.lower`). The key corresponding to each item in the list is calculated once and then used for the entire sorting process. The default value of `None` means that list items are sorted directly without calculating a separate key value.

The `functools.cmp_to_key()` utility is available to convert a 2.x style *cmp* function to a *key* function.

reverse is a boolean value. If set to `True`, then the list elements are sorted as if each comparison were reversed.

This method modifies the sequence in place for economy of space when sorting a large sequence. To remind users that it operates by side effect, it does not return the sorted sequence (use `sorted()` to explicitly request a new sorted list instance).

The `sort()` method is guaranteed to be stable. A sort is stable if it guarantees not to change the relative order of elements that compare equal --- this is helpful for sorting in multiple passes (for example, sort by department, then by salary grade).

For sorting examples and a brief sorting tutorial, see `sortinghowto`.

CPython 實作細節： While a list is being sorted, the effect of attempting to mutate, or even inspect, the list is undefined. The C implementation of Python makes the list appear empty for the duration, and raises `ValueError` if it can detect that the list has been mutated during a sort.

4.6.5 Tuples

Tuples are immutable sequences, typically used to store collections of heterogeneous data (such as the 2-tuples produced by the `enumerate()` built-in). Tuples are also used for cases where an immutable sequence of homogeneous data is needed (such as allowing storage in a `set` or `dict` instance).

class `tuple` (`[iterable]`)

Tuples may be constructed in a number of ways:

- Using a pair of parentheses to denote the empty tuple: `()`
- Using a trailing comma for a singleton tuple: `a,` or `(a,)`
- Separating items with commas: `a, b, c` or `(a, b, c)`
- Using the `tuple()` built-in: `tuple()` or `tuple(iterable)`

The constructor builds a tuple whose items are the same and in the same order as *iterable*'s items. *iterable* may be either a sequence, a container that supports iteration, or an iterator object. If *iterable* is already a tuple, it is returned unchanged. For example, `tuple('abc')` returns `('a', 'b', 'c')` and `tuple([1, 2, 3])` returns `(1, 2, 3)`. If no argument is given, the constructor creates a new empty tuple, `()`.

Note that it is actually the comma which makes a tuple, not the parentheses. The parentheses are optional, except in the empty tuple case, or when they are needed to avoid syntactic ambiguity. For example, `f(a, b, c)` is a function call with three arguments, while `f((a, b, c))` is a function call with a 3-tuple as the sole argument.

Tuples implement all of the *common* sequence operations.

For heterogeneous collections of data where access by name is clearer than access by index, `collections.namedtuple()` may be a more appropriate choice than a simple tuple object.

4.6.6 Ranges

The *range* type represents an immutable sequence of numbers and is commonly used for looping a specific number of times in `for` loops.

class `range` (*stop*)

class `range` (*start*, *stop*`[, step]`)

The arguments to the range constructor must be integers (either built-in `int` or any object that implements the `__index__()` special method). If the *step* argument is omitted, it defaults to 1. If the *start* argument is omitted, it defaults to 0. If *step* is zero, `ValueError` is raised.

For a positive *step*, the contents of a range *r* are determined by the formula `r[i] = start + step*i` where `i >= 0` and `r[i] < stop`.

For a negative *step*, the contents of the range are still determined by the formula `r[i] = start + step*i`, but the constraints are `i >= 0` and `r[i] > stop`.

A range object will be empty if `r[0]` does not meet the value constraint. Ranges do support negative indices, but these are interpreted as indexing from the end of the sequence determined by the positive indices.

Ranges containing absolute values larger than `sys.maxsize` are permitted but some features (such as `len()`) may raise `OverflowError`.

Range examples:


```

>>> list(range(10))
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> list(range(1, 11))
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
>>> list(range(0, 30, 5))
[0, 5, 10, 15, 20, 25]
>>> list(range(0, 10, 3))
[0, 3, 6, 9]
>>> list(range(0, -10, -1))
[0, -1, -2, -3, -4, -5, -6, -7, -8, -9]
>>> list(range(0))
[]
>>> list(range(1, 0))
[]

```

Ranges implement all of the *common* sequence operations except concatenation and repetition (due to the fact that range objects can only represent sequences that follow a strict pattern and repetition and concatenation will usually violate that pattern).

start

The value of the *start* parameter (or 0 if the parameter was not supplied)

stop

The value of the *stop* parameter

step

The value of the *step* parameter (or 1 if the parameter was not supplied)

The advantage of the *range* type over a regular *list* or *tuple* is that a *range* object will always take the same (small) amount of memory, no matter the size of the range it represents (as it only stores the *start*, *stop* and *step* values, calculating individual items and subranges as needed).

Range objects implement the *collections.abc.Sequence* ABC, and provide features such as containment tests, element index lookup, slicing and support for negative indices (see *Sequence Types --- list, tuple, range*):

```

>>> r = range(0, 20, 2)
>>> r
range(0, 20, 2)
>>> 11 in r
False
>>> 10 in r
True
>>> r.index(10)
5
>>> r[5]
10
>>> r[:5]
range(0, 10, 2)
>>> r[-1]
18

```

Testing range objects for equality with `==` and `!=` compares them as sequences. That is, two range objects are considered equal if they represent the same sequence of values. (Note that two range objects that compare equal might have different *start*, *stop* and *step* attributes, for example `range(0) == range(2, 1, 3)` or `range(0, 3, 2) == range(0, 4, 2)`.)

在 3.2 版的變更: Implement the Sequence ABC. Support slicing and negative indices. Test *int* objects for membership in constant time instead of iterating through all items.

在 3.3 版的變更: Define `'=='` and `'!='` to compare range objects based on the sequence of values they define (instead of comparing based on object identity).

Added the *start*, *stop* and *step* attributes.

也參考:

- The [linspace recipe](#) shows how to implement a lazy version of range suitable for floating point applications.

4.7 Text Sequence Type --- `str`

Textual data in Python is handled with `str` objects, or *strings*. Strings are immutable *sequences* of Unicode code points. String literals are written in a variety of ways:

- Single quotes: `'allows embedded "double" quotes '`
- Double quotes: `"allows embedded 'single' quotes"`
- Triple quoted: `'''Three single quotes''', """Three double quotes"""`

Triple quoted strings may span multiple lines - all associated whitespace will be included in the string literal.

String literals that are part of a single expression and have only whitespace between them will be implicitly converted to a single string literal. That is, `("spam " "eggs") == "spam eggs"`.

See strings for more about the various forms of string literal, including supported escape sequences, and the `r` ("raw") prefix that disables most escape sequence processing.

Strings may also be created from other objects using the `str` constructor.

Since there is no separate "character" type, indexing a string produces strings of length 1. That is, for a non-empty string `s`, `s[0] == s[0:1]`.

There is also no mutable string type, but `str.join()` or `io.StringIO` can be used to efficiently construct strings from multiple fragments.

在 3.3 版的變更: For backwards compatibility with the Python 2 series, the `u` prefix is once again permitted on string literals. It has no effect on the meaning of string literals and cannot be combined with the `r` prefix.

```
class str (object=")
```

```
class str (object=b", encoding='utf-8', errors='strict')
```

Return a *string* version of *object*. If *object* is not provided, returns the empty string. Otherwise, the behavior of `str()` depends on whether *encoding* or *errors* is given, as follows.

If neither *encoding* nor *errors* is given, `str(object)` returns `type(object).__str__(object)`, which is the "informal" or nicely printable string representation of *object*. For string objects, this is the string itself. If *object* does not have a `__str__()` method, then `str()` falls back to returning `repr(object)`.

If at least one of *encoding* or *errors* is given, *object* should be a *bytes-like object* (e.g. *bytes* or *bytearray*). In this case, if *object* is a *bytes* (or *bytearray*) object, then `str(bytes, encoding, errors)` is equivalent to `bytes.decode(encoding, errors)`. Otherwise, the bytes object underlying the buffer object is obtained before calling `bytes.decode()`. See *Binary Sequence Types --- bytes, bytearray, memoryview* and *bufferobjects* for information on buffer objects.

Passing a *bytes* object to `str()` without the *encoding* or *errors* arguments falls under the first case of returning the informal string representation (see also the `-b` command-line option to Python). For example:

```
>>> str(b'Zoot!')
'b'Zoot!'
```

For more information on the `str` class and its methods, see *Text Sequence Type --- str* and the *String Methods* section below. To output formatted strings, see the *f-strings* and *Format String Syntax* sections. In addition, see the 文本處理 (*Text Processing*) 服務 section.

4.7.1 String Methods

Strings implement all of the *common* sequence operations, along with the additional methods described below.

Strings also support two styles of string formatting, one providing a large degree of flexibility and customization (see `str.format()`, *Format String Syntax* and *Custom String Formatting*) and the other based on C `printf` style formatting that handles a narrower range of types and is slightly harder to use correctly, but is often faster for the cases it can handle (*printf-style String Formatting*).

The 文本處理 (*Text Processing*) 服務 section of the standard library covers a number of other modules that provide various text related utilities (including regular expression support in the `re` module).

`str.capitalize()`

Return a copy of the string with its first character capitalized and the rest lowercased.

在 3.8 版的變更: The first character is now put into titlecase rather than uppercase. This means that characters like digraphs will only have their first letter capitalized, instead of the full character.

`str.casefold()`

Return a casefolded copy of the string. Casefolded strings may be used for caseless matching.

Casefolding is similar to lowercasing but more aggressive because it is intended to remove all case distinctions in a string. For example, the German lowercase letter 'ß' is equivalent to "ss". Since it is already lowercase, `lower()` would do nothing to 'ß'; `casefold()` converts it to "ss".

The casefolding algorithm is described in section 3.13 of the Unicode Standard.

在 3.3 版新加入.

`str.center(width[, fillchar])`

Return centered in a string of length *width*. Padding is done using the specified *fillchar* (default is an ASCII space). The original string is returned if *width* is less than or equal to `len(s)`.

`str.count(sub[, start[, end]])`

Return the number of non-overlapping occurrences of substring *sub* in the range [*start*, *end*]. Optional arguments *start* and *end* are interpreted as in slice notation.

If *sub* is empty, returns the number of empty strings between characters which is the length of the string plus one.

`str.encode(encoding='utf-8', errors='strict')`

Return the string encoded to *bytes*.

encoding defaults to 'utf-8'; see *Standard Encodings* for possible values.

errors controls how encoding errors are handled. If 'strict' (the default), a `UnicodeError` exception is raised. Other possible values are 'ignore', 'replace', 'xmlcharrefreplace', 'backslashreplace' and any other name registered via `codecs.register_error()`. See *Error Handlers* for details.

For performance reasons, the value of *errors* is not checked for validity unless an encoding error actually occurs, *Python Development Mode* is enabled or a debug build is used.

在 3.1 版的變更: 新增關鍵字引數的支援。

在 3.9 版的變更: The value of the *errors* argument is now checked in *Python Development Mode* and in debug mode.

`str.endswith(suffix[, start[, end]])`

Return `True` if the string ends with the specified *suffix*, otherwise return `False`. *suffix* can also be a tuple of suffixes to look for. With optional *start*, test beginning at that position. With optional *end*, stop comparing at that position.

`str.expandtabs (tabsize=8)`

Return a copy of the string where all tab characters are replaced by one or more spaces, depending on the current column and the given tab size. Tab positions occur every *tabsize* characters (default is 8, giving tab positions at columns 0, 8, 16 and so on). To expand the string, the current column is set to zero and the string is examined character by character. If the character is a tab (`\t`), one or more space characters are inserted in the result until the current column is equal to the next tab position. (The tab character itself is not copied.) If the character is a newline (`\n`) or return (`\r`), it is copied and the current column is reset to zero. Any other character is copied unchanged and the current column is incremented by one regardless of how the character is represented when printed.

```
>>> '01\t012\t0123\t01234'.expandtabs()
'01      012      0123      01234'
>>> '01\t012\t0123\t01234'.expandtabs(4)
'01  012 0123  01234'
```

`str.find (sub[, start[, end]])`

Return the lowest index in the string where substring *sub* is found within the slice `s[start:end]`. Optional arguments *start* and *end* are interpreted as in slice notation. Return `-1` if *sub* is not found.

備 F: The `find()` method should be used only if you need to know the position of *sub*. To check if *sub* is a substring or not, use the `in` operator:

```
>>> 'Py' in 'Python'
True
```

`str.format (*args, **kwargs)`

Perform a string formatting operation. The string on which this method is called can contain literal text or replacement fields delimited by braces `{}`. Each replacement field contains either the numeric index of a positional argument, or the name of a keyword argument. Returns a copy of the string where each replacement field is replaced with the string value of the corresponding argument.

```
>>> "The sum of 1 + 2 is {0}".format(1+2)
'The sum of 1 + 2 is 3'
```

See *Format String Syntax* for a description of the various formatting options that can be specified in format strings.

備 F: When formatting a number (*int*, *float*, *complex*, *decimal.Decimal* and subclasses) with the *n* type (ex: `'{:n}'.format(1234)`), the function temporarily sets the `LC_CTYPE` locale to the `LC_NUMERIC` locale to decode `decimal_point` and `thousands_sep` fields of `localeconv()` if they are non-ASCII or longer than 1 byte, and the `LC_NUMERIC` locale is different than the `LC_CTYPE` locale. This temporary change affects other threads.

在 3.7 版的變更: When formatting a number with the *n* type, the function sets temporarily the `LC_CTYPE` locale to the `LC_NUMERIC` locale in some cases.

`str.format_map (mapping)`

Similar to `str.format (**mapping)`, except that *mapping* is used directly and not copied to a *dict*. This is useful if for example *mapping* is a *dict* subclass:

```
>>> class Default(dict):
...     def __missing__(self, key):
...         return key
...
>>> '{name} was born in {country}'.format_map(Default(name='Guido'))
'Guido was born in country'
```

在 3.2 版新加入。

`str.index(sub[, start[, end]])`

Like `find()`, but raise `ValueError` when the substring is not found.

`str.isalnum()`

Return `True` if all characters in the string are alphanumeric and there is at least one character, `False` otherwise. A character `c` is alphanumeric if one of the following returns `True`: `c.isalpha()`, `c.isdecimal()`, `c.isdigit()`, or `c.isnumeric()`.

`str.isalpha()`

Return `True` if all characters in the string are alphabetic and there is at least one character, `False` otherwise. Alphabetic characters are those characters defined in the Unicode character database as "Letter", i.e., those with general category property being one of "Lm", "Lt", "Lu", "LI", or "Lo". Note that this is different from the "Alphabetic" property defined in the Unicode Standard.

`str.isascii()`

Return `True` if the string is empty or all characters in the string are ASCII, `False` otherwise. ASCII characters have code points in the range U+0000-U+007F.

在 3.7 版新加入。

`str.isdecimal()`

Return `True` if all characters in the string are decimal characters and there is at least one character, `False` otherwise. Decimal characters are those that can be used to form numbers in base 10, e.g. U+0660, ARABIC-INDIC DIGIT ZERO. Formally a decimal character is a character in the Unicode General Category "Nd".

`str.isdigit()`

Return `True` if all characters in the string are digits and there is at least one character, `False` otherwise. Digits include decimal characters and digits that need special handling, such as the compatibility superscript digits. This covers digits which cannot be used to form numbers in base 10, like the Kharosthi numbers. Formally, a digit is a character that has the property value `Numeric_Type=Digit` or `Numeric_Type=Decimal`.

`str.isidentifier()`

Return `True` if the string is a valid identifier according to the language definition, section identifiers.

Call `keyword.iskeyword()` to test whether string `s` is a reserved identifier, such as `def` and `class`.

範例：

```
>>> from keyword import iskeyword
>>> 'hello'.isidentifier(), iskeyword('hello')
(True, False)
>>> 'def'.isidentifier(), iskeyword('def')
(True, True)
```

`str.islower()`

Return `True` if all cased characters⁴ in the string are lowercase and there is at least one cased character, `False` otherwise.

`str.isnumeric()`

Return `True` if all characters in the string are numeric characters, and there is at least one character, `False` otherwise. Numeric characters include digit characters, and all characters that have the Unicode numeric value property, e.g. U+2155, VULGAR FRACTION ONE FIFTH. Formally, numeric characters are those with the property value `Numeric_Type=Digit`, `Numeric_Type=Decimal` or `Numeric_Type=Numeric`.

`str.isprintable()`

Return `True` if all characters in the string are printable or the string is empty, `False` otherwise. Nonprintable characters are those characters defined in the Unicode character database as "Other" or "Separator", excepting

⁴ Cased characters are those with general category property being one of "Lu" (Letter, uppercase), "Ll" (Letter, lowercase), or "Lt" (Letter, titlecase).

the ASCII space (0x20) which is considered printable. (Note that printable characters in this context are those which should not be escaped when `repr()` is invoked on a string. It has no bearing on the handling of strings written to `sys.stdout` or `sys.stderr`.)

`str.isspace()`

Return `True` if there are only whitespace characters in the string and there is at least one character, `False` otherwise.

A character is *whitespace* if in the Unicode character database (see [unicodedata](#)), either its general category is `Zs` ("Separator, space"), or its bidirectional class is one of `WS`, `B`, or `S`.

`str.istitle()`

Return `True` if the string is a titlecased string and there is at least one character, for example uppercase characters may only follow uncased characters and lowercase characters only cased ones. Return `False` otherwise.

`str.isupper()`

Return `True` if all cased characters^{Page 49, 4} in the string are uppercase and there is at least one cased character, `False` otherwise.

```
>>> 'BANANA'.isupper()
True
>>> 'banana'.isupper()
False
>>> 'baNana'.isupper()
False
>>> ''.isupper()
False
```

`str.join(iterable)`

Return a string which is the concatenation of the strings in *iterable*. A `TypeError` will be raised if there are any non-string values in *iterable*, including `bytes` objects. The separator between elements is the string providing this method.

`str.ljust(width[, fillchar])`

Return the string left justified in a string of length *width*. Padding is done using the specified *fillchar* (default is an ASCII space). The original string is returned if *width* is less than or equal to `len(s)`.

`str.lower()`

Return a copy of the string with all the cased characters^{Page 49, 4} converted to lowercase.

The lowercasing algorithm used is described in section 3.13 of the Unicode Standard.

`str.lstrip([chars])`

Return a copy of the string with leading characters removed. The *chars* argument is a string specifying the set of characters to be removed. If omitted or `None`, the *chars* argument defaults to removing whitespace. The *chars* argument is not a prefix; rather, all combinations of its values are stripped:

```
>>> '   spacious   '.lstrip()
'spacious'
>>> 'www.example.com'.lstrip('cmowz.')
'example.com'
```

See `str.removeprefix()` for a method that will remove a single prefix string rather than all of a set of characters. For example:

```
>>> 'Arthur: three!'.lstrip('Arthur: ')
'ee!'
>>> 'Arthur: three!'.removeprefix('Arthur: ')
'three!'
```

static `str.maketrans(x[, y[, z]])`

This static method returns a translation table usable for `str.translate()`.

If there is only one argument, it must be a dictionary mapping Unicode ordinals (integers) or characters (strings of length 1) to Unicode ordinals, strings (of arbitrary lengths) or `None`. Character keys will then be converted to ordinals.

If there are two arguments, they must be strings of equal length, and in the resulting dictionary, each character in `x` will be mapped to the character at the same position in `y`. If there is a third argument, it must be a string, whose characters will be mapped to `None` in the result.

`str.partition(sep)`

Split the string at the first occurrence of `sep`, and return a 3-tuple containing the part before the separator, the separator itself, and the part after the separator. If the separator is not found, return a 3-tuple containing the string itself, followed by two empty strings.

`str.removeprefix(prefix, /)`

If the string starts with the `prefix` string, return `string[len(prefix) :]`. Otherwise, return a copy of the original string:

```
>>> 'TestHook'.removeprefix('Test')
'Hook'
>>> 'BaseTestCase'.removeprefix('Test')
'BaseTestCase'
```

在 3.9 版新加入.

`str.removesuffix(suffix, /)`

If the string ends with the `suffix` string and that `suffix` is not empty, return `string[:-len(suffix)]`. Otherwise, return a copy of the original string:

```
>>> 'MiscTests'.removesuffix('Tests')
'Misc'
>>> 'TmpDirMixin'.removesuffix('Tests')
'TmpDirMixin'
```

在 3.9 版新加入.

`str.replace(old, new[, count])`

Return a copy of the string with all occurrences of substring `old` replaced by `new`. If the optional argument `count` is given, only the first `count` occurrences are replaced.

`str.rfind(sub[, start[, end]])`

Return the highest index in the string where substring `sub` is found, such that `sub` is contained within `s[start:end]`. Optional arguments `start` and `end` are interpreted as in slice notation. Return `-1` on failure.

`str.rindex(sub[, start[, end]])`

Like `rfind()` but raises `ValueError` when the substring `sub` is not found.

`str.rjust(width[, fillchar])`

Return the string right justified in a string of length `width`. Padding is done using the specified `fillchar` (default is an ASCII space). The original string is returned if `width` is less than or equal to `len(s)`.

`str.rpartition(sep)`

Split the string at the last occurrence of `sep`, and return a 3-tuple containing the part before the separator, the separator itself, and the part after the separator. If the separator is not found, return a 3-tuple containing two empty strings, followed by the string itself.

`str.rsplit(sep=None, maxsplit=-1)`

Return a list of the words in the string, using `sep` as the delimiter string. If `maxsplit` is given, at most `maxsplit` splits are done, the *rightmost* ones. If `sep` is not specified or `None`, any whitespace string is a separator. Except for splitting from the right, `rsplit()` behaves like `split()` which is described in detail below.

`str.rstrip([chars])`

Return a copy of the string with trailing characters removed. The *chars* argument is a string specifying the set of characters to be removed. If omitted or *None*, the *chars* argument defaults to removing whitespace. The *chars* argument is not a suffix; rather, all combinations of its values are stripped:

```
>>> '   spacious   '.rstrip()
'   spacious'
>>> 'mississippi'.rstrip('ipz')
'mississ'
```

See `str.removesuffix()` for a method that will remove a single suffix string rather than all of a set of characters. For example:

```
>>> 'Monty Python'.rstrip(' Python')
'M'
>>> 'Monty Python'.removesuffix(' Python')
'Monty'
```

`str.split(sep=None, maxsplit=-1)`

Return a list of the words in the string, using *sep* as the delimiter string. If *maxsplit* is given, at most *maxsplit* splits are done (thus, the list will have at most *maxsplit*+1 elements). If *maxsplit* is not specified or -1, then there is no limit on the number of splits (all possible splits are made).

If *sep* is given, consecutive delimiters are not grouped together and are deemed to delimit empty strings (for example, `'1,,2'.split(',')` returns `['1', '', '2']`). The *sep* argument may consist of multiple characters (for example, `'1<>2<>3'.split('<>')` returns `['1', '2', '3']`). Splitting an empty string with a specified separator returns `['']`.

舉例來 F:

```
>>> '1,2,3'.split(',')
['1', '2', '3']
>>> '1,2,3'.split(',', maxsplit=1)
['1', '2,3']
>>> '1,2,,3'.split(',')
['1', '2', '', '3', '']
```

If *sep* is not specified or is *None*, a different splitting algorithm is applied: runs of consecutive whitespace are regarded as a single separator, and the result will contain no empty strings at the start or end if the string has leading or trailing whitespace. Consequently, splitting an empty string or a string consisting of just whitespace with a *None* separator returns `[]`.

舉例來 F:

```
>>> '1 2 3'.split()
['1', '2', '3']
>>> '1 2 3'.split(maxsplit=1)
['1', '2 3']
>>> ' 1 2 3 '.split()
['1', '2', '3']
```

`str.splitlines(keepends=False)`

Return a list of the lines in the string, breaking at line boundaries. Line breaks are not included in the resulting list unless *keepends* is given and true.

This method splits on the following line boundaries. In particular, the boundaries are a superset of *universal newlines*.

Representation	描述
<code>\n</code>	Line Feed
<code>\r</code>	Carriage Return
<code>\r\n</code>	Carriage Return + Line Feed
<code>\v</code> 或 <code>\x0b</code>	Line Tabulation
<code>\f</code> 或 <code>\x0c</code>	Form Feed
<code>\x1c</code>	File Separator
<code>\x1d</code>	Group Separator
<code>\x1e</code>	Record Separator
<code>\x85</code>	Next Line (C1 Control Code)
<code>\u2028</code>	Line Separator
<code>\u2029</code>	Paragraph Separator

在 3.2 版的變更: `\v` and `\f` added to list of line boundaries.

舉例來:

```
>>> 'ab c\n\nde fg\rkl\r\n'.splitlines()
['ab c', '', 'de fg', 'kl']
>>> 'ab c\n\nde fg\rkl\r\n'.splitlines(keepends=True)
['ab c\n', '\n', 'de fg\r', 'kl\r\n']
```

Unlike `split()` when a delimiter string `sep` is given, this method returns an empty list for the empty string, and a terminal line break does not result in an extra line:

```
>>> "".splitlines()
[]
>>> "One line\n".splitlines()
['One line']
```

For comparison, `split('\n')` gives:

```
>>> ''.split('\n')
['']
>>> 'Two lines\n'.split('\n')
['Two lines', '']
```

`str.startswith(prefix[, start[, end]])`

Return True if string starts with the *prefix*, otherwise return False. *prefix* can also be a tuple of prefixes to look for. With optional *start*, test string beginning at that position. With optional *end*, stop comparing string at that position.

`str.strip([chars])`

Return a copy of the string with the leading and trailing characters removed. The *chars* argument is a string specifying the set of characters to be removed. If omitted or None, the *chars* argument defaults to removing whitespace. The *chars* argument is not a prefix or suffix; rather, all combinations of its values are stripped:

```
>>> '   spacious   '.strip()
'spacious'
>>> 'www.example.com'.strip('cmowz.')
'example'
```

The outermost leading and trailing *chars* argument values are stripped from the string. Characters are removed from the leading end until reaching a string character that is not contained in the set of characters in *chars*. A similar action takes place on the trailing end. For example:

```
>>> comment_string = '#..... Section 3.2.1 Issue #32 .....'
>>> comment_string.strip('.#! ')
'Section 3.2.1 Issue #32'
```

`str.swapcase()`

Return a copy of the string with uppercase characters converted to lowercase and vice versa. Note that it is not necessarily true that `s.swapcase().swapcase() == s`.

`str.title()`

Return a titlecased version of the string where words start with an uppercase character and the remaining characters are lowercase.

舉例來 F:

```
>>> 'Hello world'.title()
'Hello World'
```

The algorithm uses a simple language-independent definition of a word as groups of consecutive letters. The definition works in many contexts but it means that apostrophes in contractions and possessives form word boundaries, which may not be the desired result:

```
>>> "they're bill's friends from the UK".title()
'They'Re Bill'S Friends From The Uk'
```

The `string.capwords()` function does not have this problem, as it splits words on spaces only.

Alternatively, a workaround for apostrophes can be constructed using regular expressions:

```
>>> import re
>>> def titlecase(s):
...     return re.sub(r"[A-Za-z]+('[A-Za-z]+)?",
...                   lambda mo: mo.group(0).capitalize(),
...                   s)
...
>>> titlecase("they're bill's friends.")
'They're Bill's Friends.'
```

`str.translate(table)`

Return a copy of the string in which each character has been mapped through the given translation table. The table must be an object that implements indexing via `__getitem__()`, typically a *mapping* or *sequence*. When indexed by a Unicode ordinal (an integer), the table object can do any of the following: return a Unicode ordinal or a string, to map the character to one or more other characters; return `None`, to delete the character from the return string; or raise a *LookupError* exception, to map the character to itself.

You can use `str.maketrans()` to create a translation map from character-to-character mappings in different formats.

See also the *codecs* module for a more flexible approach to custom character mappings.

`str.upper()`

Return a copy of the string with all the cased characters^{Page 49, 4} converted to uppercase. Note that `s.upper().isupper()` might be `False` if `s` contains uncased characters or if the Unicode category of the resulting character(s) is not "Lu" (Letter, uppercase), but e.g. "Lt" (Letter, titlecase).

The uppercasing algorithm used is described in section 3.13 of the Unicode Standard.

`str.zfill(width)`

Return a copy of the string left filled with ASCII '0' digits to make a string of length *width*. A leading sign prefix ('+'/'-') is handled by inserting the padding *after* the sign character rather than before. The original string is returned if *width* is less than or equal to `len(s)`.

舉例來 F:

```
>>> "42".zfill(5)
'00042'
>>> "-42".zfill(5)
'-0042'
```

4.7.2 printf-style String Formatting

備F: The formatting operations described here exhibit a variety of quirks that lead to a number of common errors (such as failing to display tuples and dictionaries correctly). Using the newer formatted string literals, the `str.format()` interface, or *template strings* may help avoid these errors. Each of these alternatives provides their own trade-offs and benefits of simplicity, flexibility, and/or extensibility.

String objects have one unique built-in operation: the `%` operator (modulo). This is also known as the string *formatting* or *interpolation* operator. Given `format % values` (where *format* is a string), `%` conversion specifications in *format* are replaced with zero or more elements of *values*. The effect is similar to using the `sprintf()` in the C language.

If *format* requires a single argument, *values* may be a single non-tuple object.⁵ Otherwise, *values* must be a tuple with exactly the number of items specified by the format string, or a single mapping object (for example, a dictionary).

A conversion specifier contains two or more characters and has the following components, which must occur in this order:

1. The `'%'` character, which marks the start of the specifier.
2. Mapping key (optional), consisting of a parenthesised sequence of characters (for example, `(somename)`).
3. Conversion flags (optional), which affect the result of some conversion types.
4. Minimum field width (optional). If specified as an `'*'` (asterisk), the actual width is read from the next element of the tuple in *values*, and the object to convert comes after the minimum field width and optional precision.
5. Precision (optional), given as a `'.'` (dot) followed by the precision. If specified as `'*'` (an asterisk), the actual precision is read from the next element of the tuple in *values*, and the value to convert comes after the precision.
6. Length modifier (optional).
7. Conversion type.

When the right argument is a dictionary (or other mapping type), then the formats in the string *must* include a parenthesised mapping key into that dictionary inserted immediately after the `'%'` character. The mapping key selects the value to be formatted from the mapping. For example:

```
>>> print('%(language)s has %(number)03d quote types.' %
...       {'language': "Python", "number": 2})
Python has 002 quote types.
```

In this case no `*` specifiers may occur in a format (since they require a sequential parameter list).

The conversion flag characters are:

Flag	Meaning
<code>'#'</code>	The value conversion will use the "alternate form" (where defined below).
<code>'0'</code>	The conversion will be zero padded for numeric values.
<code>'-'</code>	The converted value is left adjusted (overrides the <code>'0'</code> conversion if both are given).
<code>' '</code>	(a space) A blank should be left before a positive number (or empty string) produced by a signed conversion.
<code>'+'</code>	A sign character (<code>'+'</code> or <code>'-'</code>) will precede the conversion (overrides a "space" flag).

A length modifier (`h`, `l`, or `L`) may be present, but is ignored as it is not necessary for Python -- so e.g. `%ld` is identical to `%d`.

The conversion types are:

⁵ To format only a tuple you should therefore provide a singleton tuple whose only element is the tuple to be formatted.

Con- version	Meaning	F 解
'd'	Signed integer decimal.	
'i'	Signed integer decimal.	
'o'	Signed octal value.	(1)
'u'	Obsolete type -- it is identical to 'd'.	(6)
'x'	Signed hexadecimal (lowercase).	(2)
'X'	Signed hexadecimal (uppercase).	(2)
'e'	Floating point exponential format (lowercase).	(3)
'E'	Floating point exponential format (uppercase).	(3)
'f'	Floating point decimal format.	(3)
'F'	Floating point decimal format.	(3)
'g'	Floating point format. Uses lowercase exponential format if exponent is less than -4 or not less than precision, decimal format otherwise.	(4)
'G'	Floating point format. Uses uppercase exponential format if exponent is less than -4 or not less than precision, decimal format otherwise.	(4)
'c'	Single character (accepts integer or single character string).	
'r'	String (converts any Python object using <code>repr()</code>).	(5)
's'	String (converts any Python object using <code>str()</code>).	(5)
'a'	String (converts any Python object using <code>ascii()</code>).	(5)
'%'	No argument is converted, results in a '%' character in the result.	

F解:

- (1) The alternate form causes a leading octal specifier ('0o') to be inserted before the first digit.
- (2) The alternate form causes a leading '0x' or '0X' (depending on whether the 'x' or 'X' format was used) to be inserted before the first digit.
- (3) The alternate form causes the result to always contain a decimal point, even if no digits follow it.
The precision determines the number of digits after the decimal point and defaults to 6.
- (4) The alternate form causes the result to always contain a decimal point, and trailing zeroes are not removed as they would otherwise be.
The precision determines the number of significant digits before and after the decimal point and defaults to 6.
- (5) If precision is N, the output is truncated to N characters.
- (6) 參 F PEP 237。

Since Python strings have an explicit length, %s conversions do not assume that '\0' is the end of the string.

在 3.1 版的變更: %f conversions for numbers whose absolute value is over 1e50 are no longer replaced by %g conversions.

4.8 Binary Sequence Types --- bytes, bytearray, memoryview

The core built-in types for manipulating binary data are `bytes` and `bytearray`. They are supported by `memoryview` which uses the buffer protocol to access the memory of other binary objects without needing to make a copy.

The `array` module supports efficient storage of basic data types like 32-bit integers and IEEE754 double-precision floating values.

4.8.1 Bytes Objects

Bytes objects are immutable sequences of single bytes. Since many major binary protocols are based on the ASCII text encoding, bytes objects offer several methods that are only valid when working with ASCII compatible data and are closely related to string objects in a variety of other ways.

class bytes ([*source*[, *encoding*[, *errors*]]])

Firstly, the syntax for bytes literals is largely the same as that for string literals, except that a `b` prefix is added:

- Single quotes: `b'still allows embedded "double" quotes'`
- Double quotes: `b"still allows embedded 'single' quotes"`
- Triple quoted: `b'''3 single quotes''',b"""3 double quotes"""`

Only ASCII characters are permitted in bytes literals (regardless of the declared source code encoding). Any binary values over 127 must be entered into bytes literals using the appropriate escape sequence.

As with string literals, bytes literals may also use a `r` prefix to disable processing of escape sequences. See strings for more about the various forms of bytes literal, including supported escape sequences.

While bytes literals and representations are based on ASCII text, bytes objects actually behave like immutable sequences of integers, with each value in the sequence restricted such that $0 \leq x < 256$ (attempts to violate this restriction will trigger *ValueError*). This is done deliberately to emphasise that while many binary formats include ASCII based elements and can be usefully manipulated with some text-oriented algorithms, this is not generally the case for arbitrary binary data (blindly applying text processing algorithms to binary data formats that are not ASCII compatible will usually lead to data corruption).

In addition to the literal forms, bytes objects can be created in a number of other ways:

- A zero-filled bytes object of a specified length: `bytes(10)`
- From an iterable of integers: `bytes(range(20))`
- Copying existing binary data via the buffer protocol: `bytes(obj)`

Also see the *bytes* built-in.

Since 2 hexadecimal digits correspond precisely to a single byte, hexadecimal numbers are a commonly used format for describing binary data. Accordingly, the bytes type has an additional class method to read data in that format:

classmethod fromhex (*string*)

This *bytes* class method returns a bytes object, decoding the given string object. The string must contain two hexadecimal digits per byte, with ASCII whitespace being ignored.

```
>>> bytes.fromhex('2Ef0 F1f2 ')
b'\xf0\xf1\xf2'
```

在 3.7 版的變更: *bytes.fromhex()* now skips all ASCII whitespace in the string, not just spaces.

A reverse conversion function exists to transform a bytes object into its hexadecimal representation.

hex ([*sep*[, *bytes_per_sep*]])

Return a string object containing two hexadecimal digits for each byte in the instance.

```
>>> b'\xf0\xf1\xf2'.hex()
'f0f1f2'
```

If you want to make the hex string easier to read, you can specify a single character separator *sep* parameter to include in the output. By default, this separator will be included between each byte. A second optional *bytes_per_sep* parameter controls the spacing. Positive values calculate the separator position from the right, negative values from the left.

```
>>> value = b'\xf0\xf1\xf2'
>>> value.hex('-')
'f0-f1-f2'
>>> value.hex('_', 2)
'f0_f1f2'
>>> b'UUDDLRLRAB'.hex(' ', -4)
'55554444 4c524c52 4142'
```

在 3.5 版新加入。

在 3.8 版的變更: `bytes.hex()` now supports optional *sep* and *bytes_per_sep* parameters to insert separators between bytes in the hex output.

Since bytes objects are sequences of integers (akin to a tuple), for a bytes object *b*, `b[0]` will be an integer, while `b[0:1]` will be a bytes object of length 1. (This contrasts with text strings, where both indexing and slicing will produce a string of length 1)

The representation of bytes objects uses the literal format (`b'...'`) since it is often more useful than e.g. `bytes([46, 46, 46])`. You can always convert a bytes object into a list of integers using `list(b)`.

4.8.2 bytearray Objects

`bytearray` objects are a mutable counterpart to `bytes` objects.

class bytearray (`[source[, encoding[, errors]]]`)

There is no dedicated literal syntax for bytearray objects, instead they are always created by calling the constructor:

- Creating an empty instance: `bytearray()`
- Creating a zero-filled instance with a given length: `bytearray(10)`
- From an iterable of integers: `bytearray(range(20))`
- Copying existing binary data via the buffer protocol: `bytearray(b'Hi!')`

As bytearray objects are mutable, they support the *mutable* sequence operations in addition to the common bytes and bytearray operations described in *Bytes and Bytearray Operations*.

Also see the `bytearray` built-in.

Since 2 hexadecimal digits correspond precisely to a single byte, hexadecimal numbers are a commonly used format for describing binary data. Accordingly, the bytearray type has an additional class method to read data in that format:

classmethod fromhex (*string*)

This `bytearray` class method returns bytearray object, decoding the given string object. The string must contain two hexadecimal digits per byte, with ASCII whitespace being ignored.

```
>>> bytearray.fromhex('2Ef0 F1f2 ')
bytearray(b'\xf0\xf1\xf2')
```

在 3.7 版的變更: `bytearray.fromhex()` now skips all ASCII whitespace in the string, not just spaces.

A reverse conversion function exists to transform a bytearray object into its hexadecimal representation.

hex (`[sep[, bytes_per_sep]]`)

Return a string object containing two hexadecimal digits for each byte in the instance.

```
>>> bytearray(b'\xf0\xf1\xf2').hex()
'f0f1f2'
```


在 3.5 版新加入。

在 3.8 版的變更: Similar to `bytes.hex()`, `bytearray.hex()` now supports optional `sep` and `bytes_per_sep` parameters to insert separators between bytes in the hex output.

Since bytearray objects are sequences of integers (akin to a list), for a bytearray object `b`, `b[0]` will be an integer, while `b[0:1]` will be a bytearray object of length 1. (This contrasts with text strings, where both indexing and slicing will produce a string of length 1)

The representation of bytearray objects uses the bytes literal format (`bytearray(b'...')`) since it is often more useful than e.g. `bytearray([46, 46, 46])`. You can always convert a bytearray object into a list of integers using `list(b)`.

4.8.3 Bytes and Bytearray Operations

Both bytes and bytearray objects support the *common* sequence operations. They interoperate not just with operands of the same type, but with any *bytes-like object*. Due to this flexibility, they can be freely mixed in operations without causing errors. However, the return type of the result may depend on the order of operands.

備 F: The methods on bytes and bytearray objects don't accept strings as their arguments, just as the methods on strings don't accept bytes as their arguments. For example, you have to write:

```
a = "abc"
b = a.replace("a", "f")
```

和:

```
a = b"abc"
b = a.replace(b"a", b"f")
```

Some bytes and bytearray operations assume the use of ASCII compatible binary formats, and hence should be avoided when working with arbitrary binary data. These restrictions are covered below.

備 F: Using these ASCII based operations to manipulate binary data that is not stored in an ASCII based format may lead to data corruption.

The following methods on bytes and bytearray objects can be used with arbitrary binary data.

`bytes.count(sub[, start[, end]])`

`bytearray.count(sub[, start[, end]])`

Return the number of non-overlapping occurrences of subsequence `sub` in the range `[start, end]`. Optional arguments `start` and `end` are interpreted as in slice notation.

The subsequence to search for may be any *bytes-like object* or an integer in the range 0 to 255.

If `sub` is empty, returns the number of empty slices between characters which is the length of the bytes object plus one.

在 3.3 版的變更: Also accept an integer in the range 0 to 255 as the subsequence.

`bytes.removeprefix(prefix, /)`

`bytearray.removeprefix(prefix, /)`

If the binary data starts with the `prefix` string, return `bytes[len(prefix):]`. Otherwise, return a copy of the original binary data:

```
>>> b'TestHook'.removeprefix(b'Test')
b'Hook'
>>> b'BaseTestCase'.removeprefix(b'Test')
b'BaseTestCase'
```

The *prefix* may be any *bytes-like object*.

備 F: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

在 3.9 版新加入.

`bytes.removeprefix(suffix, /)`

`bytearray.removeprefix(suffix, /)`

If the binary data ends with the *suffix* string and that *suffix* is not empty, return `bytes[:-len(suffix)]`. Otherwise, return a copy of the original binary data:

```
>>> b'MiscTests'.removeprefix(b'Tests')
b'Misc'
>>> b'TmpDirMixin'.removeprefix(b'Tests')
b'TmpDirMixin'
```

The *suffix* may be any *bytes-like object*.

備 F: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

在 3.9 版新加入.

`bytes.decode(encoding='utf-8', errors='strict')`

`bytearray.decode(encoding='utf-8', errors='strict')`

Return the bytes decoded to a *str*.

encoding defaults to `'utf-8'`; see *Standard Encodings* for possible values.

errors controls how decoding errors are handled. If `'strict'` (the default), a *UnicodeError* exception is raised. Other possible values are `'ignore'`, `'replace'`, and any other name registered via *codecs.register_error()*. See *Error Handlers* for details.

For performance reasons, the value of *errors* is not checked for validity unless a decoding error actually occurs, *Python Development Mode* is enabled or a debug build is used.

備 F: Passing the *encoding* argument to *str* allows decoding any *bytes-like object* directly, without needing to make a temporary *bytes* or *bytearray* object.

在 3.1 版的變更: 新增關鍵字引數的支援。

在 3.9 版的變更: The value of the *errors* argument is now checked in *Python Development Mode* and in debug mode.

`bytes.endswith(suffix[, start[, end]])`

`bytearray.endswith(suffix[, start[, end]])`

Return `True` if the binary data ends with the specified *suffix*, otherwise return `False`. *suffix* can also be a tuple of suffixes to look for. With optional *start*, test beginning at that position. With optional *end*, stop comparing at that position.

The *suffix(es)* to search for may be any *bytes-like object*.

`bytes.find(sub[, start[, end]])`

`bytearray.find(sub[, start[, end]])`

Return the lowest index in the data where the subsequence *sub* is found, such that *sub* is contained in the slice `s[start:end]`. Optional arguments *start* and *end* are interpreted as in slice notation. Return `-1` if *sub* is not found.

The subsequence to search for may be any *bytes-like object* or an integer in the range 0 to 255.

備 註: The `find()` method should be used only if you need to know the position of `sub`. To check if `sub` is a substring or not, use the `in` operator:

```
>>> b'Py' in b'Python'
True
```

在 3.3 版的變更: Also accept an integer in the range 0 to 255 as the subsequence.

`bytes.index(sub[, start[, end]])`

`bytearray.index(sub[, start[, end]])`

Like `find()`, but raise `ValueError` when the subsequence is not found.

The subsequence to search for may be any *bytes-like object* or an integer in the range 0 to 255.

在 3.3 版的變更: Also accept an integer in the range 0 to 255 as the subsequence.

`bytes.join(iterable)`

`bytearray.join(iterable)`

Return a bytes or bytearray object which is the concatenation of the binary data sequences in `iterable`. A `TypeError` will be raised if there are any values in `iterable` that are not *bytes-like objects*, including `str` objects. The separator between elements is the contents of the bytes or bytearray object providing this method.

static `bytes.maketrans(from, to)`

static `bytearray.maketrans(from, to)`

This static method returns a translation table usable for `bytes.translate()` that will map each character in `from` into the character at the same position in `to`; `from` and `to` must both be *bytes-like objects* and have the same length.

在 3.1 版新加入.

`bytes.partition(sep)`

`bytearray.partition(sep)`

Split the sequence at the first occurrence of `sep`, and return a 3-tuple containing the part before the separator, the separator itself or its bytearray copy, and the part after the separator. If the separator is not found, return a 3-tuple containing a copy of the original sequence, followed by two empty bytes or bytearray objects.

The separator to search for may be any *bytes-like object*.

`bytes.replace(old, new[, count])`

`bytearray.replace(old, new[, count])`

Return a copy of the sequence with all occurrences of subsequence `old` replaced by `new`. If the optional argument `count` is given, only the first `count` occurrences are replaced.

The subsequence to search for and its replacement may be any *bytes-like object*.

備 註: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.rfind(sub[, start[, end]])`

`bytearray.rfind(sub[, start[, end]])`

Return the highest index in the sequence where the subsequence `sub` is found, such that `sub` is contained within `s[start:end]`. Optional arguments `start` and `end` are interpreted as in slice notation. Return `-1` on failure.

The subsequence to search for may be any *bytes-like object* or an integer in the range 0 to 255.

在 3.3 版的變更: Also accept an integer in the range 0 to 255 as the subsequence.

`bytes.rindex(sub[, start[, end]])`

`bytearray.rindex(sub[, start[, end]])`

Like `rfind()` but raises `ValueError` when the subsequence *sub* is not found.

The subsequence to search for may be any *bytes-like object* or an integer in the range 0 to 255.

在 3.3 版的變更: Also accept an integer in the range 0 to 255 as the subsequence.

`bytes.rpartition(sep)`

`bytearray.rpartition(sep)`

Split the sequence at the last occurrence of *sep*, and return a 3-tuple containing the part before the separator, the separator itself or its bytearray copy, and the part after the separator. If the separator is not found, return a 3-tuple containing two empty bytes or bytearray objects, followed by a copy of the original sequence.

The separator to search for may be any *bytes-like object*.

`bytes.startswith(prefix[, start[, end]])`

`bytearray.startswith(prefix[, start[, end]])`

Return True if the binary data starts with the specified *prefix*, otherwise return False. *prefix* can also be a tuple of prefixes to look for. With optional *start*, test beginning at that position. With optional *end*, stop comparing at that position.

The prefix(es) to search for may be any *bytes-like object*.

`bytes.translate(table, /, delete=b'')`

`bytearray.translate(table, /, delete=b'')`

Return a copy of the bytes or bytearray object where all bytes occurring in the optional argument *delete* are removed, and the remaining bytes have been mapped through the given translation table, which must be a bytes object of length 256.

You can use the `bytes.maketrans()` method to create a translation table.

Set the *table* argument to None for translations that only delete characters:

```
>>> b'read this short text'.translate(None, b'aeiou')
b'rd ths shrt txt'
```

在 3.6 版的變更: *delete* is now supported as a keyword argument.

The following methods on bytes and bytearray objects have default behaviours that assume the use of ASCII compatible binary formats, but can still be used with arbitrary binary data by passing appropriate arguments. Note that all of the bytearray methods in this section do *not* operate in place, and instead produce new objects.

`bytes.center(width[, fillbyte])`

`bytearray.center(width[, fillbyte])`

Return a copy of the object centered in a sequence of length *width*. Padding is done using the specified *fillbyte* (default is an ASCII space). For *bytes* objects, the original sequence is returned if *width* is less than or equal to `len(s)`.

備 F: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.ljust(width[, fillbyte])`

`bytearray.ljust(width[, fillbyte])`

Return a copy of the object left justified in a sequence of length *width*. Padding is done using the specified *fillbyte* (default is an ASCII space). For *bytes* objects, the original sequence is returned if *width* is less than or equal to `len(s)`.

備註: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.lstrip([chars])`

`bytearray.lstrip([chars])`

Return a copy of the sequence with specified leading bytes removed. The *chars* argument is a binary sequence specifying the set of byte values to be removed - the name refers to the fact this method is usually used with ASCII characters. If omitted or `None`, the *chars* argument defaults to removing ASCII whitespace. The *chars* argument is not a prefix; rather, all combinations of its values are stripped:

```
>>> b'   spacious   '.lstrip()
b'spacious'
>>> b'www.example.com'.lstrip(b'cmowz.')
b'example.com'
```

The binary sequence of byte values to remove may be any *bytes-like object*. See `removeprefix()` for a method that will remove a single prefix string rather than all of a set of characters. For example:

```
>>> b'Arthur: three!'.lstrip(b'Arthur: ')
b'ee!'
>>> b'Arthur: three!'.removeprefix(b'Arthur: ')
b'three!'
```

備註: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.rjust(width[, fillbyte])`

`bytearray.rjust(width[, fillbyte])`

Return a copy of the object right justified in a sequence of length *width*. Padding is done using the specified *fillbyte* (default is an ASCII space). For *bytes* objects, the original sequence is returned if *width* is less than or equal to `len(s)`.

備註: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.rsplit(sep=None, maxsplit=-1)`

`bytearray.rsplit(sep=None, maxsplit=-1)`

Split the binary sequence into subsequences of the same type, using *sep* as the delimiter string. If *maxsplit* is given, at most *maxsplit* splits are done, the *rightmost* ones. If *sep* is not specified or `None`, any subsequence consisting solely of ASCII whitespace is a separator. Except for splitting from the right, `rsplit()` behaves like `split()` which is described in detail below.

`bytes.rstrip([chars])`

`bytearray.rstrip([chars])`

Return a copy of the sequence with specified trailing bytes removed. The *chars* argument is a binary sequence specifying the set of byte values to be removed - the name refers to the fact this method is usually used with ASCII characters. If omitted or `None`, the *chars* argument defaults to removing ASCII whitespace. The *chars* argument is not a suffix; rather, all combinations of its values are stripped:

```
>>> b'   spacious   '.rstrip()
b'   spacious'
>>> b'mississippi'.rstrip(b'ipz')
b'mississ'
```

The binary sequence of byte values to remove may be any *bytes-like object*. See `removesuffix()` for a method that will remove a single suffix string rather than all of a set of characters. For example:

```
>>> b'Monty Python'.rstrip(b' Python')
b'M'
>>> b'Monty Python'.removesuffix(b' Python')
b'Monty'
```

備 F: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.split (sep=None, maxsplit=-1)`

`bytearray.split (sep=None, maxsplit=-1)`

Split the binary sequence into subsequences of the same type, using *sep* as the delimiter string. If *maxsplit* is given and non-negative, at most *maxsplit* splits are done (thus, the list will have at most *maxsplit*+1 elements). If *maxsplit* is not specified or is -1, then there is no limit on the number of splits (all possible splits are made).

If *sep* is given, consecutive delimiters are not grouped together and are deemed to delimit empty subsequences (for example, `b'1,,2'.split(b',')` returns `[b'1', b'', b'2']`). The *sep* argument may consist of a multibyte sequence (for example, `b'1<>2<>3'.split(b'<>')` returns `[b'1', b'2', b'3']`). Splitting an empty sequence with a specified separator returns `[b'']` or `[bytearray(b'')]` depending on the type of object being split. The *sep* argument may be any *bytes-like object*.

舉例來 F:

```
>>> b'1,2,3'.split(b',')
[b'1', b'2', b'3']
>>> b'1,2,3'.split(b',', maxsplit=1)
[b'1', b'2,3']
>>> b'1,2,,3'.split(b',')
[b'1', b'2', b'', b'3', b'']
```

If *sep* is not specified or is `None`, a different splitting algorithm is applied: runs of consecutive ASCII whitespace are regarded as a single separator, and the result will contain no empty strings at the start or end if the sequence has leading or trailing whitespace. Consequently, splitting an empty sequence or a sequence consisting solely of ASCII whitespace without a specified separator returns `[]`.

舉例來 F:

```
>>> b'1 2 3'.split()
[b'1', b'2', b'3']
>>> b'1 2 3'.split(maxsplit=1)
[b'1', b'2 3']
>>> b' 1 2 3 '.split()
[b'1', b'2', b'3']
```

`bytes.strip ([chars])`

`bytearray.strip ([chars])`

Return a copy of the sequence with specified leading and trailing bytes removed. The *chars* argument is a binary sequence specifying the set of byte values to be removed - the name refers to the fact this method is usually used with ASCII characters. If omitted or `None`, the *chars* argument defaults to removing ASCII whitespace. The *chars* argument is not a prefix or suffix; rather, all combinations of its values are stripped:

```
>>> b'   spacious   '.strip()
b'spacious'
>>> b'www.example.com'.strip(b'cmowz.')
b'example'
```

The binary sequence of byte values to remove may be any *bytes-like object*.

備註: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

The following methods on bytes and bytearray objects assume the use of ASCII compatible binary formats and should not be applied to arbitrary binary data. Note that all of the bytearray methods in this section do *not* operate in place, and instead produce new objects.

`bytes.capitalize()`

`bytearray.capitalize()`

Return a copy of the sequence with each byte interpreted as an ASCII character, and the first byte capitalized and the rest lowercased. Non-ASCII byte values are passed through unchanged.

備註: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.expandtabs(tabsize=8)`

`bytearray.expandtabs(tabsize=8)`

Return a copy of the sequence where all ASCII tab characters are replaced by one or more ASCII spaces, depending on the current column and the given tab size. Tab positions occur every *tabsize* bytes (default is 8, giving tab positions at columns 0, 8, 16 and so on). To expand the sequence, the current column is set to zero and the sequence is examined byte by byte. If the byte is an ASCII tab character (`b'\t'`), one or more space characters are inserted in the result until the current column is equal to the next tab position. (The tab character itself is not copied.) If the current byte is an ASCII newline (`b'\n'`) or carriage return (`b'\r'`), it is copied and the current column is reset to zero. Any other byte value is copied unchanged and the current column is incremented by one regardless of how the byte value is represented when printed:

```
>>> b'01\t012\t0123\t01234'.expandtabs()
b'01      012      0123      01234'
>>> b'01\t012\t0123\t01234'.expandtabs(4)
b'01  012 0123  01234'
```

備註: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.isalnum()`

`bytearray.isalnum()`

Return True if all bytes in the sequence are alphabetical ASCII characters or ASCII decimal digits and the sequence is not empty, False otherwise. Alphabetic ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ'`. ASCII decimal digits are those byte values in the sequence `b'0123456789'`.

舉例來:

```
>>> b'ABCabc1'.isalnum()
True
>>> b'ABC abc1'.isalnum()
False
```

`bytes.isalpha()`

`bytearray.isalpha()`

Return True if all bytes in the sequence are alphabetic ASCII characters and the sequence is not empty, False otherwise. Alphabetic ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ'`.

舉例來 F:

```
>>> b'ABCabc'.isalpha()
True
>>> b'ABCabc1'.isalpha()
False
```

`bytes.isascii()`

`bytearray.isascii()`

Return True if the sequence is empty or all bytes in the sequence are ASCII, False otherwise. ASCII bytes are in the range 0-0x7F.

在 3.7 版新加入.

`bytes.isdigit()`

`bytearray.isdigit()`

Return True if all bytes in the sequence are ASCII decimal digits and the sequence is not empty, False otherwise. ASCII decimal digits are those byte values in the sequence `b'0123456789'`.

舉例來 F:

```
>>> b'1234'.isdigit()
True
>>> b'1.23'.isdigit()
False
```

`bytes.islower()`

`bytearray.islower()`

Return True if there is at least one lowercase ASCII character in the sequence and no uppercase ASCII characters, False otherwise.

舉例來 F:

```
>>> b'hello world'.islower()
True
>>> b'Hello world'.islower()
False
```

Lowercase ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyz'`. Uppercase ASCII characters are those byte values in the sequence `b'ABCDEFGHIJKLMNOPQRSTUVWXYZ'`.

`bytes.isspace()`

`bytearray.isspace()`

Return True if all bytes in the sequence are ASCII whitespace and the sequence is not empty, False otherwise. ASCII whitespace characters are those byte values in the sequence `b' \t\n\r\x0b\f'` (space, tab, newline, carriage return, vertical tab, form feed).

`bytes.istitle()`

`bytearray.istitle()`

Return True if the sequence is ASCII titlecase and the sequence is not empty, False otherwise. See `bytes.title()` for more details on the definition of "titlecase".

舉例來 F:

```
>>> b'Hello World'.istitle()
True
>>> b'Hello world'.istitle()
False
```

`bytes.isupper()`

`bytearray.isupper()`

Return True if there is at least one uppercase alphabetic ASCII character in the sequence and no lowercase ASCII characters, False otherwise.

舉例來:

```
>>> b'HELLO WORLD'.isupper()
True
>>> b'Hello world'.isupper()
False
```

Lowercase ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyz'`. Uppercase ASCII characters are those byte values in the sequence `b'ABCDEFGHIJKLMNOPQRSTUVWXYZ'`.

`bytes.lower()``bytearray.lower()`

Return a copy of the sequence with all the uppercase ASCII characters converted to their corresponding lowercase counterpart.

舉例來:

```
>>> b'Hello World'.lower()
b'hello world'
```

Lowercase ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyz'`. Uppercase ASCII characters are those byte values in the sequence `b'ABCDEFGHIJKLMNOPQRSTUVWXYZ'`.

備: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.splitlines(keepends=False)``bytearray.splitlines(keepends=False)`

Return a list of the lines in the binary sequence, breaking at ASCII line boundaries. This method uses the *universal newlines* approach to splitting lines. Line breaks are not included in the resulting list unless *keepends* is given and true.

舉例來:

```
>>> b'ab c\nnde fg\rkl\r\n'.splitlines()
[b'ab c', b'', b'de fg', b'kl']
>>> b'ab c\nnde fg\rkl\r\n'.splitlines(keepends=True)
[b'ab c\n', b'\n', b'de fg\r', b'kl\r\n']
```

Unlike `split()` when a delimiter string *sep* is given, this method returns an empty list for the empty string, and a terminal line break does not result in an extra line:

```
>>> b"".split(b'\n'), b"Two lines\n".split(b'\n')
([b''], [b'Two lines', b''])
>>> b"".splitlines(), b"One line\n".splitlines()
([], [b'One line'])
```

`bytes.swapcase()``bytearray.swapcase()`

Return a copy of the sequence with all the lowercase ASCII characters converted to their corresponding uppercase counterpart and vice-versa.

舉例來:

```
>>> b'Hello World'.swapcase()
b'hELLO wORLD'
```

Lowercase ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyz'`. Uppercase ASCII characters are those byte values in the sequence `b'ABCDEFGHIJKLMNOPQRSTUVWXYZ'`.

Unlike `str.swapcase()`, it is always the case that `bin.swapcase().swapcase() == bin` for the binary versions. Case conversions are symmetrical in ASCII, even though that is not generally true for arbitrary Unicode code points.

備 F: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.title()`

`bytearray.title()`

Return a titlecased version of the binary sequence where words start with an uppercase ASCII character and the remaining characters are lowercase. Uncased byte values are left unmodified.

舉例來 F:

```
>>> b'Hello world'.title()
b'Hello World'
```

Lowercase ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyz'`. Uppercase ASCII characters are those byte values in the sequence `b'ABCDEFGHIJKLMNOPQRSTUVWXYZ'`. All other byte values are uncased.

The algorithm uses a simple language-independent definition of a word as groups of consecutive letters. The definition works in many contexts but it means that apostrophes in contractions and possessives form word boundaries, which may not be the desired result:

```
>>> b"they're bill's friends from the UK".title()
b'They'Re Bill'S Friends From The Uk"
```

A workaround for apostrophes can be constructed using regular expressions:

```
>>> import re
>>> def titlecase(s):
...     return re.sub(rb"[A-Za-z]+(' [A-Za-z]+)?",
...                     lambda mo: mo.group(0)[0:1].upper() +
...                                   mo.group(0)[1:].lower(),
...                     s)
>>> titlecase(b"they're bill's friends.")
b'They're Bill's Friends.'
```

備 F: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.upper()`

`bytearray.upper()`

Return a copy of the sequence with all the lowercase ASCII characters converted to their corresponding uppercase counterpart.

舉例來 F:

```
>>> b'Hello World'.upper()
b'HELLO WORLD'
```

Lowercase ASCII characters are those byte values in the sequence `b'abcdefghijklmnopqrstuvwxyz'`. Uppercase ASCII characters are those byte values in the sequence `b'ABCDEFGHIJKLMNOPQRSTUVWXYZ'`.

備 注: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

`bytes.zfill(width)`

`bytearray.zfill(width)`

Return a copy of the sequence left filled with ASCII `b'0'` digits to make a sequence of length *width*. A leading sign prefix (`b'+' / b'-'`) is handled by inserting the padding *after* the sign character rather than before. For *bytes* objects, the original sequence is returned if *width* is less than or equal to `len(seq)`.

舉例來 注:

```
>>> b"42".zfill(5)
b'00042'
>>> b"-42".zfill(5)
b'-0042'
```

備 注: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

4.8.4 printf-style Bytes Formatting

備 注: The formatting operations described here exhibit a variety of quirks that lead to a number of common errors (such as failing to display tuples and dictionaries correctly). If the value being printed may be a tuple or dictionary, wrap it in a tuple.

Bytes objects (*bytes*/*bytearray*) have one unique built-in operation: the `%` operator (modulo). This is also known as the bytes *formatting* or *interpolation* operator. Given *format % values* (where *format* is a bytes object), `%` conversion specifications in *format* are replaced with zero or more elements of *values*. The effect is similar to using the `sprintf()` in the C language.

If *format* requires a single argument, *values* may be a single non-tuple object.^{Page 55, 5} Otherwise, *values* must be a tuple with exactly the number of items specified by the format bytes object, or a single mapping object (for example, a dictionary).

A conversion specifier contains two or more characters and has the following components, which must occur in this order:

1. The `'%'` character, which marks the start of the specifier.
2. Mapping key (optional), consisting of a parenthesised sequence of characters (for example, `(somename)`).
3. Conversion flags (optional), which affect the result of some conversion types.
4. Minimum field width (optional). If specified as an `'*'` (asterisk), the actual width is read from the next element of the tuple in *values*, and the object to convert comes after the minimum field width and optional precision.
5. Precision (optional), given as a `'.'` (dot) followed by the precision. If specified as `'*'` (an asterisk), the actual precision is read from the next element of the tuple in *values*, and the value to convert comes after the precision.

6. Length modifier (optional).

7. Conversion type.

When the right argument is a dictionary (or other mapping type), then the formats in the bytes object *must* include a parenthesised mapping key into that dictionary inserted immediately after the '%' character. The mapping key selects the value to be formatted from the mapping. For example:

```
>>> print(b'%(language)s has %(number)03d quote types.' %
...       {b'language': b'Python', b'number': 2})
b'Python has 002 quote types.'
```

In this case no * specifiers may occur in a format (since they require a sequential parameter list).

The conversion flag characters are:

Flag	Meaning
'#'	The value conversion will use the "alternate form" (where defined below).
'0'	The conversion will be zero padded for numeric values.
'-'	The converted value is left adjusted (overrides the '0' conversion if both are given).
' '	(a space) A blank should be left before a positive number (or empty string) produced by a signed conversion.
'+'	A sign character ('+' or '-') will precede the conversion (overrides a "space" flag).

A length modifier (h, l, or L) may be present, but is ignored as it is not necessary for Python -- so e.g. %ld is identical to %d.

The conversion types are:

Con- version	Meaning	解
'd'	Signed integer decimal.	
'i'	Signed integer decimal.	
'o'	Signed octal value.	(1)
'u'	Obsolete type -- it is identical to 'd'.	(8)
'x'	Signed hexadecimal (lowercase).	(2)
'X'	Signed hexadecimal (uppercase).	(2)
'e'	Floating point exponential format (lowercase).	(3)
'E'	Floating point exponential format (uppercase).	(3)
'f'	Floating point decimal format.	(3)
'F'	Floating point decimal format.	(3)
'g'	Floating point format. Uses lowercase exponential format if exponent is less than -4 or not less than precision, decimal format otherwise.	(4)
'G'	Floating point format. Uses uppercase exponential format if exponent is less than -4 or not less than precision, decimal format otherwise.	(4)
'c'	Single byte (accepts integer or single byte objects).	
'b'	Bytes (any object that follows the buffer protocol or has __bytes__()).	(5)
's'	's' is an alias for 'b' and should only be used for Python2/3 code bases.	(6)
'a'	Bytes (converts any Python object using repr(obj).encode('ascii', 'backslashreplace')).	(5)
'r'	'r' is an alias for 'a' and should only be used for Python2/3 code bases.	(7)
'%'	No argument is converted, results in a '%' character in the result.	

解:

- (1) The alternate form causes a leading octal specifier ('0o') to be inserted before the first digit.
- (2) The alternate form causes a leading '0x' or '0X' (depending on whether the 'x' or 'X' format was used) to be inserted before the first digit.

- (3) The alternate form causes the result to always contain a decimal point, even if no digits follow it.

The precision determines the number of digits after the decimal point and defaults to 6.

- (4) The alternate form causes the result to always contain a decimal point, and trailing zeroes are not removed as they would otherwise be.

The precision determines the number of significant digits before and after the decimal point and defaults to 6.

- (5) If precision is *N*, the output is truncated to *N* characters.

- (6) `b'%s'` is deprecated, but will not be removed during the 3.x series.

- (7) `b'%r'` is deprecated, but will not be removed during the 3.x series.

- (8) 參 237。

備: The bytearray version of this method does *not* operate in place - it always produces a new object, even if no changes were made.

也參考:

PEP 461 - Adding % formatting to bytes and bytearray

在 3.5 版新加入。

4.8.5 Memory Views

`memoryview` objects allow Python code to access the internal data of an object that supports the buffer protocol without copying.

class `memoryview` (*object*)

Create a `memoryview` that references *object*. *object* must support the buffer protocol. Built-in objects that support the buffer protocol include `bytes` and `bytearray`.

A `memoryview` has the notion of an *element*, which is the atomic memory unit handled by the originating *object*. For many simple types such as `bytes` and `bytearray`, an element is a single byte, but other types such as `array.array` may have bigger elements.

`len(view)` is equal to the length of *tolist*. If `view.ndim == 0`, the length is 1. If `view.ndim == 1`, the length is equal to the number of elements in the view. For higher dimensions, the length is equal to the length of the nested list representation of the view. The `itemsize` attribute will give you the number of bytes in a single element.

A `memoryview` supports slicing and indexing to expose its data. One-dimensional slicing will result in a subview:

```
>>> v = memoryview(b'abcefg')
>>> v[1]
98
>>> v[-1]
103
>>> v[1:4]
<memory at 0x7f3ddc9f4350>
>>> bytes(v[1:4])
b'bce'
```

If *format* is one of the native format specifiers from the `struct` module, indexing with an integer or a tuple of integers is also supported and returns a single *element* with the correct type. One-dimensional memoryviews can be indexed with an integer or a one-integer tuple. Multi-dimensional memoryviews can be indexed with tuples of exactly *ndim* integers where *ndim* is the number of dimensions. Zero-dimensional memoryviews can be indexed with the empty tuple.

Here is an example with a non-byte format:

```

>>> import array
>>> a = array.array('l', [-11111111, 22222222, -33333333, 44444444])
>>> m = memoryview(a)
>>> m[0]
-11111111
>>> m[-1]
44444444
>>> m[::2].tolist()
[-11111111, -33333333]

```

If the underlying object is writable, the memoryview supports one-dimensional slice assignment. Resizing is not allowed:

```

>>> data = bytearray(b'abcefg')
>>> v = memoryview(data)
>>> v.readonly
False
>>> v[0] = ord(b'z')
>>> data
bytearray(b'zbcefg')
>>> v[1:4] = b'123'
>>> data
bytearray(b'z123fg')
>>> v[2:3] = b'spam'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: memoryview assignment: lvalue and rvalue have different structures
>>> v[2:6] = b'spam'
>>> data
bytearray(b'z1spam')

```

One-dimensional memoryviews of *hashable* (read-only) types with formats 'B', 'b' or 'c' are also hashable. The hash is defined as `hash(m) == hash(m.tobytes())`:

```

>>> v = memoryview(b'abcefg')
>>> hash(v) == hash(b'abcefg')
True
>>> hash(v[2:4]) == hash(b'ce')
True
>>> hash(v[::-2]) == hash(b'abcefg'[::-2])
True

```

在 3.3 版的變更: One-dimensional memoryviews can now be sliced. One-dimensional memoryviews with formats 'B', 'b' or 'c' are now *hashable*.

在 3.4 版的變更: memoryview is now registered automatically with `collections.abc.Sequence`

在 3.5 版的變更: memoryviews can now be indexed with tuple of integers.

`memoryview` has several methods:

`__eq__` (exporter)

A memoryview and a **PEP 3118** exporter are equal if their shapes are equivalent and if all corresponding values are equal when the operands' respective format codes are interpreted using `struct` syntax.

For the subset of `struct` format strings currently supported by `tolist()`, `v` and `w` are equal if `v.tolist() == w.tolist()`:

```

>>> import array
>>> a = array.array('I', [1, 2, 3, 4, 5])
>>> b = array.array('d', [1.0, 2.0, 3.0, 4.0, 5.0])
>>> c = array.array('b', [5, 3, 1])
>>> x = memoryview(a)

```

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```

>>> y = memoryview(b)
>>> x == a == y == b
True
>>> x.tolist() == a.tolist() == y.tolist() == b.tolist()
True
>>> z = y[::-2]
>>> z == c
True
>>> z.tolist() == c.tolist()
True

```

If either format string is not supported by the `struct` module, then the objects will always compare as unequal (even if the format strings and buffer contents are identical):

```

>>> from ctypes import BigEndianStructure, c_long
>>> class BEPoint(BigEndianStructure):
...     _fields_ = [("x", c_long), ("y", c_long)]
...
>>> point = BEPoint(100, 200)
>>> a = memoryview(point)
>>> b = memoryview(point)
>>> a == point
False
>>> a == b
False

```

Note that, as with floating point numbers, `v is w` does *not* imply `v == w` for memoryview objects.

在 3.3 版的變更: Previous versions compared the raw memory disregarding the item format and the logical array structure.

tobytes (*order='C'*)

Return the data in the buffer as a bytestring. This is equivalent to calling the `bytes` constructor on the memoryview.

```

>>> m = memoryview(b"abc")
>>> m.tobytes()
b'abc'
>>> bytes(m)
b'abc'

```

For non-contiguous arrays the result is equal to the flattened list representation with all elements converted to bytes. `tobytes()` supports all format strings, including those that are not in `struct` module syntax.

在 3.8 版新加入: `order` can be {'C', 'F', 'A'}. When `order` is 'C' or 'F', the data of the original array is converted to C or Fortran order. For contiguous views, 'A' returns an exact copy of the physical memory. In particular, in-memory Fortran order is preserved. For non-contiguous views, the data is converted to C first. `order=None` is the same as `order='C'`.

hex (*[sep[, bytes_per_sep]]*)

Return a string object containing two hexadecimal digits for each byte in the buffer.

```

>>> m = memoryview(b"abc")
>>> m.hex()
'616263'

```

在 3.5 版新加入.

在 3.8 版的變更: Similar to `bytes.hex()`, `memoryview.hex()` now supports optional `sep` and `bytes_per_sep` parameters to insert separators between bytes in the hex output.

tolist()

Return the data in the buffer as a list of elements.

```
>>> memoryview(b'abc').tolist()
[97, 98, 99]
>>> import array
>>> a = array.array('d', [1.1, 2.2, 3.3])
>>> m = memoryview(a)
>>> m.tolist()
[1.1, 2.2, 3.3]
```

在 3.3 版的變更: `tolist()` now supports all single character native formats in `struct` module syntax as well as multi-dimensional representations.

toreadonly()

Return a readonly version of the memoryview object. The original memoryview object is unchanged.

```
>>> m = memoryview(bytearray(b'abc'))
>>> mm = m.toreadonly()
>>> mm.tolist()
[97, 98, 99]
>>> mm[0] = 42
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: cannot modify read-only memory
>>> m[0] = 43
>>> mm.tolist()
[43, 98, 99]
```

在 3.8 版新加入.

release()

Release the underlying buffer exposed by the memoryview object. Many objects take special actions when a view is held on them (for example, a `bytearray` would temporarily forbid resizing); therefore, calling `release()` is handy to remove these restrictions (and free any dangling resources) as soon as possible.

After this method has been called, any further operation on the view raises a `ValueError` (except `release()` itself which can be called multiple times):

```
>>> m = memoryview(b'abc')
>>> m.release()
>>> m[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operation forbidden on released memoryview object
```

The context management protocol can be used for a similar effect, using the `with` statement:

```
>>> with memoryview(b'abc') as m:
...     m[0]
...
97
>>> m[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operation forbidden on released memoryview object
```

在 3.2 版新加入.

cast(format[, shape])

Cast a memoryview to a new format or shape. `shape` defaults to `[byte_length//new_itemsize]`, which means that the result view will be one-dimensional. The return value is a new memoryview, but the buffer itself is not copied. Supported casts are 1D -> C-*contiguous* and C-*contiguous* -> 1D.

The destination format is restricted to a single element native format in `struct` syntax. One of the formats must be a byte format ('B', 'b' or 'c'). The byte length of the result must be the same as the original length. Note that all byte lengths may depend on the operating system.

Cast 1D/long to 1D/unsigned bytes:

```
>>> import array
>>> a = array.array('l', [1,2,3])
>>> x = memoryview(a)
>>> x.format
'l'
>>> x.itemsize
8
>>> len(x)
3
>>> x.nbytes
24
>>> y = x.cast('B')
>>> y.format
'B'
>>> y.itemsize
1
>>> len(y)
24
>>> y.nbytes
24
```

Cast 1D/unsigned bytes to 1D/char:

```
>>> b = bytearray(b'zyz')
>>> x = memoryview(b)
>>> x[0] = b'a'
Traceback (most recent call last):
...
TypeError: memoryview: invalid type for format 'B'
>>> y = x.cast('c')
>>> y[0] = b'a'
>>> b
bytearray(b'ayz')
```

Cast 1D/bytes to 3D/integers to 1D/signed char:

```
>>> import struct
>>> buf = struct.pack("i"*12, *list(range(12)))
>>> x = memoryview(buf)
>>> y = x.cast('i', shape=[2,2,3])
>>> y.tolist()
[[[0, 1, 2], [3, 4, 5]], [[6, 7, 8], [9, 10, 11]]]
>>> y.format
'i'
>>> y.itemsize
4
>>> len(y)
2
>>> y.nbytes
48
>>> z = y.cast('b')
>>> z.format
'b'
>>> z.itemsize
1
>>> len(z)
48
```

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```
>>> z.nbytes
48
```

Cast 1D/unsigned long to 2D/unsigned long:

```
>>> buf = struct.pack("L"*6, *list(range(6)))
>>> x = memoryview(buf)
>>> y = x.cast('L', shape=[2,3])
>>> len(y)
2
>>> y.nbytes
48
>>> y.tolist()
[[0, 1, 2], [3, 4, 5]]
```

在 3.3 版新加入.

在 3.5 版的變更: The source format is no longer restricted when casting to a byte view.

There are also several readonly attributes available:

obj

The underlying object of the memoryview:

```
>>> b = bytearray(b'xyz')
>>> m = memoryview(b)
>>> m.obj is b
True
```

在 3.3 版新加入.

nbytes

`nbytes == product(shape) * itemsize == len(m.tobytes())`. This is the amount of space in bytes that the array would use in a contiguous representation. It is not necessarily equal to `len(m)`:

```
>>> import array
>>> a = array.array('i', [1,2,3,4,5])
>>> m = memoryview(a)
>>> len(m)
5
>>> m.nbytes
20
>>> y = m[::2]
>>> len(y)
3
>>> y.nbytes
12
>>> len(y.tobytes())
12
```

Multi-dimensional arrays:

```
>>> import struct
>>> buf = struct.pack("d"*12, *[1.5*x for x in range(12)])
>>> x = memoryview(buf)
>>> y = x.cast('d', shape=[3,4])
>>> y.tolist()
[[0.0, 1.5, 3.0, 4.5], [6.0, 7.5, 9.0, 10.5], [12.0, 13.5, 15.0, 16.5]]
>>> len(y)
3
```

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```
>>> y.nbytes
96
```

在 3.3 版新加入.

readonly

A bool indicating whether the memory is read only.

format

A string containing the format (in *struct* module style) for each element in the view. A memoryview can be created from exporters with arbitrary format strings, but some methods (e.g. *tolist()*) are restricted to native single element formats.

在 3.3 版的變更: format 'B' is now handled according to the struct module syntax. This means that `memoryview(b'abc')[0] == b'abc'[0] == 97`.

itemsizes

The size in bytes of each element of the memoryview:

```
>>> import array, struct
>>> m = memoryview(array.array('H', [32000, 32001, 32002]))
>>> m.itemsize
2
>>> m[0]
32000
>>> struct.calcsize('H') == m.itemsize
True
```

ndim

An integer indicating how many dimensions of a multi-dimensional array the memory represents.

shape

A tuple of integers the length of *ndim* giving the shape of the memory as an N-dimensional array.

在 3.3 版的變更: An empty tuple instead of None when *ndim* = 0.

strides

A tuple of integers the length of *ndim* giving the size in bytes to access each element for each dimension of the array.

在 3.3 版的變更: An empty tuple instead of None when *ndim* = 0.

suboffsets

Used internally for PIL-style arrays. The value is informational only.

c_contiguous

A bool indicating whether the memory is C-*contiguous*.

在 3.3 版新加入.

f_contiguous

A bool indicating whether the memory is Fortran *contiguous*.

在 3.3 版新加入.

contiguous

A bool indicating whether the memory is *contiguous*.

在 3.3 版新加入.

4.9 Set Types --- set, frozenset

A *set* object is an unordered collection of distinct *hashable* objects. Common uses include membership testing, removing duplicates from a sequence, and computing mathematical operations such as intersection, union, difference, and symmetric difference. (For other containers see the built-in *dict*, *list*, and *tuple* classes, and the *collections* module.)

Like other collections, sets support `x in set`, `len(set)`, and `for x in set`. Being an unordered collection, sets do not record element position or order of insertion. Accordingly, sets do not support indexing, slicing, or other sequence-like behavior.

There are currently two built-in set types, *set* and *frozenset*. The *set* type is mutable --- the contents can be changed using methods like `add()` and `remove()`. Since it is mutable, it has no hash value and cannot be used as either a dictionary key or as an element of another set. The *frozenset* type is immutable and *hashable* --- its contents cannot be altered after it is created; it can therefore be used as a dictionary key or as an element of another set.

Non-empty sets (not frozensets) can be created by placing a comma-separated list of elements within braces, for example: `{'jack', 'sjoerd'}`, in addition to the *set* constructor.

The constructors for both classes work the same:

```
class set ([iterable])
```

```
class frozenset ([iterable])
```

Return a new set or frozenset object whose elements are taken from *iterable*. The elements of a set must be *hashable*. To represent sets of sets, the inner sets must be *frozenset* objects. If *iterable* is not specified, a new empty set is returned.

Sets can be created by several means:

- Use a comma-separated list of elements within braces: `{'jack', 'sjoerd'}`
- Use a set comprehension: `{c for c in 'abracadabra' if c not in 'abc'}`
- Use the type constructor: `set()`, `set('foobar')`, `set(['a', 'b', 'foo'])`

Instances of *set* and *frozenset* provide the following operations:

```
len(s)
```

Return the number of elements in set *s* (cardinality of *s*).

```
x in s
```

Test *x* for membership in *s*.

```
x not in s
```

Test *x* for non-membership in *s*.

```
isdisjoint(other)
```

Return `True` if the set has no elements in common with *other*. Sets are disjoint if and only if their intersection is the empty set.

```
issubset(other)
```

```
set <= other
```

Test whether every element in the set is in *other*.

```
set < other
```

Test whether the set is a proper subset of *other*, that is, `set <= other` and `set != other`.

```
issuperset(other)
```

```
set >= other
```

Test whether every element in *other* is in the set.

set > **other**

Test whether the set is a proper superset of *other*, that is, `set >= other` and `set != other`.

union (**others*)

set | **other** | ...

Return a new set with elements from the set and all others.

intersection (**others*)

set & **other** & ...

Return a new set with elements common to the set and all others.

difference (**others*)

set - **other** - ...

Return a new set with elements in the set that are not in the others.

symmetric_difference (*other*)

set ^ **other**

Return a new set with elements in either the set or *other* but not both.

copy ()

Return a shallow copy of the set.

Note, the non-operator versions of `union()`, `intersection()`, `difference()`, `symmetric_difference()`, `issubset()`, and `issuperset()` methods will accept any iterable as an argument. In contrast, their operator based counterparts require their arguments to be sets. This precludes error-prone constructions like `set('abc') & 'cbs'` in favor of the more readable `set('abc').intersection('cbs')`.

Both `set` and `frozenset` support set to set comparisons. Two sets are equal if and only if every element of each set is contained in the other (each is a subset of the other). A set is less than another set if and only if the first set is a proper subset of the second set (is a subset, but is not equal). A set is greater than another set if and only if the first set is a proper superset of the second set (is a superset, but is not equal).

Instances of `set` are compared to instances of `frozenset` based on their members. For example, `set('abc') == frozenset('abc')` returns `True` and so does `set('abc')` in `set([frozenset('abc')])`.

The subset and equality comparisons do not generalize to a total ordering function. For example, any two nonempty disjoint sets are not equal and are not subsets of each other, so *all* of the following return `False`: `a < b`, `a == b`, or `a > b`.

Since sets only define partial ordering (subset relationships), the output of the `list.sort()` method is undefined for lists of sets.

Set elements, like dictionary keys, must be *hashable*.

Binary operations that mix `set` instances with `frozenset` return the type of the first operand. For example: `frozenset('ab') | set('bc')` returns an instance of `frozenset`.

The following table lists operations available for `set` that do not apply to immutable instances of `frozenset`:

update (**others*)

set |= **other** | ...

Update the set, adding elements from all others.

intersection_update (**others*)

set &= **other** & ...

Update the set, keeping only elements found in it and all others.

difference_update (**others*)

set -= other | ...

Update the set, removing elements found in others.

symmetric_difference_update (*other*)

set ^= other

Update the set, keeping only elements found in either set, but not in both.

add (*elem*)

Add element *elem* to the set.

remove (*elem*)

Remove element *elem* from the set. Raises *KeyError* if *elem* is not contained in the set.

discard (*elem*)

Remove element *elem* from the set if it is present.

pop ()

Remove and return an arbitrary element from the set. Raises *KeyError* if the set is empty.

clear ()

Remove all elements from the set.

Note, the non-operator versions of the *update()*, *intersection_update()*, *difference_update()*, and *symmetric_difference_update()* methods will accept any iterable as an argument.

Note, the *elem* argument to the *__contains__()*, *remove()*, and *discard()* methods may be a set. To support searching for an equivalent frozenset, a temporary one is created from *elem*.

4.10 Mapping Types --- dict

A *mapping* object maps *hashable* values to arbitrary objects. Mappings are mutable objects. There is currently only one standard mapping type, the *dictionary*. (For other containers see the built-in *list*, *set*, and *tuple* classes, and the *collections* module.)

A dictionary's keys are *almost* arbitrary values. Values that are not *hashable*, that is, values containing lists, dictionaries or other mutable types (that are compared by value rather than by object identity) may not be used as keys. Values that compare equal (such as 1, 1.0, and True) can be used interchangeably to index the same dictionary entry.

class dict (**kwargs)

class dict (*mapping*, **kwargs)

class dict (*iterable*, **kwargs)

Return a new dictionary initialized from an optional positional argument and a possibly empty set of keyword arguments.

Dictionaries can be created by several means:

- Use a comma-separated list of key: value pairs within braces: {'jack': 4098, 'sjoerd': 4127} or {4098: 'jack', 4127: 'sjoerd'}
- Use a dict comprehension: {}, {x: x ** 2 for x in range(10)}
- Use the type constructor: dict(), dict([('foo', 100), ('bar', 200)]), dict(foo=100, bar=200)

If no positional argument is given, an empty dictionary is created. If a positional argument is given and it is a mapping object, a dictionary is created with the same key-value pairs as the mapping object. Otherwise, the positional argument must be an *iterable* object. Each item in the iterable must itself be an iterable with exactly two objects. The first object of each item becomes a key in the new dictionary, and the second object

the corresponding value. If a key occurs more than once, the last value for that key becomes the corresponding value in the new dictionary.

If keyword arguments are given, the keyword arguments and their values are added to the dictionary created from the positional argument. If a key being added is already present, the value from the keyword argument replaces the value from the positional argument.

To illustrate, the following examples all return a dictionary equal to `{"one": 1, "two": 2, "three": 3}`:

```
>>> a = dict(one=1, two=2, three=3)
>>> b = {'one': 1, 'two': 2, 'three': 3}
>>> c = dict(zip(['one', 'two', 'three'], [1, 2, 3]))
>>> d = dict([('two', 2), ('one', 1), ('three', 3)])
>>> e = dict({'three': 3, 'one': 1, 'two': 2})
>>> f = dict({'one': 1, 'three': 3}, two=2)
>>> a == b == c == d == e == f
True
```

Providing keyword arguments as in the first example only works for keys that are valid Python identifiers. Otherwise, any valid keys can be used.

These are the operations that dictionaries support (and therefore, custom mapping types should support too):

list(d)

Return a list of all the keys used in the dictionary *d*.

len(d)

Return the number of items in the dictionary *d*.

d[key]

Return the item of *d* with key *key*. Raises a *KeyError* if *key* is not in the map.

If a subclass of `dict` defines a method `__missing__()` and *key* is not present, the `d[key]` operation calls that method with the key *key* as argument. The `d[key]` operation then returns or raises whatever is returned or raised by the `__missing__(key)` call. No other operations or methods invoke `__missing__()`. If `__missing__()` is not defined, *KeyError* is raised. `__missing__()` must be a method; it cannot be an instance variable:

```
>>> class Counter(dict):
...     def __missing__(self, key):
...         return 0
>>> c = Counter()
>>> c['red']
0
>>> c['red'] += 1
>>> c['red']
1
```

The example above shows part of the implementation of `collections.Counter`. A different `__missing__` method is used by `collections.defaultdict`.

d[key] = value

Set `d[key]` to *value*.

del d[key]

Remove `d[key]` from *d*. Raises a *KeyError* if *key* is not in the map.

key in d

Return True if *d* has a key *key*, else False.

key not in d

Equivalent to `not key in d`.

iter(d)

Return an iterator over the keys of the dictionary. This is a shortcut for `iter(d.keys())`.

clear()

Remove all items from the dictionary.

copy()

Return a shallow copy of the dictionary.

classmethod fromkeys(iterable[, value])

Create a new dictionary with keys from *iterable* and values set to *value*.

fromkeys() is a class method that returns a new dictionary. *value* defaults to `None`. All of the values refer to just a single instance, so it generally doesn't make sense for *value* to be a mutable object such as an empty list. To get distinct values, use a dict comprehension instead.

get(key[, default])

Return the value for *key* if *key* is in the dictionary, else *default*. If *default* is not given, it defaults to `None`, so that this method never raises a *KeyError*.

items()

Return a new view of the dictionary's items ((*key*, *value*) pairs). See the *documentation of view objects*.

keys()

Return a new view of the dictionary's keys. See the *documentation of view objects*.

pop(key[, default])

If *key* is in the dictionary, remove it and return its value, else return *default*. If *default* is not given and *key* is not in the dictionary, a *KeyError* is raised.

popitem()

Remove and return a (*key*, *value*) pair from the dictionary. Pairs are returned in LIFO (last-in, first-out) order.

popitem() is useful to destructively iterate over a dictionary, as often used in set algorithms. If the dictionary is empty, calling *popitem()* raises a *KeyError*.

在 3.7 版的變更: LIFO order is now guaranteed. In prior versions, *popitem()* would return an arbitrary key/value pair.

reversed(d)

Return a reverse iterator over the keys of the dictionary. This is a shortcut for `reversed(d.keys())`.

在 3.8 版新加入.

setdefault(key[, default])

If *key* is in the dictionary, return its value. If not, insert *key* with a value of *default* and return *default*. *default* defaults to `None`.

update([other])

Update the dictionary with the key/value pairs from *other*, overwriting existing keys. Return `None`.

update() accepts either another dictionary object or an iterable of key/value pairs (as tuples or other iterables of length two). If keyword arguments are specified, the dictionary is then updated with those key/value pairs: `d.update(red=1, blue=2)`.

values()

Return a new view of the dictionary's values. See the *documentation of view objects*.

An equality comparison between one `dict.values()` view and another will always return `False`. This also applies when comparing `dict.values()` to itself:

```
>>> d = {'a': 1}
>>> d.values() == d.values()
False
```

d | other

Create a new dictionary with the merged keys and values of *d* and *other*, which must both be dictionaries. The values of *other* take priority when *d* and *other* share keys.

在 3.9 版新加入.

d |= other

Update the dictionary *d* with keys and values from *other*, which may be either a *mapping* or an *iterable* of key/value pairs. The values of *other* take priority when *d* and *other* share keys.

在 3.9 版新加入.

Dictionaries compare equal if and only if they have the same (key, value) pairs (regardless of ordering). Order comparisons ('<', '<=', '>=', '>') raise *TypeError*.

Dictionaries preserve insertion order. Note that updating a key does not affect the order. Keys added after deletion are inserted at the end.

```
>>> d = {"one": 1, "two": 2, "three": 3, "four": 4}
>>> d
{'one': 1, 'two': 2, 'three': 3, 'four': 4}
>>> list(d)
['one', 'two', 'three', 'four']
>>> list(d.values())
[1, 2, 3, 4]
>>> d["one"] = 42
>>> d
{'one': 42, 'two': 2, 'three': 3, 'four': 4}
>>> del d["two"]
>>> d["two"] = None
>>> d
{'one': 42, 'three': 3, 'four': 4, 'two': None}
```

在 3.7 版的變更: Dictionary order is guaranteed to be insertion order. This behavior was an implementation detail of CPython from 3.6.

Dictionaries and dictionary views are reversible.

```
>>> d = {"one": 1, "two": 2, "three": 3, "four": 4}
>>> d
{'one': 1, 'two': 2, 'three': 3, 'four': 4}
>>> list(reversed(d))
['four', 'three', 'two', 'one']
>>> list(reversed(d.values()))
[4, 3, 2, 1]
>>> list(reversed(d.items()))
[('four', 4), ('three', 3), ('two', 2), ('one', 1)]
```

在 3.8 版的變更: Dictionaries are now reversible.

也參考:

types.MappingProxyType can be used to create a read-only view of a *dict*.

4.10.1 字典視圖物件

The objects returned by `dict.keys()`, `dict.values()` and `dict.items()` are *view objects*. They provide a dynamic view on the dictionary's entries, which means that when the dictionary changes, the view reflects these changes.

Dictionary views can be iterated over to yield their respective data, and support membership tests:

len(dictview)

Return the number of entries in the dictionary.

iter(dictview)

Return an iterator over the keys, values or items (represented as tuples of (key, value)) in the dictionary.

Keys and values are iterated over in insertion order. This allows the creation of (value, key) pairs using `zip()`: `pairs = zip(d.values(), d.keys())`. Another way to create the same list is `pairs = [(v, k) for (k, v) in d.items()]`.

Iterating views while adding or deleting entries in the dictionary may raise a `RuntimeError` or fail to iterate over all entries.

在 3.7 版的變更: Dictionary order is guaranteed to be insertion order.

x in dictview

Return `True` if `x` is in the underlying dictionary's keys, values or items (in the latter case, `x` should be a (key, value) tuple).

reversed(dictview)

Return a reverse iterator over the keys, values or items of the dictionary. The view will be iterated in reverse order of the insertion.

在 3.8 版的變更: Dictionary views are now reversible.

dictview.mapping

Return a `types.MappingProxyType` that wraps the original dictionary to which the view refers.

在 3.10 版新加入.

Keys views are set-like since their entries are unique and *hashable*. If all values are hashable, so that (key, value) pairs are unique and hashable, then the items view is also set-like. (Values views are not treated as set-like since the entries are generally not unique.) For set-like views, all of the operations defined for the abstract base class `collections.abc.Set` are available (for example, `==`, `<`, or `^`).

An example of dictionary view usage:

```
>>> dishes = {'eggs': 2, 'sausage': 1, 'bacon': 1, 'spam': 500}
>>> keys = dishes.keys()
>>> values = dishes.values()

>>> # iteration
>>> n = 0
>>> for val in values:
...     n += val
>>> print(n)
504

>>> # keys and values are iterated over in the same order (insertion order)
>>> list(keys)
['eggs', 'sausage', 'bacon', 'spam']
>>> list(values)
[2, 1, 1, 500]

>>> # view objects are dynamic and reflect dict changes
>>> del dishes['eggs']
```

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```

>>> del dishes['sausage']
>>> list(keys)
['bacon', 'spam']

>>> # set operations
>>> keys & {'eggs', 'bacon', 'salad'}
{'bacon'}
>>> keys ^ {'sausage', 'juice'} == {'juice', 'sausage', 'bacon', 'spam'}
True
>>> keys | ['juice', 'juice', 'juice'] == {'bacon', 'spam', 'juice'}
True

>>> # get back a read-only proxy for the original dictionary
>>> values.mapping
mappingproxy({'bacon': 1, 'spam': 500})
>>> values.mapping['spam']
500

```

4.11 Context Manager Types

Python's `with` statement supports the concept of a runtime context defined by a context manager. This is implemented using a pair of methods that allow user-defined classes to define a runtime context that is entered before the statement body is executed and exited when the statement ends:

`contextmanager.__enter__()`

Enter the runtime context and return either this object or another object related to the runtime context. The value returned by this method is bound to the identifier in the `as` clause of `with` statements using this context manager.

An example of a context manager that returns itself is a *file object*. File objects return themselves from `__enter__()` to allow `open()` to be used as the context expression in a `with` statement.

An example of a context manager that returns a related object is the one returned by `decimal.localcontext()`. These managers set the active decimal context to a copy of the original decimal context and then return the copy. This allows changes to be made to the current decimal context in the body of the `with` statement without affecting code outside the `with` statement.

`contextmanager.__exit__(exc_type, exc_val, exc_tb)`

Exit the runtime context and return a Boolean flag indicating if any exception that occurred should be suppressed. If an exception occurred while executing the body of the `with` statement, the arguments contain the exception type, value and traceback information. Otherwise, all three arguments are `None`.

Returning a true value from this method will cause the `with` statement to suppress the exception and continue execution with the statement immediately following the `with` statement. Otherwise the exception continues propagating after this method has finished executing. Exceptions that occur during execution of this method will replace any exception that occurred in the body of the `with` statement.

The exception passed in should never be reraised explicitly - instead, this method should return a false value to indicate that the method completed successfully and does not want to suppress the raised exception. This allows context management code to easily detect whether or not an `__exit__()` method has actually failed.

Python defines several context managers to support easy thread synchronisation, prompt closure of files or other objects, and simpler manipulation of the active decimal arithmetic context. The specific types are not treated specially beyond their implementation of the context management protocol. See the `contextlib` module for some examples.

Python's *generators* and the `contextlib.contextmanager` decorator provide a convenient way to implement these protocols. If a generator function is decorated with the `contextlib.contextmanager` decorator, it will return a context manager implementing the necessary `__enter__()` and `__exit__()` methods, rather than the iterator produced by an undecorated generator function.

Note that there is no specific slot for any of these methods in the type structure for Python objects in the Python/C API. Extension types wanting to define these methods must provide them as a normal Python accessible method. Compared to the overhead of setting up the runtime context, the overhead of a single class dictionary lookup is negligible.

4.12 Type Annotation Types --- Generic Alias, Union

The core built-in types for *type annotations* are *Generic Alias* and *Union*.

4.12.1 Generic Alias Type

`GenericAlias` objects are generally created by subscripting a class. They are most often used with container classes, such as `list` or `dict`. For example, `list[int]` is a `GenericAlias` object created by subscripting the `list` class with the argument `int`. `GenericAlias` objects are intended primarily for use with *type annotations*.

備 F: It is generally only possible to subscript a class if the class implements the special method `__class_getitem__()`.

A `GenericAlias` object acts as a proxy for a *generic type*, implementing *parameterized generics*.

For a container class, the argument(s) supplied to a subscription of the class may indicate the type(s) of the elements an object contains. For example, `set[bytes]` can be used in type annotations to signify a *set* in which all the elements are of type `bytes`.

For a class which defines `__class_getitem__()` but is not a container, the argument(s) supplied to a subscription of the class will often indicate the return type(s) of one or more methods defined on an object. For example, *regular expressions* can be used on both the `str` data type and the `bytes` data type:

- If `x = re.search('foo', 'foo')`, `x` will be a *re.Match* object where the return values of `x.group(0)` and `x[0]` will both be of type `str`. We can represent this kind of object in type annotations with the `GenericAlias` `re.Match[str]`.
- If `y = re.search(b'bar', b'bar')`, (note the `b` for `bytes`), `y` will also be an instance of *re.Match*, but the return values of `y.group(0)` and `y[0]` will both be of type `bytes`. In type annotations, we would represent this variety of *re.Match* objects with `re.Match[bytes]`.

`GenericAlias` objects are instances of the class `types.GenericAlias`, which can also be used to create `GenericAlias` objects directly.

T[X, Y, ...]

Creates a `GenericAlias` representing a type `T` parameterized by types `X`, `Y`, and more depending on the `T` used. For example, a function expecting a `list` containing `float` elements:

```
def average(values: list[float]) -> float:
    return sum(values) / len(values)
```

Another example for *mapping* objects, using a `dict`, which is a generic type expecting two type parameters representing the key type and the value type. In this example, the function expects a `dict` with keys of type `str` and values of type `int`:

```
def send_post_request(url: str, body: dict[str, int]) -> None:
    ...
```

The builtin functions `isinstance()` and `issubclass()` do not accept `GenericAlias` types for their second argument:

```
>>> isinstance([1, 2], list[str])
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: isinstance() argument 2 cannot be a parameterized generic
```

The Python runtime does not enforce *type annotations*. This extends to generic types and their type parameters. When creating a container object from a `GenericAlias`, the elements in the container are not checked against their type. For example, the following code is discouraged, but will run without errors:

```
>>> t = list[str]
>>> t([1, 2, 3])
[1, 2, 3]
```

Furthermore, parameterized generics erase type parameters during object creation:

```
>>> t = list[str]
>>> type(t)
<class 'types.GenericAlias'>

>>> l = t()
>>> type(l)
<class 'list'>
```

Calling `repr()` or `str()` on a generic shows the parameterized type:

```
>>> repr(list[int])
'list[int]'

>>> str(list[int])
'list[int]'
```

The `__getitem__()` method of generic containers will raise an exception to disallow mistakes like `dict[str][str]`:

```
>>> dict[str][str]
Traceback (most recent call last):
...
TypeError: dict[str] is not a generic class
```

However, such expressions are valid when *type variables* are used. The index must have as many elements as there are type variable items in the `GenericAlias` object's `__args__`.

```
>>> from typing import TypeVar
>>> Y = TypeVar('Y')
>>> dict[str, Y][int]
dict[str, int]
```

Standard Generic Classes

The following standard library classes support parameterized generics. This list is non-exhaustive.

- `tuple`
- `list`
- `dict`
- `set`
- `frozenset`
- `type`

- `collections.deque`
- `collections.defaultdict`
- `collections.OrderedDict`
- `collections.Counter`
- `collections.ChainMap`
- `collections.abc.Awaitable`
- `collections.abc.Coroutine`
- `collections.abc.AsyncIterable`
- `collections.abc.AsyncIterator`
- `collections.abc.AsyncGenerator`
- `collections.abc.Iterable`
- `collections.abc.Iterator`
- `collections.abc.Generator`
- `collections.abc.Reversible`
- `collections.abc.Container`
- `collections.abc.Collection`
- `collections.abc.Callable`
- `collections.abc.Set`
- `collections.abc.MutableSet`
- `collections.abc.Mapping`
- `collections.abc.MutableMapping`
- `collections.abc.Sequence`
- `collections.abc.MutableSequence`
- `collections.abc.ByteString`
- `collections.abc.MappingView`
- `collections.abc.KeysView`
- `collections.abc.ItemsView`
- `collections.abc.ValuesView`
- `contextlib.AbstractContextManager`
- `contextlib.AbstractAsyncContextManager`
- `dataclasses.Field`
- `functools.cached_property`
- `functools.partialmethod`
- `os.PathLike`
- `queue.LifoQueue`
- `queue.Queue`
- `queue.PriorityQueue`
- `queue.SimpleQueue`
- `re.Pattern`

- `re.Match`
- `shelve.BsdDbShelf`
- `shelve.DbfilenameShelf`
- `shelve.Shelf`
- `types.MappingProxyType`
- `weakref.WeakKeyDictionary`
- `weakref.WeakMethod`
- `weakref.WeakSet`
- `weakref.WeakValueDictionary`

Special Attributes of GenericAlias objects

All parameterized generics implement special read-only attributes.

`genericalias.__origin__`

This attribute points at the non-parameterized generic class:

```
>>> list[int].__origin__
<class 'list'>
```

`genericalias.__args__`

This attribute is a *tuple* (possibly of length 1) of generic types passed to the original `__class_getitem__()` of the generic class:

```
>>> dict[str, list[int]].__args__
(<class 'str'>, list[int])
```

`genericalias.__parameters__`

This attribute is a lazily computed tuple (possibly empty) of unique type variables found in `__args__`:

```
>>> from typing import TypeVar

>>> T = TypeVar('T')
>>> list[T].__parameters__
(~T,)
```

備 註: A `GenericAlias` object with `typing.ParamSpec` parameters may not have correct `__parameters__` after substitution because `typing.ParamSpec` is intended primarily for static type checking.

`genericalias.__unpacked__`

A boolean that is true if the alias has been unpacked using the `*` operator (see `TypeVarTuple`).

在 3.11 版新加入。

也参考:

PEP 484 - Type Hints

Introducing Python's framework for type annotations.

PEP 585 - Type Hinting Generics In Standard Collections

Introducing the ability to natively parameterize standard-library classes, provided they implement the special class method `__class_getitem__()`.

Generics, user-defined generics and `typing.Generic`

Documentation on how to implement generic classes that can be parameterized at runtime and understood by static type-checkers.

在 3.9 版新加入.

4.12.2 Union Type

A union object holds the value of the `|` (bitwise or) operation on multiple *type objects*. These types are intended primarily for *type annotations*. The union type expression enables cleaner type hinting syntax compared to `typing.Union`.

X | Y | ...

Defines a union object which holds types X, Y, and so forth. `X | Y` means either X or Y. It is equivalent to `typing.Union[X, Y]`. For example, the following function expects an argument of type *int* or *float*:

```
def square(number: int | float) -> int | float:
    return number ** 2
```

備 F: The `|` operand cannot be used at runtime to define unions where one or more members is a forward reference. For example, `int | "Foo"`, where `"Foo"` is a reference to a class not yet defined, will fail at runtime. For unions which include forward references, present the whole expression as a string, e.g. `"int | Foo"`.

`union_object == other`

Union objects can be tested for equality with other union objects. Details:

- Unions of unions are flattened:

```
(int | str) | float == int | str | float
```

- Redundant types are removed:

```
int | str | int == int | str
```

- When comparing unions, the order is ignored:

```
int | str == str | int
```

- It is compatible with `typing.Union`:

```
int | str == typing.Union[int, str]
```

- Optional types can be spelled as a union with `None`:

```
str | None == typing.Optional[str]
```

`isinstance(obj, union_object)`**`issubclass(obj, union_object)`**

Calls to `isinstance()` and `issubclass()` are also supported with a union object:

```
>>> isinstance("", int | str)
True
```

However, *parameterized generics* in union objects cannot be checked:

```
>>> isinstance(1, int | list[int]) # short-circuit evaluation
True
>>> isinstance([1], int | list[int])
Traceback (most recent call last):
...
TypeError: isinstance() argument 2 cannot be a parameterized generic
```

The user-exposed type for the union object can be accessed from `types.UnionType` and used for `isinstance()` checks. An object cannot be instantiated from the type:

```
>>> import types
>>> isinstance(int | str, types.UnionType)
True
>>> types.UnionType()
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: cannot create 'types.UnionType' instances
```

備 註: The `__or__()` method for type objects was added to support the syntax `X | Y`. If a metaclass implements `__or__()`, the Union may override it:

```
>>> class M(type):
...     def __or__(self, other):
...         return "Hello"
...
>>> class C(metaclass=M):
...     pass
...
>>> C | int
'Hello'
>>> int | C
int | C
```

也参考:

PEP 604 -- PEP proposing the `X | Y` syntax and the Union type.

在 3.10 版新加入.

4.13 Other Built-in Types

The interpreter supports several other kinds of objects. Most of these support only one or two operations.

4.13.1 模組

The only special operation on a module is attribute access: `m.name`, where *m* is a module and *name* accesses a name defined in *m*'s symbol table. Module attributes can be assigned to. (Note that the `import` statement is not, strictly speaking, an operation on a module object; `import foo` does not require a module object named *foo* to exist, rather it requires an (external) *definition* for a module named *foo* somewhere.)

A special attribute of every module is `__dict__`. This is the dictionary containing the module's symbol table. Modifying this dictionary will actually change the module's symbol table, but direct assignment to the `__dict__` attribute is not possible (you can write `m.__dict__['a'] = 1`, which defines `m.a` to be 1, but you can't write `m.__dict__ = {}`). Modifying `__dict__` directly is not recommended.

Modules built into the interpreter are written like this: `<module 'sys' (built-in)>`. If loaded from a file, they are written as `<module 'os' from '/usr/local/lib/pythonX.Y/os.pyc'>`.

4.13.2 Classes and Class Instances

See objects and class for these.

4.13.3 函式

Function objects are created by function definitions. The only operation on a function object is to call it: `func(argument-list)`.

There are really two flavors of function objects: built-in functions and user-defined functions. Both support the same operation (to call the function), but the implementation is different, hence the different object types.

更多資訊請見 `function`。

4.13.4 Methods

Methods are functions that are called using the attribute notation. There are two flavors: built-in methods (such as `append()` on lists) and class instance method. Built-in methods are described with the types that support them.

If you access a method (a function defined in a class namespace) through an instance, you get a special object: a *bound method* (also called instance method) object. When called, it will add the `self` argument to the argument list. Bound methods have two special read-only attributes: `m.__self__` is the object on which the method operates, and `m.__func__` is the function implementing the method. Calling `m(arg-1, arg-2, ..., arg-n)` is completely equivalent to calling `m.__func__(m.__self__, arg-1, arg-2, ..., arg-n)`.

Like function objects, bound method objects support getting arbitrary attributes. However, since method attributes are actually stored on the underlying function object (`method.__func__`), setting method attributes on bound methods is disallowed. Attempting to set an attribute on a method results in an `AttributeError` being raised. In order to set a method attribute, you need to explicitly set it on the underlying function object:

```
>>> class C:
...     def method(self):
...         pass
...
>>> c = C()
>>> c.method.whoami = 'my name is method' # can't set on the method
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AttributeError: 'method' object has no attribute 'whoami'
>>> c.method.__func__.whoami = 'my name is method'
>>> c.method.whoami
'my name is method'
```

See instance-methods for more information.

4.13.5 Code Objects

Code objects are used by the implementation to represent “pseudo-compiled” executable Python code such as a function body. They differ from function objects because they don’t contain a reference to their global execution environment. Code objects are returned by the built-in `compile()` function and can be extracted from function objects through their `__code__` attribute. See also the `code` module.

Accessing `__code__` raises an `auditing event` object. `__getattr__` with arguments `obj` and `"__code__"`.

A code object can be executed or evaluated by passing it (instead of a source string) to the `exec()` or `eval()` built-in functions.

更多資訊請見 `types`。

4.13.6 Type Objects

Type objects represent the various object types. An object's type is accessed by the built-in function `type()`. There are no special operations on types. The standard module `types` defines names for all standard built-in types.

Types are written like this: `<class 'int'>`.

4.13.7 The Null Object

This object is returned by functions that don't explicitly return a value. It supports no special operations. There is exactly one null object, named `None` (a built-in name). `type(None)` produces the same singleton.

It is written as `None`.

4.13.8 The Ellipsis Object

This object is commonly used by slicing (see slicings). It supports no special operations. There is exactly one ellipsis object, named `Ellipsis` (a built-in name). `type(Ellipsis)` produces the `Ellipsis` singleton.

It is written as `Ellipsis` or `...`.

4.13.9 The NotImplemented Object

This object is returned from comparisons and binary operations when they are asked to operate on types they don't support. See comparisons for more information. There is exactly one `NotImplemented` object. `type(NotImplemented)` produces the singleton instance.

It is written as `NotImplemented`.

4.13.10 Boolean Values

Boolean values are the two constant objects `False` and `True`. They are used to represent truth values (although other values can also be considered false or true). In numeric contexts (for example when used as the argument to an arithmetic operator), they behave like the integers 0 and 1, respectively. The built-in function `bool()` can be used to convert any value to a Boolean, if the value can be interpreted as a truth value (see section 真値検測 above).

They are written as `False` and `True`, respectively.

4.13.11 Internal Objects

See types for this information. It describes stack frame objects, traceback objects, and slice objects.

4.14 Special Attributes

The implementation adds a few special read-only attributes to several object types, where they are relevant. Some of these are not reported by the `dir()` built-in function.

`object.__dict__`

A dictionary or other mapping object used to store an object's (writable) attributes.

`instance.__class__`

The class to which a class instance belongs.

class. **__bases__**

The tuple of base classes of a class object.

definition. **__name__**

The name of the class, function, method, descriptor, or generator instance.

definition. **__qualname__**

The *qualified name* of the class, function, method, descriptor, or generator instance.

在 3.3 版新加入。

class. **__mro__**

This attribute is a tuple of classes that are considered when looking for base classes during method resolution.

class. **mro()**

This method can be overridden by a metaclass to customize the method resolution order for its instances. It is called at class instantiation, and its result is stored in `__mro__`.

class. **__subclasses__()**

Each class keeps a list of weak references to its immediate subclasses. This method returns a list of all those references still alive. The list is in definition order. Example:

```
>>> int.__subclasses__()
[<class 'bool'>, <enum 'IntEnum'>, <flag 'IntFlag'>, <class 're._constants._
↳NamedIntConstant'>]
```

4.15 Integer string conversion length limitation

CPython has a global limit for converting between `int` and `str` to mitigate denial of service attacks. This limit *only* applies to decimal or other non-power-of-two number bases. Hexadecimal, octal, and binary conversions are unlimited. The limit can be configured.

The `int` type in CPython is an arbitrary length number stored in binary form (commonly known as a “bignum”). There exists no algorithm that can convert a string to a binary integer or a binary integer to a string in linear time, *unless* the base is a power of 2. Even the best known algorithms for base 10 have sub-quadratic complexity. Converting a large value such as `int('1' * 500_000)` can take over a second on a fast CPU.

Limiting conversion size offers a practical way to avoid [CVE-2020-10735](#).

The limit is applied to the number of digit characters in the input or output string when a non-linear conversion algorithm would be involved. Underscores and the sign are not counted towards the limit.

When an operation would exceed the limit, a `ValueError` is raised:

```
>>> import sys
>>> sys.set_int_max_str_digits(4300) # Illustrative, this is the default.
>>> _ = int('2' * 5432)
Traceback (most recent call last):
...
ValueError: Exceeds the limit (4300 digits) for integer string conversion: value_
↳has 5432 digits; use sys.set_int_max_str_digits() to increase the limit
>>> i = int('2' * 4300)
>>> len(str(i))
4300
>>> i_squared = i*i
>>> len(str(i_squared))
Traceback (most recent call last):
...
ValueError: Exceeds the limit (4300 digits) for integer string conversion; use sys.
↳set_int_max_str_digits() to increase the limit
>>> len(hex(i_squared))
```

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```
7144 >>> assert int(hex(i_squared), base=16) == i*i # Hexadecimal is unlimited.
```

The default limit is 4300 digits as provided in `sys.int_info.default_max_str_digits`. The lowest limit that can be configured is 640 digits as provided in `sys.int_info.str_digits_check_threshold`.

Verification:

```
>>> import sys
>>> assert sys.int_info.default_max_str_digits == 4300, sys.int_info
>>> assert sys.int_info.str_digits_check_threshold == 640, sys.int_info
>>> msg = int('578966293710682886880994035146873798396722250538762761564'
...           '9252925514383915483333812743580549779436104706260696366600'
...           '571186405732').to_bytes(53, 'big')
```

在 3.11 版新加入.

4.15.1 Affected APIs

The limitation only applies to potentially slow conversions between `int` and `str` or `bytes`:

- `int(string)` with default base 10.
- `int(string, base)` for all bases that are not a power of 2.
- `str(integer)`.
- `repr(integer)`.
- any other string conversion to base 10, for example `f"{integer}", "{}".format(integer)`, or `b"%d" % integer`.

The limitations do not apply to functions with a linear algorithm:

- `int(string, base)` with base 2, 4, 8, 16, or 32.
- `int.from_bytes()` and `int.to_bytes()`.
- `hex()`, `oct()`, `bin()`.
- *Format Specification Mini-Language* for hex, octal, and binary numbers.
- `str` to `float`.
- `str` to `decimal.Decimal`.

4.15.2 Configuring the limit

Before Python starts up you can use an environment variable or an interpreter command line flag to configure the limit:

- PYTHONINTMAXSTRDIGITS, e.g. PYTHONINTMAXSTRDIGITS=640 python3 to set the limit to 640 or PYTHONINTMAXSTRDIGITS=0 python3 to disable the limitation.
- -X int_max_str_digits, e.g. python3 -X int_max_str_digits=640
- `sys.flags.int_max_str_digits` contains the value of PYTHONINTMAXSTRDIGITS or -X int_max_str_digits. If both the env var and the -X option are set, the -X option takes precedence. A value of -1 indicates that both were unset, thus a value of `sys.int_info.default_max_str_digits` was used during initialization.

From code, you can inspect the current limit and set a new one using these `sys` APIs:

- `sys.get_int_max_str_digits()` and `sys.set_int_max_str_digits()` are a getter and setter for the interpreter-wide limit. Subinterpreters have their own limit.

Information about the default and minimum can be found in `sys.int_info`:

- `sys.int_info.default_max_str_digits` is the compiled-in default limit.
- `sys.int_info.str_digits_check_threshold` is the lowest accepted value for the limit (other than 0 which disables it).

在 3.11 版新加入.

警告: Setting a low limit *can* lead to problems. While rare, code exists that contains integer constants in decimal in their source that exceed the minimum threshold. A consequence of setting the limit is that Python source code containing decimal integer literals longer than the limit will encounter an error during parsing, usually at startup time or import time or even at installation time - anytime an up to date `.pyc` does not already exist for the code. A workaround for source that contains such large constants is to convert them to `0x` hexadecimal form as it has no limit.

Test your application thoroughly if you use a low limit. Ensure your tests run with the limit set early via the environment or flag so that it applies during startup and even during any installation step that may invoke Python to precompile `.py` sources to `.pyc` files.

4.15.3 Recommended configuration

The default `sys.int_info.default_max_str_digits` is expected to be reasonable for most applications. If your application requires a different limit, set it from your main entry point using Python version agnostic code as these APIs were added in security patch releases in versions before 3.11.

範例:

```
>>> import sys
>>> if hasattr(sys, "set_int_max_str_digits"):
...     upper_bound = 68000
...     lower_bound = 4004
...     current_limit = sys.get_int_max_str_digits()
...     if current_limit == 0 or current_limit > upper_bound:
...         sys.set_int_max_str_digits(upper_bound)
...     elif current_limit < lower_bound:
...         sys.set_int_max_str_digits(lower_bound)
```

If you need to disable it entirely, set it to 0.

解

📦 建的例外

In Python, all exceptions must be instances of a class that derives from `BaseException`. In a `try` statement with an `except` clause that mentions a particular class, that clause also handles any exception classes derived from that class (but not exception classes from which *it* is derived). Two exception classes that are not related via subclassing are never equivalent, even if they have the same name.

The built-in exceptions listed in this chapter can be generated by the interpreter or built-in functions. Except where mentioned, they have an “associated value” indicating the detailed cause of the error. This may be a string or a tuple of several items of information (e.g., an error code and a string explaining the code). The associated value is usually passed as arguments to the exception class’s constructor.

User code can raise built-in exceptions. This can be used to test an exception handler or to report an error condition “just like” the situation in which the interpreter raises the same exception; but beware that there is nothing to prevent user code from raising an inappropriate error.

The built-in exception classes can be subclassed to define new exceptions; programmers are encouraged to derive new exceptions from the `Exception` class or one of its subclasses, and not from `BaseException`. More information on defining exceptions is available in the Python Tutorial under `tut-userexceptions`.

5.1 Exception context

Three attributes on exception objects provide information about the context in which the exception was raised:

`BaseException.__context__`

`BaseException.__cause__`

`BaseException.__suppress_context__`

When raising a new exception while another exception is already being handled, the new exception’s `__context__` attribute is automatically set to the handled exception. An exception may be handled when an `except` or `finally` clause, or a `with` statement, is used.

This implicit exception context can be supplemented with an explicit cause by using `from` with `raise`:

```
raise new_exc from original_exc
```

The expression following `from` must be an exception or `None`. It will be set as `__cause__` on the raised exception. Setting `__cause__` also implicitly sets the `__suppress_context__` attribute to `True`, so that using `raise new_exc from None` effectively replaces the old exception with the new one for display

purposes (e.g. converting `KeyError` to `AttributeError`), while leaving the old exception available in `__context__` for introspection when debugging.

The default traceback display code shows these chained exceptions in addition to the traceback for the exception itself. An explicitly chained exception in `__cause__` is always shown when present. An implicitly chained exception in `__context__` is shown only if `__cause__` is `None` and `__suppress_context__` is `false`.

In either case, the exception itself is always shown after any chained exceptions so that the final line of the traceback always shows the last exception that was raised.

5.2 繼承自 F 建的例外

User code can create subclasses that inherit from an exception type. It's recommended to only subclass one exception type at a time to avoid any possible conflicts between how the bases handle the `args` attribute, as well as due to possible memory layout incompatibilities.

CPython 實作細節： Most built-in exceptions are implemented in C for efficiency, see: [Objects/exceptions.c](#). Some have custom memory layouts which makes it impossible to create a subclass that inherits from multiple exception types. The memory layout of a type is an implementation detail and might change between Python versions, leading to new conflicts in the future. Therefore, it's recommended to avoid subclassing multiple exception types altogether.

5.3 Base classes

The following exceptions are used mostly as base classes for other exceptions.

exception `BaseException`

The base class for all built-in exceptions. It is not meant to be directly inherited by user-defined classes (for that, use `Exception`). If `str()` is called on an instance of this class, the representation of the argument(s) to the instance are returned, or the empty string when there were no arguments.

`args`

The tuple of arguments given to the exception constructor. Some built-in exceptions (like `OSError`) expect a certain number of arguments and assign a special meaning to the elements of this tuple, while others are usually called only with a single string giving an error message.

`with_traceback(tb)`

This method sets `tb` as the new traceback for the exception and returns the exception object. It was more commonly used before the exception chaining features of [PEP 3134](#) became available. The following example shows how we can convert an instance of `SomeException` into an instance of `OtherException` while preserving the traceback. Once raised, the current frame is pushed onto the traceback of the `OtherException`, as would have happened to the traceback of the original `SomeException` had we allowed it to propagate to the caller.

```
try:
    ...
except SomeException:
    tb = sys.exception().__traceback__
    raise OtherException(...).with_traceback(tb)
```

`__traceback__`

A writable field that holds the traceback object associated with this exception. See also: `raise`.

`add_note(note)`

Add the string `note` to the exception's notes which appear in the standard traceback after the exception string. A `TypeError` is raised if `note` is not a string.

在 3.11 版新加入。

__notes__

A list of the notes of this exception, which were added with `add_note()`. This attribute is created when `add_note()` is called.

在 3.11 版新加入。

exception Exception

All built-in, non-system-exiting exceptions are derived from this class. All user-defined exceptions should also be derived from this class.

exception ArithmeticError

The base class for those built-in exceptions that are raised for various arithmetic errors: *OverflowError*, *ZeroDivisionError*, *FloatingPointError*.

exception BufferError

Raised when a buffer related operation cannot be performed.

exception LookupError

The base class for the exceptions that are raised when a key or index used on a mapping or sequence is invalid: *IndexError*, *KeyError*. This can be raised directly by `codecs.lookup()`.

5.4 Concrete exceptions

The following exceptions are the exceptions that are usually raised.

exception AssertionError

Raised when an `assert` statement fails.

exception AttributeError

Raised when an attribute reference (see attribute-references) or assignment fails. (When an object does not support attribute references or attribute assignments at all, *TypeError* is raised.)

The `name` and `obj` attributes can be set using keyword-only arguments to the constructor. When set they represent the name of the attribute that was attempted to be accessed and the object that was accessed for said attribute, respectively.

在 3.10 版的變更: 新增 `name` 與 `obj` 屬性。

exception EOFError

Raised when the `input()` function hits an end-of-file condition (EOF) without reading any data. (N.B.: the `io.IOBase.read()` and `io.IOBase.readline()` methods return an empty string when they hit EOF.)

exception FloatingPointError

Not currently used.

exception GeneratorExit

Raised when a *generator* or *coroutine* is closed; see `generator.close()` and `coroutine.close()`. It directly inherits from *BaseException* instead of *Exception* since it is technically not an error.

exception ImportError

Raised when the `import` statement has troubles trying to load a module. Also raised when the "from list" in `from ... import` has a name that cannot be found.

The optional `name` and `path` keyword-only arguments set the corresponding attributes:

name

The name of the module that was attempted to be imported.

path

The path to any file which triggered the exception.

在 3.3 版的變更: 新增 `name` 與 `path` 屬性。

exception ModuleNotFoundError

A subclass of `ImportError` which is raised by `import` when a module could not be located. It is also raised when `None` is found in `sys.modules`.

在 3.6 版新加入。

exception IndexError

Raised when a sequence subscript is out of range. (Slice indices are silently truncated to fall in the allowed range; if an index is not an integer, `TypeError` is raised.)

exception KeyError

Raised when a mapping (dictionary) key is not found in the set of existing keys.

exception KeyboardInterrupt

Raised when the user hits the interrupt key (normally `Control-C` or `Delete`). During execution, a check for interrupts is made regularly. The exception inherits from `BaseException` so as to not be accidentally caught by code that catches `Exception` and thus prevent the interpreter from exiting.

備 F: Catching a `KeyboardInterrupt` requires special consideration. Because it can be raised at unpredictable points, it may, in some circumstances, leave the running program in an inconsistent state. It is generally best to allow `KeyboardInterrupt` to end the program as quickly as possible or avoid raising it entirely. (See *Note on Signal Handlers and Exceptions*.)

exception MemoryError

Raised when an operation runs out of memory but the situation may still be rescued (by deleting some objects). The associated value is a string indicating what kind of (internal) operation ran out of memory. Note that because of the underlying memory management architecture (C's `malloc()` function), the interpreter may not always be able to completely recover from this situation; it nevertheless raises an exception so that a stack traceback can be printed, in case a run-away program was the cause.

exception NameError

Raised when a local or global name is not found. This applies only to unqualified names. The associated value is an error message that includes the name that could not be found.

The `name` attribute can be set using a keyword-only argument to the constructor. When set it represent the name of the variable that was attempted to be accessed.

在 3.10 版的變更: 新增 `name` 屬性。

exception NotImplementedError

This exception is derived from `RuntimeError`. In user defined base classes, abstract methods should raise this exception when they require derived classes to override the method, or while the class is being developed to indicate that the real implementation still needs to be added.

備 F: It should not be used to indicate that an operator or method is not meant to be supported at all -- in that case either leave the operator / method undefined or, if a subclass, set it to `None`.

備 F: `NotImplementedError` and `NotImplemented` are not interchangeable, even though they have similar names and purposes. See `NotImplemented` for details on when to use it.

exception OSError ([arg])

exception OSError (*errno*, *strerror*[, *filename*[, *winerror*[, *filename2*]]])

This exception is raised when a system function returns a system-related error, including I/O failures such as “file not found” or “disk full” (not for illegal argument types or other incidental errors).

The second form of the constructor sets the corresponding attributes, described below. The attributes default to *None* if not specified. For backwards compatibility, if three arguments are passed, the *args* attribute contains only a 2-tuple of the first two constructor arguments.

The constructor often actually returns a subclass of *OSError*, as described in *OS exceptions* below. The particular subclass depends on the final *errno* value. This behaviour only occurs when constructing *OSError* directly or via an alias, and is not inherited when subclassing.

errno

A numeric error code from the C variable *errno*.

winerror

Under Windows, this gives you the native Windows error code. The *errno* attribute is then an approximate translation, in POSIX terms, of that native error code.

Under Windows, if the *winerror* constructor argument is an integer, the *errno* attribute is determined from the Windows error code, and the *errno* argument is ignored. On other platforms, the *winerror* argument is ignored, and the *winerror* attribute does not exist.

strerror

The corresponding error message, as provided by the operating system. It is formatted by the C functions *perror()* under POSIX, and *FormatMessage()* under Windows.

filename

filename2

For exceptions that involve a file system path (such as *open()* or *os.unlink()*), *filename* is the file name passed to the function. For functions that involve two file system paths (such as *os.rename()*), *filename2* corresponds to the second file name passed to the function.

在 3.3 版的變更: *EnvironmentError*, *IOError*, *WindowsError*, *socket.error*, *select.error* and *mmap.error* have been merged into *OSError*, and the constructor may return a subclass.

在 3.4 版的變更: The *filename* attribute is now the original file name passed to the function, instead of the name encoded to or decoded from the *filesystem encoding and error handler*. Also, the *filename2* constructor argument and attribute was added.

exception OverflowError

Raised when the result of an arithmetic operation is too large to be represented. This cannot occur for integers (which would rather raise *MemoryError* than give up). However, for historical reasons, *OverflowError* is sometimes raised for integers that are outside a required range. Because of the lack of standardization of floating point exception handling in C, most floating point operations are not checked.

exception RecursionError

This exception is derived from *RuntimeError*. It is raised when the interpreter detects that the maximum recursion depth (see *sys.getrecursionlimit()*) is exceeded.

在 3.5 版新加入: Previously, a plain *RuntimeError* was raised.

exception ReferenceError

This exception is raised when a weak reference proxy, created by the *weakref.proxy()* function, is used to access an attribute of the referent after it has been garbage collected. For more information on weak references, see the *weakref* module.

exception RuntimeError

Raised when an error is detected that doesn’t fall in any of the other categories. The associated value is a string indicating what precisely went wrong.

exception StopIteration

Raised by built-in function `next()` and an *iterator*'s `__next__()` method to signal that there are no further items produced by the iterator.

value

The exception object has a single attribute `value`, which is given as an argument when constructing the exception, and defaults to `None`.

When a *generator* or *coroutine* function returns, a new `StopIteration` instance is raised, and the value returned by the function is used as the `value` parameter to the constructor of the exception.

If a generator code directly or indirectly raises `StopIteration`, it is converted into a `RuntimeError` (retaining the `StopIteration` as the new exception's cause).

在 3.3 版的變更: Added `value` attribute and the ability for generator functions to use it to return a value.

在 3.5 版的變更: Introduced the `RuntimeError` transformation via `from __future__ import generator_stop`, see [PEP 479](#).

在 3.7 版的變更: Enable [PEP 479](#) for all code by default: a `StopIteration` error raised in a generator is transformed into a `RuntimeError`.

exception StopAsyncIteration

Must be raised by `__anext__()` method of an *asynchronous iterator* object to stop the iteration.

在 3.5 版新加入.

exception SyntaxError (message, details)

Raised when the parser encounters a syntax error. This may occur in an `import` statement, in a call to the built-in functions `compile()`, `exec()`, or `eval()`, or when reading the initial script or standard input (also interactively).

The `str()` of the exception instance returns only the error message. `Details` is a tuple whose members are also available as separate attributes.

filename

The name of the file the syntax error occurred in.

lineno

Which line number in the file the error occurred in. This is 1-indexed: the first line in the file has a `lineno` of 1.

offset

The column in the line where the error occurred. This is 1-indexed: the first character in the line has an `offset` of 1.

text

The source code text involved in the error.

end_lineno

Which line number in the file the error occurred ends in. This is 1-indexed: the first line in the file has a `lineno` of 1.

end_offset

The column in the end line where the error occurred finishes. This is 1-indexed: the first character in the line has an `offset` of 1.

For errors in f-string fields, the message is prefixed by "f-string: " and the offsets are offsets in a text constructed from the replacement expression. For example, compiling `f'Bad {a b} field'` results in this `args` attribute: (`f-string: ...', ('', 1, 2, '(a b)n', 1, 5)`).

在 3.10 版的變更: 新增 `end_lineno` 與 `end_offset` 屬性。

exception IndentationError

Base class for syntax errors related to incorrect indentation. This is a subclass of `SyntaxError`.

exception TabError

Raised when indentation contains an inconsistent use of tabs and spaces. This is a subclass of *IndentationError*.

exception SystemError

Raised when the interpreter finds an internal error, but the situation does not look so serious to cause it to abandon all hope. The associated value is a string indicating what went wrong (in low-level terms).

You should report this to the author or maintainer of your Python interpreter. Be sure to report the version of the Python interpreter (`sys.version`; it is also printed at the start of an interactive Python session), the exact error message (the exception's associated value) and if possible the source of the program that triggered the error.

exception SystemExit

This exception is raised by the `sys.exit()` function. It inherits from *BaseException* instead of *Exception* so that it is not accidentally caught by code that catches *Exception*. This allows the exception to properly propagate up and cause the interpreter to exit. When it is not handled, the Python interpreter exits; no stack traceback is printed. The constructor accepts the same optional argument passed to `sys.exit()`. If the value is an integer, it specifies the system exit status (passed to C's `exit()` function); if it is `None`, the exit status is zero; if it has another type (such as a string), the object's value is printed and the exit status is one.

A call to `sys.exit()` is translated into an exception so that clean-up handlers (*finally* clauses of *try* statements) can be executed, and so that a debugger can execute a script without running the risk of losing control. The `os._exit()` function can be used if it is absolutely positively necessary to exit immediately (for example, in the child process after a call to `os.fork()`).

code

The exit status or error message that is passed to the constructor. (Defaults to `None`.)

exception TypeError

Raised when an operation or function is applied to an object of inappropriate type. The associated value is a string giving details about the type mismatch.

This exception may be raised by user code to indicate that an attempted operation on an object is not supported, and is not meant to be. If an object is meant to support a given operation but has not yet provided an implementation, *NotImplementedError* is the proper exception to raise.

Passing arguments of the wrong type (e.g. passing a *list* when an *int* is expected) should result in a *TypeError*, but passing arguments with the wrong value (e.g. a number outside expected boundaries) should result in a *ValueError*.

exception UnboundLocalError

Raised when a reference is made to a local variable in a function or method, but no value has been bound to that variable. This is a subclass of *NameError*.

exception UnicodeError

Raised when a Unicode-related encoding or decoding error occurs. It is a subclass of *ValueError*.

UnicodeError has attributes that describe the encoding or decoding error. For example, `err.object[err.start:err.end]` gives the particular invalid input that the codec failed on.

encoding

The name of the encoding that raised the error.

reason

A string describing the specific codec error.

object

The object the codec was attempting to encode or decode.

start

The first index of invalid data in *object*.

end

The index after the last invalid data in *object*.

exception UnicodeEncodeError

Raised when a Unicode-related error occurs during encoding. It is a subclass of *UnicodeError*.

exception UnicodeDecodeError

Raised when a Unicode-related error occurs during decoding. It is a subclass of *UnicodeError*.

exception UnicodeTranslateError

Raised when a Unicode-related error occurs during translating. It is a subclass of *UnicodeError*.

exception ValueError

Raised when an operation or function receives an argument that has the right type but an inappropriate value, and the situation is not described by a more precise exception such as *IndexError*.

exception ZeroDivisionError

Raised when the second argument of a division or modulo operation is zero. The associated value is a string indicating the type of the operands and the operation.

The following exceptions are kept for compatibility with previous versions; starting from Python 3.3, they are aliases of *OSError*.

exception EnvironmentError

exception IOError

exception WindowsError

Only available on Windows.

5.4.1 OS exceptions

The following exceptions are subclasses of *OSError*, they get raised depending on the system error code.

exception BlockingIOError

Raised when an operation would block on an object (e.g. socket) set for non-blocking operation. Corresponds to `errno` *EAGAIN*, *EALREADY*, *EWOULDBLOCK* and *EINPROGRESS*.

In addition to those of *OSError*, *BlockingIOError* can have one more attribute:

characters_written

An integer containing the number of characters written to the stream before it blocked. This attribute is available when using the buffered I/O classes from the *io* module.

exception ChildProcessError

Raised when an operation on a child process failed. Corresponds to `errno` *ECHILD*.

exception ConnectionError

A base class for connection-related issues.

Subclasses are *BrokenPipeError*, *ConnectionAbortedError*, *ConnectionRefusedError* and *ConnectionResetError*.

exception BrokenPipeError

A subclass of *ConnectionError*, raised when trying to write on a pipe while the other end has been closed, or trying to write on a socket which has been shutdown for writing. Corresponds to `errno` *EPIPE* and *ESHUTDOWN*.

exception ConnectionAbortedError

A subclass of *ConnectionError*, raised when a connection attempt is aborted by the peer. Corresponds to `errno` *ECONNABORTED*.

exception ConnectionRefusedError

A subclass of *ConnectionError*, raised when a connection attempt is refused by the peer. Corresponds to errno *ECONNREFUSED*.

exception ConnectionResetError

A subclass of *ConnectionError*, raised when a connection is reset by the peer. Corresponds to errno *ECONNRESET*.

exception FileExistsError

Raised when trying to create a file or directory which already exists. Corresponds to errno *EEXIST*.

exception FileNotFoundError

Raised when a file or directory is requested but doesn't exist. Corresponds to errno *ENOENT*.

exception InterruptedError

Raised when a system call is interrupted by an incoming signal. Corresponds to errno *EINTR*.

在 3.5 版的變更: Python now retries system calls when a syscall is interrupted by a signal, except if the signal handler raises an exception (see [PEP 475](#) for the rationale), instead of raising *InterruptedError*.

exception IsADirectoryError

Raised when a file operation (such as *os.remove()*) is requested on a directory. Corresponds to errno *EISDIR*.

exception NotADirectoryError

Raised when a directory operation (such as *os.listdir()*) is requested on something which is not a directory. On most POSIX platforms, it may also be raised if an operation attempts to open or traverse a non-directory file as if it were a directory. Corresponds to errno *ENOTDIR*.

exception PermissionError

Raised when trying to run an operation without the adequate access rights - for example filesystem permissions. Corresponds to errno *EACCES*, *EPERM*, and *ENOTCAPABLE*.

在 3.11.1 版的變更: WASI's *ENOTCAPABLE* is now mapped to *PermissionError*.

exception ProcessLookupError

Raised when a given process doesn't exist. Corresponds to errno *ESRCH*.

exception TimeoutError

Raised when a system function timed out at the system level. Corresponds to errno *ETIMEDOUT*.

在 3.3 版新加入: All the above *OSError* subclasses were added.

也參考:

[PEP 3151](#) - Reworking the OS and IO exception hierarchy

5.5 警告

The following exceptions are used as warning categories; see the *Warning Categories* documentation for more details.

exception Warning

Base class for warning categories.

exception UserWarning

Base class for warnings generated by user code.

exception DeprecationWarning

Base class for warnings about deprecated features when those warnings are intended for other Python developers.

Ignored by the default warning filters, except in the `__main__` module (**PEP 565**). Enabling the *Python Development Mode* shows this warning.

The deprecation policy is described in **PEP 387**.

exception PendingDeprecationWarning

Base class for warnings about features which are obsolete and expected to be deprecated in the future, but are not deprecated at the moment.

This class is rarely used as emitting a warning about a possible upcoming deprecation is unusual, and *DeprecationWarning* is preferred for already active deprecations.

Ignored by the default warning filters. Enabling the *Python Development Mode* shows this warning.

The deprecation policy is described in **PEP 387**.

exception SyntaxWarning

Base class for warnings about dubious syntax.

exception RuntimeWarning

Base class for warnings about dubious runtime behavior.

exception FutureWarning

Base class for warnings about deprecated features when those warnings are intended for end users of applications that are written in Python.

exception ImportWarning

Base class for warnings about probable mistakes in module imports.

Ignored by the default warning filters. Enabling the *Python Development Mode* shows this warning.

exception UnicodeWarning

Base class for warnings related to Unicode.

exception EncodingWarning

Base class for warnings related to encodings.

細節請見選擇性加入的編碼警告。

在 3.10 版新加入。

exception BytesWarning

Base class for warnings related to *bytes* and *bytearray*.

exception ResourceWarning

Base class for warnings related to resource usage.

Ignored by the default warning filters. Enabling the *Python Development Mode* shows this warning.

在 3.2 版新加入。

5.6 Exception groups

The following are used when it is necessary to raise multiple unrelated exceptions. They are part of the exception hierarchy so they can be handled with `except` like all other exceptions. In addition, they are recognised by `except*`, which matches their subgroups based on the types of the contained exceptions.

exception `ExceptionGroup(msg, excs)`

exception `BaseExceptionGroup(msg, excs)`

Both of these exception types wrap the exceptions in the sequence `excs`. The `msg` parameter must be a string. The difference between the two classes is that `BaseExceptionGroup` extends `BaseException` and it can wrap any exception, while `ExceptionGroup` extends `Exception` and it can only wrap subclasses of `Exception`. This design is so that `except Exception` catches an `ExceptionGroup` but not `BaseExceptionGroup`.

The `BaseExceptionGroup` constructor returns an `ExceptionGroup` rather than a `BaseExceptionGroup` if all contained exceptions are `Exception` instances, so it can be used to make the selection automatic. The `ExceptionGroup` constructor, on the other hand, raises a `TypeError` if any contained exception is not an `Exception` subclass.

message

The `msg` argument to the constructor. This is a read-only attribute.

exceptions

A tuple of the exceptions in the `excs` sequence given to the constructor. This is a read-only attribute.

subgroup(condition)

Returns an exception group that contains only the exceptions from the current group that match `condition`, or `None` if the result is empty.

The condition can be either a function that accepts an exception and returns true for those that should be in the subgroup, or it can be an exception type or a tuple of exception types, which is used to check for a match using the same check that is used in an `except` clause.

The nesting structure of the current exception is preserved in the result, as are the values of its `message`, `__traceback__`, `__cause__`, `__context__` and `__notes__` fields. Empty nested groups are omitted from the result.

The condition is checked for all exceptions in the nested exception group, including the top-level and any nested exception groups. If the condition is true for such an exception group, it is included in the result in full.

split(condition)

Like `subgroup()`, but returns the pair `(match, rest)` where `match` is `subgroup(condition)` and `rest` is the remaining non-matching part.

derive(excs)

Returns an exception group with the same `message`, but which wraps the exceptions in `excs`.

This method is used by `subgroup()` and `split()`. A subclass needs to override it in order to make `subgroup()` and `split()` return instances of the subclass rather than `ExceptionGroup`.

`subgroup()` and `split()` copy the `__traceback__`, `__cause__`, `__context__` and `__notes__` fields from the original exception group to the one returned by `derive()`, so these fields do not need to be updated by `derive()`.

```
>>> class MyGroup(ExceptionGroup):
...     def derive(self, excs):
...         return MyGroup(self.message, excs)
...
>>> e = MyGroup("eg", [ValueError(1), TypeError(2)])
>>> e.add_note("a note")
```

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```

>>> e.__context__ = Exception("context")
>>> e.__cause__ = Exception("cause")
>>> try:
...     raise e
... except Exception as e:
...     exc = e
...
>>> match, rest = exc.split(ValueError)
>>> exc, exc.__context__, exc.__cause__, exc.__notes__
(MyGroup('eg', [ValueError(1), TypeError(2)]), Exception('context'),
↳Exception('cause'), ['a note'])
>>> match, match.__context__, match.__cause__, match.__notes__
(MyGroup('eg', [ValueError(1)]), Exception('context'), Exception('cause'),
↳['a note'])
>>> rest, rest.__context__, rest.__cause__, rest.__notes__
(MyGroup('eg', [TypeError(2)]), Exception('context'), Exception('cause'),
↳['a note'])
>>> exc.__traceback__ is match.__traceback__ is rest.__traceback__
True

```

Note that *BaseExceptionGroup* defines `__new__()`, so subclasses that need a different constructor signature need to override that rather than `__init__()`. For example, the following defines an exception group subclass which accepts an `exit_code` and constructs the group's message from it.

```

class Errors(ExceptionGroup):
    def __new__(cls, errors, exit_code):
        self = super().__new__(Errors, f"exit code: {exit_code}", errors)
        self.exit_code = exit_code
        return self

    def derive(self, excs):
        return Errors(excs, self.exit_code)

```

Like *ExceptionGroup*, any subclass of *BaseExceptionGroup* which is also a subclass of *Exception* can only wrap instances of *Exception*.

在 3.11 版新加入。

5.7 Exception hierarchy

The class hierarchy for built-in exceptions is:

```

BaseException
├── BaseExceptionGroup
├── GeneratorExit
├── KeyboardInterrupt
├── SystemExit
├── Exception
│   ├── ArithmeticError
│   │   ├── FloatingPointError
│   │   ├── OverflowError
│   │   └── ZeroDivisionError
│   ├── AssertionError
│   ├── AttributeError
│   ├── BufferError
│   ├── EOFError
│   ├── ExceptionGroup [BaseExceptionGroup]
│   ├── ImportError
│   │   └── ModuleNotFoundError

```

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```

├─ LookupError
│   └─ IndexError
│       └─ KeyError
├─ MemoryError
├─ NameError
│   └─ UnboundLocalError
├─ OSError
│   └─ BlockingIOError
│   └─ ChildProcessError
│   └─ ConnectionError
│       │   └─ BrokenPipeError
│       │   └─ ConnectionAbortedError
│       │   └─ ConnectionRefusedError
│       │   └─ ConnectionResetError
│   └─ FileExistsError
│   └─ FileNotFoundError
│   └─ InterruptedError
│   └─ IsADirectoryError
│   └─ NotADirectoryError
│   └─ PermissionError
│   └─ ProcessLookupError
│   └─ TimeoutError
├─ ReferenceError
├─ RuntimeError
│   └─ NotImplementedError
│   └─ RecursionError
├─ StopAsyncIteration
├─ StopIteration
├─ SyntaxError
│   └─ IndentationError
│       └─ TabError
├─ SystemError
├─ TypeError
├─ ValueError
│   └─ UnicodeError
│       │   └─ UnicodeDecodeError
│       │   └─ UnicodeEncodeError
│       │   └─ UnicodeTranslateError
├─ Warning
│   └─ BytesWarning
│   └─ DeprecationWarning
│   └─ EncodingWarning
│   └─ FutureWarning
│   └─ ImportWarning
│   └─ PendingDeprecationWarning
│   └─ ResourceWarning
│   └─ RuntimeWarning
│   └─ SyntaxWarning
│   └─ UnicodeWarning
│   └─ UserWarning

```

文本處理 (Text Processing) 服務

本章節介紹的模組 (module) 提供了廣泛的字串操作與其他文本處理服務。

在 *Binary Data Services* 下所描述的 *codecs* 模組也與文本處理高度相關。另外也請參閱在 *Text Sequence Type --- str* 中所描述的 Python 字串型。

6.1 string --- Common string operations

原始碼: [Lib/string.py](#)

也參考:

Text Sequence Type --- str

String Methods

6.1.1 String constants

The constants defined in this module are:

`string.ascii_letters`

The concatenation of the *ascii_lowercase* and *ascii_uppercase* constants described below. This value is not locale-dependent.

`string.ascii_lowercase`

The lowercase letters 'abcdefghijklmnopqrstuvwxyz'. This value is not locale-dependent and will not change.

`string.ascii_uppercase`

The uppercase letters 'ABCDEFGHIJKLMNOPQRSTUVWXYZ'. This value is not locale-dependent and will not change.

`string.digits`

The string '0123456789'.

`string.hexdigits`

The string `'0123456789abcdefABCDEF'`.

`string.octdigits`

The string `'01234567'`.

`string.punctuation`

String of ASCII characters which are considered punctuation characters in the C locale: `!"#$%&'()*+,-./:;<=>?@[\\]^_`{|}~`.

`string.printable`

String of ASCII characters which are considered printable. This is a combination of *digits*, *ascii_letters*, *punctuation*, and *whitespace*.

`string.whitespace`

A string containing all ASCII characters that are considered whitespace. This includes the characters space, tab, linefeed, return, formfeed, and vertical tab.

6.1.2 Custom String Formatting

The built-in string class provides the ability to do complex variable substitutions and value formatting via the *format()* method described in **PEP 3101**. The *Formatter* class in the *string* module allows you to create and customize your own string formatting behaviors using the same implementation as the built-in *format()* method.

class `string.Formatter`

The *Formatter* class has the following public methods:

format (*format_string*, /, **args*, ***kwargs*)

The primary API method. It takes a format string and an arbitrary set of positional and keyword arguments. It is just a wrapper that calls *vformat()*.

在 3.7 版的變更: A format string argument is now *positional-only*.

vformat (*format_string*, *args*, *kwargs*)

This function does the actual work of formatting. It is exposed as a separate function for cases where you want to pass in a predefined dictionary of arguments, rather than unpacking and repacking the dictionary as individual arguments using the **args* and ***kwargs* syntax. *vformat()* does the work of breaking up the format string into character data and replacement fields. It calls the various methods described below.

In addition, the *Formatter* defines a number of methods that are intended to be replaced by subclasses:

parse (*format_string*)

Loop over the *format_string* and return an iterable of tuples (*literal_text*, *field_name*, *format_spec*, *conversion*). This is used by *vformat()* to break the string into either literal text, or replacement fields.

The values in the tuple conceptually represent a span of literal text followed by a single replacement field. If there is no literal text (which can happen if two replacement fields occur consecutively), then *literal_text* will be a zero-length string. If there is no replacement field, then the values of *field_name*, *format_spec* and *conversion* will be `None`.

get_field (*field_name*, *args*, *kwargs*)

Given *field_name* as returned by *parse()* (see above), convert it to an object to be formatted. Returns a tuple (obj, used_key). The default version takes strings of the form defined in **PEP 3101**, such as `"0[name]"` or `"label.title"`. *args* and *kwargs* are as passed in to *vformat()*. The return value *used_key* has the same meaning as the *key* parameter to *get_value()*.

get_value (*key, args, kwargs*)

Retrieve a given field value. The *key* argument will be either an integer or a string. If it is an integer, it represents the index of the positional argument in *args*; if it is a string, then it represents a named argument in *kwargs*.

The *args* parameter is set to the list of positional arguments to `vformat()`, and the *kwargs* parameter is set to the dictionary of keyword arguments.

For compound field names, these functions are only called for the first component of the field name; subsequent components are handled through normal attribute and indexing operations.

So for example, the field expression '0.name' would cause `get_value()` to be called with a *key* argument of 0. The *name* attribute will be looked up after `get_value()` returns by calling the built-in `getattr()` function.

If the index or keyword refers to an item that does not exist, then an `IndexError` or `KeyError` should be raised.

check_unused_args (*used_args, args, kwargs*)

Implement checking for unused arguments if desired. The arguments to this function is the set of all argument keys that were actually referred to in the format string (integers for positional arguments, and strings for named arguments), and a reference to the *args* and *kwargs* that was passed to `vformat`. The set of unused args can be calculated from these parameters. `check_unused_args()` is assumed to raise an exception if the check fails.

format_field (*value, format_spec*)

`format_field()` simply calls the global `format()` built-in. The method is provided so that subclasses can override it.

convert_field (*value, conversion*)

Converts the value (returned by `get_field()`) given a conversion type (as in the tuple returned by the `parse()` method). The default version understands 's' (str), 'r' (repr) and 'a' (ascii) conversion types.

6.1.3 Format String Syntax

The `str.format()` method and the `Formatter` class share the same syntax for format strings (although in the case of `Formatter`, subclasses can define their own format string syntax). The syntax is related to that of formatted string literals, but it is less sophisticated and, in particular, does not support arbitrary expressions.

Format strings contain "replacement fields" surrounded by curly braces `{ }`. Anything that is not contained in braces is considered literal text, which is copied unchanged to the output. If you need to include a brace character in the literal text, it can be escaped by doubling: `{{ }` and `}}`.

The grammar for a replacement field is as follows:

```
replacement_field ::= "{" [field_name] ["!" conversion] [":" format_spec] "}"
field_name        ::= arg_name ("." attribute_name | "[" element_index "]") *
arg_name          ::= [identifier | digit+]
attribute_name    ::= identifier
element_index     ::= digit+ | index_string
index_string      ::= <any source character except "]" "> +
conversion        ::= "r" | "s" | "a"
format_spec       ::= format-spec:format_spec
```

In less formal terms, the replacement field can start with a *field_name* that specifies the object whose value is to be formatted and inserted into the output instead of the replacement field. The *field_name* is optionally followed by a *conversion* field, which is preceded by an exclamation point '!', and a *format_spec*, which is preceded by a colon ':'. These specify a non-default format for the replacement value.

另請參FFormat Specification Mini-Language 部份。

The *field_name* itself begins with an *arg_name* that is either a number or a keyword. If it's a number, it refers to a positional argument, and if it's a keyword, it refers to a named keyword argument. An *arg_name* is treated as a number if a call to `str.isdecimal()` on the string would return true. If the numerical *arg_names* in a format string are 0, 1, 2, ... in sequence, they can all be omitted (not just some) and the numbers 0, 1, 2, ... will be automatically inserted in that order. Because *arg_name* is not quote-delimited, it is not possible to specify arbitrary dictionary keys (e.g., the strings '10' or ':-]') within a format string. The *arg_name* can be followed by any number of index or attribute expressions. An expression of the form `'.name'` selects the named attribute using `getattr()`, while an expression of the form `'[index]'` does an index lookup using `__getitem__()`.

在 3.1 版的變更: The positional argument specifiers can be omitted for `str.format()`, so `'{} {}'.format(a, b)` is equivalent to `'{0} {1}'.format(a, b)`.

在 3.4 版的變更: The positional argument specifiers can be omitted for `Formatter`.

Some simple format string examples:

```
"First, thou shalt count to {0}" # References first positional argument
"Bring me a {}"                 # Implicitly references the first positional_
↪ argument
"From {} to {}".format(0, 1)    # Same as "From {0} to {1}"
"My quest is {name}."           # References keyword argument 'name'
"Weight in tons {0.weight}"     # 'weight' attribute of first positional arg
"Units destroyed: {players[0]}" # First element of keyword argument 'players'.
```

The *conversion* field causes a type coercion before formatting. Normally, the job of formatting a value is done by the `__format__()` method of the value itself. However, in some cases it is desirable to force a type to be formatted as a string, overriding its own definition of formatting. By converting the value to a string before calling `__format__()`, the normal formatting logic is bypassed.

Three conversion flags are currently supported: `'!s'` which calls `str()` on the value, `'!r'` which calls `repr()` and `'!a'` which calls `ascii()`.

一些範例:

```
"Harold's a clever {0!s}"        # Calls str() on the argument first
"Bring out the holy {name!r}"    # Calls repr() on the argument first
"More {!a}"                     # Calls ascii() on the argument first
```

The *format_spec* field contains a specification of how the value should be presented, including such details as field width, alignment, padding, decimal precision and so on. Each value type can define its own "formatting mini-language" or interpretation of the *format_spec*.

Most built-in types support a common formatting mini-language, which is described in the next section.

A *format_spec* field can also include nested replacement fields within it. These nested replacement fields may contain a field name, conversion flag and format specification, but deeper nesting is not allowed. The replacement fields within the *format_spec* are substituted before the *format_spec* string is interpreted. This allows the formatting of a value to be dynamically specified.

範例請見 *Format examples*.

Format Specification Mini-Language

"Format specifications" are used within replacement fields contained within a format string to define how individual values are presented (see *Format String Syntax* and f-strings). They can also be passed directly to the built-in `format()` function. Each formattable type may define how the format specification is to be interpreted.

Most built-in types implement the following options for format specifications, although some of the formatting options are only supported by the numeric types.

A general convention is that an empty format specification produces the same result as if you had called `str()` on the value. A non-empty format specification typically modifies the result.

The general form of a *standard format specifier* is:

```
format_spec      ::=  [[fill]align][sign]["z"]["#"]["0"][width][grouping_option]["." precision]
fill            ::=  <any character>
align           ::=  "<" | ">" | "=" | "^"
sign           ::=  "+" | "-" | " "
width           ::=  digit+
grouping_option ::=  "_" | ",",
precision      ::=  digit+
type           ::=  "b" | "c" | "d" | "e" | "E" | "f" | "F" | "g" | "G" | "n" | "o" |
```

If a valid *align* value is specified, it can be preceded by a *fill* character that can be any character and defaults to a space if omitted. It is not possible to use a literal curly brace (“{” or ”}”) as the *fill* character in a formatted string literal or when using the `str.format()` method. However, it is possible to insert a curly brace with a nested replacement field. This limitation doesn’t affect the `format()` function.

The meaning of the various alignment options is as follows:

Op- tion	Meaning
'<'	Forces the field to be left-aligned within the available space (this is the default for most objects).
'>'	Forces the field to be right-aligned within the available space (this is the default for numbers).
'='	Forces the padding to be placed after the sign (if any) but before the digits. This is used for printing fields in the form '+000000120'. This alignment option is only valid for numeric types. It becomes the default for numbers when '0' immediately precedes the field width.
'^'	Forces the field to be centered within the available space.

Note that unless a minimum field width is defined, the field width will always be the same size as the data to fill it, so that the alignment option has no meaning in this case.

The *sign* option is only valid for number types, and can be one of the following:

Op- tion	Meaning
'+'	indicates that a sign should be used for both positive as well as negative numbers.
'-'	indicates that a sign should be used only for negative numbers (this is the default behavior).
space	indicates that a leading space should be used on positive numbers, and a minus sign on negative numbers.

The 'z' option coerces negative zero floating-point values to positive zero after rounding to the format precision. This option is only valid for floating-point presentation types.

在 3.11 版的變更: 新增 'z' 選項 (請見 [PEP 682](#))。

The '#' option causes the “alternate form” to be used for the conversion. The alternate form is defined differently for different types. This option is only valid for integer, float and complex types. For integers, when binary, octal, or hexadecimal output is used, this option adds the respective prefix '0b', '0o', '0x', or '0X' to the output value. For float and complex the alternate form causes the result of the conversion to always contain a decimal-point character, even if no digits follow it. Normally, a decimal-point character appears in the result of these conversions only if a digit follows it. In addition, for 'g' and 'G' conversions, trailing zeros are not removed from the result.

The ',' option signals the use of a comma for a thousands separator. For a locale aware separator, use the 'n' integer presentation type instead.

在 3.1 版的變更: 新增 ',' 選項 (請見 [PEP 378](#))。

The '_' option signals the use of an underscore for a thousands separator for floating point presentation types and for integer presentation type 'd'. For integer presentation types 'b', 'o', 'x', and 'X', underscores will be inserted every 4 digits. For other presentation types, specifying this option is an error.

在 3.6 版的變更: 新增 '_' 選項 (請見 [PEP 515](#))。

width is a decimal integer defining the minimum total field width, including any prefixes, separators, and other formatting characters. If not specified, then the field width will be determined by the content.

When no explicit alignment is given, preceding the *width* field by a zero ('0') character enables sign-aware zero-padding for numeric types. This is equivalent to a *fill* character of '0' with an *alignment* type of '='.

在 3.10 版的變更: Preceding the *width* field by '0' no longer affects the default alignment for strings.

The *precision* is a decimal integer indicating how many digits should be displayed after the decimal point for presentation types 'f' and 'F', or before and after the decimal point for presentation types 'g' or 'G'. For string presentation types the field indicates the maximum field size - in other words, how many characters will be used from the field content. The *precision* is not allowed for integer presentation types.

Finally, the *type* determines how the data should be presented.

The available string presentation types are:

Type	Meaning
's'	String format. This is the default type for strings and may be omitted.
None	The same as 's'.

The available integer presentation types are:

Type	Meaning
'b'	Binary format. Outputs the number in base 2.
'c'	Character. Converts the integer to the corresponding unicode character before printing.
'd'	Decimal Integer. Outputs the number in base 10.
'o'	Octal format. Outputs the number in base 8.
'x'	Hex format. Outputs the number in base 16, using lower-case letters for the digits above 9.
'X'	Hex format. Outputs the number in base 16, using upper-case letters for the digits above 9. In case '#' is specified, the prefix '0x' will be upper-cased to '0X' as well.
'n'	Number. This is the same as 'd', except that it uses the current locale setting to insert the appropriate number separator characters.
None	The same as 'd'.

In addition to the above presentation types, integers can be formatted with the floating point presentation types listed below (except 'n' and None). When doing so, `float()` is used to convert the integer to a floating point number before formatting.

The available presentation types for *float* and *Decimal* values are:

Type	Meaning
'e'	Scientific notation. For a given precision <code>p</code> , formats the number in scientific notation with the letter 'e' separating the coefficient from the exponent. The coefficient has one digit before and <code>p</code> digits after the decimal point, for a total of <code>p + 1</code> significant digits. With no precision given, uses a precision of 6 digits after the decimal point for <code>float</code> , and shows all coefficient digits for <code>Decimal</code> . If no digits follow the decimal point, the decimal point is also removed unless the <code>#</code> option is used.
'E'	Scientific notation. Same as 'e' except it uses an upper case 'E' as the separator character.
'f'	Fixed-point notation. For a given precision <code>p</code> , formats the number as a decimal number with exactly <code>p</code> digits following the decimal point. With no precision given, uses a precision of 6 digits after the decimal point for <code>float</code> , and uses a precision large enough to show all coefficient digits for <code>Decimal</code> . If no digits follow the decimal point, the decimal point is also removed unless the <code>#</code> option is used.
'F'	Fixed-point notation. Same as 'f', but converts <code>nan</code> to <code>NAN</code> and <code>inf</code> to <code>INF</code> .
'g'	General format. For a given precision <code>p >= 1</code> , this rounds the number to <code>p</code> significant digits and then formats the result in either fixed-point format or in scientific notation, depending on its magnitude. A precision of 0 is treated as equivalent to a precision of 1. The precise rules are as follows: suppose that the result formatted with presentation type 'e' and precision <code>p-1</code> would have exponent <code>exp</code> . Then, if <code>m <= exp < p</code> , where <code>m</code> is -4 for floats and -6 for <code>Decimals</code> , the number is formatted with presentation type 'f' and precision <code>p-1-exp</code> . Otherwise, the number is formatted with presentation type 'e' and precision <code>p-1</code> . In both cases insignificant trailing zeros are removed from the significand, and the decimal point is also removed if there are no remaining digits following it, unless the '#' option is used. With no precision given, uses a precision of 6 significant digits for <code>float</code> . For <code>Decimal</code> , the coefficient of the result is formed from the coefficient digits of the value; scientific notation is used for values smaller than <code>1e-6</code> in absolute value and values where the place value of the least significant digit is larger than 1, and fixed-point notation is used otherwise. Positive and negative infinity, positive and negative zero, and nans, are formatted as <code>inf</code> , <code>-inf</code> , <code>0</code> , <code>-0</code> and <code>nan</code> respectively, regardless of the precision.
'G'	General format. Same as 'g' except switches to 'E' if the number gets too large. The representations of infinity and NaN are uppercased, too.
'n'	Number. This is the same as 'g', except that it uses the current locale setting to insert the appropriate number separator characters.
'%'	Percentage. Multiplies the number by 100 and displays in fixed ('f') format, followed by a percent sign.
None	For <code>float</code> this is the same as 'g', except that when fixed-point notation is used to format the result, it always includes at least one digit past the decimal point. The precision used is as large as needed to represent the given value faithfully. For <code>Decimal</code> , this is the same as either 'g' or 'G' depending on the value of <code>context.capitals</code> for the current decimal context. The overall effect is to match the output of <code>str()</code> as altered by the other format modifiers.

Format examples

This section contains examples of the `str.format()` syntax and comparison with the old %-formatting.

In most of the cases the syntax is similar to the old %-formatting, with the addition of the `{}` and with `:` used instead of `%`. For example, `'%03.2f'` can be translated to `{:03.2f}`.

The new format syntax also supports new and different options, shown in the following examples.

Accessing arguments by position:

```
>>> '{0}, {1}, {2}'.format('a', 'b', 'c')
'a, b, c'
```

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```
>>> '{} , {} , {}'.format('a', 'b', 'c') # 3.1+ only
'a, b, c'
>>> '{2} , {1} , {0}'.format('a', 'b', 'c')
'c, b, a'
>>> '{2} , {1} , {0}'.format(*'abc')      # unpacking argument sequence
'c, b, a'
>>> '{0}{1}{0}'.format('abra', 'cad')    # arguments' indices can be repeated
'abracadabra'
```

Accessing arguments by name:

```
>>> 'Coordinates: {latitude}, {longitude}'.format(latitude='37.24N', longitude='-
↳115.81W')
'Coordinates: 37.24N, -115.81W'
>>> coord = {'latitude': '37.24N', 'longitude': '-115.81W'}
>>> 'Coordinates: {latitude}, {longitude}'.format(**coord)
'Coordinates: 37.24N, -115.81W'
```

Accessing arguments' attributes:

```
>>> c = 3-5j
>>> ('The complex number {0} is formed from the real part {0.real} '
... 'and the imaginary part {0.imag}.').format(c)
'The complex number (3-5j) is formed from the real part 3.0 and the imaginary part
↳-5.0.'
>>> class Point:
...     def __init__(self, x, y):
...         self.x, self.y = x, y
...     def __str__(self):
...         return 'Point({self.x}, {self.y})'.format(self=self)
...
>>> str(Point(4, 2))
'Point(4, 2)'
```

Accessing arguments' items:

```
>>> coord = (3, 5)
>>> 'X: {0[0]}; Y: {0[1]}'.format(coord)
'X: 3; Y: 5'
```

Replacing %s and %r:

```
>>> "repr() shows quotes: {!r}; str() doesn't: {!s}".format('test1', 'test2')
'repr() shows quotes: 'test1'; str() doesn't: test2'
```

Aligning the text and specifying a width:

```
>>> '{:<30}'.format('left aligned')
'left aligned'
>>> '{:>30}'.format('right aligned')
'right aligned'
>>> '{:^30}'.format('centered')
'centered'
>>> '{:*^30}'.format('centered') # use '*' as a fill char
'*****centered*****'
```

Replacing %f, %-f, and % f and specifying a sign:

```
>>> '{:+f}; {:+f}'.format(3.14, -3.14) # show it always
'+3.140000; -3.140000'
>>> '{: f}; {: f}'.format(3.14, -3.14) # show a space for positive numbers
```

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```
' 3.140000; -3.140000'
>>> '{:-f}; {:-f}'.format(3.14, -3.14) # show only the minus -- same as '{:f};
↳{:f}'
'3.140000; -3.140000'
```

Replacing %x and %o and converting the value to different bases:

```
>>> # format also supports binary numbers
>>> "int: {0:d}; hex: {0:x}; oct: {0:o}; bin: {0:b}".format(42)
'int: 42; hex: 2a; oct: 52; bin: 101010'
>>> # with 0x, 0o, or 0b as prefix:
>>> "int: {0:d}; hex: {0:#x}; oct: {0:#o}; bin: {0:#b}".format(42)
'int: 42; hex: 0x2a; oct: 0o52; bin: 0b101010'
```

Using the comma as a thousands separator:

```
>>> '{:,}'.format(1234567890)
'1,234,567,890'
```

Expressing a percentage:

```
>>> points = 19
>>> total = 22
>>> 'Correct answers: {:.2%}'.format(points/total)
'Correct answers: 86.36%'
```

Using type-specific formatting:

```
>>> import datetime
>>> d = datetime.datetime(2010, 7, 4, 12, 15, 58)
>>> '{:%Y-%m-%d %H:%M:%S}'.format(d)
'2010-07-04 12:15:58'
```

Nesting arguments and more complex examples:

```
>>> for align, text in zip('<^>', ['left', 'center', 'right']):
...     '{0:{fill}{align}16}'.format(text, fill=align, align=align)
...
'left<<<<<<<<<<<<'
'^^^^^center^^^^^'
'>>>>>>>>>>>>right'
>>>
>>> octets = [192, 168, 0, 1]
>>> '{:02X}{:02X}{:02X}{:02X}'.format(*octets)
'C0A80001'
>>> int(_, 16)
3232235521
>>>
>>> width = 5
>>> for num in range(5,12):
...     for base in 'dXob':
...         print('{0:{width}{base}}'.format(num, base=base, width=width), end=' ')
...     print()
...
5      5      5      101
6      6      6      110
7      7      7      111
8      8      10     1000
9      9      11     1001
10     A      12     1010
11     B      13     1011
```


6.1.4 Template strings

Template strings provide simpler string substitutions as described in [PEP 292](#). A primary use case for template strings is for internationalization (i18n) since in that context, the simpler syntax and functionality makes it easier to translate than other built-in string formatting facilities in Python. As an example of a library built on template strings for i18n, see the [flufl.i18n](#) package.

Template strings support `$`-based substitutions, using the following rules:

- `$$` is an escape; it is replaced with a single `$`.
- `$identifier` names a substitution placeholder matching a mapping key of `"identifier"`. By default, `"identifier"` is restricted to any case-insensitive ASCII alphanumeric string (including underscores) that starts with an underscore or ASCII letter. The first non-identifier character after the `$` character terminates this placeholder specification.
- `${identifier}` is equivalent to `$identifier`. It is required when valid identifier characters follow the placeholder but are not part of the placeholder, such as `"${noun}ification"`.

Any other appearance of `$` in the string will result in a `ValueError` being raised.

The `string` module provides a `Template` class that implements these rules. The methods of `Template` are:

class `string.Template(template)`

The constructor takes a single argument which is the template string.

substitute(mapping={}, /, **kwds)

Performs the template substitution, returning a new string. *mapping* is any dictionary-like object with keys that match the placeholders in the template. Alternatively, you can provide keyword arguments, where the keywords are the placeholders. When both *mapping* and *kwds* are given and there are duplicates, the placeholders from *kwds* take precedence.

safe_substitute(mapping={}, /, **kwds)

Like `substitute()`, except that if placeholders are missing from *mapping* and *kwds*, instead of raising a `KeyError` exception, the original placeholder will appear in the resulting string intact. Also, unlike with `substitute()`, any other appearances of the `$` will simply return `$` instead of raising `ValueError`.

While other exceptions may still occur, this method is called "safe" because it always tries to return a usable string instead of raising an exception. In another sense, `safe_substitute()` may be anything other than safe, since it will silently ignore malformed templates containing dangling delimiters, unmatched braces, or placeholders that are not valid Python identifiers.

is_valid()

Returns false if the template has invalid placeholders that will cause `substitute()` to raise `ValueError`.

在 3.11 版新加入。

get_identifiers()

Returns a list of the valid identifiers in the template, in the order they first appear, ignoring any invalid identifiers.

在 3.11 版新加入。

`Template` instances also provide one public data attribute:

template

This is the object passed to the constructor's *template* argument. In general, you shouldn't change it, but read-only access is not enforced.

Here is an example of how to use a `Template`:


```
>>> from string import Template
>>> s = Template('$who likes $what')
>>> s.substitute(who='tim', what='kung pao')
'tim likes kung pao'
>>> d = dict(who='tim')
>>> Template('Give $who $100').substitute(d)
Traceback (most recent call last):
...
ValueError: Invalid placeholder in string: line 1, col 11
>>> Template('$who likes $what').substitute(d)
Traceback (most recent call last):
...
KeyError: 'what'
>>> Template('$who likes $what').safe_substitute(d)
'tim likes $what'
```

Advanced usage: you can derive subclasses of *Template* to customize the placeholder syntax, delimiter character, or the entire regular expression used to parse template strings. To do this, you can override these class attributes:

- *delimiter* -- This is the literal string describing a placeholder introducing delimiter. The default value is `$`. Note that this should *not* be a regular expression, as the implementation will call `re.escape()` on this string as needed. Note further that you cannot change the delimiter after class creation (i.e. a different delimiter must be set in the subclass's class namespace).
- *idpattern* -- This is the regular expression describing the pattern for non-braced placeholders. The default value is the regular expression `(?a: [_a-z] [_a-z0-9]*)`. If this is given and *braceidpattern* is `None` this pattern will also apply to braced placeholders.

備F: Since default *flags* is `re.IGNORECASE`, pattern `[a-z]` can match with some non-ASCII characters. That's why we use the local `a` flag here.

在 3.7 版的變更: *braceidpattern* can be used to define separate patterns used inside and outside the braces.

- *braceidpattern* -- This is like *idpattern* but describes the pattern for braced placeholders. Defaults to `None` which means to fall back to *idpattern* (i.e. the same pattern is used both inside and outside braces). If given, this allows you to define different patterns for braced and unbraced placeholders.

在 3.7 版新加入.

- *flags* -- The regular expression flags that will be applied when compiling the regular expression used for recognizing substitutions. The default value is `re.IGNORECASE`. Note that `re.VERBOSE` will always be added to the flags, so custom *idpatterns* must follow conventions for verbose regular expressions.

在 3.2 版新加入.

Alternatively, you can provide the entire regular expression pattern by overriding the class attribute *pattern*. If you do this, the value must be a regular expression object with four named capturing groups. The capturing groups correspond to the rules given above, along with the invalid placeholder rule:

- *escaped* -- This group matches the escape sequence, e.g. `$$`, in the default pattern.
- *named* -- This group matches the unbraced placeholder name; it should not include the delimiter in capturing group.
- *braced* -- This group matches the brace enclosed placeholder name; it should not include either the delimiter or braces in the capturing group.
- *invalid* -- This group matches any other delimiter pattern (usually a single delimiter), and it should appear last in the regular expression.

The methods on this class will raise *ValueError* if the pattern matches the template without one of these named groups matching.

6.1.5 Helper functions

`string.capwords(s, sep=None)`

Split the argument into words using `str.split()`, capitalize each word using `str.capitalize()`, and join the capitalized words using `str.join()`. If the optional second argument `sep` is absent or `None`, runs of whitespace characters are replaced by a single space and leading and trailing whitespace are removed, otherwise `sep` is used to split and join the words.

6.2 re --- 正規表示式 (regular expression) 操作

原始碼: [Lib/re/](#)

This module provides regular expression matching operations similar to those found in Perl.

Both patterns and strings to be searched can be Unicode strings (`str`) as well as 8-bit strings (`bytes`). However, Unicode strings and 8-bit strings cannot be mixed: that is, you cannot match a Unicode string with a bytes pattern or vice-versa; similarly, when asking for a substitution, the replacement string must be of the same type as both the pattern and the search string.

Regular expressions use the backslash character (`'\'`) to indicate special forms or to allow special characters to be used without invoking their special meaning. This collides with Python's usage of the same character for the same purpose in string literals; for example, to match a literal backslash, one might have to write `'\\\\'` as the pattern string, because the regular expression must be `\\`, and each backslash must be expressed as `\\` inside a regular Python string literal. Also, please note that any invalid escape sequences in Python's usage of the backslash in string literals now generate a `DeprecationWarning` and in the future this will become a `SyntaxError`. This behaviour will happen even if it is a valid escape sequence for a regular expression.

The solution is to use Python's raw string notation for regular expression patterns; backslashes are not handled in any special way in a string literal prefixed with `'r'`. So `r"\n"` is a two-character string containing `'\'` and `'n'`, while `"\n"` is a one-character string containing a newline. Usually patterns will be expressed in Python code using this raw string notation.

It is important to note that most regular expression operations are available as module-level functions and methods on *compiled regular expressions*. The functions are shortcuts that don't require you to compile a regex object first, but miss some fine-tuning parameters.

也參考:

The third-party `regex` module, which has an API compatible with the standard library `re` module, but offers additional functionality and a more thorough Unicode support.

6.2.1 Regular Expression Syntax

A regular expression (or RE) specifies a set of strings that matches it; the functions in this module let you check if a particular string matches a given regular expression (or if a given regular expression matches a particular string, which comes down to the same thing).

Regular expressions can be concatenated to form new regular expressions; if *A* and *B* are both regular expressions, then *AB* is also a regular expression. In general, if a string *p* matches *A* and another string *q* matches *B*, the string *pq* will match *AB*. This holds unless *A* or *B* contain low precedence operations; boundary conditions between *A* and *B*; or have numbered group references. Thus, complex expressions can easily be constructed from simpler primitive expressions like the ones described here. For details of the theory and implementation of regular expressions, consult the Friedl book [Frie09], or almost any textbook about compiler construction.

A brief explanation of the format of regular expressions follows. For further information and a gentler presentation, consult the `regex-howto`.

Regular expressions can contain both special and ordinary characters. Most ordinary characters, like `'A'`, `'a'`, or `'0'`, are the simplest regular expressions; they simply match themselves. You can concatenate ordinary characters,

so `last` matches the string `'last'`. (In the rest of this section, we'll write RE's in this special style, usually without quotes, and strings to be matched 'in single quotes'.)

Some characters, like `'|'` or `'('`, are special. Special characters either stand for classes of ordinary characters, or affect how the regular expressions around them are interpreted.

Repetition operators or quantifiers (`*`, `+`, `?`, `{m,n}`, etc) cannot be directly nested. This avoids ambiguity with the non-greedy modifier suffix `?`, and with other modifiers in other implementations. To apply a second repetition to an inner repetition, parentheses may be used. For example, the expression `(?:a{6})*` matches any multiple of six 'a' characters.

The special characters are:

- .**

(Dot.) In the default mode, this matches any character except a newline. If the `DOTALL` flag has been specified, this matches any character including a newline.
- ^**

(Caret.) Matches the start of the string, and in `MULTILINE` mode also matches immediately after each newline.
- \$**

Matches the end of the string or just before the newline at the end of the string, and in `MULTILINE` mode also matches before a newline. `foo` matches both 'foo' and 'foobar', while the regular expression `foo$` matches only 'foo'. More interestingly, searching for `foo.$` in `'foo1\nfoo2\n'` matches 'foo2' normally, but 'foo1' in `MULTILINE` mode; searching for a single `$` in `'foo\n'` will find two (empty) matches: one just before the newline, and one at the end of the string.
- ***

Causes the resulting RE to match 0 or more repetitions of the preceding RE, as many repetitions as are possible. `ab*` will match 'a', 'ab', or 'a' followed by any number of 'b's.
- +**

Causes the resulting RE to match 1 or more repetitions of the preceding RE. `ab+` will match 'a' followed by any non-zero number of 'b's; it will not match just 'a'.
- ?**

Causes the resulting RE to match 0 or 1 repetitions of the preceding RE. `ab?` will match either 'a' or 'ab'.
- *?, +?, ??**

The `'*'`, `'+'`, and `'?'` quantifiers are all *greedy*; they match as much text as possible. Sometimes this behaviour isn't desired; if the RE `<.*>` is matched against `'<a> b <c>'`, it will match the entire string, and not just `'<a>'`. Adding `?` after the quantifier makes it perform the match in *non-greedy* or *minimal* fashion; as few characters as possible will be matched. Using the RE `<.*?>` will match only `'<a>'`.
- *+, ++, ?+**

Like the `'*'`, `'+'`, and `'?'` quantifiers, those where `'+'` is appended also match as many times as possible. However, unlike the true greedy quantifiers, these do not allow back-tracking when the expression following it fails to match. These are known as *possessive* quantifiers. For example, `a*a` will match 'aaaa' because the `a*` will match all 4 'a's, but, when the final 'a' is encountered, the expression is backtracked so that in the end the `a*` ends up matching 3 'a's total, and the fourth 'a' is matched by the final 'a'. However, when `a*+a` is used to match 'aaaa', the `a*+` will match all 4 'a's, but when the final 'a' fails to find any more characters to match, the expression cannot be backtracked and will thus fail to match. `x*+`, `x++` and `x?+` are equivalent to `(?>x*)`, `(?>x+)` and `(?>x?)` correspondingly.

在 3.11 版新加入.
- {m}**

Specifies that exactly *m* copies of the previous RE should be matched; fewer matches cause the entire RE not to match. For example, `a{6}` will match exactly six 'a' characters, but not five.
- {m,n}**

Causes the resulting RE to match from *m* to *n* repetitions of the preceding RE, attempting to match as many repetitions as possible. For example, `a{3,5}` will match from 3 to 5 'a' characters. Omitting *m* specifies a lower bound of zero, and omitting *n* specifies an infinite upper bound. As an example, `a{4,}b` will match

'aaaab' or a thousand 'a' characters followed by a 'b', but not 'aaab'. The comma may not be omitted or the modifier would be confused with the previously described form.

{m, n}?

Causes the resulting RE to match from *m* to *n* repetitions of the preceding RE, attempting to match as *few* repetitions as possible. This is the non-greedy version of the previous quantifier. For example, on the 6-character string 'aaaaaa', `a{3, 5}` will match 5 'a' characters, while `a{3, 5}?` will only match 3 characters.

{m, n}+

Causes the resulting RE to match from *m* to *n* repetitions of the preceding RE, attempting to match as many repetitions as possible *without* establishing any backtracking points. This is the possessive version of the quantifier above. For example, on the 6-character string 'aaaaaa', `a{3, 5}+aa` attempt to match 5 'a' characters, then, requiring 2 more 'a's, will need more characters than available and thus fail, while `a{3, 5}aa` will match with `a{3, 5}` capturing 5, then 4 'a's by backtracking and then the final 2 'a's are matched by the final `aa` in the pattern. `x{m, n}+` is equivalent to `(?>x{m, n})`.

在 3.11 版新加入。

Either escapes special characters (permitting you to match characters like '*', '?', and so forth), or signals a special sequence; special sequences are discussed below.

If you're not using a raw string to express the pattern, remember that Python also uses the backslash as an escape sequence in string literals; if the escape sequence isn't recognized by Python's parser, the backslash and subsequent character are included in the resulting string. However, if Python would recognize the resulting sequence, the backslash should be repeated twice. This is complicated and hard to understand, so it's highly recommended that you use raw strings for all but the simplest expressions.

[]

Used to indicate a set of characters. In a set:

- Characters can be listed individually, e.g. `[amk]` will match 'a', 'm', or 'k'.
- Ranges of characters can be indicated by giving two characters and separating them by a '-' , for example `[a-z]` will match any lowercase ASCII letter, `[0-5][0-9]` will match all the two-digits numbers from 00 to 59, and `[0-9A-Fa-f]` will match any hexadecimal digit. If - is escaped (e.g. `[a\ -z]`) or if it's placed as the first or last character (e.g. `[-a]` or `[a-]`), it will match a literal '-'.
- Special characters lose their special meaning inside sets. For example, `[+*]` will match any of the literal characters '(', '+', '*', or ')'
- Character classes such as `\w` or `\S` (defined below) are also accepted inside a set, although the characters they match depend on the *flags* used.
- Characters that are not within a range can be matched by *complementing* the set. If the first character of the set is '^', all the characters that are *not* in the set will be matched. For example, `[^5]` will match any character except '5', and `[^ ^]` will match any character except '^'. ^ has no special meaning if it's not the first character in the set.
- To match a literal ']' inside a set, precede it with a backslash, or place it at the beginning of the set. For example, both `[() \ \{ \}]` and `[\{ \} \[\]` will match a right bracket, as well as left bracket, braces, and parentheses.
- Support of nested sets and set operations as in [Unicode Technical Standard #18](#) might be added in the future. This would change the syntax, so to facilitate this change a *FutureWarning* will be raised in ambiguous cases for the time being. That includes sets starting with a literal '[' or containing literal character sequences '--', '&&', '~~', and '||'. To avoid a warning escape them with a backslash.

在 3.7 版的變更: *FutureWarning* is raised if a character set contains constructs that will change semantically in the future.

|

`A|B`, where *A* and *B* can be arbitrary REs, creates a regular expression that will match either *A* or *B*. An arbitrary number of REs can be separated by the '|' in this way. This can be used inside groups (see below) as well. As the target string is scanned, REs separated by '|' are tried from left to right. When one pattern completely matches, that branch is accepted. This means that once *A* matches, *B* will not be tested further,

even if it would produce a longer overall match. In other words, the `|` operator is never greedy. To match a literal `|`, use `\|`, or enclose it inside a character class, as in `[|]`.

(...)

Matches whatever regular expression is inside the parentheses, and indicates the start and end of a group; the contents of a group can be retrieved after a match has been performed, and can be matched later in the string with the `\number` special sequence, described below. To match the literals `'(` or `)'`, use `\(` or `\)`, or enclose them inside a character class: `[()]`.

(?...)

This is an extension notation (a `'?'` following a `'(` is not meaningful otherwise). The first character after the `'?'` determines what the meaning and further syntax of the construct is. Extensions usually do not create a new group; `(?P<name>...)` is the only exception to this rule. Following are the currently supported extensions.

(?aiLmsux)

(One or more letters from the set `'a', 'i', 'L', 'm', 's', 'u', 'x'`.) The group matches the empty string; the letters set the corresponding flags for the entire regular expression:

- `re.A` (ASCII-only matching)
- `re.I` (ignore case)
- `re.L` (locale dependent)
- `re.M` (multi-line)
- `re.S` (dot matches all)
- `re.U` (Unicode matching)
- `re.X` (verbose)

(The flags are described in 模組 容.) This is useful if you wish to include the flags as part of the regular expression, instead of passing a *flag* argument to the `re.compile()` function. Flags should be used first in the expression string.

在 3.11 版的變更: This construction can only be used at the start of the expression.

(?:...)

A non-capturing version of regular parentheses. Matches whatever regular expression is inside the parentheses, but the substring matched by the group *cannot* be retrieved after performing a match or referenced later in the pattern.

(?aiLmsux-imsx:...)

(Zero or more letters from the set `'a', 'i', 'L', 'm', 's', 'u', 'x'`, optionally followed by `'-'` followed by one or more letters from the `'i', 'm', 's', 'x'`.) The letters set or remove the corresponding flags for the part of the expression:

- `re.A` (ASCII-only matching)
- `re.I` (ignore case)
- `re.L` (locale dependent)
- `re.M` (multi-line)
- `re.S` (dot matches all)
- `re.U` (Unicode matching)
- `re.X` (verbose)

(The flags are described in 模組 容.)

The letters `'a', 'L'` and `'u'` are mutually exclusive when used as inline flags, so they can't be combined or follow `'-'`. Instead, when one of them appears in an inline group, it overrides the matching mode in the enclosing group. In Unicode patterns `(?a:...)` switches to ASCII-only matching, and `(?u:...)` switches to Unicode matching (default). In bytes patterns `(?L:...)` switches to locale dependent matching, and `(?a:...)` switches to ASCII-only matching (default). This override is only in effect for the narrow inline group, and the original matching mode is restored outside of the group.

在 3.6 版新加入。

在 3.7 版的變更: The letters 'a', 'L' and 'u' also can be used in a group.

(?>...)

Attempts to match ... as if it was a separate regular expression, and if successful, continues to match the rest of the pattern following it. If the subsequent pattern fails to match, the stack can only be unwound to a point *before* the (?>...) because once exited, the expression, known as an *atomic group*, has thrown away all stack points within itself. Thus, (?>.*). would never match anything because first the .* would match all characters possible, then, having nothing left to match, the final . would fail to match. Since there are no stack points saved in the Atomic Group, and there is no stack point before it, the entire expression would thus fail to match.

在 3.11 版新加入。

(?P<name>...)

Similar to regular parentheses, but the substring matched by the group is accessible via the symbolic group name *name*. Group names must be valid Python identifiers, and each group name must be defined only once within a regular expression. A symbolic group is also a numbered group, just as if the group were not named.

Named groups can be referenced in three contexts. If the pattern is (?P<quote>['"])*?(?P=quote) (i.e. matching a string quoted with either single or double quotes):

Context of reference to group "quote"	Ways to reference it
in the same pattern itself	<ul style="list-style-type: none"> (?P=quote) (as shown) \1
when processing match object <i>m</i>	<ul style="list-style-type: none"> m.group('quote') m.end('quote') (etc.)
in a string passed to the <i>repl</i> argument of <i>re.sub()</i>	<ul style="list-style-type: none"> \g<quote> \g<1> \1

在 3.11 版之後被 用: Group *name* containing characters outside the ASCII range (b'\x00'-b'\x7f') in *bytes* patterns.

(?P=name)

A backreference to a named group; it matches whatever text was matched by the earlier group named *name*.

(?#...)

A comment; the contents of the parentheses are simply ignored.

(?=...)

Matches if ... matches next, but doesn't consume any of the string. This is called a *lookahead assertion*. For example, *Isaac* (?=Asimov) will match 'Isaac ' only if it's followed by 'Asimov'.

(?!...)

Matches if ... doesn't match next. This is a *negative lookahead assertion*. For example, *Isaac* (?!Asimov) will match 'Isaac ' only if it's *not* followed by 'Asimov'.

(?<=...)

Matches if the current position in the string is preceded by a match for ... that ends at the current position. This is called a *positive lookbehind assertion*. (?<=abc)def will find a match in 'abcdef', since the lookbehind will back up 3 characters and check if the contained pattern matches. The contained pattern must only match strings of some fixed length, meaning that abc or a|b are allowed, but a* and a{3,4} are not. Note that patterns which start with positive lookbehind assertions will not match at the beginning of the string being searched; you will most likely want to use the *search()* function rather than the *match()* function:


```
>>> import re
>>> m = re.search('(?<=abc)def', 'abcdef')
>>> m.group(0)
'def'
```

This example looks for a word following a hyphen:

```
>>> m = re.search(r'(?<=-)\w+', 'spam-egg')
>>> m.group(0)
'egg'
```

在 3.5 版的變更: Added support for group references of fixed length.

(?!...)

Matches if the current position in the string is not preceded by a match for ... This is called a *negative lookbehind assertion*. Similar to positive lookbehind assertions, the contained pattern must only match strings of some fixed length. Patterns which start with negative lookbehind assertions may match at the beginning of the string being searched.

(?(id/name)yes-pattern|no-pattern)

Will try to match with `yes-pattern` if the group with given *id* or *name* exists, and with `no-pattern` if it doesn't. `no-pattern` is optional and can be omitted. For example, `(<)?(\w+@\w+(?:\.\w+)+)(?(1)>|$)` is a poor email matching pattern, which will match with `'<user@host.com>'` as well as `'user@host.com'`, but not with `'<user@host.com'` nor `'user@host.com>'`.

在 3.11 版之後被用: Group *id* containing anything except ASCII digits. Group *name* containing characters outside the ASCII range (b'\x00'-b'\x7f') in *bytes* replacement strings.

The special sequences consist of `'\'` and a character from the list below. If the ordinary character is not an ASCII digit or an ASCII letter, then the resulting RE will match the second character. For example, `\$` matches the character `'$'`.

\number

Matches the contents of the group of the same number. Groups are numbered starting from 1. For example, `(.+)\1` matches `'the the'` or `'55 55'`, but not `'thethe'` (note the space after the group). This special sequence can only be used to match one of the first 99 groups. If the first digit of *number* is 0, or *number* is 3 octal digits long, it will not be interpreted as a group match, but as the character with octal value *number*. Inside the `'[' and ']'` of a character class, all numeric escapes are treated as characters.

\A

Matches only at the start of the string.

\b

Matches the empty string, but only at the beginning or end of a word. A word is defined as a sequence of word characters. Note that formally, `\b` is defined as the boundary between a `\w` and a `\W` character (or vice versa), or between `\w` and the beginning or end of the string. This means that `r'\bat\b'` matches `'at'`, `'at.'`, `'(at)'`, and `'as at ay'` but not `'attempt'` or `'atlas'`.

The default word characters in Unicode (str) patterns are Unicode alphanumerics and the underscore, but this can be changed by using the *ASCII* flag. Word boundaries are determined by the current locale if the *LOCALE* flag is used.

備: Inside a character range, `\b` represents the backspace character, for compatibility with Python's string literals.

\B

Matches the empty string, but only when it is *not* at the beginning or end of a word. This means that `r'at\B'` matches `'athens'`, `'atom'`, `'attorney'`, but not `'at'`, `'at.'`, or `'at!'`. `\B` is the opposite of `\b`, so word characters in Unicode (str) patterns are Unicode alphanumerics or the underscore, although this can be changed by using the *ASCII* flag. Word boundaries are determined by the current locale if the *LOCALE* flag is used.

\d**For Unicode (str) patterns:**

Matches any Unicode decimal digit (that is, any character in Unicode character category `[Nd]`). This includes `[0-9]`, and also many other digit characters.

Matches `[0-9]` if the `ASCII` flag is used.

For 8-bit (bytes) patterns:

Matches any decimal digit in the ASCII character set; this is equivalent to `[0-9]`.

\D

Matches any character which is not a decimal digit. This is the opposite of `\d`.

Matches `[^0-9]` if the `ASCII` flag is used.

\s**For Unicode (str) patterns:**

Matches Unicode whitespace characters (which includes `[\t\n\r\f\v]`, and also many other characters, for example the non-breaking spaces mandated by typography rules in many languages).

Matches `[\t\n\r\f\v]` if the `ASCII` flag is used.

For 8-bit (bytes) patterns:

Matches characters considered whitespace in the ASCII character set; this is equivalent to `[\t\n\r\f\v]`.

\S

Matches any character which is not a whitespace character. This is the opposite of `\s`.

Matches `[^\t\n\r\f\v]` if the `ASCII` flag is used.

\w**For Unicode (str) patterns:**

Matches Unicode word characters; this includes all Unicode alphanumeric characters (as defined by `str.isalnum()`), as well as the underscore (`_`).

Matches `[a-zA-Z0-9_]` if the `ASCII` flag is used.

For 8-bit (bytes) patterns:

Matches characters considered alphanumeric in the ASCII character set; this is equivalent to `[a-zA-Z0-9_]`. If the `LOCALE` flag is used, matches characters considered alphanumeric in the current locale and the underscore.

\W

Matches any character which is not a word character. This is the opposite of `\w`. By default, matches non-underscore (`_`) characters for which `str.isalnum()` returns `False`.

Matches `[^a-zA-Z0-9_]` if the `ASCII` flag is used.

If the `LOCALE` flag is used, matches characters which are neither alphanumeric in the current locale nor the underscore.

\Z

Matches only at the end of the string.

Most of the standard escapes supported by Python string literals are also accepted by the regular expression parser:

<code>\a</code>	<code>\b</code>	<code>\f</code>	<code>\n</code>
<code>\N</code>	<code>\r</code>	<code>\t</code>	<code>\u</code>
<code>\U</code>	<code>\v</code>	<code>\x</code>	<code>\\</code>

(Note that `\b` is used to represent word boundaries, and means "backspace" only inside character classes.)

`'\u'`, `'\U'`, and `'\N'` escape sequences are only recognized in Unicode (str) patterns. In bytes patterns they are errors. Unknown escapes of ASCII letters are reserved for future use and treated as errors.

Octal escapes are included in a limited form. If the first digit is a 0, or if there are three octal digits, it is considered an octal escape. Otherwise, it is a group reference. As for string literals, octal escapes are always at most three digits in length.

在 3.3 版的變更: The `'\u'` and `'\U'` escape sequences have been added.

在 3.6 版的變更: Unknown escapes consisting of `'\'` and an ASCII letter now are errors.

在 3.8 版的變更: The `'\N{name}'` escape sequence has been added. As in string literals, it expands to the named Unicode character (e.g. `'\N{EM DASH}'`).

6.2.2 模組 `re` 內容

The module defines several functions, constants, and an exception. Some of the functions are simplified versions of the full featured methods for compiled regular expressions. Most non-trivial applications always use the compiled form.

Flags

在 3.6 版的變更: Flag constants are now instances of `RegexFlag`, which is a subclass of `enum.IntFlag`.

class `re.RegexFlag`

An `enum.IntFlag` class containing the regex options listed below.

在 3.11 版新加入: - added to `__all__`

`re.A`

`re.ASCII`

Make `\w`, `\W`, `\b`, `\B`, `\d`, `\D`, `\s` and `\S` perform ASCII-only matching instead of full Unicode matching. This is only meaningful for Unicode (`str`) patterns, and is ignored for bytes patterns.

Corresponds to the inline flag `(?a)`.

備註: The `U` flag still exists for backward compatibility, but is redundant in Python 3 since matches are Unicode by default for `str` patterns, and Unicode matching isn't allowed for bytes patterns. `UNICODE` and the inline flag `(?u)` are similarly redundant.

`re.DEBUG`

Display debug information about compiled expression.

No corresponding inline flag.

`re.I`

`re.IGNORECASE`

Perform case-insensitive matching; expressions like `[A-Z]` will also match lowercase letters. Full Unicode matching (such as `Ü` matching `ü`) also works unless the `ASCII` flag is used to disable non-ASCII matches. The current locale does not change the effect of this flag unless the `LOCALE` flag is also used.

Corresponds to the inline flag `(?i)`.

Note that when the Unicode patterns `[a-z]` or `[A-Z]` are used in combination with the `IGNORECASE` flag, they will match the 52 ASCII letters and 4 additional non-ASCII letters: `'İ'` (U+0130, Latin capital letter I with dot above), `'ı'` (U+0131, Latin small letter dotless i), `'ſ'` (U+017F, Latin small letter long s) and `'K'` (U+212A, Kelvin sign). If the `ASCII` flag is used, only letters `'a'` to `'z'` and `'A'` to `'Z'` are matched.

`re.L`

re.LOCALE

Make `\w`, `\W`, `\b`, `\B` and case-insensitive matching dependent on the current locale. This flag can be used only with bytes patterns.

Corresponds to the inline flag `(?L)`.

警告： This flag is discouraged; consider Unicode matching instead. The locale mechanism is very unreliable as it only handles one "culture" at a time and only works with 8-bit locales. Unicode matching is enabled by default for Unicode (str) patterns and it is able to handle different locales and languages.

在 3.6 版的變更: `LOCALE` can be used only with bytes patterns and is not compatible with `ASCII`.

在 3.7 版的變更: Compiled regular expression objects with the `LOCALE` flag no longer depend on the locale at compile time. Only the locale at matching time affects the result of matching.

re.M**re.MULTILINE**

When specified, the pattern character `'^'` matches at the beginning of the string and at the beginning of each line (immediately following each newline); and the pattern character `'$'` matches at the end of the string and at the end of each line (immediately preceding each newline). By default, `'^'` matches only at the beginning of the string, and `'$'` only at the end of the string and immediately before the newline (if any) at the end of the string.

Corresponds to the inline flag `(?m)`.

re.NOFLAG

Indicates no flag being applied, the value is 0. This flag may be used as a default value for a function keyword argument or as a base value that will be conditionally ORed with other flags. Example of use as a default value:

```
def myfunc(text, flag=re.NOFLAG):  
    return re.match(text, flag)
```

在 3.11 版新加入.

re.S**re.DOTALL**

Make the `'.'` special character match any character at all, including a newline; without this flag, `'.'` will match anything *except* a newline.

Corresponds to the inline flag `(?s)`.

re.U**re.UNICODE**

In Python 3, Unicode characters are matched by default for `str` patterns. This flag is therefore redundant with **no effect** and is only kept for backward compatibility.

See `ASCII` to restrict matching to ASCII characters instead.

re.X**re.VERBOSE**

This flag allows you to write regular expressions that look nicer and are more readable by allowing you to visually separate logical sections of the pattern and add comments. Whitespace within the pattern is ignored, except when in a character class, or when preceded by an unescaped backslash, or within tokens like `*?`, `(?:` or `(?P<...>.` For example, `(? :` and `* ?` are not allowed. When a line contains a `#` that is not in a character class and is not preceded by an unescaped backslash, all characters from the leftmost such `#` through the end of the line are ignored.

This means that the two following regular expression objects that match a decimal number are functionally equal:

```
a = re.compile(r"""\d + # the integral part
               \. # the decimal point
               \d * # some fractional digits""", re.X)
b = re.compile(r"\d+\.\d*")
```

Corresponds to the inline flag `(?x)`.

Functions

`re.compile(pattern, flags=0)`

Compile a regular expression pattern into a *regular expression object*, which can be used for matching using its `match()`, `search()` and other methods, described below.

The expression's behaviour can be modified by specifying a *flags* value. Values can be any of the *flags* variables, combined using bitwise OR (the `|` operator).

The sequence

```
prog = re.compile(pattern)
result = prog.match(string)
```

等價於：

```
result = re.match(pattern, string)
```

but using `re.compile()` and saving the resulting regular expression object for reuse is more efficient when the expression will be used several times in a single program.

備F: The compiled versions of the most recent patterns passed to `re.compile()` and the module-level matching functions are cached, so programs that use only a few regular expressions at a time needn't worry about compiling regular expressions.

`re.search(pattern, string, flags=0)`

Scan through *string* looking for the first location where the regular expression *pattern* produces a match, and return a corresponding *Match*. Return `None` if no position in the string matches the pattern; note that this is different from finding a zero-length match at some point in the string.

`re.match(pattern, string, flags=0)`

If zero or more characters at the beginning of *string* match the regular expression *pattern*, return a corresponding *Match*. Return `None` if the string does not match the pattern; note that this is different from a zero-length match.

Note that even in *MULTILINE* mode, `re.match()` will only match at the beginning of the string and not at the beginning of each line.

If you want to locate a match anywhere in *string*, use `search()` instead (see also *search() vs. match()*).

`re.fullmatch(pattern, string, flags=0)`

If the whole *string* matches the regular expression *pattern*, return a corresponding *Match*. Return `None` if the string does not match the pattern; note that this is different from a zero-length match.

在 3.4 版新加入。

`re.split(pattern, string, maxsplit=0, flags=0)`

Split *string* by the occurrences of *pattern*. If capturing parentheses are used in *pattern*, then the text of all groups in the pattern are also returned as part of the resulting list. If *maxsplit* is nonzero, at most *maxsplit* splits occur, and the remainder of the string is returned as the final element of the list.

```
>>> re.split(r'\W+', 'Words, words, words.')
['Words', 'words', 'words', '']
>>> re.split(r'(\W+)', 'Words, words, words.')
['Words', '', ' ', 'words', '', ' ', 'words', '.', '']
>>> re.split(r'\W+', 'Words, words, words.', 1)
['Words', 'words, words.']
>>> re.split('[a-f]+', '0a3B9', flags=re.IGNORECASE)
['0', '3', '9']
```

If there are capturing groups in the separator and it matches at the start of the string, the result will start with an empty string. The same holds for the end of the string:

```
>>> re.split(r'(\W+)', '...words, words...')
['', '...', 'words', '', ' ', 'words', '...', '']
```

That way, separator components are always found at the same relative indices within the result list.

Empty matches for the pattern split the string only when not adjacent to a previous empty match.

```
>>> re.split(r'\b', 'Words, words, words.')
['', 'Words', '', ' ', 'words', '', ' ', 'words', '.', '']
>>> re.split(r'\W*', '...words...')
['', '', 'w', 'o', 'r', 'd', 's', '', '']
>>> re.split(r'(\W*)', '...words...')
['', '...', '', '', 'w', '', 'o', '', 'r', '', 'd', '', 's', '...', '', '', '']
```

在 3.1 版的變更: Added the optional flags argument.

在 3.7 版的變更: Added support of splitting on a pattern that could match an empty string.

re.findall (*pattern*, *string*, *flags=0*)

Return all non-overlapping matches of *pattern* in *string*, as a list of strings or tuples. The *string* is scanned left-to-right, and matches are returned in the order found. Empty matches are included in the result.

The result depends on the number of capturing groups in the pattern. If there are no groups, return a list of strings matching the whole pattern. If there is exactly one group, return a list of strings matching that group. If multiple groups are present, return a list of tuples of strings matching the groups. Non-capturing groups do not affect the form of the result.

```
>>> re.findall(r'\bf[a-z]*', 'which foot or hand fell fastest')
['foot', 'fell', 'fastest']
>>> re.findall(r'(\w+)=(\d+)', 'set width=20 and height=10')
[('width', '20'), ('height', '10')]
```

在 3.7 版的變更: Non-empty matches can now start just after a previous empty match.

re.finditer (*pattern*, *string*, *flags=0*)

Return an *iterator* yielding *Match* objects over all non-overlapping matches for the RE *pattern* in *string*. The *string* is scanned left-to-right, and matches are returned in the order found. Empty matches are included in the result.

在 3.7 版的變更: Non-empty matches can now start just after a previous empty match.

re.sub (*pattern*, *repl*, *string*, *count=0*, *flags=0*)

Return the string obtained by replacing the leftmost non-overlapping occurrences of *pattern* in *string* by the replacement *repl*. If the pattern isn't found, *string* is returned unchanged. *repl* can be a string or a function; if it is a string, any backslash escapes in it are processed. That is, `\n` is converted to a single newline character, `\r` is converted to a carriage return, and so forth. Unknown escapes of ASCII letters are reserved for future use and treated as errors. Other unknown escapes such as `\6` are left alone. Backreferences, such as `\6`, are replaced with the substring matched by group 6 in the pattern. For example:

```
>>> re.sub(r'def\s+([a-zA-Z_][a-zA-Z_0-9]*)\s*(\s*\n\s*):',
...        r'static PyObject*\numpy_1(void)\n{ ',
...        'def myfunc():')
'static PyObject*\numpy_myfunc(void)\n{'
```

If *repl* is a function, it is called for every non-overlapping occurrence of *pattern*. The function takes a single *Match* argument, and returns the replacement string. For example:

```
>>> def dashrepl(matchobj):
...     if matchobj.group(0) == '-': return ' '
...     else: return '-'
>>> re.sub('-{1,2}', dashrepl, 'pro---gram-files')
'pro--gram files'
>>> re.sub(r'\sAND\s', ' & ', 'Baked Beans And Spam', flags=re.IGNORECASE)
'Baked Beans & Spam'
```

The pattern may be a string or a *Pattern*.

The optional argument *count* is the maximum number of pattern occurrences to be replaced; *count* must be a non-negative integer. If omitted or zero, all occurrences will be replaced. Empty matches for the pattern are replaced only when not adjacent to a previous empty match, so `sub('x*', '-', 'abxd')` returns `'-a-b--d-'`.

In string-type *repl* arguments, in addition to the character escapes and backreferences described above, `\g<name>` will use the substring matched by the group named *name*, as defined by the `(?P<name>...)` syntax. `\g<number>` uses the corresponding group number; `\g<2>` is therefore equivalent to `\2`, but isn't ambiguous in a replacement such as `\g<2>0`. `\20` would be interpreted as a reference to group 20, not a reference to group 2 followed by the literal character `'0'`. The backreference `\g<0>` substitutes in the entire substring matched by the RE.

在 3.1 版的變更: Added the optional flags argument.

在 3.5 版的變更: Unmatched groups are replaced with an empty string.

在 3.6 版的變更: Unknown escapes in *pattern* consisting of `'\'` and an ASCII letter now are errors.

在 3.7 版的變更: Unknown escapes in *repl* consisting of `'\'` and an ASCII letter now are errors.

在 3.7 版的變更: Empty matches for the pattern are replaced when adjacent to a previous non-empty match.

在 3.11 版之後被採用: Group *id* containing anything except ASCII digits. Group *name* containing characters outside the ASCII range (`b'\x00'-b'\x7f'`) in *bytes* replacement strings.

re.subn (*pattern*, *repl*, *string*, *count*=0, *flags*=0)

Perform the same operation as `sub()`, but return a tuple (*new_string*, *number_of_subs_made*).

在 3.1 版的變更: Added the optional flags argument.

在 3.5 版的變更: Unmatched groups are replaced with an empty string.

re.escape (*pattern*)

Escape special characters in *pattern*. This is useful if you want to match an arbitrary literal string that may have regular expression metacharacters in it. For example:

```
>>> print(re.escape('https://www.python.org'))
https://www.python.org

>>> legal_chars = string.ascii_lowercase + string.digits + "!#$%&'*+-.^_`|~:"
>>> print('[%s]+' % re.escape(legal_chars))
[abcdefghijklmnopqrstuvwxyz0123456789!#$%&'*\+\-\.^_`|~:]+

>>> operators = ['+', '-', '*', '/', '**']
>>> print(''.join(map(re.escape, sorted(operators, reverse=True))))
/|-|+|*|**|
```

This function must not be used for the replacement string in `sub()` and `subn()`, only backslashes should be escaped. For example:

```
>>> digits_re = r'\d+'
>>> sample = '/usr/sbin/sendmail - 0 errors, 12 warnings'
>>> print(re.sub(digits_re, digits_re.replace('\\', r'\\'), sample))
/usr/sbin/sendmail - \d+ errors, \d+ warnings
```

在 3.3 版的變更: The `'_'` character is no longer escaped.

在 3.7 版的變更: Only characters that can have special meaning in a regular expression are escaped. As a result, `'!'`, `'\"'`, `'%'`, `'\"'`, `'.'`, `'/'`, `':'`, `','`, `'<'`, `'='`, `'>'`, `'@'`, and `'\"'` are no longer escaped.

`re.purge()`

Clear the regular expression cache.

Exceptions

exception `re.error` (*msg*, *pattern=None*, *pos=None*)

Exception raised when a string passed to one of the functions here is not a valid regular expression (for example, it might contain unmatched parentheses) or when some other error occurs during compilation or matching. It is never an error if a string contains no match for a pattern. The error instance has the following additional attributes:

msg

The unformatted error message.

pattern

The regular expression pattern.

pos

The index in *pattern* where compilation failed (may be `None`).

lineno

The line corresponding to *pos* (may be `None`).

colno

The column corresponding to *pos* (may be `None`).

在 3.5 版的變更: 新增額外屬性。

6.2.3 Regular Expression Objects

class `re.Pattern`

Compiled regular expression object returned by `re.compile()`.

在 3.9 版的變更: `re.Pattern` supports `[]` to indicate a Unicode (str) or bytes pattern. See *Generic Alias Type*.

`Pattern.search(string[, pos[, endpos]])`

Scan through *string* looking for the first location where this regular expression produces a match, and return a corresponding *Match*. Return `None` if no position in the string matches the pattern; note that this is different from finding a zero-length match at some point in the string.

The optional second parameter *pos* gives an index in the string where the search is to start; it defaults to 0. This is not completely equivalent to slicing the string; the `'^'` pattern character matches at the real beginning of the string and at positions just after a newline, but not necessarily at the index where the search is to start.

The optional parameter *endpos* limits how far the string will be searched; it will be as if the string is *endpos* characters long, so only the characters from *pos* to *endpos* - 1 will be searched for a match. If *endpos* is less than

pos, no match will be found; otherwise, if *rx* is a compiled regular expression object, `rx.search(string, 0, 50)` is equivalent to `rx.search(string[:50], 0)`.

```
>>> pattern = re.compile("d")
>>> pattern.search("dog")      # Match at index 0
<re.Match object; span=(0, 1), match='d'>
>>> pattern.search("dog", 1)   # No match; search doesn't include the "d"
```

`Pattern.match(string[, pos[, endpos]])`

If zero or more characters at the *beginning* of *string* match this regular expression, return a corresponding *Match*. Return *None* if the string does not match the pattern; note that this is different from a zero-length match.

The optional *pos* and *endpos* parameters have the same meaning as for the *search()* method.

```
>>> pattern = re.compile("o")
>>> pattern.match("dog")      # No match as "o" is not at the start of "dog".
>>> pattern.match("dog", 1)   # Match as "o" is the 2nd character of "dog".
<re.Match object; span=(1, 2), match='o'>
```

If you want to locate a match anywhere in *string*, use *search()* instead (see also *search()* vs. *match()*).

`Pattern.fullmatch(string[, pos[, endpos]])`

If the whole *string* matches this regular expression, return a corresponding *Match*. Return *None* if the string does not match the pattern; note that this is different from a zero-length match.

The optional *pos* and *endpos* parameters have the same meaning as for the *search()* method.

```
>>> pattern = re.compile("o[gh]")
>>> pattern.fullmatch("dog")  # No match as "o" is not at the start of "dog"
→ ".
>>> pattern.fullmatch("ogre") # No match as not the full string matches.
>>> pattern.fullmatch("doggie", 1, 3) # Matches within given limits.
<re.Match object; span=(1, 3), match='og'>
```

在 3.4 版新加入.

`Pattern.split(string, maxsplit=0)`

Identical to the *split()* function, using the compiled pattern.

`Pattern.findall(string[, pos[, endpos]])`

Similar to the *findall()* function, using the compiled pattern, but also accepts optional *pos* and *endpos* parameters that limit the search region like for *search()*.

`Pattern.finditer(string[, pos[, endpos]])`

Similar to the *finditer()* function, using the compiled pattern, but also accepts optional *pos* and *endpos* parameters that limit the search region like for *search()*.

`Pattern.sub(repl, string, count=0)`

Identical to the *sub()* function, using the compiled pattern.

`Pattern.subn(repl, string, count=0)`

Identical to the *subn()* function, using the compiled pattern.

`Pattern.flags`

The regex matching flags. This is a combination of the flags given to *compile()*, any *(? . . .)* inline flags in the pattern, and implicit flags such as *UNICODE* if the pattern is a Unicode string.

`Pattern.groups`

The number of capturing groups in the pattern.

Pattern.groupindex

A dictionary mapping any symbolic group names defined by `(?P<id>)` to group numbers. The dictionary is empty if no symbolic groups were used in the pattern.

Pattern.pattern

The pattern string from which the pattern object was compiled.

在 3.7 版的變更: Added support of `copy.copy()` and `copy.deepcopy()`. Compiled regular expression objects are considered atomic.

6.2.4 Match Objects

Match objects always have a boolean value of `True`. Since `match()` and `search()` return `None` when there is no match, you can test whether there was a match with a simple `if` statement:

```
match = re.search(pattern, string)
if match:
    process(match)
```

class re.Match

Match object returned by successful matches and searches.

在 3.9 版的變更: `re.Match` supports `[]` to indicate a Unicode (str) or bytes match. See *Generic Alias Type*.

Match.expand(template)

Return the string obtained by doing backslash substitution on the template string *template*, as done by the `sub()` method. Escapes such as `\n` are converted to the appropriate characters, and numeric backreferences (`\1`, `\2`) and named backreferences (`\g<1>`, `\g<name>`) are replaced by the contents of the corresponding group. The backreference `\g<0>` will be replaced by the entire match.

在 3.5 版的變更: Unmatched groups are replaced with an empty string.

Match.group([group1, ...])

Returns one or more subgroups of the match. If there is a single argument, the result is a single string; if there are multiple arguments, the result is a tuple with one item per argument. Without arguments, *group1* defaults to zero (the whole match is returned). If a *groupN* argument is zero, the corresponding return value is the entire matching string; if it is in the inclusive range `[1..99]`, it is the string matching the corresponding parenthesized group. If a group number is negative or larger than the number of groups defined in the pattern, an `IndexError` exception is raised. If a group is contained in a part of the pattern that did not match, the corresponding result is `None`. If a group is contained in a part of the pattern that matched multiple times, the last match is returned.

```
>>> m = re.match(r"(\w+) (\w+)", "Isaac Newton, physicist")
>>> m.group(0)           # The entire match
'Isaac Newton'
>>> m.group(1)           # The first parenthesized subgroup.
'Isaac'
>>> m.group(2)           # The second parenthesized subgroup.
'Newton'
>>> m.group(1, 2)        # Multiple arguments give us a tuple.
('Isaac', 'Newton')
```

If the regular expression uses the `(?P<name>...)` syntax, the *groupN* arguments may also be strings identifying groups by their group name. If a string argument is not used as a group name in the pattern, an `IndexError` exception is raised.

A moderately complicated example:

```
>>> m = re.match(r"(?P<first_name>\w+) (?P<last_name>\w+)", "Malcolm Reynolds")
>>> m.group('first_name')
```

(繼續下一頁)

(繼續上一頁)

```
'Malcolm'
>>> m.group('last_name')
'Reynolds'
```

Named groups can also be referred to by their index:

```
>>> m.group(1)
'Malcolm'
>>> m.group(2)
'Reynolds'
```

If a group matches multiple times, only the last match is accessible:

```
>>> m = re.match(r"(.)+", "a1b2c3") # Matches 3 times.
>>> m.group(1)                       # Returns only the last match.
'c3'
```

Match.**__getitem__**(g)

This is identical to `m.group(g)`. This allows easier access to an individual group from a match:

```
>>> m = re.match(r"(\w+) (\w+)", "Isaac Newton, physicist")
>>> m[0]          # The entire match
'Isaac Newton'
>>> m[1]          # The first parenthesized subgroup.
'Isaac'
>>> m[2]          # The second parenthesized subgroup.
'Newton'
```

Named groups are supported as well:

```
>>> m = re.match(r"(?P<first_name>\w+) (?P<last_name>\w+)", "Isaac Newton")
>>> m['first_name']
'Isaac'
>>> m['last_name']
'Newton'
```

在 3.6 版新加入.

Match.**groups**(default=None)

Return a tuple containing all the subgroups of the match, from 1 up to however many groups are in the pattern. The *default* argument is used for groups that did not participate in the match; it defaults to None.

舉例來 F:

```
>>> m = re.match(r"(\d+)\.(\d+)", "24.1632")
>>> m.groups()
('24', '1632')
```

If we make the decimal place and everything after it optional, not all groups might participate in the match. These groups will default to None unless the *default* argument is given:

```
>>> m = re.match(r"(\d+)\.?(\\d+)?", "24")
>>> m.groups()          # Second group defaults to None.
('24', None)
>>> m.groups('0')      # Now, the second group defaults to '0'.
('24', '0')
```

Match.**groupdict**(default=None)

Return a dictionary containing all the *named* subgroups of the match, keyed by the subgroup name. The *default* argument is used for groups that did not participate in the match; it defaults to None. For example:

```
>>> m = re.match(r"(?P<first_name>\w+) (?P<last_name>\w+)", "Malcolm Reynolds")
>>> m.groupdict()
{'first_name': 'Malcolm', 'last_name': 'Reynolds'}
```

`Match.start([group])`

`Match.end([group])`

Return the indices of the start and end of the substring matched by *group*; *group* defaults to zero (meaning the whole matched substring). Return `-1` if *group* exists but did not contribute to the match. For a match object *m*, and a group *g* that did contribute to the match, the substring matched by group *g* (equivalent to `m.group(g)`) is

```
m.string[m.start(g):m.end(g)]
```

Note that `m.start(group)` will equal `m.end(group)` if *group* matched a null string. For example, after `m = re.search('b(c?)', 'cba')`, `m.start(0)` is 1, `m.end(0)` is 2, `m.start(1)` and `m.end(1)` are both 2, and `m.start(2)` raises an `IndexError` exception.

An example that will remove `remove_this` from email addresses:

```
>>> email = "tony@tremove_thisger.net"
>>> m = re.search("remove_this", email)
>>> email[:m.start()] + email[m.end():]
'tony@tiger.net'
```

`Match.span([group])`

For a match *m*, return the 2-tuple `(m.start(group), m.end(group))`. Note that if *group* did not contribute to the match, this is `(-1, -1)`. *group* defaults to zero, the entire match.

`Match.pos`

The value of *pos* which was passed to the `search()` or `match()` method of a *regex object*. This is the index into the string at which the RE engine started looking for a match.

`Match.endpos`

The value of *endpos* which was passed to the `search()` or `match()` method of a *regex object*. This is the index into the string beyond which the RE engine will not go.

`Match.lastindex`

The integer index of the last matched capturing group, or `None` if no group was matched at all. For example, the expressions `(a)b`, `((a)(b))`, and `((ab))` will have `lastindex == 1` if applied to the string `'ab'`, while the expression `(a)(b)` will have `lastindex == 2`, if applied to the same string.

`Match.lastgroup`

The name of the last matched capturing group, or `None` if the group didn't have a name, or if no group was matched at all.

`Match.re`

The *regular expression object* whose `match()` or `search()` method produced this match instance.

`Match.string`

The string passed to `match()` or `search()`.

在 3.7 版的變更: Added support of `copy.copy()` and `copy.deepcopy()`. Match objects are considered atomic.

6.2.5 Regular Expression Examples

Checking for a Pair

In this example, we'll use the following helper function to display match objects a little more gracefully:

```
def displaymatch(match):
    if match is None:
        return None
    return '<Match: %r, groups=%r>' % (match.group(), match.groups())
```

Suppose you are writing a poker program where a player's hand is represented as a 5-character string with each character representing a card, "a" for ace, "k" for king, "q" for queen, "j" for jack, "t" for 10, and "2" through "9" representing the card with that value.

To see if a given string is a valid hand, one could do the following:

```
>>> valid = re.compile(r"^[a2-9tjqk]{5}$")
>>> displaymatch(valid.match("akt5q")) # Valid.
"<Match: 'akt5q', groups=()>"
>>> displaymatch(valid.match("akt5e")) # Invalid.
>>> displaymatch(valid.match("akt")) # Invalid.
>>> displaymatch(valid.match("727ak")) # Valid.
"<Match: '727ak', groups=()>"
```

That last hand, "727ak", contained a pair, or two of the same valued cards. To match this with a regular expression, one could use backreferences as such:

```
>>> pair = re.compile(r"^(.*)\1")
>>> displaymatch(pair.match("717ak")) # Pair of 7s.
"<Match: '717', groups=('7',)>"
>>> displaymatch(pair.match("718ak")) # No pairs.
>>> displaymatch(pair.match("354aa")) # Pair of aces.
"<Match: '354aa', groups=('a',)>"
```

To find out what card the pair consists of, one could use the `group()` method of the match object in the following manner:

```
>>> pair = re.compile(r"^(.*)\1")
>>> pair.match("717ak").group(1)
'7'

# Error because re.match() returns None, which doesn't have a group() method:
>>> pair.match("718ak").group(1)
Traceback (most recent call last):
  File "<pyshe11#23>", line 1, in <module>
    re.match(r"^(.*)\1", "718ak").group(1)
AttributeError: 'NoneType' object has no attribute 'group'

>>> pair.match("354aa").group(1)
'a'
```

Simulating scanf()

Python does not currently have an equivalent to `scanf()`. Regular expressions are generally more powerful, though also more verbose, than `scanf()` format strings. The table below offers some more-or-less equivalent mappings between `scanf()` format tokens and regular expressions.

scanf() Token	Regular Expression
%c	.
%5c	.{5}
%d	[−+]? \d+
%e, %E, %f, %g	[−+]? (\d+ (\.\d*)? \.\d+) ([eE] [−+]? \d+)?
%i	[−+]? (0[xX] [\dA−Fa−f]+ 0[0−7]* \d+)
%o	[−+]? [0−7]+
%s	\S+
%u	\d+
%x, %X	[−+]? (0[xX])? [\dA−Fa−f]+

To extract the filename and numbers from a string like

```
/usr/sbin/sendmail - 0 errors, 4 warnings
```

you would use a `scanf()` format like

```
%s - %d errors, %d warnings
```

The equivalent regular expression would be

```
(\S+) - (\d+) errors, (\d+) warnings
```

search() vs. match()

Python offers different primitive operations based on regular expressions:

- `re.match()` checks for a match only at the beginning of the string
- `re.search()` checks for a match anywhere in the string (this is what Perl does by default)
- `re.fullmatch()` checks for entire string to be a match

舉例來 F:

```
>>> re.match("c", "abcdef")      # No match
>>> re.search("c", "abcdef")     # Match
<re.Match object; span=(2, 3), match='c'>
>>> re.fullmatch("p.*n", "python") # Match
<re.Match object; span=(0, 6), match='python'>
>>> re.fullmatch("r.*n", "python") # No match
```

Regular expressions beginning with `'^'` can be used with `search()` to restrict the match at the beginning of the string:

```
>>> re.match("c", "abcdef")      # No match
>>> re.search("^c", "abcdef")    # No match
>>> re.search("^a", "abcdef")    # Match
<re.Match object; span=(0, 1), match='a'>
```

Note however that in *MULTILINE* mode `match()` only matches at the beginning of the string, whereas using `search()` with a regular expression beginning with `'^'` will match at the beginning of each line.

```
>>> re.match("X", "A\\nB\\nX", re.MULTILINE) # No match
>>> re.search("^X", "A\\nB\\nX", re.MULTILINE) # Match
<re.Match object; span=(4, 5), match='X'>
```

Making a Phonebook

`split()` splits a string into a list delimited by the passed pattern. The method is invaluable for converting textual data into data structures that can be easily read and modified by Python as demonstrated in the following example that creates a phonebook.

First, here is the input. Normally it may come from a file, here we are using triple-quoted string syntax

```
>>> text = """Ross McFluff: 834.345.1254 155 Elm Street
...
... Ronald Heathmore: 892.345.3428 436 Finley Avenue
... Frank Burger: 925.541.7625 662 South Dogwood Way
...
...
... Heather Albrecht: 548.326.4584 919 Park Place"""
```

The entries are separated by one or more newlines. Now we convert the string into a list with each nonempty line having its own entry:

```
>>> entries = re.split("\\n+", text)
>>> entries
['Ross McFluff: 834.345.1254 155 Elm Street',
 'Ronald Heathmore: 892.345.3428 436 Finley Avenue',
 'Frank Burger: 925.541.7625 662 South Dogwood Way',
 'Heather Albrecht: 548.326.4584 919 Park Place']
```

Finally, split each entry into a list with first name, last name, telephone number, and address. We use the `maxsplit` parameter of `split()` because the address has spaces, our splitting pattern, in it:

```
>>> [re.split("?: ", entry, 3) for entry in entries]
[['Ross', 'McFluff', '834.345.1254', '155 Elm Street'],
 ['Ronald', 'Heathmore', '892.345.3428', '436 Finley Avenue'],
 ['Frank', 'Burger', '925.541.7625', '662 South Dogwood Way'],
 ['Heather', 'Albrecht', '548.326.4584', '919 Park Place']]
```

The `?:` pattern matches the colon after the last name, so that it does not occur in the result list. With a `maxsplit` of 4, we could separate the house number from the street name:

```
>>> [re.split("?: ", entry, 4) for entry in entries]
[['Ross', 'McFluff', '834.345.1254', '155', 'Elm Street'],
 ['Ronald', 'Heathmore', '892.345.3428', '436', 'Finley Avenue'],
 ['Frank', 'Burger', '925.541.7625', '662', 'South Dogwood Way'],
 ['Heather', 'Albrecht', '548.326.4584', '919', 'Park Place']]
```

Text Munging

`sub()` replaces every occurrence of a pattern with a string or the result of a function. This example demonstrates using `sub()` with a function to “munge” text, or randomize the order of all the characters in each word of a sentence except for the first and last characters:

```
>>> def repl(m):
...     inner_word = list(m.group(2))
...     random.shuffle(inner_word)
...     return m.group(1) + "".join(inner_word) + m.group(3)
```

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```
>>> text = "Professor Abdolmalek, please report your absences promptly."
>>> re.sub(r"(\w)(\w+)(\w)", repl, text)
'Poefsrosr Aealmlobdk, pslaee reorpt your abnseces plmrptoy.'
>>> re.sub(r"(\w)(\w+)(\w)", repl, text)
'Pofsroser Aodlambelk, plasee reorpt yuor asnebces potlmpy.'
```

Finding all Adverbs

findall() matches *all* occurrences of a pattern, not just the first one as *search()* does. For example, if a writer wanted to find all of the adverbs in some text, they might use *findall()* in the following manner:

```
>>> text = "He was carefully disguised but captured quickly by police."
>>> re.findall(r"\w+ly\b", text)
['carefully', 'quickly']
```

Finding all Adverbs and their Positions

If one wants more information about all matches of a pattern than the matched text, *finditer()* is useful as it provides *Match* objects instead of strings. Continuing with the previous example, if a writer wanted to find all of the adverbs *and their positions* in some text, they would use *finditer()* in the following manner:

```
>>> text = "He was carefully disguised but captured quickly by police."
>>> for m in re.finditer(r"\w+ly\b", text):
...     print('%02d-%02d: %s' % (m.start(), m.end(), m.group(0)))
07-16: carefully
40-47: quickly
```

Raw String Notation

Raw string notation (`r"text"`) keeps regular expressions sane. Without it, every backslash (`'\'`) in a regular expression would have to be prefixed with another one to escape it. For example, the two following lines of code are functionally identical:

```
>>> re.match(r"W(.)\1W", " ff ")
<re.Match object; span=(0, 4), match=' ff '>
>>> re.match("\\W(.)\\1\\W", " ff ")
<re.Match object; span=(0, 4), match=' ff '>
```

When one wants to match a literal backslash, it must be escaped in the regular expression. With raw string notation, this means `r"\"`. Without raw string notation, one must use `"\\\"`, making the following lines of code functionally identical:

```
>>> re.match(r"\\", r"\\")
<re.Match object; span=(0, 1), match='\\ '>
>>> re.match("\\\\", r"\\")
<re.Match object; span=(0, 1), match='\\ '>
```

Writing a Tokenizer

A [tokenizer](#) or [scanner](#) analyzes a string to categorize groups of characters. This is a useful first step in writing a compiler or interpreter.

The text categories are specified with regular expressions. The technique is to combine those into a single master regular expression and to loop over successive matches:

```
from typing import NamedTuple
import re

class Token(NamedTuple):
    type: str
    value: str
    line: int
    column: int

def tokenize(code):
    keywords = {'IF', 'THEN', 'ENDIF', 'FOR', 'NEXT', 'GOSUB', 'RETURN'}
    token_specification = [
        ('NUMBER',  r'\d+(\.\d*)?'), # Integer or decimal number
        ('ASSIGN',   r':='),          # Assignment operator
        ('END',      r';'),            # Statement terminator
        ('ID',       r'[A-Za-z]+'),   # Identifiers
        ('OP',       r'[+-*\/]'),     # Arithmetic operators
        ('NEWLINE',  r'\n'),          # Line endings
        ('SKIP',     r'[ \t]+'),      # Skip over spaces and tabs
        ('MISMATCH', r'.'),           # Any other character
    ]
    tok_regex = '|'.join('(?P<%s>%s)' % pair for pair in token_specification)
    line_num = 1
    line_start = 0
    for mo in re.finditer(tok_regex, code):
        kind = mo.lastgroup
        value = mo.group()
        column = mo.start() - line_start
        if kind == 'NUMBER':
            value = float(value) if '.' in value else int(value)
        elif kind == 'ID' and value in keywords:
            kind = value
        elif kind == 'NEWLINE':
            line_start = mo.end()
            line_num += 1
            continue
        elif kind == 'SKIP':
            continue
        elif kind == 'MISMATCH':
            raise RuntimeError(f'{value!r} unexpected on line {line_num!r}')
        yield Token(kind, value, line_num, column)

statements = '''
    IF quantity THEN
        total := total + price * quantity;
        tax := price * 0.05;
    ENDIF;
'''

for token in tokenize(statements):
    print(token)
```

The tokenizer produces the following output:

```

Token(type='IF', value='IF', line=2, column=4)
Token(type='ID', value='quantity', line=2, column=7)
Token(type='THEN', value='THEN', line=2, column=16)
Token(type='ID', value='total', line=3, column=8)
Token(type='ASSIGN', value=':=', line=3, column=14)
Token(type='ID', value='total', line=3, column=17)
Token(type='OP', value='+', line=3, column=23)
Token(type='ID', value='price', line=3, column=25)
Token(type='OP', value='*', line=3, column=31)
Token(type='ID', value='quantity', line=3, column=33)
Token(type='END', value=';', line=3, column=41)
Token(type='ID', value='tax', line=4, column=8)
Token(type='ASSIGN', value=':=', line=4, column=12)
Token(type='ID', value='price', line=4, column=15)
Token(type='OP', value='*', line=4, column=21)
Token(type='NUMBER', value=0.05, line=4, column=23)
Token(type='END', value=';', line=4, column=27)
Token(type='ENDIF', value='ENDIF', line=5, column=4)
Token(type='END', value=';', line=5, column=9)

```

6.3 difflib --- Helpers for computing deltas

原始碼: [Lib/difflib.py](#)

This module provides classes and functions for comparing sequences. It can be used for example, for comparing files, and can produce information about file differences in various formats, including HTML and context and unified diffs. For comparing directories and files, see also, the [filecmp](#) module.

class difflib.SequenceMatcher

This is a flexible class for comparing pairs of sequences of any type, so long as the sequence elements are *hashable*. The basic algorithm predates, and is a little fancier than, an algorithm published in the late 1980's by Ratcliff and Obershelp under the hyperbolic name "gestalt pattern matching." The idea is to find the longest contiguous matching subsequence that contains no "junk" elements; these "junk" elements are ones that are uninteresting in some sense, such as blank lines or whitespace. (Handling junk is an extension to the Ratcliff and Obershelp algorithm.) The same idea is then applied recursively to the pieces of the sequences to the left and to the right of the matching subsequence. This does not yield minimal edit sequences, but does tend to yield matches that "look right" to people.

Timing: The basic Ratcliff-Obershelp algorithm is cubic time in the worst case and quadratic time in the expected case. *SequenceMatcher* is quadratic time for the worst case and has expected-case behavior dependent in a complicated way on how many elements the sequences have in common; best case time is linear.

Automatic junk heuristic: *SequenceMatcher* supports a heuristic that automatically treats certain sequence items as junk. The heuristic counts how many times each individual item appears in the sequence. If an item's duplicates (after the first one) account for more than 1% of the sequence and the sequence is at least 200 items long, this item is marked as "popular" and is treated as junk for the purpose of sequence matching. This heuristic can be turned off by setting the `autojunk` argument to `False` when creating the *SequenceMatcher*.

在 3.2 版的變更: Added the *autojunk* parameter.

class difflib.Differ

This is a class for comparing sequences of lines of text, and producing human-readable differences or deltas. Differ uses *SequenceMatcher* both to compare sequences of lines, and to compare sequences of characters within similar (near-matching) lines.

Each line of a *Differ* delta begins with a two-letter code:

Code	Meaning
' - '	line unique to sequence 1
' + '	line unique to sequence 2
' '	line common to both sequences
' ? '	line not present in either input sequence

Lines beginning with '?' attempt to guide the eye to intraline differences, and were not present in either input sequence. These lines can be confusing if the sequences contain tab characters.

class `difflib.HtmlDiff`

This class can be used to create an HTML table (or a complete HTML file containing the table) showing a side by side, line by line comparison of text with inter-line and intra-line change highlights. The table can be generated in either full or contextual difference mode.

The constructor for this class is:

__init__ (*tabsize=8, wrapcolumn=None, linejunk=None, charjunk=IS_CHARACTER_JUNK*)

Initializes instance of `HtmlDiff`.

tabsize is an optional keyword argument to specify tab stop spacing and defaults to 8.

wrapcolumn is an optional keyword to specify column number where lines are broken and wrapped, defaults to `None` where lines are not wrapped.

linejunk and *charjunk* are optional keyword arguments passed into `ndiff()` (used by `HtmlDiff` to generate the side by side HTML differences). See `ndiff()` documentation for argument default values and descriptions.

The following methods are public:

make_file (*fromlines, tolines, fromdesc="", todesc="", context=False, numlines=5, *, charset='utf-8'*)

Compares *fromlines* and *toline*s (lists of strings) and returns a string which is a complete HTML file containing a table showing line by line differences with inter-line and intra-line changes highlighted.

fromdesc and *todesc* are optional keyword arguments to specify from/to file column header strings (both default to an empty string).

context and *numlines* are both optional keyword arguments. Set *context* to `True` when contextual differences are to be shown, else the default is `False` to show the full files. *numlines* defaults to 5. When *context* is `True` *numlines* controls the number of context lines which surround the difference highlights. When *context* is `False` *numlines* controls the number of lines which are shown before a difference highlight when using the "next" hyperlinks (setting to zero would cause the "next" hyperlinks to place the next difference highlight at the top of the browser without any leading context).

備註: *fromdesc* and *todesc* are interpreted as unescaped HTML and should be properly escaped while receiving input from untrusted sources.

在 3.5 版的變更: *charset* keyword-only argument was added. The default charset of HTML document changed from 'ISO-8859-1' to 'utf-8'.

make_table (*fromlines, tolines, fromdesc="", todesc="", context=False, numlines=5*)

Compares *fromlines* and *toline*s (lists of strings) and returns a string which is a complete HTML table showing line by line differences with inter-line and intra-line changes highlighted.

The arguments for this method are the same as those for the `make_file()` method.

`Tools/scripts/diff.py` is a command-line front-end to this class and contains a good example of its use.

`difflib.context_diff(a, b, fromfile="", tofile="", fromfiledate="", tofiledate="", n=3, lineterm='\n')`

Compare *a* and *b* (lists of strings); return a delta (a *generator* generating the delta lines) in context diff format.

Context diffs are a compact way of showing just the lines that have changed plus a few lines of context. The changes are shown in a before/after style. The number of context lines is set by *n* which defaults to three.

By default, the diff control lines (those with `***` or `---`) are created with a trailing newline. This is helpful so that inputs created from `io.IOBase.readlines()` result in diffs that are suitable for use with `io.IOBase.writelines()` since both the inputs and outputs have trailing newlines.

For inputs that do not have trailing newlines, set the *lineterm* argument to `" "` so that the output will be uniformly newline free.

The context diff format normally has a header for filenames and modification times. Any or all of these may be specified using strings for *fromfile*, *tofile*, *fromfiledate*, and *tofiledate*. The modification times are normally expressed in the ISO 8601 format. If not specified, the strings default to blanks.

```
>>> import sys
>>> from difflib import *
>>> s1 = ['bacon\n', 'eggs\n', 'ham\n', 'guido\n']
>>> s2 = ['python\n', 'eggy\n', 'hamster\n', 'guido\n']
>>> sys.stdout.writelines(context_diff(s1, s2, fromfile='before.py',
...                                   tofile='after.py'))
...
*** before.py
--- after.py
*****
*** 1,4 ****
! bacon
! eggs
! ham
! guido
--- 1,4 ----
! python
! eggy
! hamster
! guido
```

一個更詳盡的範例請見 [A command-line interface to difflib](#).

`difflib.get_close_matches(word, possibilities, n=3, cutoff=0.6)`

Return a list of the best "good enough" matches. *word* is a sequence for which close matches are desired (typically a string), and *possibilities* is a list of sequences against which to match *word* (typically a list of strings).

Optional argument *n* (default 3) is the maximum number of close matches to return; *n* must be greater than 0.

Optional argument *cutoff* (default 0.6) is a float in the range [0, 1]. Possibilities that don't score at least that similar to *word* are ignored.

The best (no more than *n*) matches among the possibilities are returned in a list, sorted by similarity score, most similar first.

```
>>> get_close_matches('appel', ['ape', 'apple', 'peach', 'puppy'])
['apple', 'ape']
>>> import keyword
>>> get_close_matches('wheel', keyword.kwlist)
['while']
>>> get_close_matches('pineapple', keyword.kwlist)
[]
>>> get_close_matches('accept', keyword.kwlist)
['except']
```

`difflib.ndiff(a, b, linejunk=None, charjunk=IS_CHARACTER_JUNK)`

Compare *a* and *b* (lists of strings); return a *Differ*-style delta (a *generator* generating the delta lines).

Optional keyword parameters *linejunk* and *charjunk* are filtering functions (or `None`):

linejunk: A function that accepts a single string argument, and returns true if the string is junk, or false if not. The default is `None`. There is also a module-level function `IS_LINE_JUNK()`, which filters out lines without visible characters, except for at most one pound character ('#') -- however the underlying `SequenceMatcher` class does a dynamic analysis of which lines are so frequent as to constitute noise, and this usually works better than using this function.

charjunk: A function that accepts a character (a string of length 1), and returns if the character is junk, or false if not. The default is module-level function `IS_CHARACTER_JUNK()`, which filters out whitespace characters (a blank or tab; it's a bad idea to include newline in this!).

`Tools/scripts/ndiff.py` is a command-line front-end to this function.

```
>>> diff = ndiff('one\ntwo\nthree\n'.splitlines(keepends=True),
...             'ore\ntree\nemu\n'.splitlines(keepends=True))
>>> print(''.join(diff), end="")
- one
? ^
+ ore
? ^
- two
- three
? -
+ tree
+ emu
```

`diff.lib.restore(sequence, which)`

Return one of the two sequences that generated a delta.

Given a *sequence* produced by `Differ.compare()` or `ndiff()`, extract lines originating from file 1 or 2 (parameter *which*), stripping off line prefixes.

範例:

```
>>> diff = ndiff('one\ntwo\nthree\n'.splitlines(keepends=True),
...             'ore\ntree\nemu\n'.splitlines(keepends=True))
>>> diff = list(diff) # materialize the generated delta into a list
>>> print(''.join	restore(diff, 1)), end="")
one
two
three
>>> print(''.join	restore(diff, 2)), end="")
ore
tree
emu
```

`diff.lib.unified_diff(a, b, fromfile="", tofile="", fromfiledate="", tofiledate="", n=3, lineterm='\n')`

Compare *a* and *b* (lists of strings); return a delta (a *generator* generating the delta lines) in unified diff format.

Unified diffs are a compact way of showing just the lines that have changed plus a few lines of context. The changes are shown in an inline style (instead of separate before/after blocks). The number of context lines is set by *n* which defaults to three.

By default, the diff control lines (those with ---, +++, or @@) are created with a trailing newline. This is helpful so that inputs created from `io.IOBase.readlines()` result in diffs that are suitable for use with `io.IOBase.writelines()` since both the inputs and outputs have trailing newlines.

For inputs that do not have trailing newlines, set the *lineterm* argument to "" so that the output will be uniformly newline free.

The unified diff format normally has a header for filenames and modification times. Any or all of these may be specified using strings for *fromfile*, *tofile*, *fromfiledate*, and *tofiledate*. The modification times are normally expressed in the ISO 8601 format. If not specified, the strings default to blanks.

```

>>> s1 = ['bacon\n', 'eggs\n', 'ham\n', 'guido\n']
>>> s2 = ['python\n', 'eggy\n', 'hamster\n', 'guido\n']
>>> sys.stdout.writelines(unified_diff(s1, s2, fromfile='before.py', tofile=
→ 'after.py'))
--- before.py
+++ after.py
@@ -1,4 +1,4 @@
-bacon
-eggs
-ham
+python
+eggy
+hamster
+guido

```

一個更詳盡的範例請見 [A command-line interface to difflib](#)。

`difflib.diff_bytes(dfunc, a, b, fromfile=b", tofile=b", fromfiledate=b", tofiledate=b", n=3, lineterm=b'\n')`

Compare *a* and *b* (lists of bytes objects) using *dfunc*; yield a sequence of delta lines (also bytes) in the format returned by *dfunc*. *dfunc* must be a callable, typically either `unified_diff()` or `context_diff()`.

Allows you to compare data with unknown or inconsistent encoding. All inputs except *n* must be bytes objects, not str. Works by losslessly converting all inputs (except *n*) to str, and calling `dfunc(a, b, fromfile, tofile, fromfiledate, tofiledate, n, lineterm)`. The output of *dfunc* is then converted back to bytes, so the delta lines that you receive have the same unknown/inconsistent encodings as *a* and *b*.

在 3.5 版新加入。

`difflib.IS_LINE_JUNK(line)`

Return True for ignorable lines. The line *line* is ignorable if *line* is blank or contains a single '#', otherwise it is not ignorable. Used as a default for parameter *linejunk* in `ndiff()` in older versions.

`difflib.IS_CHARACTER_JUNK(ch)`

Return True for ignorable characters. The character *ch* is ignorable if *ch* is a space or tab, otherwise it is not ignorable. Used as a default for parameter *charjunk* in `ndiff()`.

也參考：

Pattern Matching: The Gestalt Approach

Discussion of a similar algorithm by John W. Ratcliff and D. E. Metzener. This was published in *Dr. Dobb's Journal* in July, 1988.

6.3.1 SequenceMatcher 物件

The `SequenceMatcher` class has this constructor:

class `difflib.SequenceMatcher` (*isjunk=None*, *a=""*, *b=""*, *autojunk=True*)

Optional argument *isjunk* must be None (the default) or a one-argument function that takes a sequence element and returns true if and only if the element is "junk" and should be ignored. Passing None for *isjunk* is equivalent to passing `lambda x: False`; in other words, no elements are ignored. For example, pass:

```
lambda x: x in "\t"
```

if you're comparing lines as sequences of characters, and don't want to synch up on blanks or hard tabs.

The optional arguments *a* and *b* are sequences to be compared; both default to empty strings. The elements of both sequences must be *hashable*.

The optional argument *autojunk* can be used to disable the automatic junk heuristic.

在 3.2 版的變更: Added the *autojunk* parameter.

SequenceMatcher objects get three data attributes: *bjunk* is the set of elements of *b* for which *isjunk* is True; *bpopular* is the set of non-junk elements considered popular by the heuristic (if it is not disabled); *b2j* is a dict mapping the remaining elements of *b* to a list of positions where they occur. All three are reset whenever *b* is reset with `set_seqs()` or `set_seq2()`.

在 3.2 版新加入: The *bjunk* and *bpopular* attributes.

`SequenceMatcher` objects have the following methods:

set_seqs (*a*, *b*)

Set the two sequences to be compared.

`SequenceMatcher` computes and caches detailed information about the second sequence, so if you want to compare one sequence against many sequences, use `set_seq2()` to set the commonly used sequence once and call `set_seq1()` repeatedly, once for each of the other sequences.

set_seq1 (*a*)

Set the first sequence to be compared. The second sequence to be compared is not changed.

set_seq2 (*b*)

Set the second sequence to be compared. The first sequence to be compared is not changed.

find_longest_match (*alo*=0, *ahi*=None, *blo*=0, *bhi*=None)

Find longest matching block in `a[alo:ahi]` and `b[blo:bhi]`.

If *isjunk* was omitted or None, `find_longest_match()` returns (*i*, *j*, *k*) such that `a[i:i+k]` is equal to `b[j:j+k]`, where `alo <= i <= i+k <= ahi` and `blo <= j <= j+k <= bhi`. For all (*i'*, *j'*, *k'*) meeting those conditions, the additional conditions `k >= k'`, `i <= i'`, and if `i == i'`, `j <= j'` are also met. In other words, of all maximal matching blocks, return one that starts earliest in *a*, and of all those maximal matching blocks that start earliest in *a*, return the one that starts earliest in *b*.

```
>>> s = SequenceMatcher(None, "abcd", "abcd abcd")
>>> s.find_longest_match(0, 5, 0, 9)
Match(a=0, b=4, size=5)
```

If *isjunk* was provided, first the longest matching block is determined as above, but with the additional restriction that no junk element appears in the block. Then that block is extended as far as possible by matching (only) junk elements on both sides. So the resulting block never matches on junk except as identical junk happens to be adjacent to an interesting match.

Here's the same example as before, but considering blanks to be junk. That prevents 'abcd' from matching the 'abcd' at the tail end of the second sequence directly. Instead only the 'abcd' can match, and matches the leftmost 'abcd' in the second sequence:

```
>>> s = SequenceMatcher(lambda x: x==" ", "abcd", "abcd abcd")
>>> s.find_longest_match(0, 5, 0, 9)
Match(a=1, b=0, size=4)
```

If no blocks match, this returns (*alo*, *blo*, 0).

This method returns a *named tuple* `Match(a, b, size)`.

在 3.9 版的變更: 新增預設引數。

get_matching_blocks ()

Return list of triples describing non-overlapping matching subsequences. Each triple is of the form (*i*, *j*, *n*), and means that `a[i:i+n] == b[j:j+n]`. The triples are monotonically increasing in *i* and *j*.

The last triple is a dummy, and has the value (`len(a)`, `len(b)`, 0). It is the only triple with `n == 0`. If (*i*, *j*, *n*) and (*i'*, *j'*, *n'*) are adjacent triples in the list, and the second is not the last triple in the list, then `i+n < i'` or `j+n < j'`; in other words, adjacent triples always describe non-adjacent equal blocks.

```
>>> s = SequenceMatcher(None, "abxcd", "abcd")
>>> s.get_matching_blocks()
[Match(a=0, b=0, size=2), Match(a=3, b=2, size=2), Match(a=5, b=4, size=0)]
```

get_opcodes()

Return list of 5-tuples describing how to turn *a* into *b*. Each tuple is of the form (tag, *i1*, *i2*, *j1*, *j2*). The first tuple has *i1* == *j1* == 0, and remaining tuples have *i1* equal to the *i2* from the preceding tuple, and, likewise, *j1* equal to the previous *j2*.

The *tag* values are strings, with these meanings:

Value	Meaning
'replace'	<code>a[i1:i2]</code> should be replaced by <code>b[j1:j2]</code> .
'delete'	<code>a[i1:i2]</code> should be deleted. Note that <i>j1</i> == <i>j2</i> in this case.
'insert'	<code>b[j1:j2]</code> should be inserted at <code>a[i1:i1]</code> . Note that <i>i1</i> == <i>i2</i> in this case.
'equal'	<code>a[i1:i2]</code> == <code>b[j1:j2]</code> (the sub-sequences are equal).

舉例來F:

```
>>> a = "qabxcd"
>>> b = "abycdf"
>>> s = SequenceMatcher(None, a, b)
>>> for tag, i1, i2, j1, j2 in s.get_opcodes():
...     print('{:7}   a[{}:{}] --> b[{}:{}] {!r:>8} --> {!r}'.format(
...         tag, i1, i2, j1, j2, a[i1:i2], b[j1:j2]))
delete   a[0:1] --> b[0:0]      'q' --> ''
equal    a[1:3] --> b[0:2]      'ab' --> 'ab'
replace  a[3:4] --> b[2:3]      'x' --> 'y'
equal    a[4:6] --> b[3:5]      'cd' --> 'cd'
insert   a[6:6] --> b[5:6]      '' --> 'f'
```

get_grouped_opcodes(n=3)

Return a *generator* of groups with up to *n* lines of context.

Starting with the groups returned by `get_opcodes()`, this method splits out smaller change clusters and eliminates intervening ranges which have no changes.

The groups are returned in the same format as `get_opcodes()`.

ratio()

Return a measure of the sequences' similarity as a float in the range [0, 1].

Where *T* is the total number of elements in both sequences, and *M* is the number of matches, this is $2.0 * M / T$. Note that this is 1.0 if the sequences are identical, and 0.0 if they have nothing in common.

This is expensive to compute if `get_matching_blocks()` or `get_opcodes()` hasn't already been called, in which case you may want to try `quick_ratio()` or `real_quick_ratio()` first to get an upper bound.

備F: Caution: The result of a `ratio()` call may depend on the order of the arguments. For instance:

```
>>> SequenceMatcher(None, 'tide', 'diet').ratio()
0.25
>>> SequenceMatcher(None, 'diet', 'tide').ratio()
0.5
```

quick_ratio()

Return an upper bound on `ratio()` relatively quickly.

real_quick_ratio()

Return an upper bound on *ratio()* very quickly.

The three methods that return the ratio of matching to total characters can give different results due to differing levels of approximation, although *quick_ratio()* and *real_quick_ratio()* are always at least as large as *ratio()*:

```
>>> s = SequenceMatcher(None, "abcd", "bcde")
>>> s.ratio()
0.75
>>> s.quick_ratio()
0.75
>>> s.real_quick_ratio()
1.0
```

6.3.2 SequenceMatcher 范例

This example compares two strings, considering blanks to be “junk”:

```
>>> s = SequenceMatcher(lambda x: x == " ",
...                       "private Thread currentThread;",
...                       "private volatile Thread currentThread;")
```

ratio() returns a float in [0, 1], measuring the similarity of the sequences. As a rule of thumb, a *ratio()* value over 0.6 means the sequences are close matches:

```
>>> print(round(s.ratio(), 3))
0.866
```

If you’re only interested in where the sequences match, *get_matching_blocks()* is handy:

```
>>> for block in s.get_matching_blocks():
...     print("a[%d] and b[%d] match for %d elements" % block)
a[0] and b[0] match for 8 elements
a[8] and b[17] match for 21 elements
a[29] and b[38] match for 0 elements
```

Note that the last tuple returned by *get_matching_blocks()* is always a dummy, (*len(a)*, *len(b)*, 0), and this is the only case in which the last tuple element (number of elements matched) is 0.

If you want to know how to change the first sequence into the second, use *get_opcodes()*:

```
>>> for opcode in s.get_opcodes():
...     print("%6s a[%d:%d] b[%d:%d]" % opcode)
equal a[0:8] b[0:8]
insert a[8:8] b[8:17]
equal a[8:29] b[17:38]
```

也参考:

- The *get_close_matches()* function in this module which shows how simple code building on *SequenceMatcher* can be used to do useful work.
- [Simple version control recipe](#) for a small application built with *SequenceMatcher*.

6.3.3 Differ Objects

Note that *Differ*-generated deltas make no claim to be **minimal** diffs. To the contrary, minimal diffs are often counter-intuitive, because they synch up anywhere possible, sometimes accidental matches 100 pages apart. Restricting synch points to contiguous matches preserves some notion of locality, at the occasional cost of producing a longer diff.

The *Differ* class has this constructor:

```
class difflib.Differ (linejunk=None, charjunk=None)
```

Optional keyword parameters *linejunk* and *charjunk* are for filter functions (or None):

linejunk: A function that accepts a single string argument, and returns true if the string is junk. The default is None, meaning that no line is considered junk.

charjunk: A function that accepts a single character argument (a string of length 1), and returns true if the character is junk. The default is None, meaning that no character is considered junk.

These junk-filtering functions speed up matching to find differences and do not cause any differing lines or characters to be ignored. Read the description of the *find_longest_match()* method's *isjunk* parameter for an explanation.

Differ objects are used (deltas generated) via a single method:

```
compare (a, b)
```

Compare two sequences of lines, and generate the delta (a sequence of lines).

Each sequence must contain individual single-line strings ending with newlines. Such sequences can be obtained from the *readlines()* method of file-like objects. The delta generated also consists of newline-terminated strings, ready to be printed as-is via the *writelines()* method of a file-like object.

6.3.4 Differ Example

This example compares two texts. First we set up the texts, sequences of individual single-line strings ending with newlines (such sequences can also be obtained from the *readlines()* method of file-like objects):

```
>>> text1 = ''' 1. Beautiful is better than ugly.
... 2. Explicit is better than implicit.
... 3. Simple is better than complex.
... 4. Complex is better than complicated.
... '''.splitlines(keepends=True)
>>> len(text1)
4
>>> text1[0][-1]
'\n'
>>> text2 = ''' 1. Beautiful is better than ugly.
... 3. Simple is better than complex.
... 4. Complicated is better than complex.
... 5. Flat is better than nested.
... '''.splitlines(keepends=True)
```

Next we instantiate a *Differ* object:

```
>>> d = Differ()
```

Note that when instantiating a *Differ* object we may pass functions to filter out line and character "junk." See the *Differ()* constructor for details.

Finally, we compare the two:

```
>>> result = list(d.compare(text1, text2))
```


result is a list of strings, so let's pretty-print it:

```
>>> from pprint import pprint
>>> pprint(result)
['  1. Beautiful is better than ugly.\n',
'-  2. Explicit is better than implicit.\n',
'-  3. Simple is better than complex.\n',
'+  3.   Simple is better than complex.\n',
'?    ++\n',
'-  4. Complex is better than complicated.\n',
'?      ^                ---- ^\n',
'+  4. Complicated is better than complex.\n',
'?      ++++ ^                ^\n',
'+  5. Flat is better than nested.\n']
```

As a single multi-line string it looks like this:

```
>>> import sys
>>> sys.stdout.writelines(result)
1. Beautiful is better than ugly.
- 2. Explicit is better than implicit.
- 3. Simple is better than complex.
+ 3.   Simple is better than complex.
?    ++
- 4. Complex is better than complicated.
?      ^                ---- ^
+ 4. Complicated is better than complex.
?      ++++ ^                ^
+ 5. Flat is better than nested.
```

6.3.5 A command-line interface to difflib

This example shows how to use difflib to create a diff-like utility. It is also contained in the Python source distribution, as Tools/scripts/diff.py.

```
#!/usr/bin/env python3
""" Command line interface to difflib.py providing diffs in four formats:

* ndiff:    lists every line and highlights interline changes.
* context:  highlights clusters of changes in a before/after format.
* unified:  highlights clusters of changes in an inline format.
* html:     generates side by side comparison with change highlights.

"""

import sys, os, difflib, argparse
from datetime import datetime, timezone

def file_mtime(path):
    t = datetime.fromtimestamp(os.stat(path).st_mtime,
                             timezone.utc)
    return t.astimezone().isoformat()

def main():
    parser = argparse.ArgumentParser()
    parser.add_argument('-c', action='store_true', default=False,
                        help='Produce a context format diff (default)')
    parser.add_argument('-u', action='store_true', default=False,
                        help='Produce a unified format diff')
    parser.add_argument('-m', action='store_true', default=False,
```

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```

        help='Produce HTML side by side diff '
        '(can use -c and -l in conjunction)')
    parser.add_argument('-n', action='store_true', default=False,
        help='Produce a ndiff format diff')
    parser.add_argument('-l', '--lines', type=int, default=3,
        help='Set number of context lines (default 3)')
    parser.add_argument('fromfile')
    parser.add_argument('tofile')
    options = parser.parse_args()

    n = options.lines
    fromfile = options.fromfile
    tofile = options.tofile

    fromdate = file_mtime(fromfile)
    todate = file_mtime(tofile)
    with open(fromfile) as ff:
        fromlines = ff.readlines()
    with open(tofile) as tf:
        tolines = tf.readlines()

    if options.u:
        diff = difflib.unified_diff(fromlines, tolines, fromfile, tofile, fromdate,
→ todate, n=n)
    elif options.n:
        diff = difflib.ndiff(fromlines, tolines)
    elif options.m:
        diff = difflib.HtmlDiff().make_file(fromlines, tolines, fromfile, tofile,
→ context=options.c, numlines=n)
    else:
        diff = difflib.context_diff(fromlines, tolines, fromfile, tofile, fromdate,
→ todate, n=n)

    sys.stdout.writelines(diff)

if __name__ == '__main__':
    main()

```

6.4 textwrap --- Text wrapping and filling

原始碼: [Lib/textwrap.py](#)

The *textwrap* module provides some convenience functions, as well as *TextWrapper*, the class that does all the work. If you're just wrapping or filling one or two text strings, the convenience functions should be good enough; otherwise, you should use an instance of *TextWrapper* for efficiency.

```

textwrap.wrap(text, width=70, *, initial_indent="", subsequent_indent="", expand_tabs=True,
    replace_whitespace=True, fix_sentence_endings=False, break_long_words=True,
    drop_whitespace=True, break_on_hyphens=True, tabsize=8, max_lines=None, placeholder='
    [...]')

```

Wraps the single paragraph in *text* (a string) so every line is at most *width* characters long. Returns a list of output lines, without final newlines.

Optional keyword arguments correspond to the instance attributes of *TextWrapper*, documented below.

See the *TextWrapper.wrap()* method for additional details on how *wrap()* behaves.

```
textwrap.fill(text, width=70, *, initial_indent="", subsequent_indent="", expand_tabs=True,
               replace_whitespace=True, fix_sentence_endings=False, break_long_words=True,
               drop_whitespace=True, break_on_hyphens=True, tabsize=8, max_lines=None, placeholder='
[...]')
```

Wraps the single paragraph in *text*, and returns a single string containing the wrapped paragraph. *fill()* is shorthand for

```
"\n".join(wrap(text, ...))
```

In particular, *fill()* accepts exactly the same keyword arguments as *wrap()*.

```
textwrap.shorten(text, width, *, fix_sentence_endings=False, break_long_words=True,
                 break_on_hyphens=True, placeholder='[...]')
```

Collapse and truncate the given *text* to fit in the given *width*.

First the whitespace in *text* is collapsed (all whitespace is replaced by single spaces). If the result fits in the *width*, it is returned. Otherwise, enough words are dropped from the end so that the remaining words plus the *placeholder* fit within *width*:

```
>>> textwrap.shorten("Hello world!", width=12)
'Hello world!'
>>> textwrap.shorten("Hello world!", width=11)
'Hello [...]'
>>> textwrap.shorten("Hello world", width=10, placeholder="...")
'Hello...'
```

Optional keyword arguments correspond to the instance attributes of *TextWrapper*, documented below. Note that the whitespace is collapsed before the text is passed to the *TextWrapper fill()* function, so changing the value of *tabsize*, *expand_tabs*, *drop_whitespace*, and *replace_whitespace* will have no effect.

在 3.4 版新加入.

```
textwrap.dedent(text)
```

Remove any common leading whitespace from every line in *text*.

This can be used to make triple-quoted strings line up with the left edge of the display, while still presenting them in the source code in indented form.

Note that tabs and spaces are both treated as whitespace, but they are not equal: the lines " hello" and "\thello" are considered to have no common leading whitespace.

Lines containing only whitespace are ignored in the input and normalized to a single newline character in the output.

舉例來:

```
def test():
    # end first line with \ to avoid the empty line!
    s = '''\
    hello
    world
    '''
    print(repr(s))          # prints '    hello\n        world\n    '
    print(repr(dedent(s)))  # prints 'hello\n world\n'
```

```
textwrap.indent(text, prefix, predicate=None)
```

Add *prefix* to the beginning of selected lines in *text*.

Lines are separated by calling *text.splitlines(True)*.

By default, *prefix* is added to all lines that do not consist solely of whitespace (including any line endings).

舉例來:

```
>>> s = 'hello\n\n \nworld'
>>> indent(s, ' ')
'  hello\n\n \n  world'
```

The optional *predicate* argument can be used to control which lines are indented. For example, it is easy to add *prefix* to even empty and whitespace-only lines:

```
>>> print(indent(s, '+ ', lambda line: True))
+ hello
+
+
+ world
```

在 3.3 版新加入.

wrap(), *fill()* and *shorten()* work by creating a *TextWrapper* instance and calling a single method on it. That instance is not reused, so for applications that process many text strings using *wrap()* and/or *fill()*, it may be more efficient to create your own *TextWrapper* object.

Text is preferably wrapped on whitespaces and right after the hyphens in hyphenated words; only then will long words be broken if necessary, unless *TextWrapper.break_long_words* is set to false.

class `textwrap.TextWrapper` (***kwargs*)

The *TextWrapper* constructor accepts a number of optional keyword arguments. Each keyword argument corresponds to an instance attribute, so for example

```
wrapper = TextWrapper(initial_indent="* ")
```

is the same as

```
wrapper = TextWrapper()
wrapper.initial_indent = "* "
```

You can re-use the same *TextWrapper* object many times, and you can change any of its options through direct assignment to instance attributes between uses.

The *TextWrapper* instance attributes (and keyword arguments to the constructor) are as follows:

width

(default: 70) The maximum length of wrapped lines. As long as there are no individual words in the input text longer than *width*, *TextWrapper* guarantees that no output line will be longer than *width* characters.

expand_tabs

(default: True) If true, then all tab characters in *text* will be expanded to spaces using the *expandtabs()* method of *text*.

tabsize

(default: 8) If *expand_tabs* is true, then all tab characters in *text* will be expanded to zero or more spaces, depending on the current column and the given tab size.

在 3.3 版新加入.

replace_whitespace

(default: True) If true, after tab expansion but before wrapping, the *wrap()* method will replace each whitespace character with a single space. The whitespace characters replaced are as follows: tab, newline, vertical tab, formfeed, and carriage return ('`\t`', '`\n`', '`\v`', '`\f`', '`\r`').

備 F: If *expand_tabs* is false and *replace_whitespace* is true, each tab character will be replaced by a single space, which is *not* the same as tab expansion.

備註: If `replace_whitespace` is false, newlines may appear in the middle of a line and cause strange output. For this reason, text should be split into paragraphs (using `str.splitlines()` or similar) which are wrapped separately.

drop_whitespace

(default: `True`) If true, whitespace at the beginning and ending of every line (after wrapping but before indenting) is dropped. Whitespace at the beginning of the paragraph, however, is not dropped if non-whitespace follows it. If whitespace being dropped takes up an entire line, the whole line is dropped.

initial_indent

(default: `' '`) String that will be prepended to the first line of wrapped output. Counts towards the length of the first line. The empty string is not indented.

subsequent_indent

(default: `' '`) String that will be prepended to all lines of wrapped output except the first. Counts towards the length of each line except the first.

fix_sentence_endings

(default: `False`) If true, `TextWrapper` attempts to detect sentence endings and ensure that sentences are always separated by exactly two spaces. This is generally desired for text in a monospaced font. However, the sentence detection algorithm is imperfect: it assumes that a sentence ending consists of a lowercase letter followed by one of `'.'`, `','`, `':'`, or `'?'`, possibly followed by one of `'\"'` or `'\"'`, followed by a space. One problem with this algorithm is that it is unable to detect the difference between "Dr." in

```
[...] Dr. Frankenstein's monster [...]
```

and "Spot." in

```
[...] See Spot. See Spot run [...]
```

`fix_sentence_endings` is false by default.

Since the sentence detection algorithm relies on `string.lowercase` for the definition of "lowercase letter", and a convention of using two spaces after a period to separate sentences on the same line, it is specific to English-language texts.

break_long_words

(default: `True`) If true, then words longer than `width` will be broken in order to ensure that no lines are longer than `width`. If it is false, long words will not be broken, and some lines may be longer than `width`. (Long words will be put on a line by themselves, in order to minimize the amount by which `width` is exceeded.)

break_on_hyphens

(default: `True`) If true, wrapping will occur preferably on whitespaces and right after hyphens in compound words, as it is customary in English. If false, only whitespaces will be considered as potentially good places for line breaks, but you need to set `break_long_words` to false if you want truly inseparable words. Default behaviour in previous versions was to always allow breaking hyphenated words.

max_lines

(default: `None`) If not `None`, then the output will contain at most `max_lines` lines, with `placeholder` appearing at the end of the output.

在 3.4 版新加入.

placeholder

(default: `' [...]'`) String that will appear at the end of the output text if it has been truncated.

在 3.4 版新加入.

`TextWrapper` also provides some public methods, analogous to the module-level convenience functions:

wrap (*text*)

Wraps the single paragraph in *text* (a string) so every line is at most *width* characters long. All wrapping options are taken from instance attributes of the *TextWrapper* instance. Returns a list of output lines, without final newlines. If the wrapped output has no content, the returned list is empty.

fill (*text*)

Wraps the single paragraph in *text*, and returns a single string containing the wrapped paragraph.

6.5 unicodedata --- Unicode Database

This module provides access to the Unicode Character Database (UCD) which defines character properties for all Unicode characters. The data contained in this database is compiled from the [UCD version 14.0.0](#).

The module uses the same names and symbols as defined by Unicode Standard Annex #44, "Unicode Character Database". It defines the following functions:

`unicodedata.lookup(name)`

Look up character by name. If a character with the given name is found, return the corresponding character. If not found, *KeyError* is raised.

在 3.3 版的變更: Support for name aliases¹ and named sequences² has been added.

`unicodedata.name(chr[, default])`

Returns the name assigned to the character *chr* as a string. If no name is defined, *default* is returned, or, if not given, *ValueError* is raised.

`unicodedata.decimal(chr[, default])`

Returns the decimal value assigned to the character *chr* as integer. If no such value is defined, *default* is returned, or, if not given, *ValueError* is raised.

`unicodedata.digit(chr[, default])`

Returns the digit value assigned to the character *chr* as integer. If no such value is defined, *default* is returned, or, if not given, *ValueError* is raised.

`unicodedata.numeric(chr[, default])`

Returns the numeric value assigned to the character *chr* as float. If no such value is defined, *default* is returned, or, if not given, *ValueError* is raised.

`unicodedata.category(chr)`

Returns the general category assigned to the character *chr* as string.

`unicodedata.bidirectional(chr)`

Returns the bidirectional class assigned to the character *chr* as string. If no such value is defined, an empty string is returned.

`unicodedata.combining(chr)`

Returns the canonical combining class assigned to the character *chr* as integer. Returns 0 if no combining class is defined.

`unicodedata.east_asian_width(chr)`

Returns the east asian width assigned to the character *chr* as string.

`unicodedata.mirrored(chr)`

Returns the mirrored property assigned to the character *chr* as integer. Returns 1 if the character has been identified as a "mirrored" character in bidirectional text, 0 otherwise.

¹ <https://www.unicode.org/Public/14.0.0/ucd/NameAliases.txt>

² <https://www.unicode.org/Public/14.0.0/ucd/NamedSequences.txt>

`unicodedata.decomposition(chr)`

Returns the character decomposition mapping assigned to the character *chr* as string. An empty string is returned in case no such mapping is defined.

`unicodedata.normalize(form, unistr)`

Return the normal form *form* for the Unicode string *unistr*. Valid values for *form* are 'NFC', 'NFKC', 'NFD', and 'NFKD'.

The Unicode standard defines various normalization forms of a Unicode string, based on the definition of canonical equivalence and compatibility equivalence. In Unicode, several characters can be expressed in various way. For example, the character U+00C7 (LATIN CAPITAL LETTER C WITH CEDILLA) can also be expressed as the sequence U+0043 (LATIN CAPITAL LETTER C) U+0327 (COMBINING CEDILLA).

For each character, there are two normal forms: normal form C and normal form D. Normal form D (NFD) is also known as canonical decomposition, and translates each character into its decomposed form. Normal form C (NFC) first applies a canonical decomposition, then composes pre-combined characters again.

In addition to these two forms, there are two additional normal forms based on compatibility equivalence. In Unicode, certain characters are supported which normally would be unified with other characters. For example, U+2160 (ROMAN NUMERAL ONE) is really the same thing as U+0049 (LATIN CAPITAL LETTER I). However, it is supported in Unicode for compatibility with existing character sets (e.g. gb2312).

The normal form KD (NFKD) will apply the compatibility decomposition, i.e. replace all compatibility characters with their equivalents. The normal form KC (NFKC) first applies the compatibility decomposition, followed by the canonical composition.

Even if two unicode strings are normalized and look the same to a human reader, if one has combining characters and the other doesn't, they may not compare equal.

`unicodedata.is_normalized(form, unistr)`

Return whether the Unicode string *unistr* is in the normal form *form*. Valid values for *form* are 'NFC', 'NFKC', 'NFD', and 'NFKD'.

在 3.8 版新加入。

In addition, the module exposes the following constant:

`unicodedata.unidata_version`

The version of the Unicode database used in this module.

`unicodedata.ucd_3_2_0`

This is an object that has the same methods as the entire module, but uses the Unicode database version 3.2 instead, for applications that require this specific version of the Unicode database (such as IDNA).

範例:

```
>>> import unicodedata
>>> unicodedata.lookup('LEFT CURLY BRACKET')
'{'
>>> unicodedata.name('/')
'SOLIDUS'
>>> unicodedata.decimal('9')
9
>>> unicodedata.decimal('a')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: not a decimal
>>> unicodedata.category('A') # 'L'etter, 'u'ppercase
'Lu'
>>> unicodedata.bidirectional('\u0660') # 'A'rabic, 'N'umber
'AN'
```

F 解

6.6 stringprep --- Internet String Preparation

原始碼: [Lib/stringprep.py](#)

When identifying things (such as host names) in the internet, it is often necessary to compare such identifications for “equality”. Exactly how this comparison is executed may depend on the application domain, e.g. whether it should be case-insensitive or not. It may be also necessary to restrict the possible identifications, to allow only identifications consisting of “printable” characters.

RFC 3454 defines a procedure for “preparing” Unicode strings in internet protocols. Before passing strings onto the wire, they are processed with the preparation procedure, after which they have a certain normalized form. The RFC defines a set of tables, which can be combined into profiles. Each profile must define which tables it uses, and what other optional parts of the `stringprep` procedure are part of the profile. One example of a `stringprep` profile is `nameprep`, which is used for internationalized domain names.

The module `stringprep` only exposes the tables from **RFC 3454**. As these tables would be very large to represent as dictionaries or lists, the module uses the Unicode character database internally. The module source code itself was generated using the `mkstringprep.py` utility.

As a result, these tables are exposed as functions, not as data structures. There are two kinds of tables in the RFC: sets and mappings. For a set, `stringprep` provides the “characteristic function”, i.e. a function that returns `True` if the parameter is part of the set. For mappings, it provides the mapping function: given the key, it returns the associated value. Below is a list of all functions available in the module.

`stringprep.in_table_a1 (code)`

Determine whether *code* is in tableA.1 (Unassigned code points in Unicode 3.2).

`stringprep.in_table_b1 (code)`

Determine whether *code* is in tableB.1 (Commonly mapped to nothing).

`stringprep.map_table_b2 (code)`

Return the mapped value for *code* according to tableB.2 (Mapping for case-folding used with NFKC).

`stringprep.map_table_b3 (code)`

Return the mapped value for *code* according to tableB.3 (Mapping for case-folding used with no normalization).

`stringprep.in_table_c11 (code)`

Determine whether *code* is in tableC.1.1 (ASCII space characters).

`stringprep.in_table_c12 (code)`

Determine whether *code* is in tableC.1.2 (Non-ASCII space characters).

`stringprep.in_table_c11_c12 (code)`

Determine whether *code* is in tableC.1 (Space characters, union of C.1.1 and C.1.2).

`stringprep.in_table_c21 (code)`

Determine whether *code* is in tableC.2.1 (ASCII control characters).

`stringprep.in_table_c22 (code)`

Determine whether *code* is in tableC.2.2 (Non-ASCII control characters).

`stringprep.in_table_c21_c22 (code)`

Determine whether *code* is in tableC.2 (Control characters, union of C.2.1 and C.2.2).

`stringprep.in_table_c3 (code)`

Determine whether *code* is in tableC.3 (Private use).

`stringprep.in_table_c4 (code)`

Determine whether *code* is in tableC.4 (Non-character code points).

`stringprep.in_table_c5 (code)`

Determine whether *code* is in tableC.5 (Surrogate codes).

`stringprep.in_table_c6 (code)`

Determine whether *code* is in tableC.6 (Inappropriate for plain text).

`stringprep.in_table_c7 (code)`

Determine whether *code* is in tableC.7 (Inappropriate for canonical representation).

`stringprep.in_table_c8 (code)`

Determine whether *code* is in tableC.8 (Change display properties or are deprecated).

`stringprep.in_table_c9 (code)`

Determine whether *code* is in tableC.9 (Tagging characters).

`stringprep.in_table_d1 (code)`

Determine whether *code* is in tableD.1 (Characters with bidirectional property "R" or "AL").

`stringprep.in_table_d2 (code)`

Determine whether *code* is in tableD.2 (Characters with bidirectional property "L").

6.7 readline --- GNU readline interface

The *readline* module defines a number of functions to facilitate completion and reading/writing of history files from the Python interpreter. This module can be used directly, or via the *rlcompleter* module, which supports completion of Python identifiers at the interactive prompt. Settings made using this module affect the behaviour of both the interpreter's interactive prompt and the prompts offered by the built-in *input()* function.

Readline keybindings may be configured via an initialization file, typically `.inputrc` in your home directory. See [Readline Init File](#) in the GNU Readline manual for information about the format and allowable constructs of that file, and the capabilities of the Readline library in general.

備註: The underlying Readline library API may be implemented by the `libedit` library instead of GNU readline. On macOS the *readline* module detects which library is being used at run time.

The configuration file for `libedit` is different from that of GNU readline. If you programmatically load configuration strings you can check for the text "libedit" in `readline.__doc__` to differentiate between GNU readline and `libedit`.

If you use *editline*/*libedit* readline emulation on macOS, the initialization file located in your home directory is named `.editrc`. For example, the following content in `~/.editrc` will turn ON *vi* keybindings and TAB completion:

```
python:bind -v
python:bind ^I rl_complete
```

6.7.1 Init file

The following functions relate to the init file and user configuration:

`readline.parse_and_bind(string)`

Execute the init line provided in the *string* argument. This calls `rl_parse_and_bind()` in the underlying library.

`readline.read_init_file([filename])`

Execute a readline initialization file. The default filename is the last filename used. This calls `rl_read_init_file()` in the underlying library.

6.7.2 Line buffer

The following functions operate on the line buffer:

`readline.get_line_buffer()`

Return the current contents of the line buffer (`rl_line_buffer` in the underlying library).

`readline.insert_text(string)`

Insert text into the line buffer at the cursor position. This calls `rl_insert_text()` in the underlying library, but ignores the return value.

`readline.redisplay()`

Change what's displayed on the screen to reflect the current contents of the line buffer. This calls `rl_redisplay()` in the underlying library.

6.7.3 History file

The following functions operate on a history file:

`readline.read_history_file([filename])`

Load a readline history file, and append it to the history list. The default filename is `~/.history`. This calls `read_history()` in the underlying library.

`readline.write_history_file([filename])`

Save the history list to a readline history file, overwriting any existing file. The default filename is `~/.history`. This calls `write_history()` in the underlying library.

`readline.append_history_file(nelements[, filename])`

Append the last *nelements* items of history to a file. The default filename is `~/.history`. The file must already exist. This calls `append_history()` in the underlying library. This function only exists if Python was compiled for a version of the library that supports it.

在 3.5 版新加入。

`readline.get_history_length()`

`readline.set_history_length(length)`

Set or return the desired number of lines to save in the history file. The `write_history_file()` function uses this value to truncate the history file, by calling `history_truncate_file()` in the underlying library. Negative values imply unlimited history file size.

6.7.4 History list

The following functions operate on a global history list:

`readline.clear_history()`

Clear the current history. This calls `clear_history()` in the underlying library. The Python function only exists if Python was compiled for a version of the library that supports it.

`readline.get_current_history_length()`

Return the number of items currently in the history. (This is different from `get_history_length()`, which returns the maximum number of lines that will be written to a history file.)

`readline.get_history_item(index)`

Return the current contents of history item at *index*. The item index is one-based. This calls `history_get()` in the underlying library.

`readline.remove_history_item(pos)`

Remove history item specified by its position from the history. The position is zero-based. This calls `remove_history()` in the underlying library.

`readline.replace_history_item(pos, line)`

Replace history item specified by its position with *line*. The position is zero-based. This calls `replace_history_entry()` in the underlying library.

`readline.add_history(line)`

Append *line* to the history buffer, as if it was the last line typed. This calls `add_history()` in the underlying library.

`readline.set_auto_history(enabled)`

Enable or disable automatic calls to `add_history()` when reading input via `readline`. The *enabled* argument should be a Boolean value that when true, enables auto history, and that when false, disables auto history.

在 3.6 版新加入。

CPython 實作細節： Auto history is enabled by default, and changes to this do not persist across multiple sessions.

6.7.5 Startup hooks

`readline.set_startup_hook([function])`

Set or remove the function invoked by the `rl_startup_hook` callback of the underlying library. If *function* is specified, it will be used as the new hook function; if omitted or `None`, any function already installed is removed. The hook is called with no arguments just before `readline` prints the first prompt.

`readline.set_pre_input_hook([function])`

Set or remove the function invoked by the `rl_pre_input_hook` callback of the underlying library. If *function* is specified, it will be used as the new hook function; if omitted or `None`, any function already installed is removed. The hook is called with no arguments after the first prompt has been printed and just before `readline` starts reading input characters. This function only exists if Python was compiled for a version of the library that supports it.

6.7.6 Completion

The following functions relate to implementing a custom word completion function. This is typically operated by the Tab key, and can suggest and automatically complete a word being typed. By default, Readline is set up to be used by `rlcompleter` to complete Python identifiers for the interactive interpreter. If the `readline` module is to be used with a custom completer, a different set of word delimiters should be set.

`readline.set_completer([function])`

Set or remove the completer function. If *function* is specified, it will be used as the new completer function; if omitted or `None`, any completer function already installed is removed. The completer function is called as `function(text, state)`, for *state* in 0, 1, 2, ..., until it returns a non-string value. It should return the next possible completion starting with *text*.

The installed completer function is invoked by the *entry_func* callback passed to `rl_completion_matches()` in the underlying library. The *text* string comes from the first parameter to the `rl_attempted_completion_function` callback of the underlying library.

`readline.get_completer()`

Get the completer function, or `None` if no completer function has been set.

`readline.get_completion_type()`

Get the type of completion being attempted. This returns the `rl_completion_type` variable in the underlying library as an integer.

`readline.get_begidx()`

`readline.get_endidx()`

Get the beginning or ending index of the completion scope. These indexes are the *start* and *end* arguments passed to the `rl_attempted_completion_function` callback of the underlying library. The values may be different in the same input editing scenario based on the underlying C readline implementation. Ex: libedit is known to behave differently than libreadline.

`readline.set_completer_delims(string)`

`readline.get_completer_delims()`

Set or get the word delimiters for completion. These determine the start of the word to be considered for completion (the completion scope). These functions access the `rl_completer_word_break_characters` variable in the underlying library.

`readline.set_completion_display_matches_hook([function])`

Set or remove the completion display function. If *function* is specified, it will be used as the new completion display function; if omitted or `None`, any completion display function already installed is removed. This sets or clears the `rl_completion_display_matches_hook` callback in the underlying library. The completion display function is called as `function(substitution, [matches], longest_match_length)` once each time matches need to be displayed.

6.7.7 范例

The following example demonstrates how to use the `readline` module's history reading and writing functions to automatically load and save a history file named `.python_history` from the user's home directory. The code below would normally be executed automatically during interactive sessions from the user's `PYTHONSTARTUP` file.

```
import atexit
import os
import readline

histfile = os.path.join(os.path.expanduser("~"), ".python_history")
try:
    readline.read_history_file(histfile)
    # default history len is -1 (infinite), which may grow unruly
    readline.set_history_length(1000)
```

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```
except FileNotFoundError:
    pass

atexit.register(readline.write_history_file, histfile)
```

This code is actually automatically run when Python is run in interactive mode (see [Readline configuration](#)).

The following example achieves the same goal but supports concurrent interactive sessions, by only appending the new history.

```
import atexit
import os
import readline
histfile = os.path.join(os.path.expanduser("~"), ".python_history")

try:
    readline.read_history_file(histfile)
    h_len = readline.get_current_history_length()
except FileNotFoundError:
    open(histfile, 'wb').close()
    h_len = 0

def save(prev_h_len, histfile):
    new_h_len = readline.get_current_history_length()
    readline.set_history_length(1000)
    readline.append_history_file(new_h_len - prev_h_len, histfile)
atexit.register(save, h_len, histfile)
```

The following example extends the `code.InteractiveConsole` class to support history save/restore.

```
import atexit
import code
import os
import readline

class HistoryConsole(code.InteractiveConsole):
    def __init__(self, locals=None, filename="<console>",
                 histfile=os.path.expanduser("~/console-history")):
        code.InteractiveConsole.__init__(self, locals, filename)
        self.init_history(histfile)

    def init_history(self, histfile):
        readline.parse_and_bind("tab: complete")
        if hasattr(readline, "read_history_file"):
            try:
                readline.read_history_file(histfile)
            except FileNotFoundError:
                pass
            atexit.register(self.save_history, histfile)

    def save_history(self, histfile):
        readline.set_history_length(1000)
        readline.write_history_file(histfile)
```

6.8 rlcompleter --- Completion function for GNU readline

原始碼: [Lib/rlcompleter.py](#)

The `rlcompleter` module defines a completion function suitable to be passed to `set_completer()` in the `readline` module.

When this module is imported on a Unix platform with the `readline` module available, an instance of the `Completer` class is automatically created and its `complete()` method is set as the `readline completer`. The method provides completion of valid Python identifiers and keywords.

範例:

```
>>> import rlcompleter
>>> import readline
>>> readline.parse_and_bind("tab: complete")
>>> readline. <TAB PRESSED>
readline.__doc__          readline.get_line_buffer(  readline.read_init_file(
readline.__file__         readline.insert_text(      readline.set_completer(
readline.__name__         readline.parse_and_bind(
>>> readline.
```

The `rlcompleter` module is designed for use with Python's interactive mode. Unless Python is run with the `-S` option, the module is automatically imported and configured (see [Readline configuration](#)).

On platforms without `readline`, the `Completer` class defined by this module can still be used for custom purposes.

class `rlcompleter.Completer`

Completer objects have the following method:

complete (*text*, *state*)

Return the next possible completion for *text*.

When called by the `readline` module, this method is called successively with `state == 0, 1, 2, ...` until the method returns `None`.

If called for *text* that doesn't include a period character (`'.'`), it will complete from names currently defined in `__main__`, `builtins` and keywords (as defined by the `keyword` module).

If called for a dotted name, it will try to evaluate anything without obvious side-effects (functions will not be evaluated, but it can generate calls to `__getattr__()`) up to the last part, and find matches for the rest via the `dir()` function. Any exception raised during the evaluation of the expression is caught, silenced and `None` is returned.

Binary Data Services

The modules described in this chapter provide some basic services operations for manipulation of binary data. Other operations on binary data, specifically in relation to file formats and network protocols, are described in the relevant sections.

Some libraries described under 文本處理 (*Text Processing*) 服務 also work with either ASCII-compatible binary formats (for example, *re*) or all binary data (for example, *difflib*).

In addition, see the documentation for Python's built-in binary data types in *Binary Sequence Types --- bytes, bytearray, memoryview*.

7.1 struct --- Interpret bytes as packed binary data

原始碼: [Lib/struct.py](#)

This module converts between Python values and C structs represented as Python *bytes* objects. Compact *format strings* describe the intended conversions to/from Python values. The module's functions and objects can be used for two largely distinct applications, data exchange with external sources (files or network connections), or data transfer between the Python application and the C layer.

備註: When no prefix character is given, native mode is the default. It packs or unpacks data based on the platform and compiler on which the Python interpreter was built. The result of packing a given C struct includes pad bytes which maintain proper alignment for the C types involved; similarly, alignment is taken into account when unpacking. In contrast, when communicating data between external sources, the programmer is responsible for defining byte ordering and padding between elements. See *Byte Order, Size, and Alignment* for details.

Several *struct* functions (and methods of *Struct*) take a *buffer* argument. This refers to objects that implement the bufferobjects and provide either a readable or read-writable buffer. The most common types used for that purpose are *bytes* and *bytearray*, but many other types that can be viewed as an array of bytes implement the buffer protocol, so that they can be read/filled without additional copying from a *bytes* object.

7.1.1 函式與例外

The module defines the following exception and functions:

exception `struct.error`

Exception raised on various occasions; argument is a string describing what is wrong.

`struct.pack(format, v1, v2, ...)`

Return a bytes object containing the values *v1*, *v2*, ... packed according to the format string *format*. The arguments must match the values required by the format exactly.

`struct.pack_into(format, buffer, offset, v1, v2, ...)`

Pack the values *v1*, *v2*, ... according to the format string *format* and write the packed bytes into the writable buffer *buffer* starting at position *offset*. Note that *offset* is a required argument.

`struct.unpack(format, buffer)`

Unpack from the buffer *buffer* (presumably packed by `pack(format, ...)`) according to the format string *format*. The result is a tuple even if it contains exactly one item. The buffer's size in bytes must match the size required by the format, as reflected by `calcsize()`.

`struct.unpack_from(format, /, buffer, offset=0)`

Unpack from *buffer* starting at position *offset*, according to the format string *format*. The result is a tuple even if it contains exactly one item. The buffer's size in bytes, starting at position *offset*, must be at least the size required by the format, as reflected by `calcsize()`.

`struct.iter_unpack(format, buffer)`

Iteratively unpack from the buffer *buffer* according to the format string *format*. This function returns an iterator which will read equally sized chunks from the buffer until all its contents have been consumed. The buffer's size in bytes must be a multiple of the size required by the format, as reflected by `calcsize()`.

Each iteration yields a tuple as specified by the format string.

在 3.4 版新加入.

`struct.calcsize(format)`

Return the size of the struct (and hence of the bytes object produced by `pack(format, ...)`) corresponding to the format string *format*.

7.1.2 Format Strings

Format strings describe the data layout when packing and unpacking data. They are built up from *format characters*, which specify the type of data being packed/unpacked. In addition, special characters control the *byte order*, *size* and *alignment*. Each format string consists of an optional prefix character which describes the overall properties of the data and one or more format characters which describe the actual data values and padding.

Byte Order, Size, and Alignment

By default, C types are represented in the machine's native format and byte order, and properly aligned by skipping pad bytes if necessary (according to the rules used by the C compiler). This behavior is chosen so that the bytes of a packed struct correspond exactly to the memory layout of the corresponding C struct. Whether to use native byte ordering and padding or standard formats depends on the application.

Alternatively, the first character of the format string can be used to indicate the byte order, size and alignment of the packed data, according to the following table:

Character	Byte order	Size	Alignment
@	native	native	native
=	native	standard	none
<	little-endian	standard	none
>	big-endian	standard	none
!	network (= big-endian)	standard	none

If the first character is not one of these, '@' is assumed.

備 例: The number 1023 (0x3ff in hexadecimal) has the following byte representations:

- 03 ff in big-endian (>)
- ff 03 in little-endian (<)

Python example:

```
>>> import struct
>>> struct.pack('>h', 1023)
b'\x03\xff'
>>> struct.pack('<h', 1023)
b'\xff\x03'
```

Native byte order is big-endian or little-endian, depending on the host system. For example, Intel x86, AMD64 (x86-64), and Apple M1 are little-endian; IBM z and many legacy architectures are big-endian. Use `sys.byteorder` to check the endianness of your system.

Native size and alignment are determined using the C compiler's `sizeof` expression. This is always combined with native byte order.

Standard size depends only on the format character; see the table in the *Format Characters* section.

Note the difference between '@' and '=': both use native byte order, but the size and alignment of the latter is standardized.

The form '!' represents the network byte order which is always big-endian as defined in [IETF RFC 1700](#).

There is no way to indicate non-native byte order (force byte-swapping); use the appropriate choice of '<' or '>'.

解:

- (1) Padding is only automatically added between successive structure members. No padding is added at the beginning or the end of the encoded struct.
- (2) No padding is added when using non-native size and alignment, e.g. with '<', '>', '=', and '!'.
- (3) To align the end of a structure to the alignment requirement of a particular type, end the format with the code for that type with a repeat count of zero. See 範例.

Format Characters

Format characters have the following meaning; the conversion between C and Python values should be obvious given their types. The 'Standard size' column refers to the size of the packed value in bytes when using standard size; that is, when the format string starts with one of '<', '>', '!' or '='. When using native size, the size of the packed value is platform-dependent.

Format	C Type	Python type	Standard size	解
x	pad byte	no value		(7)
c	char	bytes of length 1	1	
b	signed char	integer	1	(1), (2)
B	unsigned char	integer	1	(2)
?	_Bool	bool	1	(1)
h	short	integer	2	(2)
H	unsigned short	integer	2	(2)
i	int	integer	4	(2)
I	unsigned int	integer	4	(2)
l	long	integer	4	(2)
L	unsigned long	integer	4	(2)
q	long long	integer	8	(2)
Q	unsigned long long	integer	8	(2)
n	ssize_t	integer		(3)
N	size_t	integer		(3)
e	(6)	float	2	(4)
f	float	float	4	(4)
d	double	float	8	(4)
s	char[]	bytes		(9)
p	char[]	bytes		(8)
P	void*	integer		(5)

在 3.3 版的變更: 新增 'n' 與 'N' 格式的支援。

在 3.6 版的變更: 新增 'e' 格式的支援。

解:

- (1) The '?' conversion code corresponds to the `_Bool` type defined by C99. If this type is not available, it is simulated using a `char`. In standard mode, it is always represented by one byte.
- (2) When attempting to pack a non-integer using any of the integer conversion codes, if the non-integer has a `__index__()` method then that method is called to convert the argument to an integer before packing.

在 3.2 版的變更: Added use of the `__index__()` method for non-integers.

- (3) The 'n' and 'N' conversion codes are only available for the native size (selected as the default or with the '@' byte order character). For the standard size, you can use whichever of the other integer formats fits your application.
- (4) For the 'f', 'd' and 'e' conversion codes, the packed representation uses the IEEE 754 binary32, binary64 or binary16 format (for 'f', 'd' or 'e' respectively), regardless of the floating-point format used by the platform.
- (5) The 'P' format character is only available for the native byte ordering (selected as the default or with the '@' byte order character). The byte order character '=' chooses to use little- or big-endian ordering based on the host system. The struct module does not interpret this as native ordering, so the 'P' format is not available.
- (6) The IEEE 754 binary16 "half precision" type was introduced in the 2008 revision of the [IEEE 754 standard](#). It has a sign bit, a 5-bit exponent and 11-bit precision (with 10 bits explicitly stored), and can represent numbers between approximately 6.1×10^{-5} and 6.5×10^4 at full precision. This type is not widely supported by C compilers: on a typical machine, an unsigned short can be used for storage, but not for math operations. See the Wikipedia page on the [half-precision floating-point format](#) for more information.
- (7) When packing, 'x' inserts one NUL byte.
- (8) The 'p' format character encodes a "Pascal string", meaning a short variable-length string stored in a *fixed number of bytes*, given by the count. The first byte stored is the length of the string, or 255, whichever is smaller. The bytes of the string follow. If the string passed in to `pack()` is too long (longer than the count minus 1), only the leading `count-1` bytes of the string are stored. If the string is shorter than `count-1`, it

is padded with null bytes so that exactly count bytes in all are used. Note that for `unpack()`, the 'p' format character consumes count bytes, but that the string returned can never contain more than 255 bytes.

- (9) For the 's' format character, the count is interpreted as the length of the bytes, not a repeat count like for the other format characters; for example, '10s' means a single 10-byte string mapping to or from a single Python byte string, while '10c' means 10 separate one byte character elements (e.g., ccccccccccc) mapping to or from ten different Python byte objects. (See 範例 for a concrete demonstration of the difference.) If a count is not given, it defaults to 1. For packing, the string is truncated or padded with null bytes as appropriate to make it fit. For unpacking, the resulting bytes object always has exactly the specified number of bytes. As a special case, '0s' means a single, empty string (while '0c' means 0 characters).

A format character may be preceded by an integral repeat count. For example, the format string '4h' means exactly the same as 'hhhh'.

Whitespace characters between formats are ignored; a count and its format must not contain whitespace though.

When packing a value `x` using one of the integer formats ('b', 'B', 'h', 'H', 'i', 'I', 'l', 'L', 'q', 'Q'), if `x` is outside the valid range for that format then `struct.error` is raised.

在 3.1 版的變更: Previously, some of the integer formats wrapped out-of-range values and raised `DeprecationWarning` instead of `struct.error`.

For the '?' format character, the return value is either `True` or `False`. When packing, the truth value of the argument object is used. Either 0 or 1 in the native or standard bool representation will be packed, and any non-zero value will be `True` when unpacking.

範例

備 F: Native byte order examples (designated by the '@' format prefix or lack of any prefix character) may not match what the reader's machine produces as that depends on the platform and compiler.

Pack and unpack integers of three different sizes, using big endian ordering:

```
>>> from struct import *
>>> pack(">bhl", 1, 2, 3)
b'\x01\x00\x02\x00\x00\x00\x03'
>>> unpack('>bhl', b'\x01\x00\x02\x00\x00\x00\x03')
(1, 2, 3)
>>> calcsizes('>bhl')
7
```

Attempt to pack an integer which is too large for the defined field:

```
>>> pack(">h", 99999)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
struct.error: 'h' format requires -32768 <= number <= 32767
```

Demonstrate the difference between 's' and 'c' format characters:

```
>>> pack("@ccc", b'1', b'2', b'3')
b'123'
>>> pack("@3s", b'123')
b'123'
```

Unpacked fields can be named by assigning them to variables or by wrapping the result in a named tuple:

```
>>> record = b'raymond \x32\x12\x08\x01\x08'
>>> name, serialnum, school, gradelevel = unpack('<10sHHb', record)
```

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(繼續上一頁)

```
>>> from collections import namedtuple
>>> Student = namedtuple('Student', 'name serialnum school gradelevel')
>>> Student._make(unpack('<10sHHb', record))
Student(name=b'raymond', serialnum=4658, school=264, gradelevel=8)
```

The ordering of format characters may have an impact on size in native mode since padding is implicit. In standard mode, the user is responsible for inserting any desired padding. Note in the first pack call below that three NUL bytes were added after the packed '#' to align the following integer on a four-byte boundary. In this example, the output was produced on a little endian machine:

```
>>> pack('@ci', b'#', 0x12131415)
b'\x00\x00\x00\x15\x14\x13\x12#'
>>> pack('@ic', 0x12131415, b'#')
b'\x15\x14\x13\x12#'
>>> calcsizes('@ci')
8
>>> calcsizes('@ic')
5
```

The following format 'llh01' results in two pad bytes being added at the end, assuming the platform's longs are aligned on 4-byte boundaries:

```
>>> pack('@llh01', 1, 2, 3)
b'\x00\x00\x00\x01\x00\x00\x00\x02\x00\x03\x00\x00'
```

也參考:

array 模組

Packed binary storage of homogeneous data.

json 模組

JSON encoder and decoder.

pickle 模組

Python object serialization.

7.1.3 Applications

Two main applications for the *struct* module exist, data interchange between Python and C code within an application or another application compiled using the same compiler (*native formats*), and data interchange between applications using agreed upon data layout (*standard formats*). Generally speaking, the format strings constructed for these two domains are distinct.

Native Formats

When constructing format strings which mimic native layouts, the compiler and machine architecture determine byte ordering and padding. In such cases, the @ format character should be used to specify native byte ordering and data sizes. Internal pad bytes are normally inserted automatically. It is possible that a zero-repeat format code will be needed at the end of a format string to round up to the correct byte boundary for proper alignment of consecutive chunks of data.

Consider these two simple examples (on a 64-bit, little-endian machine):

```
>>> calcsizes('@lh1')
24
>>> calcsizes('@llh')
18
```

Data is not padded to an 8-byte boundary at the end of the second format string without the use of extra padding. A zero-repeat format code solves that problem:

```
>>> calcsize('@11h01')
24
```

The 'x' format code can be used to specify the repeat, but for native formats it is better to use a zero-repeat format like '01'.

By default, native byte ordering and alignment is used, but it is better to be explicit and use the '@' prefix character.

Standard Formats

When exchanging data beyond your process such as networking or storage, be precise. Specify the exact byte order, size, and alignment. Do not assume they match the native order of a particular machine. For example, network byte order is big-endian, while many popular CPUs are little-endian. By defining this explicitly, the user need not care about the specifics of the platform their code is running on. The first character should typically be < or > (or !). Padding is the responsibility of the programmer. The zero-repeat format character won't work. Instead, the user must explicitly add 'x' pad bytes where needed. Revisiting the examples from the previous section, we have:

```
>>> calcsize('<qh6xq')
24
>>> pack('<qh6xq', 1, 2, 3) == pack('@1h1', 1, 2, 3)
True
>>> calcsize('@11h')
18
>>> pack('@11h', 1, 2, 3) == pack('<qqh', 1, 2, 3)
True
>>> calcsize('<qqh6x')
24
>>> calcsize('@11h01')
24
>>> pack('@11h01', 1, 2, 3) == pack('<qqh6x', 1, 2, 3)
True
```

The above results (executed on a 64-bit machine) aren't guaranteed to match when executed on different machines. For example, the examples below were executed on a 32-bit machine:

```
>>> calcsize('<qqh6x')
24
>>> calcsize('@11h01')
12
>>> pack('@11h01', 1, 2, 3) == pack('<qqh6x', 1, 2, 3)
False
```

7.1.4 Classes

The *struct* module also defines the following type:

class *struct.Struct* (*format*)

Return a new Struct object which writes and reads binary data according to the format string *format*. Creating a Struct object once and calling its methods is more efficient than calling module-level functions with the same format since the format string is only compiled once.

備F: The compiled versions of the most recent format strings passed to *Struct* and the module-level functions are cached, so programs that use only a few format strings needn't worry about reusing a single *Struct* instance.

Compiled Struct objects support the following methods and attributes:

pack (*v1*, *v2*, ...)

Identical to the `pack()` function, using the compiled format. (`len(result)` will equal *size*.)

pack_into (*buffer*, *offset*, *v1*, *v2*, ...)

Identical to the `pack_into()` function, using the compiled format.

unpack (*buffer*)

Identical to the `unpack()` function, using the compiled format. The buffer's size in bytes must equal *size*.

unpack_from (*buffer*, *offset*=0)

Identical to the `unpack_from()` function, using the compiled format. The buffer's size in bytes, starting at position *offset*, must be at least *size*.

iter_unpack (*buffer*)

Identical to the `iter_unpack()` function, using the compiled format. The buffer's size in bytes must be a multiple of *size*.

在 3.4 版新加入.

format

The format string used to construct this Struct object.

在 3.7 版的變更: The format string type is now *str* instead of *bytes*.

size

The calculated size of the struct (and hence of the bytes object produced by the `pack()` method) corresponding to *format*.

7.2 codecs --- Codec registry and base classes

原始碼: [Lib/codecs.py](#)

This module defines base classes for standard Python codecs (encoders and decoders) and provides access to the internal Python codec registry, which manages the codec and error handling lookup process. Most standard codecs are *text encodings*, which encode text to bytes (and decode bytes to text), but there are also codecs provided that encode text to text, and bytes to bytes. Custom codecs may encode and decode between arbitrary types, but some module features are restricted to be used specifically with *text encodings* or with codecs that encode to *bytes*.

The module defines the following functions for encoding and decoding with any codec:

`codecs.encode(obj, encoding='utf-8', errors='strict')`

Encodes *obj* using the codec registered for *encoding*.

Errors may be given to set the desired error handling scheme. The default error handler is 'strict' meaning that encoding errors raise *ValueError* (or a more codec specific subclass, such as *UnicodeEncodeError*). Refer to *Codec Base Classes* for more information on codec error handling.

`codecs.decode(obj, encoding='utf-8', errors='strict')`

Decodes *obj* using the codec registered for *encoding*.

Errors may be given to set the desired error handling scheme. The default error handler is 'strict' meaning that decoding errors raise *ValueError* (or a more codec specific subclass, such as *UnicodeDecodeError*). Refer to *Codec Base Classes* for more information on codec error handling.

The full details for each codec can also be looked up directly:

`codecs.lookup(encoding)`

Looks up the codec info in the Python codec registry and returns a *CodecInfo* object as defined below.

Encodings are first looked up in the registry's cache. If not found, the list of registered search functions is scanned. If no *CodecInfo* object is found, a *LookupError* is raised. Otherwise, the *CodecInfo* object is stored in the cache and returned to the caller.

class `codecs.CodecInfo` (*encode*, *decode*, *streamreader*=None, *streamwriter*=None,
incrementalencoder=None, *incrementaldecoder*=None, *name*=None)

Codec details when looking up the codec registry. The constructor arguments are stored in attributes of the same name:

name

The name of the encoding.

encode

decode

The stateless encoding and decoding functions. These must be functions or methods which have the same interface as the *encode()* and *decode()* methods of Codec instances (see *Codec Interface*). The functions or methods are expected to work in a stateless mode.

incrementalencoder

incrementaldecoder

Incremental encoder and decoder classes or factory functions. These have to provide the interface defined by the base classes *IncrementalEncoder* and *IncrementalDecoder*, respectively. Incremental codecs can maintain state.

streamwriter

streamreader

Stream writer and reader classes or factory functions. These have to provide the interface defined by the base classes *StreamWriter* and *StreamReader*, respectively. Stream codecs can maintain state.

To simplify access to the various codec components, the module provides these additional functions which use *lookup()* for the codec lookup:

`codecs.getencoder(encoding)`

Look up the codec for the given encoding and return its encoder function.

Raises a *LookupError* in case the encoding cannot be found.

`codecs.getdecoder(encoding)`

Look up the codec for the given encoding and return its decoder function.

Raises a *LookupError* in case the encoding cannot be found.

`codecs.getincrementalencoder(encoding)`

Look up the codec for the given encoding and return its incremental encoder class or factory function.

Raises a *LookupError* in case the encoding cannot be found or the codec doesn't support an incremental encoder.

`codecs.getincrementaldecoder(encoding)`

Look up the codec for the given encoding and return its incremental decoder class or factory function.

Raises a *LookupError* in case the encoding cannot be found or the codec doesn't support an incremental decoder.

`codecs.getreader(encoding)`

Look up the codec for the given encoding and return its *StreamReader* class or factory function.

Raises a *LookupError* in case the encoding cannot be found.

`codecs.getwriter(encoding)`

Look up the codec for the given encoding and return its *StreamWriter* class or factory function.

Raises a *LookupError* in case the encoding cannot be found.

Custom codecs are made available by registering a suitable codec search function:

`codecs.register(search_function)`

Register a codec search function. Search functions are expected to take one argument, being the encoding name in all lower case letters with hyphens and spaces converted to underscores, and return a *CodecInfo* object. In case a search function cannot find a given encoding, it should return *None*.

在 3.9 版的變更: Hyphens and spaces are converted to underscore.

`codecs.unregister(search_function)`

Unregister a codec search function and clear the registry's cache. If the search function is not registered, do nothing.

在 3.10 版新加入.

While the builtin *open()* and the associated *io* module are the recommended approach for working with encoded text files, this module provides additional utility functions and classes that allow the use of a wider range of codecs when working with binary files:

`codecs.open(filename, mode='r', encoding=None, errors='strict', buffering=-1)`

Open an encoded file using the given *mode* and return an instance of *StreamReaderWriter*, providing transparent encoding/decoding. The default file mode is 'r', meaning to open the file in read mode.

備註: If *encoding* is not *None*, then the underlying encoded files are always opened in binary mode. No automatic conversion of '\n' is done on reading and writing. The *mode* argument may be any binary mode acceptable to the built-in *open()* function; the 'b' is automatically added.

encoding specifies the encoding which is to be used for the file. Any encoding that encodes to and decodes from bytes is allowed, and the data types supported by the file methods depend on the codec used.

errors may be given to define the error handling. It defaults to 'strict' which causes a *ValueError* to be raised in case an encoding error occurs.

buffering has the same meaning as for the built-in *open()* function. It defaults to -1 which means that the default buffer size will be used.

在 3.11 版的變更: The 'U' mode has been removed.

`codecs.EncodedFile(file, data_encoding, file_encoding=None, errors='strict')`

Return a *StreamRecoder* instance, a wrapped version of *file* which provides transparent transcoding. The original file is closed when the wrapped version is closed.

Data written to the wrapped file is decoded according to the given *data_encoding* and then written to the original file as bytes using *file_encoding*. Bytes read from the original file are decoded according to *file_encoding*, and the result is encoded using *data_encoding*.

If *file_encoding* is not given, it defaults to *data_encoding*.

errors may be given to define the error handling. It defaults to 'strict', which causes *ValueError* to be raised in case an encoding error occurs.

`codecs.iterencode(iterator, encoding, errors='strict', **kwargs)`

Uses an incremental encoder to iteratively encode the input provided by *iterator*. This function is a *generator*. The *errors* argument (as well as any other keyword argument) is passed through to the incremental encoder.

This function requires that the codec accept text *str* objects to encode. Therefore it does not support bytes-to-bytes encoders such as *base64_codec*.

`codecs.iterdecode(iterator, encoding, errors='strict', **kwargs)`

Uses an incremental decoder to iteratively decode the input provided by *iterator*. This function is a *generator*. The *errors* argument (as well as any other keyword argument) is passed through to the incremental decoder.

This function requires that the codec accept *bytes* objects to decode. Therefore it does not support text-to-text encoders such as `rot_13`, although `rot_13` may be used equivalently with `iterencode()`.

The module also provides the following constants which are useful for reading and writing to platform dependent files:

```
codecs.BOM
codecs.BOM_BE
codecs.BOM_LE
codecs.BOM_UTF8
codecs.BOM_UTF16
codecs.BOM_UTF16_BE
codecs.BOM_UTF16_LE
codecs.BOM_UTF32
codecs.BOM_UTF32_BE
codecs.BOM_UTF32_LE
```

These constants define various byte sequences, being Unicode byte order marks (BOMs) for several encodings. They are used in UTF-16 and UTF-32 data streams to indicate the byte order used, and in UTF-8 as a Unicode signature. `BOM_UTF16` is either `BOM_UTF16_BE` or `BOM_UTF16_LE` depending on the platform's native byte order, `BOM` is an alias for `BOM_UTF16`, `BOM_LE` for `BOM_UTF16_LE` and `BOM_BE` for `BOM_UTF16_BE`. The others represent the BOM in UTF-8 and UTF-32 encodings.

7.2.1 Codec Base Classes

The `codecs` module defines a set of base classes which define the interfaces for working with codec objects, and can also be used as the basis for custom codec implementations.

Each codec has to define four interfaces to make it usable as codec in Python: stateless encoder, stateless decoder, stream reader and stream writer. The stream reader and writers typically reuse the stateless encoder/decoder to implement the file protocols. Codec authors also need to define how the codec will handle encoding and decoding errors.

Error Handlers

To simplify and standardize error handling, codecs may implement different error handling schemes by accepting the *errors* string argument:

```
>>> 'German ß, ð'.encode(encoding='ascii', errors='backslashreplace')
b'German \\xdf, \\u2013'
>>> 'German ß, ð'.encode(encoding='ascii', errors='xmlcharrefreplace')
b'German &#223;, &#2013;'
```

The following error handlers can be used with all Python *Standard Encodings* codecs:

Value	Meaning
'strict'	Raise <code>UnicodeError</code> (or a subclass), this is the default. Implemented in <code>strict_errors()</code> .
'ignore'	Ignore the malformed data and continue without further notice. Implemented in <code>ignore_errors()</code> .
'replace'	Replace with a replacement marker. On encoding, use ? (ASCII character). On decoding, use <code>U+FFFD</code> , the official REPLACEMENT CHARACTER. Implemented in <code>replace_errors()</code> .
'backslashreplace'	Replace with backslashed escape sequences. On encoding, use hexadecimal form of Unicode code point with formats <code>\xhh \uxxxx \Uxxxxxxxx</code> . On decoding, use hexadecimal form of byte value with format <code>\xhh</code> . Implemented in <code>backslashreplace_errors()</code> .
'surrogateescape'	On decoding, replace byte with individual surrogate code ranging from <code>U+DC80</code> to <code>U+DCFF</code> . This code will then be turned back into the same byte when the 'surrogateescape' error handler is used when encoding the data. (See PEP 383 for more.)

The following error handlers are only applicable to encoding (within *text encodings*):

Value	Meaning
'xmlcharref'	Replace with XML/HTML numeric character reference, which is a decimal form of Unicode code point with format <code>&#num;</code> . Implemented in <code>xmlcharrefreplace_errors()</code> .
'namereplac'	Replace with <code>\N{...}</code> escape sequences, what appears in the braces is the Name property from Unicode Character Database. Implemented in <code>namereplace_errors()</code> .

In addition, the following error handler is specific to the given codecs:

Value	Codecs	Meaning
'surrog'	utf-8, utf-16, utf-32, utf-16-be, utf-16-le, utf-32-be, utf-32-le	Allow encoding and decoding surrogate code point (<code>U+D800 - U+DFFF</code>) as normal code point. Otherwise these codecs treat the presence of surrogate code point in <i>str</i> as an error.

在 3.1 版新加入: The 'surrogateescape' and 'surrogatepass' error handlers.

在 3.4 版的變更: The 'surrogatepass' error handler now works with utf-16* and utf-32* codecs.

在 3.5 版新加入: The 'namereplace' error handler.

在 3.5 版的變更: The 'backslashreplace' error handler now works with decoding and translating.

The set of allowed values can be extended by registering a new named error handler:

`codecs.register_error(name, error_handler)`

Register the error handling function *error_handler* under the name *name*. The *error_handler* argument will be called during encoding and decoding in case of an error, when *name* is specified as the errors parameter.

For encoding, *error_handler* will be called with a `UnicodeEncodeError` instance, which contains information about the location of the error. The error handler must either raise this or a different exception, or return a tuple with a replacement for the unencodable part of the input and a position where encoding should continue. The replacement may be either *str* or *bytes*. If the replacement is bytes, the encoder will simply copy them into the output buffer. If the replacement is a string, the encoder will encode the replacement. Encoding continues on original input at the specified position. Negative position values will be treated as being relative to the end of the input string. If the resulting position is out of bound an `IndexError` will be raised.

Decoding and translating works similarly, except `UnicodeDecodeError` or `UnicodeTranslateError` will be passed to the handler and that the replacement from the error handler will be put into the output directly.

Previously registered error handlers (including the standard error handlers) can be looked up by name:

`codecs.lookup_error(name)`

Return the error handler previously registered under the name *name*.

Raises a `LookupError` in case the handler cannot be found.

The following standard error handlers are also made available as module level functions:

`codecs.strict_errors(exception)`

Implements the 'strict' error handling.

Each encoding or decoding error raises a `UnicodeError`.

`codecs.ignore_errors(exception)`

Implements the 'ignore' error handling.

Malformed data is ignored; encoding or decoding is continued without further notice.

`codecs.replace_errors(exception)`

Implements the 'replace' error handling.

Substitutes ? (ASCII character) for encoding errors or `U+FFFD` (the official REPLACEMENT CHARACTER) for decoding errors.

`codecs.backslashreplace_errors(exception)`

Implements the 'backslashreplace' error handling.

Malformed data is replaced by a backslashed escape sequence. On encoding, use the hexadecimal form of Unicode code point with formats `\xhh \uxxxx \Uxxxxxxxx`. On decoding, use the hexadecimal form of byte value with format `\xhh`.

在 3.5 版的變更: Works with decoding and translating.

`codecs.xmlcharrefreplace_errors(exception)`

Implements the 'xmlcharrefreplace' error handling (for encoding within *text encoding* only).

The unencodable character is replaced by an appropriate XML/HTML numeric character reference, which is a decimal form of Unicode code point with format `&#num;`.

`codecs.namereplace_errors(exception)`

Implements the 'namereplace' error handling (for encoding within *text encoding* only).

The unencodable character is replaced by a `\N{...}` escape sequence. The set of characters that appear in the braces is the Name property from Unicode Character Database. For example, the German lowercase letter 'ß' will be converted to byte sequence `\N{LATIN SMALL LETTER SHARP S}`.

在 3.5 版新加入.

Stateless Encoding and Decoding

The base `Codec` class defines these methods which also define the function interfaces of the stateless encoder and decoder:

class `codecs.Codec`

encode (*input*, *errors*='strict')

Encodes the object *input* and returns a tuple (output object, length consumed). For instance, *text encoding* converts a string object to a bytes object using a particular character set encoding (e.g., `cp1252` or `iso-8859-1`).

The *errors* argument defines the error handling to apply. It defaults to 'strict' handling.

The method may not store state in the `Codec` instance. Use `StreamWriter` for codecs which have to keep state in order to make encoding efficient.

The encoder must be able to handle zero length input and return an empty object of the output object type in this situation.

decode (*input*, *errors*='strict')

Decodes the object *input* and returns a tuple (output object, length consumed). For instance, for a *text encoding*, decoding converts a bytes object encoded using a particular character set encoding to a string object.

For text encodings and bytes-to-bytes codecs, *input* must be a bytes object or one which provides the read-only buffer interface -- for example, buffer objects and memory mapped files.

The *errors* argument defines the error handling to apply. It defaults to 'strict' handling.

The method may not store state in the *Codec* instance. Use *StreamReader* for codecs which have to keep state in order to make decoding efficient.

The decoder must be able to handle zero length input and return an empty object of the output object type in this situation.

Incremental Encoding and Decoding

The *IncrementalEncoder* and *IncrementalDecoder* classes provide the basic interface for incremental encoding and decoding. Encoding/decoding the input isn't done with one call to the stateless encoder/decoder function, but with multiple calls to the *encode()*/*decode()* method of the incremental encoder/decoder. The incremental encoder/decoder keeps track of the encoding/decoding process during method calls.

The joined output of calls to the *encode()*/*decode()* method is the same as if all the single inputs were joined into one, and this input was encoded/decoded with the stateless encoder/decoder.

IncrementalEncoder 物件

The *IncrementalEncoder* class is used for encoding an input in multiple steps. It defines the following methods which every incremental encoder must define in order to be compatible with the Python codec registry.

class `codecs.IncrementalEncoder` (*errors*='strict')

Constructor for an *IncrementalEncoder* instance.

All incremental encoders must provide this constructor interface. They are free to add additional keyword arguments, but only the ones defined here are used by the Python codec registry.

The *IncrementalEncoder* may implement different error handling schemes by providing the *errors* keyword argument. See *Error Handlers* for possible values.

The *errors* argument will be assigned to an attribute of the same name. Assigning to this attribute makes it possible to switch between different error handling strategies during the lifetime of the *IncrementalEncoder* object.

encode (*object*, *final*=False)

Encodes *object* (taking the current state of the encoder into account) and returns the resulting encoded object. If this is the last call to *encode()* *final* must be true (the default is false).

reset ()

Reset the encoder to the initial state. The output is discarded: call `.encode(object, final=True)`, passing an empty byte or text string if necessary, to reset the encoder and to get the output.

getstate ()

Return the current state of the encoder which must be an integer. The implementation should make sure that 0 is the most common state. (States that are more complicated than integers can be converted into an integer by marshaling/pickling the state and encoding the bytes of the resulting string into an integer.)

setstate (*state*)

Set the state of the encoder to *state*. *state* must be an encoder state returned by *getstate()*.

IncrementalDecoder 物件

The *IncrementalDecoder* class is used for decoding an input in multiple steps. It defines the following methods which every incremental decoder must define in order to be compatible with the Python codec registry.

class `codecs.IncrementalDecoder` (*errors*='strict')

Constructor for an *IncrementalDecoder* instance.

All incremental decoders must provide this constructor interface. They are free to add additional keyword arguments, but only the ones defined here are used by the Python codec registry.

The *IncrementalDecoder* may implement different error handling schemes by providing the *errors* keyword argument. See *Error Handlers* for possible values.

The *errors* argument will be assigned to an attribute of the same name. Assigning to this attribute makes it possible to switch between different error handling strategies during the lifetime of the *IncrementalDecoder* object.

decode (*object*, *final*=False)

Decodes *object* (taking the current state of the decoder into account) and returns the resulting decoded object. If this is the last call to *decode()* *final* must be true (the default is false). If *final* is true the decoder must decode the input completely and must flush all buffers. If this isn't possible (e.g. because of incomplete byte sequences at the end of the input) it must initiate error handling just like in the stateless case (which might raise an exception).

reset ()

Reset the decoder to the initial state.

getstate ()

Return the current state of the decoder. This must be a tuple with two items, the first must be the buffer containing the still undecoded input. The second must be an integer and can be additional state info. (The implementation should make sure that 0 is the most common additional state info.) If this additional state info is 0 it must be possible to set the decoder to the state which has no input buffered and 0 as the additional state info, so that feeding the previously buffered input to the decoder returns it to the previous state without producing any output. (Additional state info that is more complicated than integers can be converted into an integer by marshaling/pickling the info and encoding the bytes of the resulting string into an integer.)

setstate (*state*)

Set the state of the decoder to *state*. *state* must be a decoder state returned by *getstate()*.

Stream Encoding and Decoding

The *StreamWriter* and *StreamReader* classes provide generic working interfaces which can be used to implement new encoding submodules very easily. See `encodings.utf_8` for an example of how this is done.

StreamWriter 物件

The *StreamWriter* class is a subclass of *Codec* and defines the following methods which every stream writer must define in order to be compatible with the Python codec registry.

class `codecs.StreamWriter` (*stream*, *errors*='strict')

Constructor for a *StreamWriter* instance.

All stream writers must provide this constructor interface. They are free to add additional keyword arguments, but only the ones defined here are used by the Python codec registry.

The *stream* argument must be a file-like object open for writing text or binary data, as appropriate for the specific codec.

The *StreamWriter* may implement different error handling schemes by providing the *errors* keyword argument. See *Error Handlers* for the standard error handlers the underlying stream codec may support.

The *errors* argument will be assigned to an attribute of the same name. Assigning to this attribute makes it possible to switch between different error handling strategies during the lifetime of the *StreamWriter* object.

write (*object*)

Writes the object's contents encoded to the stream.

writelines (*list*)

Writes the concatenated iterable of strings to the stream (possibly by reusing the *write()* method). Infinite or very large iterables are not supported. The standard bytes-to-bytes codecs do not support this method.

reset ()

Resets the codec buffers used for keeping internal state.

Calling this method should ensure that the data on the output is put into a clean state that allows appending of new fresh data without having to rescan the whole stream to recover state.

In addition to the above methods, the *StreamWriter* must also inherit all other methods and attributes from the underlying stream.

StreamReader 物件

The *StreamReader* class is a subclass of *Codec* and defines the following methods which every stream reader must define in order to be compatible with the Python codec registry.

class `codecs.StreamReader` (*stream*, *errors*='strict')

Constructor for a *StreamReader* instance.

All stream readers must provide this constructor interface. They are free to add additional keyword arguments, but only the ones defined here are used by the Python codec registry.

The *stream* argument must be a file-like object open for reading text or binary data, as appropriate for the specific codec.

The *StreamReader* may implement different error handling schemes by providing the *errors* keyword argument. See *Error Handlers* for the standard error handlers the underlying stream codec may support.

The *errors* argument will be assigned to an attribute of the same name. Assigning to this attribute makes it possible to switch between different error handling strategies during the lifetime of the *StreamReader* object.

The set of allowed values for the *errors* argument can be extended with *register_error()*.

read (*size=-1, chars=-1, firstline=False*)

Decodes data from the stream and returns the resulting object.

The *chars* argument indicates the number of decoded code points or bytes to return. The `read()` method will never return more data than requested, but it might return less, if there is not enough available.

The *size* argument indicates the approximate maximum number of encoded bytes or code points to read for decoding. The decoder can modify this setting as appropriate. The default value -1 indicates to read and decode as much as possible. This parameter is intended to prevent having to decode huge files in one step.

The *firstline* flag indicates that it would be sufficient to only return the first line, if there are decoding errors on later lines.

The method should use a greedy read strategy meaning that it should read as much data as is allowed within the definition of the encoding and the given size, e.g. if optional encoding endings or state markers are available on the stream, these should be read too.

readline (*size=None, keepends=True*)

Read one line from the input stream and return the decoded data.

size, if given, is passed as *size* argument to the stream's `read()` method.

If *keepends* is false line-endings will be stripped from the lines returned.

readlines (*sizehint=None, keepends=True*)

Read all lines available on the input stream and return them as a list of lines.

Line-endings are implemented using the codec's `decode()` method and are included in the list entries if *keepends* is true.

sizehint, if given, is passed as the *size* argument to the stream's `read()` method.

reset ()

Resets the codec buffers used for keeping internal state.

Note that no stream repositioning should take place. This method is primarily intended to be able to recover from decoding errors.

In addition to the above methods, the `StreamReader` must also inherit all other methods and attributes from the underlying stream.

StreamReaderWriter 物件

The `StreamReaderWriter` is a convenience class that allows wrapping streams which work in both read and write modes.

The design is such that one can use the factory functions returned by the `lookup()` function to construct the instance.

class `codecs.StreamReaderWriter` (*stream, Reader, Writer, errors='strict'*)

Creates a `StreamReaderWriter` instance. *stream* must be a file-like object. *Reader* and *Writer* must be factory functions or classes providing the `StreamReader` and `StreamWriter` interface resp. Error handling is done in the same way as defined for the stream readers and writers.

`StreamReaderWriter` instances define the combined interfaces of `StreamReader` and `StreamWriter` classes. They inherit all other methods and attributes from the underlying stream.

StreamRecoder 物件

The *StreamRecoder* translates data from one encoding to another, which is sometimes useful when dealing with different encoding environments.

The design is such that one can use the factory functions returned by the *lookup()* function to construct the instance.

class `codecs.StreamRecoder` (*stream, encode, decode, Reader, Writer, errors='strict'*)

Creates a *StreamRecoder* instance which implements a two-way conversion: *encode* and *decode* work on the frontend —the data visible to code calling *read()* and *write()*, while *Reader* and *Writer* work on the backend —the data in *stream*.

You can use these objects to do transparent transcodings, e.g., from Latin-1 to UTF-8 and back.

The *stream* argument must be a file-like object.

The *encode* and *decode* arguments must adhere to the *Codec* interface. *Reader* and *Writer* must be factory functions or classes providing objects of the *StreamReader* and *StreamWriter* interface respectively.

Error handling is done in the same way as defined for the stream readers and writers.

StreamRecoder instances define the combined interfaces of *StreamReader* and *StreamWriter* classes. They inherit all other methods and attributes from the underlying stream.

7.2.2 Encodings and Unicode

Strings are stored internally as sequences of code points in range U+0000--U+10FFFF. (See [PEP 393](#) for more details about the implementation.) Once a string object is used outside of CPU and memory, endianness and how these arrays are stored as bytes become an issue. As with other codecs, serialising a string into a sequence of bytes is known as *encoding*, and recreating the string from the sequence of bytes is known as *decoding*. There are a variety of different text serialisation codecs, which are collectively referred to as *text encodings*.

The simplest text encoding (called 'latin-1' or 'iso-8859-1') maps the code points 0--255 to the bytes 0x0--0xff, which means that a string object that contains code points above U+00FF can't be encoded with this codec. Doing so will raise a *UnicodeEncodeError* that looks like the following (although the details of the error message may differ): `UnicodeEncodeError: 'latin-1' codec can't encode character '\u1234' in position 3: ordinal not in range(256)`.

There's another group of encodings (the so called charmap encodings) that choose a different subset of all Unicode code points and how these code points are mapped to the bytes 0x0--0xff. To see how this is done simply open e.g. `encodings/cp1252.py` (which is an encoding that is used primarily on Windows). There's a string constant with 256 characters that shows you which character is mapped to which byte value.

All of these encodings can only encode 256 of the 1114112 code points defined in Unicode. A simple and straightforward way that can store each Unicode code point, is to store each code point as four consecutive bytes. There are two possibilities: store the bytes in big endian or in little endian order. These two encodings are called UTF-32-BE and UTF-32-LE respectively. Their disadvantage is that if e.g. you use UTF-32-BE on a little endian machine you will always have to swap bytes on encoding and decoding. UTF-32 avoids this problem: bytes will always be in natural endianness. When these bytes are read by a CPU with a different endianness, then bytes have to be swapped though. To be able to detect the endianness of a UTF-16 or UTF-32 byte sequence, there's the so called BOM ("Byte Order Mark"). This is the Unicode character U+FEFF. This character can be prepended to every UTF-16 or UTF-32 byte sequence. The byte swapped version of this character (0xFFFE) is an illegal character that may not appear in a Unicode text. So when the first character in a UTF-16 or UTF-32 byte sequence appears to be a U+FFFE the bytes have to be swapped on decoding. Unfortunately the character U+FEFF had a second purpose as a ZERO WIDTH NO-BREAK SPACE: a character that has no width and doesn't allow a word to be split. It can e.g. be used to give hints to a ligature algorithm. With Unicode 4.0 using U+FEFF as a ZERO WIDTH NO-BREAK SPACE has been deprecated (with U+2060 (WORD JOINER) assuming this role). Nevertheless Unicode software still must be able to handle U+FEFF in both roles: as a BOM it's a device to determine the storage layout of the encoded bytes, and vanishes once the byte sequence has been decoded into a string; as a ZERO WIDTH NO-BREAK SPACE it's a normal character that will be decoded like any other.

There's another encoding that is able to encode the full range of Unicode characters: UTF-8. UTF-8 is an 8-bit encoding, which means there are no issues with byte order in UTF-8. Each byte in a UTF-8 byte sequence consists of two parts: marker bits (the most significant bits) and payload bits. The marker bits are a sequence of zero to four 1 bits followed by a 0 bit. Unicode characters are encoded like this (with x being payload bits, which when concatenated give the Unicode character):

Range	Encoding
U-00000000 ... U-0000007F	0xxxxxxx
U-00000080 ... U-000007FF	110xxxxx 10xxxxxx
U-00000800 ... U-0000FFFF	1110xxxx 10xxxxxx 10xxxxxx
U-00010000 ... U-0010FFFF	11110xxx 10xxxxxx 10xxxxxx 10xxxxxx

The least significant bit of the Unicode character is the rightmost x bit.

As UTF-8 is an 8-bit encoding no BOM is required and any U+FEFF character in the decoded string (even if it's the first character) is treated as a ZERO WIDTH NO-BREAK SPACE.

Without external information it's impossible to reliably determine which encoding was used for encoding a string. Each charmap encoding can decode any random byte sequence. However that's not possible with UTF-8, as UTF-8 byte sequences have a structure that doesn't allow arbitrary byte sequences. To increase the reliability with which a UTF-8 encoding can be detected, Microsoft invented a variant of UTF-8 (that Python calls "utf-8-sig") for its Notepad program: Before any of the Unicode characters is written to the file, a UTF-8 encoded BOM (which looks like this as a byte sequence: 0xef, 0xbb, 0xbf) is written. As it's rather improbable that any charmap encoded file starts with these byte values (which would e.g. map to

LATIN SMALL LETTER I WITH DIAERESIS
RIGHT-POINTING DOUBLE ANGLE QUOTATION MARK
INVERTED QUESTION MARK

in iso-8859-1), this increases the probability that a utf-8-sig encoding can be correctly guessed from the byte sequence. So here the BOM is not used to be able to determine the byte order used for generating the byte sequence, but as a signature that helps in guessing the encoding. On encoding the utf-8-sig codec will write 0xef, 0xbb, 0xbf as the first three bytes to the file. On decoding utf-8-sig will skip those three bytes if they appear as the first three bytes in the file. In UTF-8, the use of the BOM is discouraged and should generally be avoided.

7.2.3 Standard Encodings

Python comes with a number of codecs built-in, either implemented as C functions or with dictionaries as mapping tables. The following table lists the codecs by name, together with a few common aliases, and the languages for which the encoding is likely used. Neither the list of aliases nor the list of languages is meant to be exhaustive. Notice that spelling alternatives that only differ in case or use a hyphen instead of an underscore are also valid aliases; therefore, e.g. 'utf-8' is a valid alias for the 'utf_8' codec.

CPython 實作細節: Some common encodings can bypass the codecs lookup machinery to improve performance. These optimization opportunities are only recognized by CPython for a limited set of (case insensitive) aliases: utf-8, utf8, latin-1, latin1, iso-8859-1, iso8859-1, mbcs (Windows only), ascii, us-ascii, utf-16, utf16, utf-32, utf32, and the same using underscores instead of dashes. Using alternative aliases for these encodings may result in slower execution.

在 3.6 版的變更: Optimization opportunity recognized for us-ascii.

Many of the character sets support the same languages. They vary in individual characters (e.g. whether the EURO SIGN is supported or not), and in the assignment of characters to code positions. For the European languages in particular, the following variants typically exist:

- an ISO 8859 codeset
- a Microsoft Windows code page, which is typically derived from an 8859 codeset, but replaces control characters with additional graphic characters

- an IBM EBCDIC code page
- an IBM PC code page, which is ASCII compatible

Codec	Aliases	語言
ascii	646, us-ascii	英文
big5	big5-tw, csbig5	繁體中文
big5hkscs	big5-hkscs, hkscs	繁體中文
cp037	IBM037, IBM039	英文
cp273	273, IBM273, csIBM273	德文 在 3.4 版新加入.
cp424	EBCDIC-CP-HE, IBM424	希伯來文
cp437	437, IBM437	英文
cp500	EBCDIC-CP-BE, EBCDIC-CP-CH, IBM500	Western Europe
cp720		阿拉伯文
cp737		希臘文
cp775	IBM775	Baltic languages
cp850	850, IBM850	Western Europe
cp852	852, IBM852	Central and Eastern Europe
cp855	855, IBM855	Bulgarian, Byelorussian, Macedonian, Russian, Serbian
cp856		希伯來文
cp857	857, IBM857	土耳其文
cp858	858, IBM858	Western Europe
cp860	860, IBM860	Portuguese
cp861	861, CP-IS, IBM861	Icelandic
cp862	862, IBM862	希伯來文
cp863	863, IBM863	Canadian
cp864	IBM864	阿拉伯文
cp865	865, IBM865	Danish, Norwegian
cp866	866, IBM866	俄羅斯文
cp869	869, CP-GR, IBM869	希臘文
cp874		泰文
cp875		希臘文
cp932	932, ms932, mskanji, ms-kanji	日文
cp949	949, ms949, uhc	韓文
cp950	950, ms950	繁體中文
cp1006		Urdu
cp1026	ibm1026	土耳其文
cp1125	1125, ibm1125, cp866u, ruscii	烏克蘭文 在 3.4 版新加入.
cp1140	ibm1140	Western Europe
cp1250	windows-1250	Central and Eastern Europe
cp1251	windows-1251	Bulgarian, Byelorussian, Macedonian, Russian, Serbian
cp1252	windows-1252	Western Europe
cp1253	windows-1253	希臘文
cp1254	windows-1254	土耳其文
cp1255	windows-1255	希伯來文
cp1256	windows-1256	阿拉伯文
cp1257	windows-1257	Baltic languages
cp1258	windows-1258	越南文
euc_jp	eucjp, ujis, u-jis	日文
euc_jis_2004	jisx0213, eucjis2004	日文
euc_jisx0213	eucjisx0213	日文

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Codec	Aliases	語言
euc_kr	euckr, korean, ksc5601, ks_c-5601, ks_c-5601-1987, kscx1001, ks_x-1001	韓文
gb2312	chinese, csiso58gb231280, euc-cn, euccn, eucgb2312-cn, gb2312-1980, gb2312-80, iso-ir-58	簡體中文
gbk	936, cp936, ms936	Unified Chinese
gb18030	gb18030-2000	Unified Chinese
hz	hzgb, hz-gb, hz-gb-2312	簡體中文
iso2022_jp	csiso2022jp, iso2022jp, iso-2022-jp	日文
iso2022_jp_1	iso2022jp-1, iso-2022-jp-1	日文
iso2022_jp_2	iso2022jp-2, iso-2022-jp-2	Japanese, Korean, Simplified Chinese, Western Europe, Greek
iso2022_jp_2004	iso2022jp-2004, iso-2022-jp-2004	日文
iso2022_jp_3	iso2022jp-3, iso-2022-jp-3	日文
iso2022_jp_ext	iso2022jp-ext, iso-2022-jp-ext	日文
iso2022_kr	csiso2022kr, iso2022kr, iso-2022-kr	韓文
latin_1	iso-8859-1, iso8859-1, 8859, cp819, latin, latin1, L1	Western Europe
iso8859_2	iso-8859-2, latin2, L2	Central and Eastern Europe
iso8859_3	iso-8859-3, latin3, L3	Esperanto, Maltese
iso8859_4	iso-8859-4, latin4, L4	Baltic languages
iso8859_5	iso-8859-5, cyrillic	Bulgarian, Byelorussian, Macedonian, Russian, Serbian
iso8859_6	iso-8859-6, arabic	阿拉伯文
iso8859_7	iso-8859-7, greek, greek8	希臘文
iso8859_8	iso-8859-8, hebrew	希伯來文
iso8859_9	iso-8859-9, latin5, L5	土耳其文
iso8859_10	iso-8859-10, latin6, L6	Nordic languages
iso8859_11	iso-8859-11, thai	Thai languages
iso8859_13	iso-8859-13, latin7, L7	Baltic languages
iso8859_14	iso-8859-14, latin8, L8	Celtic languages
iso8859_15	iso-8859-15, latin9, L9	Western Europe
iso8859_16	iso-8859-16, latin10, L10	South-Eastern Europe
johab	cp1361, ms1361	韓文
koi8_r		俄羅斯文
koi8_t		Tajik
koi8_u		在 3.5 版新加入.
kz1048	kz_1048, strk1048_2002, rk1048	烏克蘭文
mac_cyrillic	maccyrillic	Kazakh
mac_greek	macgreek	在 3.5 版新加入.
mac_iceland	maciceland	Bulgarian, Byelorussian, Macedonian, Russian, Serbian
mac_latin2	maclatin2, maccentraleurope, mac_centeuro	希臘文
mac_roman	macroman, macintosh	Icelandic
mac_turkish	macturkish	Central and Eastern Europe
ptcp154	csptcp154, pt154, cp154, cyrillic-asian	Western Europe
shift_jis	csshiftjis, shiftjis, sjis, s_jis	土耳其文
		Kazakh
		日文

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Codec	Aliases	語言
shift_jis_2004	shiftjis2004, sjis_2004, sjis2004	日文
shift_jisx0213	shiftjisx0213, sjisx0213, s_jisx0213	日文
utf_32	U32, utf32	all languages
utf_32_be	UTF-32BE	all languages
utf_32_le	UTF-32LE	all languages
utf_16	U16, utf16	all languages
utf_16_be	UTF-16BE	all languages
utf_16_le	UTF-16LE	all languages
utf_7	U7, unicode-1-1-utf-7	all languages
utf_8	U8, UTF, utf8, cp65001	all languages
utf_8_sig		all languages

在 3.4 版的變更: The utf-16* and utf-32* encoders no longer allow surrogate code points (U+D800--U+DFFF) to be encoded. The utf-32* decoders no longer decode byte sequences that correspond to surrogate code points.

在 3.8 版的變更: cp65001 is now an alias to utf_8.

7.2.4 Python Specific Encodings

A number of predefined codecs are specific to Python, so their codec names have no meaning outside Python. These are listed in the tables below based on the expected input and output types (note that while text encodings are the most common use case for codecs, the underlying codec infrastructure supports arbitrary data transforms rather than just text encodings). For asymmetric codecs, the stated meaning describes the encoding direction.

Text Encodings

The following codecs provide *str* to *bytes* encoding and *bytes-like object* to *str* decoding, similar to the Unicode text encodings.

Codec	Aliases	Meaning
idna		Implement RFC 3490 , see also encodings.idna . Only <code>errors='strict'</code> is supported.
mbscs	ansi, dbcs	Windows only: Encode the operand according to the ANSI codepage (CP_ACP).
oem		Windows only: Encode the operand according to the OEM codepage (CP_OEMCP). 在 3.6 版新加入.
palms		Encoding of PalmOS 3.5.
punycode		Implement RFC 3492 . Stateful codecs are not supported.
raw_unicode_escape		Latin-1 encoding with <code>\uXXXX</code> and <code>\UXXXXXXXX</code> for other code points. Existing backslashes are not escaped in any way. It is used in the Python pickle protocol.
undefined		Raise an exception for all conversions, even empty strings. The error handler is ignored.
unicode_escape		Encoding suitable as the contents of a Unicode literal in ASCII-encoded Python source code, except that quotes are not escaped. Decode from Latin-1 source code. Beware that Python source code actually uses UTF-8 by default.

在 3.8 版的變更: "unicode_internal" codec is removed.

Binary Transforms

The following codecs provide binary transforms: *bytes-like object* to *bytes* mappings. They are not supported by `bytes.decode()` (which only produces *str* output).

Codec	Aliases	Meaning	Encoder / decoder
base64_codec ¹	base64, base_64	Convert the operand to multiline MIME base64 (the result always includes a trailing '\n'). 在 3.4 版的變更: accepts any <i>bytes-like object</i> as input for encoding and decoding	<code>base64.encodebytes()</code> / <code>base64.decodebytes()</code>
bz2_codec	bz2	Compress the operand using bz2.	<code>bz2.compress()</code> / <code>bz2.decompress()</code>
hex_codec	hex	Convert the operand to hexadecimal representation, with two digits per byte.	<code>binascii.b2a_hex()</code> / <code>binascii.a2b_hex()</code>
quopri_codec	quopri, quotedprintable, quoted_printable	Convert the operand to MIME quoted printable.	<code>quopri.encode()</code> with <code>quotetabs=True</code> / <code>quopri.decode()</code>
uu_codec	uu	Convert the operand using uuencode.	<code>uu.encode()</code> / <code>uu.decode()</code> (Note: <code>uu</code> is deprecated.)
zlib_codec	zip, zlib	Compress the operand using gzip.	<code>zlib.compress()</code> / <code>zlib.decompress()</code>

在 3.2 版新加入: Restoration of the binary transforms.

在 3.4 版的變更: Restoration of the aliases for the binary transforms.

Text Transforms

The following codec provides a text transform: a *str* to *str* mapping. It is not supported by `str.encode()` (which only produces *bytes* output).

Codec	Aliases	Meaning
rot_13	rot13	Return the Caesar-cypher encryption of the operand.

在 3.2 版新加入: Restoration of the `rot_13` text transform.

在 3.4 版的變更: Restoration of the `rot13` alias.

7.2.5 encodings.idna --- Internationalized Domain Names in Applications

This module implements [RFC 3490](#) (Internationalized Domain Names in Applications) and [RFC 3492](#) (Nameprep: A Stringprep Profile for Internationalized Domain Names (IDN)). It builds upon the `punycode` encoding and `stringprep`.

If you need the IDNA 2008 standard from [RFC 5891](#) and [RFC 5895](#), use the third-party `idna` module.

These RFCs together define a protocol to support non-ASCII characters in domain names. A domain name containing non-ASCII characters (such as `www.Alliancefrançaise.nu`) is converted into an ASCII-compatible encoding (ACE, such as `www.xn--alliancefranaise-npb.nu`). The ACE form of the domain name is

¹ In addition to *bytes-like objects*, 'base64_codec' also accepts ASCII-only instances of *str* for decoding

then used in all places where arbitrary characters are not allowed by the protocol, such as DNS queries, HTTP *Host* fields, and so on. This conversion is carried out in the application; if possible invisible to the user: The application should transparently convert Unicode domain labels to IDNA on the wire, and convert back ACE labels to Unicode before presenting them to the user.

Python supports this conversion in several ways: the `idna` codec performs conversion between Unicode and ACE, separating an input string into labels based on the separator characters defined in [section 3.1 of RFC 3490](#) and converting each label to ACE as required, and conversely separating an input byte string into labels based on the `.` separator and converting any ACE labels found into unicode. Furthermore, the `socket` module transparently converts Unicode host names to ACE, so that applications need not be concerned about converting host names themselves when they pass them to the socket module. On top of that, modules that have host names as function parameters, such as `http.client` and `ftplib`, accept Unicode host names (`http.client` then also transparently sends an IDNA hostname in the *Host* field if it sends that field at all).

When receiving host names from the wire (such as in reverse name lookup), no automatic conversion to Unicode is performed: applications wishing to present such host names to the user should decode them to Unicode.

The module `encodings.idna` also implements the nameprep procedure, which performs certain normalizations on host names, to achieve case-insensitivity of international domain names, and to unify similar characters. The nameprep functions can be used directly if desired.

`encodings.idna.nameprep(label)`

Return the nameprepped version of *label*. The implementation currently assumes query strings, so `AllowUnassigned` is true.

`encodings.idna.ToASCII(label)`

Convert a label to ASCII, as specified in [RFC 3490](#). `UseSTD3ASCIIRules` is assumed to be false.

`encodings.idna.ToUnicode(label)`

Convert a label to Unicode, as specified in [RFC 3490](#).

7.2.6 `encodings.mbc`s --- Windows ANSI codepage

This module implements the ANSI codepage (CP_ACP).

適用: Windows。

在 3.2 版的變更: Before 3.2, the *errors* argument was ignored; 'replace' was always used to encode, and 'ignore' to decode.

在 3.3 版的變更: Support any error handler.

7.2.7 `encodings.utf_8_sig` --- UTF-8 codec with BOM signature

This module implements a variant of the UTF-8 codec. On encoding, a UTF-8 encoded BOM will be prepended to the UTF-8 encoded bytes. For the stateful encoder this is only done once (on the first write to the byte stream). On decoding, an optional UTF-8 encoded BOM at the start of the data will be skipped.

資料型

本章節所描述的模組 (module) 提供了多樣的專門資料型，例如日期與時間、固定型陣列 (fixed-type arrays)、堆積列 (heap queues)、雙端列 (double-ended queues) 與列舉 (enumerations)。

Python 也有提供一些建資料型，特別是 *dict*、*list*、*set* 與 *frozenset* 和 *tuple*。*str* 類是用來儲存 Unicode 字串，*bytes* 與 *bytearray* 類則是用來儲存二進位制資料。

本章節包含下列模組的文件：

8.1 datetime --- 日期與時間的基本型

原始碼：[Lib/datetime.py](#)

The `datetime` module supplies classes for manipulating dates and times.

While date and time arithmetic is supported, the focus of the implementation is on efficient attribute extraction for output formatting and manipulation.

小訣竅：Skip to *the format codes*.

也參考：

`calendar` 模組

General calendar related functions.

`time` 模組

Time access and conversions.

`zoneinfo` 模組

Concrete time zones representing the IANA time zone database.

Package `dateutil`

Third-party library with expanded time zone and parsing support.

Package `DateType`

Third-party library that introduces distinct static types to e.g. allow *static type checkers* to differentiate between naive and aware datetimes.

8.1.1 Aware and Naive Objects

Date and time objects may be categorized as “aware” or “naive” depending on whether or not they include timezone information.

With sufficient knowledge of applicable algorithmic and political time adjustments, such as time zone and daylight saving time information, an **aware** object can locate itself relative to other aware objects. An aware object represents a specific moment in time that is not open to interpretation.¹

A **naive** object does not contain enough information to unambiguously locate itself relative to other date/time objects. Whether a naive object represents Coordinated Universal Time (UTC), local time, or time in some other timezone is purely up to the program, just like it is up to the program whether a particular number represents metres, miles, or mass. Naive objects are easy to understand and to work with, at the cost of ignoring some aspects of reality.

For applications requiring aware objects, `datetime` and `time` objects have an optional time zone information attribute, `tzinfo`, that can be set to an instance of a subclass of the abstract `tzinfo` class. These `tzinfo` objects capture information about the offset from UTC time, the time zone name, and whether daylight saving time is in effect.

Only one concrete `tzinfo` class, the `timezone` class, is supplied by the `datetime` module. The `timezone` class can represent simple timezones with fixed offsets from UTC, such as UTC itself or North American EST and EDT timezones. Supporting timezones at deeper levels of detail is up to the application. The rules for time adjustment across the world are more political than rational, change frequently, and there is no standard suitable for every application aside from UTC.

8.1.2 常數

The `datetime` module exports the following constants:

`datetime.MINYEAR`

The smallest year number allowed in a `date` or `datetime` object. `MINYEAR` is 1.

`datetime.MAXYEAR`

The largest year number allowed in a `date` or `datetime` object. `MAXYEAR` is 9999.

`datetime.UTC`

Alias for the UTC timezone singleton `datetime.timezone.utc`.

在 3.11 版新加入。

8.1.3 Available Types

class `datetime.date`

An idealized naive date, assuming the current Gregorian calendar always was, and always will be, in effect. Attributes: `year`, `month`, and `day`.

class `datetime.time`

An idealized time, independent of any particular day, assuming that every day has exactly 24*60*60 seconds. (There is no notion of “leap seconds” here.) Attributes: `hour`, `minute`, `second`, `microsecond`, and `tzinfo`.

class `datetime.datetime`

A combination of a date and a time. Attributes: `year`, `month`, `day`, `hour`, `minute`, `second`, `microsecond`, and `tzinfo`.

class `datetime.timedelta`

A duration expressing the difference between two `datetime` or `date` instances to microsecond resolution.

¹ If, that is, we ignore the effects of Relativity

class `datetime.tzinfo`

An abstract base class for time zone information objects. These are used by the `datetime` and `time` classes to provide a customizable notion of time adjustment (for example, to account for time zone and/or daylight saving time).

class `datetime.timezone`

A class that implements the `tzinfo` abstract base class as a fixed offset from the UTC.

在 3.2 版新加入。

Objects of these types are immutable.

Subclass relationships:

```
object
  timedelta
  tzinfo
    timezone
  time
  date
    datetime
```

Common Properties

The `date`, `datetime`, `time`, and `timezone` types share these common features:

- Objects of these types are immutable.
- Objects of these types are *hashable*, meaning that they can be used as dictionary keys.
- Objects of these types support efficient pickling via the *pickle* module.

Determining if an Object is Aware or Naive

Objects of the `date` type are always naive.

An object of type `time` or `datetime` may be aware or naive.

A `datetime` object *d* is aware if both of the following hold:

1. `d.tzinfo` 不是 `None`
2. `d.tzinfo.utcoffset(d)` 不會回傳 `None`

Otherwise, *d* is naive.

A `time` object *t* is aware if both of the following hold:

1. `t.tzinfo` 不是 `None`
2. `t.tzinfo.utcoffset(None)` 有回傳 `None`。

Otherwise, *t* is naive.

The distinction between aware and naive doesn't apply to `timedelta` objects.

8.1.4 `timedelta` 物件

A `timedelta` object represents a duration, the difference between two `datetime` or `date` instances.

class `datetime.timedelta` (*days=0, seconds=0, microseconds=0, milliseconds=0, minutes=0, hours=0, weeks=0*)

All arguments are optional and default to 0. Arguments may be integers or floats, and may be positive or negative.

Only *days*, *seconds* and *microseconds* are stored internally. Arguments are converted to those units:

- 一毫秒會被轉 1000 微秒。
- 一分鐘會被轉 60 秒。
- 一小時會被轉 3600 秒。
- 一週會被轉 7 天。

and *days*, *seconds* and *microseconds* are then normalized so that the representation is unique, with

- $0 \leq \text{microseconds} < 1000000$
- $0 \leq \text{seconds} < 3600 \times 24$ (the number of seconds in one day)
- $-999999999 \leq \text{days} \leq 999999999$

The following example illustrates how any arguments besides *days*, *seconds* and *microseconds* are “merged” and normalized into those three resulting attributes:

```
>>> from datetime import timedelta
>>> delta = timedelta(
...     days=50,
...     seconds=27,
...     microseconds=10,
...     milliseconds=29000,
...     minutes=5,
...     hours=8,
...     weeks=2
... )
>>> # Only days, seconds, and microseconds remain
>>> delta
datetime.timedelta(days=64, seconds=29156, microseconds=10)
```

If any argument is a float and there are fractional microseconds, the fractional microseconds left over from all arguments are combined and their sum is rounded to the nearest microsecond using round-half-to-even tiebreaker. If no argument is a float, the conversion and normalization processes are exact (no information is lost).

If the normalized value of *days* lies outside the indicated range, `OverflowError` is raised.

Note that normalization of negative values may be surprising at first. For example:

```
>>> from datetime import timedelta
>>> d = timedelta(microseconds=-1)
>>> (d.days, d.seconds, d.microseconds)
(-1, 86399, 999999)
```

類別屬性:

`timedelta.min`

The most negative `timedelta` object, `timedelta(-999999999)`.

`timedelta.max`

The most positive `timedelta` object, `timedelta(days=999999999, hours=23, minutes=59, seconds=59, microseconds=999999)`.

`timedelta.resolution`

The smallest possible difference between non-equal `timedelta` objects, `timedelta(microseconds=1)`.

Note that, because of normalization, `timedelta.max > -timedelta.min`. `-timedelta.max` is not representable as a `timedelta` object.

Instance attributes (read-only):

屬性	Value
<code>days</code>	Between -999999999 and 999999999 inclusive
<code>seconds</code>	在 0 到 86399 (含) 之間
<code>microseconds</code>	在 0 到 999999 (含) 之間

Supported operations:

Operation	Result
<code>t1 = t2 + t3</code>	Sum of <code>t2</code> and <code>t3</code> . Afterwards <code>t1-t2 == t3</code> and <code>t1-t3 == t2</code> are true. (1)
<code>t1 = t2 - t3</code>	Difference of <code>t2</code> and <code>t3</code> . Afterwards <code>t1 == t2 - t3</code> and <code>t2 == t1 + t3</code> are true. (1)(6)
<code>t1 = t2 * i</code> or <code>t1 = i * t2</code>	Delta multiplied by an integer. Afterwards <code>t1 // i == t2</code> is true, provided <code>i != 0</code> . In general, <code>t1 * i == t1 * (i-1) + t1</code> is true. (1)
<code>t1 = t2 * f</code> or <code>t1 = f * t2</code>	Delta multiplied by a float. The result is rounded to the nearest multiple of <code>timedelta.resolution</code> using round-half-to-even.
<code>f = t2 / t3</code>	Division (3) of overall duration <code>t2</code> by interval unit <code>t3</code> . Returns a <code>float</code> object.
<code>t1 = t2 / f</code> or <code>t1 = t2 / i</code>	Delta divided by a float or an int. The result is rounded to the nearest multiple of <code>timedelta.resolution</code> using round-half-to-even.
<code>t1 = t2 // i</code> or <code>t1 = t2 // t3</code>	The floor is computed and the remainder (if any) is thrown away. In the second case, an integer is returned. (3)
<code>t1 = t2 % t3</code>	The remainder is computed as a <code>timedelta</code> object. (3)
<code>q, r = divmod(t1, t2)</code>	Computes the quotient and the remainder: <code>q = t1 // t2</code> (3) and <code>r = t1 % t2</code> . <code>q</code> is an integer and <code>r</code> is a <code>timedelta</code> object.
<code>+t1</code>	Returns a <code>timedelta</code> object with the same value. (2)
<code>-t1</code>	equivalent to <code>timedelta(-t1.days, -t1.seconds, -t1.microseconds)</code> , and to <code>t1 * -1</code> . (1)(4)
<code>abs(t)</code>	equivalent to <code>+t</code> when <code>t.days >= 0</code> , and to <code>-t</code> when <code>t.days < 0</code> . (2)
<code>str(t)</code>	Returns a string in the form <code>[D] day[s], [H]H:MM:SS[.UUUUUU]</code> , where <code>D</code> is negative for negative <code>t</code> . (5)
<code>repr(t)</code>	Returns a string representation of the <code>timedelta</code> object as a constructor call with canonical attribute values.

解:

- (1) 這是精確的，但可能會溢位。
- (2) 這是精確的，且不會溢位。
- (3) Division by 0 raises `ZeroDivisionError`.
- (4) `-timedelta.max` is not representable as a `timedelta` object.
- (5) String representations of `timedelta` objects are normalized similarly to their internal representation. This leads to somewhat unusual results for negative timedeltas. For example:

```
>>> timedelta(hours=-5)
datetime.timedelta(days=-1, seconds=68400)
>>> print(_)
-1 day, 19:00:00
```

- (6) The expression `t2 - t3` will always be equal to the expression `t2 + (-t3)` except when `t3` is equal to `timedelta.max`; in that case the former will produce a result while the latter will overflow.

In addition to the operations listed above, *timedelta* objects support certain additions and subtractions with *date* and *datetime* objects (see below).

在 3.2 版的變更: Floor division and true division of a *timedelta* object by another *timedelta* object are now supported, as are remainder operations and the *divmod()* function. True division and multiplication of a *timedelta* object by a *float* object are now supported.

timedelta objects support equality and order comparisons.

In Boolean contexts, a *timedelta* object is considered to be true if and only if it isn't equal to `timedelta(0)`.

實例方法:

`timedelta.total_seconds()`

Return the total number of seconds contained in the duration. Equivalent to `td / timedelta(seconds=1)`. For interval units other than seconds, use the division form directly (e.g. `td / timedelta(microseconds=1)`).

Note that for very large time intervals (greater than 270 years on most platforms) this method will lose microsecond accuracy.

在 3.2 版新加入.

用法范例: *timedelta*

An additional example of normalization:

```
>>> # Components of another_year add up to exactly 365 days
>>> from datetime import timedelta
>>> year = timedelta(days=365)
>>> another_year = timedelta(weeks=40, days=84, hours=23,
...                          minutes=50, seconds=600)
>>> year == another_year
True
>>> year.total_seconds()
31536000.0
```

Examples of *timedelta* arithmetic:

```
>>> from datetime import timedelta
>>> year = timedelta(days=365)
>>> ten_years = 10 * year
>>> ten_years
datetime.timedelta(days=3650)
>>> ten_years.days // 365
10
>>> nine_years = ten_years - year
>>> nine_years
datetime.timedelta(days=3285)
>>> three_years = nine_years // 3
>>> three_years, three_years.days // 365
(datetime.timedelta(days=1095), 3)
```

8.1.5 date 物件

A *date* object represents a date (year, month and day) in an idealized calendar, the current Gregorian calendar indefinitely extended in both directions.

January 1 of year 1 is called day number 1, January 2 of year 1 is called day number 2, and so on.²

class `datetime.date` (*year, month, day*)

All arguments are required. Arguments must be integers, in the following ranges:

- `MINYEAR <= year <= MAXYEAR`
- `1 <= month <= 12`
- `1 <= day <= number of days in the given month and year`

If an argument outside those ranges is given, *ValueError* is raised.

Other constructors, all class methods:

classmethod `date.today()`

回傳目前的本地日期。

這等同於 `date.fromtimestamp(time.time())`。

classmethod `date.fromtimestamp(timestamp)`

Return the local date corresponding to the POSIX timestamp, such as is returned by `time.time()`.

This may raise *OverflowError*, if the timestamp is out of the range of values supported by the platform C `localtime()` function, and *OSError* on `localtime()` failure. It's common for this to be restricted to years from 1970 through 2038. Note that on non-POSIX systems that include leap seconds in their notion of a timestamp, leap seconds are ignored by `fromtimestamp()`.

在 3.3 版的變更: Raise *OverflowError* instead of *ValueError* if the timestamp is out of the range of values supported by the platform C `localtime()` function. Raise *OSError* instead of *ValueError* on `localtime()` failure.

classmethod `date.fromordinal(ordinal)`

Return the date corresponding to the proleptic Gregorian ordinal, where January 1 of year 1 has ordinal 1.

ValueError is raised unless `1 <= ordinal <= date.max.toordinal()`. For any date *d*, `date.fromordinal(d.toordinal()) == d`.

classmethod `date.fromisoformat(date_string)`

Return a *date* corresponding to a *date_string* given in any valid ISO 8601 format, with the following exceptions:

1. Reduced precision dates are not currently supported (YYYY-MM, YYYY).
2. Extended date representations are not currently supported (±YYYYYY-MM-DD).
3. Ordinal dates are not currently supported (YYYY-OOO).

範例：

```
>>> from datetime import date
>>> date.fromisoformat('2019-12-04')
datetime.date(2019, 12, 4)
>>> date.fromisoformat('20191204')
datetime.date(2019, 12, 4)
>>> date.fromisoformat('2021-W01-1')
datetime.date(2021, 1, 4)
```

² This matches the definition of the "proleptic Gregorian" calendar in Dershowitz and Reingold's book *Calendrical Calculations*, where it's the base calendar for all computations. See the book for algorithms for converting between proleptic Gregorian ordinals and many other calendar systems.

在 3.7 版新加入。

在 3.11 版的變更: Previously, this method only supported the format YYYY-MM-DD.

classmethod `date.fromisocalendar(year, week, day)`

Return a *date* corresponding to the ISO calendar date specified by year, week and day. This is the inverse of the function `date.isocalendar()`.

在 3.8 版新加入。

類 F 屬性:

`date.min`

The earliest representable date, `date(MINYEAR, 1, 1)`.

`date.max`

The latest representable date, `date(MAXYEAR, 12, 31)`.

`date.resolution`

The smallest possible difference between non-equal date objects, `timedelta(days=1)`.

Instance attributes (read-only):

`date.year`

Between *MINYEAR* and *MAXYEAR* inclusive.

`date.month`

在 1 到 12 (含) 之間。

`date.day`

Between 1 and the number of days in the given month of the given year.

Supported operations:

Operation	Result
<code>date2 = date1 + timedelta</code>	<i>date2</i> will be <code>timedelta.days</code> days after <i>date1</i> . (1)
<code>date2 = date1 - timedelta</code>	Computes <i>date2</i> such that <code>date2 + timedelta == date1</code> . (2)
<code>timedelta = date1 - date2</code>	(3)
	Equality comparison. (4)
<code>date1 == date2</code>	
<code>date1 != date2</code>	
	Order comparison. (5)
<code>date1 < date2</code>	
<code>date1 > date2</code>	
<code>date1 <= date2</code>	
<code>date1 >= date2</code>	

F 解:

- (1) *date2* is moved forward in time if `timedelta.days > 0`, or backward if `timedelta.days < 0`. Afterward `date2 - date1 == timedelta.days`. `timedelta.seconds` and `timedelta.microseconds` are ignored. *OverflowError* is raised if `date2.year` would be smaller than *MINYEAR* or larger than *MAXYEAR*.
- (2) `timedelta.seconds` 和 `timedelta.microseconds` 被忽略。
- (3) This is exact, and cannot overflow. `timedelta.seconds` and `timedelta.microseconds` are 0, and `date2 + timedelta == date1` after.

- (4) `date` objects are equal if they represent the same date.
- (5) `date1` is considered less than `date2` when `date1` precedes `date2` in time. In other words, `date1 < date2` if and only if `date1.toordinal() < date2.toordinal()`.

In Boolean contexts, all `date` objects are considered to be true.

實例方法：

`date.replace(year=self.year, month=self.month, day=self.day)`

Return a date with the same value, except for those parameters given new values by whichever keyword arguments are specified.

範例：

```
>>> from datetime import date
>>> d = date(2002, 12, 31)
>>> d.replace(day=26)
datetime.date(2002, 12, 26)
```

`date.timetuple()`

回傳一個 `time.struct_time`，如同 `time.localtime()` 所回傳。

The hours, minutes and seconds are 0, and the DST flag is -1.

`d.timetuple()` 等價於：

```
time.struct_time((d.year, d.month, d.day, 0, 0, 0, d.weekday(), yday, -1))
```

where `yday = d.toordinal() - date(d.year, 1, 1).toordinal() + 1` is the day number within the current year starting with 1 for January 1st.

`date.toordinal()`

Return the proleptic Gregorian ordinal of the date, where January 1 of year 1 has ordinal 1. For any `date` object `d`, `date.fromordinal(d.toordinal()) == d`.

`date.weekday()`

Return the day of the week as an integer, where Monday is 0 and Sunday is 6. For example, `date(2002, 12, 4).weekday() == 2`, a Wednesday. See also `isoweekday()`.

`date.isoweekday()`

Return the day of the week as an integer, where Monday is 1 and Sunday is 7. For example, `date(2002, 12, 4).isoweekday() == 3`, a Wednesday. See also `weekday()`, `isocalendar()`.

`date.isocalendar()`

Return a *named tuple* object with three components: `year`, `week` and `weekday`.

The ISO calendar is a widely used variant of the Gregorian calendar.³

The ISO year consists of 52 or 53 full weeks, and where a week starts on a Monday and ends on a Sunday. The first week of an ISO year is the first (Gregorian) calendar week of a year containing a Thursday. This is called week number 1, and the ISO year of that Thursday is the same as its Gregorian year.

For example, 2004 begins on a Thursday, so the first week of ISO year 2004 begins on Monday, 29 Dec 2003 and ends on Sunday, 4 Jan 2004:

```
>>> from datetime import date
>>> date(2003, 12, 29).isocalendar()
datetime.ISOCalendarDate(year=2004, week=1, weekday=1)
>>> date(2004, 1, 4).isocalendar()
datetime.ISOCalendarDate(year=2004, week=1, weekday=7)
```

在 3.9 版的變更: Result changed from a tuple to a *named tuple*.

³ See R. H. van Gent's [guide to the mathematics of the ISO 8601 calendar](#) for a good explanation.

`date.isoformat()`

Return a string representing the date in ISO 8601 format, YYYY-MM-DD:

```
>>> from datetime import date
>>> date(2002, 12, 4).isoformat()
'2002-12-04'
```

`date.__str__()`

For a date *d*, `str(d)` is equivalent to `d.isoformat()`.

`date.ctime()`

Return a string representing the date:

```
>>> from datetime import date
>>> date(2002, 12, 4).ctime()
'Wed Dec 4 00:00:00 2002'
```

`d.ctime()` 等價於:

```
time.ctime(time.mktime(d.timetuple()))
```

on platforms where the native C `ctime()` function (which `time.ctime()` invokes, but which `date.ctime()` does not invoke) conforms to the C standard.

`date.strftime(format)`

Return a string representing the date, controlled by an explicit format string. Format codes referring to hours, minutes or seconds will see 0 values. See also *strftime() and strptime() Behavior* and `date.isoformat()`.

`date.__format__(format)`

Same as `date.strftime()`. This makes it possible to specify a format string for a `date` object in formatted string literals and when using `str.format()`. See also *strftime() and strptime() Behavior* and `date.isoformat()`.

用法范例: date

Example of counting days to an event:

```
>>> import time
>>> from datetime import date
>>> today = date.today()
>>> today
datetime.date(2007, 12, 5)
>>> today == date.fromtimestamp(time.time())
True
>>> my_birthday = date(today.year, 6, 24)
>>> if my_birthday < today:
...     my_birthday = my_birthday.replace(year=today.year + 1)
>>> my_birthday
datetime.date(2008, 6, 24)
>>> time_to_birthday = abs(my_birthday - today)
>>> time_to_birthday.days
202
```

更多 `date` 的用法範例:

```
>>> from datetime import date
>>> d = date.fromordinal(730920) # 730920th day after 1. 1. 0001
>>> d
datetime.date(2002, 3, 11)
```

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```

>>> # Methods related to formatting string output
>>> d.isoformat()
'2002-03-11'
>>> d.strftime("%d/%m/%y")
'11/03/02'
>>> d.strftime("%A %d. %B %Y")
'Monday 11. March 2002'
>>> d.ctime()
'Mon Mar 11 00:00:00 2002'
>>> 'The {1} is {0:%d}, the {2} is {0:%B}.'.format(d, "day", "month")
'The day is 11, the month is March.'

>>> # Methods for to extracting 'components' under different calendars
>>> t = d.timetuple()
>>> for i in t:
...     print(i)
2002          # year
3             # month
11            # day
0
0
0
0             # weekday (0 = Monday)
70            # 70th day in the year
-1

>>> ic = d.isocalendar()
>>> for i in ic:
...     print(i)
2002          # ISO year
11            # ISO week number
1             # ISO day number ( 1 = Monday )

>>> # A date object is immutable; all operations produce a new object
>>> d.replace(year=2005)
datetime.date(2005, 3, 11)

```

8.1.6 datetime 物件

A *datetime* object is a single object containing all the information from a *date* object and a *time* object.

Like a *date* object, *datetime* assumes the current Gregorian calendar extended in both directions; like a *time* object, *datetime* assumes there are exactly 3600*24 seconds in every day.

Constructor:

```
class datetime.datetime (year, month, day, hour=0, minute=0, second=0, microsecond=0, tzinfo=None,
                        *, fold=0)
```

The *year*, *month* and *day* arguments are required. *tzinfo* may be `None`, or an instance of a *tzinfo* subclass. The remaining arguments must be integers in the following ranges:

- MINYEAR <= year <= MAXYEAR,
- 1 <= month <= 12,
- 1 <= day <= number of days in the given month and year,
- 0 <= hour < 24,
- 0 <= minute < 60,
- 0 <= second < 60,
- 0 <= microsecond < 1000000,

- fold in [0, 1].

If an argument outside those ranges is given, `ValueError` is raised.

在 3.6 版的變更: Added the `fold` parameter.

Other constructors, all class methods:

classmethod `datetime.today()`

Return the current local datetime, with `tzinfo` `None`.

等價於:

```
datetime.fromtimestamp(time.time())
```

也請見 `now()`、`fromtimestamp()`。

This method is functionally equivalent to `now()`, but without a `tz` parameter.

classmethod `datetime.now(tz=None)`

Return the current local date and time.

If optional argument `tz` is `None` or not specified, this is like `today()`, but, if possible, supplies more precision than can be gotten from going through a `time.time()` timestamp (for example, this may be possible on platforms supplying the C `gettimeofday()` function).

If `tz` is not `None`, it must be an instance of a `tzinfo` subclass, and the current date and time are converted to `tz`'s time zone.

This function is preferred over `today()` and `utcnow()`.

classmethod `datetime.utcnow()`

Return the current UTC date and time, with `tzinfo` `None`.

This is like `now()`, but returns the current UTC date and time, as a naive `datetime` object. An aware current UTC datetime can be obtained by calling `datetime.now(timezone.utc)`. See also `now()`.

警告: Because naive `datetime` objects are treated by many `datetime` methods as local times, it is preferred to use aware datetimes to represent times in UTC. As such, the recommended way to create an object representing the current time in UTC is by calling `datetime.now(timezone.utc)`.

classmethod `datetime.fromtimestamp(timestamp, tz=None)`

Return the local date and time corresponding to the POSIX timestamp, such as is returned by `time.time()`. If optional argument `tz` is `None` or not specified, the timestamp is converted to the platform's local date and time, and the returned `datetime` object is naive.

If `tz` is not `None`, it must be an instance of a `tzinfo` subclass, and the timestamp is converted to `tz`'s time zone.

`fromtimestamp()` may raise `OverflowError`, if the timestamp is out of the range of values supported by the platform C `localtime()` or `gmtime()` functions, and `OSError` on `localtime()` or `gmtime()` failure. It's common for this to be restricted to years in 1970 through 2038. Note that on non-POSIX systems that include leap seconds in their notion of a timestamp, leap seconds are ignored by `fromtimestamp()`, and then it's possible to have two timestamps differing by a second that yield identical `datetime` objects. This method is preferred over `utcfromtimestamp()`.

在 3.3 版的變更: Raise `OverflowError` instead of `ValueError` if the timestamp is out of the range of values supported by the platform C `localtime()` or `gmtime()` functions. Raise `OSError` instead of `ValueError` on `localtime()` or `gmtime()` failure.

在 3.6 版的變更: `fromtimestamp()` may return instances with `fold` set to 1.

classmethod `datetime.utcnow(timestamp)`

Return the UTC *datetime* corresponding to the POSIX timestamp, with *tzinfo* `None`. (The resulting object is naive.)

This may raise *OverflowError*, if the timestamp is out of the range of values supported by the platform C `gmtime()` function, and *OSError* on `gmtime()` failure. It's common for this to be restricted to years in 1970 through 2038.

To get an aware *datetime* object, call `fromtimestamp()`:

```
datetime.fromtimestamp(timestamp, timezone.utc)
```

On the POSIX compliant platforms, it is equivalent to the following expression:

```
datetime(1970, 1, 1, tzinfo=timezone.utc) + timedelta(seconds=timestamp)
```

except the latter formula always supports the full years range: between *MINYEAR* and *MAXYEAR* inclusive.

警告: Because naive *datetime* objects are treated by many *datetime* methods as local times, it is preferred to use aware datetimes to represent times in UTC. As such, the recommended way to create an object representing a specific timestamp in UTC is by calling `datetime.fromtimestamp(timestamp, tz=timezone.utc)`.

在 3.3 版的變更: Raise *OverflowError* instead of *ValueError* if the timestamp is out of the range of values supported by the platform C `gmtime()` function. Raise *OSError* instead of *ValueError* on `gmtime()` failure.

classmethod `datetime.fromordinal(ordinal)`

Return the *datetime* corresponding to the proleptic Gregorian ordinal, where January 1 of year 1 has ordinal 1. *ValueError* is raised unless $1 \leq \text{ordinal} \leq \text{datetime.max.toordinal}()$. The hour, minute, second and microsecond of the result are all 0, and *tzinfo* is `None`.

classmethod `datetime.combine(date, time, tzinfo=self.tzinfo)`

Return a new *datetime* object whose date components are equal to the given *date* object's, and whose time components are equal to the given *time* object's. If the *tzinfo* argument is provided, its value is used to set the *tzinfo* attribute of the result, otherwise the *tzinfo* attribute of the *time* argument is used.

For any *datetime* object *d*, `d == datetime.combine(d.date(), d.time(), d.tzinfo)`. If *date* is a *datetime* object, its time components and *tzinfo* attributes are ignored.

在 3.6 版的變更: 新增 *tzinfo* 引數。

classmethod `datetime.fromisoformat(date_string)`

Return a *datetime* corresponding to a *date_string* in any valid ISO 8601 format, with the following exceptions:

1. Time zone offsets may have fractional seconds.
2. The T separator may be replaced by any single unicode character.
3. Fractional hours and minutes are not supported.
4. Reduced precision dates are not currently supported (YYYY-MM, YYYY).
5. Extended date representations are not currently supported (±YYYYYY-MM-DD).
6. Ordinal dates are not currently supported (YYYY-OOO).

範例:

```
>>> from datetime import datetime
>>> datetime.fromisoformat('2011-11-04')
datetime.datetime(2011, 11, 4, 0, 0)
```

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```

>>> datetime.fromisoformat('20111104')
datetime.datetime(2011, 11, 4, 0, 0)
>>> datetime.fromisoformat('2011-11-04T00:05:23')
datetime.datetime(2011, 11, 4, 0, 5, 23)
>>> datetime.fromisoformat('2011-11-04T00:05:23Z')
datetime.datetime(2011, 11, 4, 0, 5, 23, tzinfo=datetime.timezone.utc)
>>> datetime.fromisoformat('20111104T000523')
datetime.datetime(2011, 11, 4, 0, 5, 23)
>>> datetime.fromisoformat('2011-W01-2T00:05:23.283')
datetime.datetime(2011, 1, 4, 0, 5, 23, 283000)
>>> datetime.fromisoformat('2011-11-04 00:05:23.283')
datetime.datetime(2011, 11, 4, 0, 5, 23, 283000)
>>> datetime.fromisoformat('2011-11-04 00:05:23.283+00:00')
datetime.datetime(2011, 11, 4, 0, 5, 23, 283000, tzinfo=datetime.timezone.utc)
>>> datetime.fromisoformat('2011-11-04T00:05:23+04:00')
datetime.datetime(2011, 11, 4, 0, 5, 23,
    tzinfo=datetime.timezone(datetime.timedelta(seconds=14400)))

```

在 3.7 版新加入。

在 3.11 版的變更: Previously, this method only supported formats that could be emitted by `date.isoformat()` or `datetime.isoformat()`.

classmethod `datetime.fromisocalendar(year, week, day)`

Return a `datetime` corresponding to the ISO calendar date specified by year, week and day. The non-date components of the datetime are populated with their normal default values. This is the inverse of the function `datetime.isocalendar()`.

在 3.8 版新加入。

classmethod `datetime.strptime(date_string, format)`

Return a `datetime` corresponding to `date_string`, parsed according to `format`.

If `format` does not contain microseconds or timezone information, this is equivalent to:

```
datetime(*(time.strptime(date_string, format)[0:6]))
```

`ValueError` is raised if the `date_string` and `format` can't be parsed by `time.strptime()` or if it returns a value which isn't a time tuple. See also `strptime()` and `strptime() Behavior` and `datetime.fromisoformat()`.

類 F 屬性:

`datetime.min`

The earliest representable `datetime`, `datetime(MINYEAR, 1, 1, tzinfo=None)`.

`datetime.max`

The latest representable `datetime`, `datetime(MAXYEAR, 12, 31, 23, 59, 59, 999999, tzinfo=None)`.

`datetime.resolution`

The smallest possible difference between non-equal `datetime` objects, `timedelta(microseconds=1)`.

Instance attributes (read-only):

`datetime.year`

Between `MINYEAR` and `MAXYEAR` inclusive.

`datetime.month`

在 1 到 12 (含) 之間。

`datetime.day`

Between 1 and the number of days in the given month of the given year.

`datetime.hour`

In range (24).

`datetime.minute`

In range (60).

`datetime.second`

In range (60).

`datetime.microsecond`

In range (1000000).

`datetime.tzinfo`

The object passed as the *tzinfo* argument to the *datetime* constructor, or None if none was passed.

`datetime.fold`

In [0, 1]. Used to disambiguate wall times during a repeated interval. (A repeated interval occurs when clocks are rolled back at the end of daylight saving time or when the UTC offset for the current zone is decreased for political reasons.) The value 0 (1) represents the earlier (later) of the two moments with the same wall time representation.

在 3.6 版新加入.

Supported operations:

Operation	Result
<code>datetime2 = datetime1 + timedelta</code>	(1)
<code>datetime2 = datetime1 - timedelta</code>	(2)
<code>timedelta = datetime1 - datetime2</code>	(3)
	Equality comparison. (4)
<code>datetime1 == datetime2</code> <code>datetime1 != datetime2</code>	
	Order comparison. (5)
<code>datetime1 < datetime2</code> <code>datetime1 > datetime2</code> <code>datetime1 <= datetime2</code> <code>datetime1 >= datetime2</code>	

- (1) `datetime2` is a duration of `timedelta` removed from `datetime1`, moving forward in time if `timedelta.days > 0`, or backward if `timedelta.days < 0`. The result has the same *tzinfo* attribute as the input *datetime*, and `datetime2 - datetime1 == timedelta` after. *OverflowError* is raised if `datetime2.year` would be smaller than *MINYEAR* or larger than *MAXYEAR*. Note that no time zone adjustments are done even if the input is an aware object.
- (2) Computes the `datetime2` such that `datetime2 + timedelta == datetime1`. As for addition, the result has the same *tzinfo* attribute as the input *datetime*, and no time zone adjustments are done even if the input is aware.
- (3) Subtraction of a *datetime* from a *datetime* is defined only if both operands are naive, or if both are aware. If one is aware and the other is naive, *TypeError* is raised.

If both are naive, or both are aware and have the same *tzinfo* attribute, the *tzinfo* attributes are ignored, and the result is a *timedelta* object *t* such that `datetime2 + t == datetime1`. No time zone adjustments are done in this case.

If both are aware and have different `tzinfo` attributes, `a-b` acts as if `a` and `b` were first converted to naive UTC datetimes. The result is `(a.replace(tzinfo=None) - a.utcoffset()) - (b.replace(tzinfo=None) - b.utcoffset())` except that the implementation never overflows.

- (4) `datetime` objects are equal if they represent the same date and time, taking into account the time zone.

Naive and aware `datetime` objects are never equal. `datetime` objects are never equal to `date` objects that are not also `datetime` instances, even if they represent the same date.

If both comparands are aware, and have the same `tzinfo` attribute, the `tzinfo` and `fold` attributes are ignored and the base datetimes are compared. If both comparands are aware and have different `tzinfo` attributes, the comparison acts as comparands were first converted to UTC datetimes except that the implementation never overflows. `datetime` instances in a repeated interval are never equal to `datetime` instances in other time zone.

- (5) `datetime1` is considered less than `datetime2` when `datetime1` precedes `datetime2` in time, taking into account the time zone.

Order comparison between naive and aware `datetime` objects, as well as a `datetime` object and a `date` object that is not also a `datetime` instance, raises `TypeError`.

If both comparands are aware, and have the same `tzinfo` attribute, the `tzinfo` and `fold` attributes are ignored and the base datetimes are compared. If both comparands are aware and have different `tzinfo` attributes, the comparison acts as comparands were first converted to UTC datetimes except that the implementation never overflows.

在 3.3 版的變更: Equality comparisons between aware and naive `datetime` instances don't raise `TypeError`.

實例方法:

`datetime.date()`

Return `date` object with same year, month and day.

`datetime.time()`

Return `time` object with same hour, minute, second, microsecond and fold. `tzinfo` is `None`. See also method `timetz()`.

在 3.6 版的變更: The fold value is copied to the returned `time` object.

`datetime.timetz()`

Return `time` object with same hour, minute, second, microsecond, fold, and `tzinfo` attributes. See also method `time()`.

在 3.6 版的變更: The fold value is copied to the returned `time` object.

`datetime.replace(year=self.year, month=self.month, day=self.day, hour=self.hour, minute=self.minute, second=self.second, microsecond=self.microsecond, tzinfo=self.tzinfo, *, fold=0)`

Return a `datetime` with the same attributes, except for those attributes given new values by whichever keyword arguments are specified. Note that `tzinfo=None` can be specified to create a naive `datetime` from an aware `datetime` with no conversion of date and time data.

在 3.6 版的變更: Added the `fold` parameter.

`datetime.astimezone(tz=None)`

Return a `datetime` object with new `tzinfo` attribute `tz`, adjusting the date and time data so the result is the same UTC time as `self`, but in `tz`'s local time.

If provided, `tz` must be an instance of a `tzinfo` subclass, and its `utcoffset()` and `dst()` methods must not return `None`. If `self` is naive, it is presumed to represent time in the system timezone.

If called without arguments (or with `tz=None`) the system local timezone is assumed for the target timezone. The `.tzinfo` attribute of the converted `datetime` instance will be set to an instance of `timezone` with the zone name and offset obtained from the OS.

If `self.tzinfo` is `tz`, `self.astimezone(tz)` is equal to `self`: no adjustment of date or time data is performed. Else the result is local time in the timezone `tz`, representing the same UTC time as `self`: after `astz`

`= dt.astimezone(tz), astz - astz.utcoffset()` will have the same date and time data as `dt - dt.utcoffset()`.

If you merely want to attach a time zone object `tz` to a datetime `dt` without adjustment of date and time data, use `dt.replace(tzinfo=tz)`. If you merely want to remove the time zone object from an aware datetime `dt` without conversion of date and time data, use `dt.replace(tzinfo=None)`.

Note that the default `tzinfo.fromutc()` method can be overridden in a `tzinfo` subclass to affect the result returned by `astimezone()`. Ignoring error cases, `astimezone()` acts like:

```
def astimezone(self, tz):
    if self.tzinfo is tz:
        return self
    # Convert self to UTC, and attach the new time zone object.
    utc = (self - self.utcoffset()).replace(tzinfo=tz)
    # Convert from UTC to tz's local time.
    return tz.fromutc(utc)
```

在 3.3 版的變更: `tz` now can be omitted.

在 3.6 版的變更: The `astimezone()` method can now be called on naive instances that are presumed to represent system local time.

`datetime.utcoffset()`

If `tzinfo` is `None`, returns `None`, else returns `self.tzinfo.utcoffset(self)`, and raises an exception if the latter doesn't return `None` or a `timedelta` object with magnitude less than one day.

在 3.7 版的變更: The UTC offset is not restricted to a whole number of minutes.

`datetime.dst()`

If `tzinfo` is `None`, returns `None`, else returns `self.tzinfo.dst(self)`, and raises an exception if the latter doesn't return `None` or a `timedelta` object with magnitude less than one day.

在 3.7 版的變更: The DST offset is not restricted to a whole number of minutes.

`datetime.tzname()`

If `tzinfo` is `None`, returns `None`, else returns `self.tzinfo.tzname(self)`, raises an exception if the latter doesn't return `None` or a string object,

`datetime.timetuple()`

回傳一個 `time.struct_time`, 如同 `time.localtime()` 所回傳。

`d.timetuple()` 等價於:

```
time.struct_time((d.year, d.month, d.day,
                  d.hour, d.minute, d.second,
                  d.weekday(), yday, dst))
```

where `yday = d.toordinal() - date(d.year, 1, 1).toordinal() + 1` is the day number within the current year starting with 1 for January 1st. The `tm_isdst` flag of the result is set according to the `dst()` method: `tzinfo` is `None` or `dst()` returns `None`, `tm_isdst` is set to -1; else if `dst()` returns a non-zero value, `tm_isdst` is set to 1; else `tm_isdst` is set to 0.

`datetime.utctimetuple()`

If `datetime` instance `d` is naive, this is the same as `d.timetuple()` except that `tm_isdst` is forced to 0 regardless of what `d.dst()` returns. DST is never in effect for a UTC time.

If `d` is aware, `d` is normalized to UTC time, by subtracting `d.utcoffset()`, and a `time.struct_time` for the normalized time is returned. `tm_isdst` is forced to 0. Note that an `OverflowError` may be raised if `d.year` was `MINYEAR` or `MAXYEAR` and UTC adjustment spills over a year boundary.

警告: Because naive datetime objects are treated by many datetime methods as local times, it is preferred to use aware datetimes to represent times in UTC; as a result, using `datetime.utctimetuple()` may give misleading results. If you have a naive datetime representing UTC, use `datetime.replace(tzinfo=timezone.utc)` to make it aware, at which point you can use `datetime.timetuple()`.

`datetime.toordinal()`

Return the proleptic Gregorian ordinal of the date. The same as `self.date().toordinal()`.

`datetime.timestamp()`

Return POSIX timestamp corresponding to the `datetime` instance. The return value is a *float* similar to that returned by `time.time()`.

Naive `datetime` instances are assumed to represent local time and this method relies on the platform `C mktime()` function to perform the conversion. Since `datetime` supports wider range of values than `mktime()` on many platforms, this method may raise *OverflowError* for times far in the past or far in the future.

For aware `datetime` instances, the return value is computed as:

```
(dt - datetime(1970, 1, 1, tzinfo=timezone.utc)).total_seconds()
```

在 3.3 版新加入。

在 3.6 版的變更: The `timestamp()` method uses the *fold* attribute to disambiguate the times during a repeated interval.

備註: There is no method to obtain the POSIX timestamp directly from a naive `datetime` instance representing UTC time. If your application uses this convention and your system timezone is not set to UTC, you can obtain the POSIX timestamp by supplying `tzinfo=timezone.utc`:

```
timestamp = dt.replace(tzinfo=timezone.utc).timestamp()
```

or by calculating the timestamp directly:

```
timestamp = (dt - datetime(1970, 1, 1)) / timedelta(seconds=1)
```

`datetime.weekday()`

Return the day of the week as an integer, where Monday is 0 and Sunday is 6. The same as `self.date().weekday()`. See also `isoweekday()`.

`datetime.isoweekday()`

Return the day of the week as an integer, where Monday is 1 and Sunday is 7. The same as `self.date().isoweekday()`. See also `weekday()`, `isocalendar()`.

`datetime.isocalendar()`

Return a *named tuple* with three components: year, week and weekday. The same as `self.date().isocalendar()`.

`datetime.isoformat(sep='T', timespec='auto')`

Return a string representing the date and time in ISO 8601 format:

- YYYY-MM-DDTHH:MM:SS.ffffff, 如果 *microsecond* 不是 0
- YYYY-MM-DDTHH:MM:SS, 如果 *microsecond* 是 0

如果 `utcoffset()` 沒有回傳 `None`, 則會附加一个字串, 給出 UTC 偏移:

- YYYY-MM-DDTHH:MM:SS.ffffff+HH:MM[:SS[.ffffff]], 如果 *microsecond* 不是 0
- YYYY-MM-DDTHH:MM:SS+HH:MM[:SS[.ffffff]], 如果 *microsecond* 是 0

範例：

```
>>> from datetime import datetime, timezone
>>> datetime(2019, 5, 18, 15, 17, 8, 132263).isoformat()
'2019-05-18T15:17:08.132263'
>>> datetime(2019, 5, 18, 15, 17, tzinfo=timezone.utc).isoformat()
'2019-05-18T15:17:00+00:00'
```

The optional argument *sep* (default 'T') is a one-character separator, placed between the date and time portions of the result. For example:

```
>>> from datetime import tzinfo, timedelta, datetime
>>> class TZ(tzinfo):
...     """A time zone with an arbitrary, constant -06:39 offset."""
...     def utcoffset(self, dt):
...         return timedelta(hours=-6, minutes=-39)
...
>>> datetime(2002, 12, 25, tzinfo=TZ()).isoformat(' ')
'2002-12-25 00:00:00-06:39'
>>> datetime(2009, 11, 27, microsecond=100, tzinfo=TZ()).isoformat()
'2009-11-27T00:00:00.000100-06:39'
```

The optional argument *timespec* specifies the number of additional components of the time to include (the default is 'auto'). It can be one of the following:

- 'auto': Same as 'seconds' if *microsecond* is 0, same as 'microseconds' otherwise.
- 'hours': Include the *hour* in the two-digit HH format.
- 'minutes': Include *hour* and *minute* in HH:MM format.
- 'seconds': Include *hour*, *minute*, and *second* in HH:MM:SS format.
- 'milliseconds': Include full time, but truncate fractional second part to milliseconds. HH:MM:SS.sss format.
- 'microseconds': Include full time in HH:MM:SS.ffffff format.

備註: Excluded time components are truncated, not rounded.

ValueError will be raised on an invalid *timespec* argument:

```
>>> from datetime import datetime
>>> datetime.now().isoformat(timespec='minutes')
'2002-12-25T00:00'
>>> dt = datetime(2015, 1, 1, 12, 30, 59, 0)
>>> dt.isoformat(timespec='microseconds')
'2015-01-01T12:30:59.000000'
```

在 3.6 版的變更: Added the *timespec* parameter.

`datetime.__str__()`

For a *datetime* instance *d*, `str(d)` is equivalent to `d.isoformat(' ')`.

`datetime.ctime()`

Return a string representing the date and time:

```
>>> from datetime import datetime
>>> datetime(2002, 12, 4, 20, 30, 40).ctime()
'Wed Dec 4 20:30:40 2002'
```

The output string will *not* include time zone information, regardless of whether the input is aware or naive.

`d.ctime()` 等價於：

```
time.ctime(time.mktime(d.timetuple()))
```

on platforms where the native C `ctime()` function (which `time.ctime()` invokes, but which `datetime.ctime()` does not invoke) conforms to the C standard.

`datetime.strptime(format)`

Return a string representing the date and time, controlled by an explicit format string. See also *strftime()* and *strptime() Behavior* and `datetime.isoformat()`.

`datetime.__format__(format)`

Same as `datetime.strptime()`. This makes it possible to specify a format string for a `datetime` object in formatted string literals and when using `str.format()`. See also *strftime()* and *strptime() Behavior* and `datetime.isoformat()`.

Examples of Usage: datetime

Examples of working with `datetime` objects:

```
>>> from datetime import datetime, date, time, timezone

>>> # Using datetime.combine()
>>> d = date(2005, 7, 14)
>>> t = time(12, 30)
>>> datetime.combine(d, t)
datetime.datetime(2005, 7, 14, 12, 30)

>>> # Using datetime.now()
>>> datetime.now()
datetime.datetime(2007, 12, 6, 16, 29, 43, 79043) # GMT +1
>>> datetime.now(timezone.utc)
datetime.datetime(2007, 12, 6, 15, 29, 43, 79060, tzinfo=datetime.timezone.utc)

>>> # Using datetime.strptime()
>>> dt = datetime.strptime("21/11/06 16:30", "%d/%m/%y %H:%M")
>>> dt
datetime.datetime(2006, 11, 21, 16, 30)

>>> # Using datetime.timetuple() to get tuple of all attributes
>>> tt = dt.timetuple()
>>> for it in tt:
...     print(it)
...
2006      # year
11        # month
21        # day
16        # hour
30        # minute
0         # second
1         # weekday (0 = Monday)
325       # number of days since 1st January
-1        # dst - method tzinfo.dst() returned None

>>> # Date in ISO format
>>> ic = dt.isocalendar()
>>> for it in ic:
...     print(it)
...
2006      # ISO year
47        # ISO week
2         # ISO weekday
```

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```
>>> # Formatting a datetime
>>> dt.strftime("%A, %d. %B %Y %I:%M%p")
'Tuesday, 21. November 2006 04:30PM'
>>> 'The {1} is {0:%d}, the {2} is {0:%B}, the {3} is {0:%I:%M%p}.'.format(dt, "day
↪", "month", "time")
'The day is 21, the month is November, the time is 04:30PM.'
```

The example below defines a `tzinfo` subclass capturing time zone information for Kabul, Afghanistan, which used +4 UTC until 1945 and then +4:30 UTC thereafter:

```
from datetime import timedelta, datetime, tzinfo, timezone

class KabulTz(tzinfo):
    # Kabul used +4 until 1945, when they moved to +4:30
    UTC_MOVE_DATE = datetime(1944, 12, 31, 20, tzinfo=timezone.utc)

    def utcoffset(self, dt):
        if dt.year < 1945:
            return timedelta(hours=4)
        elif (1945, 1, 1, 0, 0) <= dt.timetuple()[5] < (1945, 1, 1, 0, 30):
            # An ambiguous ("imaginary") half-hour range representing
            # a 'fold' in time due to the shift from +4 to +4:30.
            # If dt falls in the imaginary range, use fold to decide how
            # to resolve. See PEP495.
            return timedelta(hours=4, minutes=(30 if dt.fold else 0))
        else:
            return timedelta(hours=4, minutes=30)

    def fromutc(self, dt):
        # Follow same validations as in datetime.tzinfo
        if not isinstance(dt, datetime):
            raise TypeError("fromutc() requires a datetime argument")
        if dt.tzinfo is not self:
            raise ValueError("dt.tzinfo is not self")

        # A custom implementation is required for fromutc as
        # the input to this function is a datetime with utc values
        # but with a tzinfo set to self.
        # See datetime.astimezone or fromtimestamp.
        if dt.replace(tzinfo=timezone.utc) >= self.UTC_MOVE_DATE:
            return dt + timedelta(hours=4, minutes=30)
        else:
            return dt + timedelta(hours=4)

    def dst(self, dt):
        # Kabul does not observe daylight saving time.
        return timedelta(0)

    def tzname(self, dt):
        if dt >= self.UTC_MOVE_DATE:
            return "+04:30"
        return "+04"
```

Usage of `KabulTz` from above:

```
>>> tz1 = KabulTz()

>>> # Datetime before the change
>>> dt1 = datetime(1900, 11, 21, 16, 30, tzinfo=tz1)
>>> print(dt1.utcoffset())
```

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```

4:00:00

>>> # Datetime after the change
>>> dt2 = datetime(2006, 6, 14, 13, 0, tzinfo=tz1)
>>> print(dt2.utcoffset())
4:30:00

>>> # Convert datetime to another time zone
>>> dt3 = dt2.astimezone(timezone.utc)
>>> dt3
datetime.datetime(2006, 6, 14, 8, 30, tzinfo=datetime.timezone.utc)
>>> dt2
datetime.datetime(2006, 6, 14, 13, 0, tzinfo=KabulTz())
>>> dt2 == dt3
True

```

8.1.7 time 物件

A *time* object represents a (local) time of day, independent of any particular day, and subject to adjustment via a *tzinfo* object.

class `datetime.time` (*hour=0, minute=0, second=0, microsecond=0, tzinfo=None, *, fold=0*)

All arguments are optional. *tzinfo* may be `None`, or an instance of a *tzinfo* subclass. The remaining arguments must be integers in the following ranges:

- `0 <= hour < 24`,
- `0 <= minute < 60`,
- `0 <= second < 60`,
- `0 <= microsecond < 1000000`,
- `fold` in `[0, 1]`.

If an argument outside those ranges is given, *ValueError* is raised. All default to 0 except *tzinfo*, which defaults to `None`.

類F屬性:

`time.min`

The earliest representable *time*, `time(0, 0, 0, 0)`.

`time.max`

The latest representable *time*, `time(23, 59, 59, 999999)`.

`time.resolution`

The smallest possible difference between non-equal *time* objects, `timedelta(microseconds=1)`, although note that arithmetic on *time* objects is not supported.

Instance attributes (read-only):

`time.hour`

In range (24).

`time.minute`

In range (60).

`time.second`

In range (60).

`time.microsecond`

In range(1000000).

`time.tzinfo`

The object passed as the `tzinfo` argument to the `time` constructor, or `None` if none was passed.

`time.fold`

In [0, 1]. Used to disambiguate wall times during a repeated interval. (A repeated interval occurs when clocks are rolled back at the end of daylight saving time or when the UTC offset for the current zone is decreased for political reasons.) The value 0 (1) represents the earlier (later) of the two moments with the same wall time representation.

在 3.6 版新加入。

`time` objects support equality and order comparisons, where *a* is considered less than *b* when *a* precedes *b* in time.

Naive and aware `time` objects are never equal. Order comparison between naive and aware `time` objects raises `TypeError`.

If both comparands are aware, and have the same `tzinfo` attribute, the `tzinfo` and `fold` attributes are ignored and the base times are compared. If both comparands are aware and have different `tzinfo` attributes, the comparands are first adjusted by subtracting their UTC offsets (obtained from `self.utcoffset()`).

在 3.3 版的變更: Equality comparisons between aware and naive `time` instances don't raise `TypeError`.

In Boolean contexts, a `time` object is always considered to be true.

在 3.5 版的變更: Before Python 3.5, a `time` object was considered to be false if it represented midnight in UTC. This behavior was considered obscure and error-prone and has been removed in Python 3.5. See [bpo-13936](#) for full details.

Other constructor:

classmethod `time.fromisoformat(time_string)`

Return a `time` corresponding to a `time_string` in any valid ISO 8601 format, with the following exceptions:

1. Time zone offsets may have fractional seconds.
2. The leading T, normally required in cases where there may be ambiguity between a date and a time, is not required.
3. Fractional seconds may have any number of digits (anything beyond 6 will be truncated).
4. Fractional hours and minutes are not supported.

Examples:

```
>>> from datetime import time
>>> time.fromisoformat('04:23:01')
datetime.time(4, 23, 1)
>>> time.fromisoformat('T04:23:01')
datetime.time(4, 23, 1)
>>> time.fromisoformat('T042301')
datetime.time(4, 23, 1)
>>> time.fromisoformat('04:23:01.000384')
datetime.time(4, 23, 1, 384)
>>> time.fromisoformat('04:23:01,000384')
datetime.time(4, 23, 1, 384)
>>> time.fromisoformat('04:23:01+04:00')
datetime.time(4, 23, 1, tzinfo=datetime.timezone(datetime.
↳timedelta(seconds=14400)))
>>> time.fromisoformat('04:23:01Z')
datetime.time(4, 23, 1, tzinfo=datetime.timezone.utc)
>>> time.fromisoformat('04:23:01+00:00')
datetime.time(4, 23, 1, tzinfo=datetime.timezone.utc)
```

在 3.7 版新加入。

在 3.11 版的變更: Previously, this method only supported formats that could be emitted by `time.isoformat()`.

實例方法:

`time.replace(hour=self.hour, minute=self.minute, second=self.second, microsecond=self.microsecond, tzinfo=self.tzinfo, *, fold=0)`

Return a `time` with the same value, except for those attributes given new values by whichever keyword arguments are specified. Note that `tzinfo=None` can be specified to create a naive `time` from an aware `time`, without conversion of the time data.

在 3.6 版的變更: Added the `fold` parameter.

`time.isoformat(timespec='auto')`

Return a string representing the time in ISO 8601 format, one of:

- `HH:MM:SS.ffffff`, if `microsecond` is not 0
- `HH:MM:SS`, if `microsecond` is 0
- `HH:MM:SS.ffffff+HH:MM[:SS[.ffffff]]`, if `utcoffset()` does not return `None`
- `HH:MM:SS+HH:MM[:SS[.ffffff]]`, if `microsecond` is 0 and `utcoffset()` does not return `None`

The optional argument `timespec` specifies the number of additional components of the time to include (the default is `'auto'`). It can be one of the following:

- `'auto'`: Same as `'seconds'` if `microsecond` is 0, same as `'microseconds'` otherwise.
- `'hours'`: Include the `hour` in the two-digit `HH` format.
- `'minutes'`: Include `hour` and `minute` in `HH:MM` format.
- `'seconds'`: Include `hour`, `minute`, and `second` in `HH:MM:SS` format.
- `'milliseconds'`: Include full time, but truncate fractional second part to milliseconds. `HH:MM:SS.sss` format.
- `'microseconds'`: Include full time in `HH:MM:SS.ffffff` format.

備 F: Excluded time components are truncated, not rounded.

`ValueError` will be raised on an invalid `timespec` argument.

範例:

```
>>> from datetime import time
>>> time(hour=12, minute=34, second=56, microsecond=123456).isoformat(timespec=
↪ 'minutes')
'12:34'
>>> dt = time(hour=12, minute=34, second=56, microsecond=0)
>>> dt.isoformat(timespec='microseconds')
'12:34:56.000000'
>>> dt.isoformat(timespec='auto')
'12:34:56'
```

在 3.6 版的變更: Added the `timespec` parameter.

`time.__str__()`

For a time `t`, `str(t)` is equivalent to `t.isoformat()`.

`time.strftime(format)`

Return a string representing the time, controlled by an explicit format string. See also *strftime()* and *strptime()* Behavior and *time.isoformat()*.

`time.__format__(format)`

Same as *time.strftime()*. This makes it possible to specify a format string for a *time* object in formatted string literals and when using *str.format()*. See also *strftime()* and *strptime()* Behavior and *time.isoformat()*.

`time.utcoffset()`

If *tzinfo* is *None*, returns *None*, else returns *self.tzinfo.utcoffset(None)*, and raises an exception if the latter doesn't return *None* or a *timedelta* object with magnitude less than one day.

在 3.7 版的變更: The UTC offset is not restricted to a whole number of minutes.

`time.dst()`

If *tzinfo* is *None*, returns *None*, else returns *self.tzinfo.dst(None)*, and raises an exception if the latter doesn't return *None*, or a *timedelta* object with magnitude less than one day.

在 3.7 版的變更: The DST offset is not restricted to a whole number of minutes.

`time.tzname()`

If *tzinfo* is *None*, returns *None*, else returns *self.tzinfo.tzname(None)*, or raises an exception if the latter doesn't return *None* or a string object.

用法范例: `time`

Examples of working with a *time* object:

```
>>> from datetime import time, tzinfo, timedelta
>>> class TZ1(tzinfo):
...     def utcoffset(self, dt):
...         return timedelta(hours=1)
...     def dst(self, dt):
...         return timedelta(0)
...     def tzname(self, dt):
...         return "+01:00"
...     def __repr__(self):
...         return f"{self.__class__.__name__}()"
...
>>> t = time(12, 10, 30, tzinfo=TZ1())
>>> t
datetime.time(12, 10, 30, tzinfo=TZ1())
>>> t.isoformat()
'12:10:30+01:00'
>>> t.dst()
datetime.timedelta(0)
>>> t.tzname()
'+01:00'
>>> t.strftime("%H:%M:%S %Z")
'12:10:30 +01:00'
>>> 'The {} is {:%H:%M}'.format("time", t)
'The time is 12:10.'
```

8.1.8 tzinfo 物件

class datetime.tzinfo

This is an abstract base class, meaning that this class should not be instantiated directly. Define a subclass of *tzinfo* to capture information about a particular time zone.

An instance of (a concrete subclass of) *tzinfo* can be passed to the constructors for *datetime* and *time* objects. The latter objects view their attributes as being in local time, and the *tzinfo* object supports methods revealing offset of local time from UTC, the name of the time zone, and DST offset, all relative to a date or time object passed to them.

You need to derive a concrete subclass, and (at least) supply implementations of the standard *tzinfo* methods needed by the *datetime* methods you use. The *datetime* module provides *timezone*, a simple concrete subclass of *tzinfo* which can represent timezones with fixed offset from UTC such as UTC itself or North American EST and EDT.

Special requirement for pickling: A *tzinfo* subclass must have an `__init__()` method that can be called with no arguments, otherwise it can be pickled but possibly not unpickled again. This is a technical requirement that may be relaxed in the future.

A concrete subclass of *tzinfo* may need to implement the following methods. Exactly which methods are needed depends on the uses made of aware *datetime* objects. If in doubt, simply implement all of them.

tzinfo.utcoffset(dt)

Return offset of local time from UTC, as a *timedelta* object that is positive east of UTC. If local time is west of UTC, this should be negative.

This represents the *total* offset from UTC; for example, if a *tzinfo* object represents both time zone and DST adjustments, *utcoffset()* should return their sum. If the UTC offset isn't known, return *None*. Else the value returned must be a *timedelta* object strictly between `-timedelta(hours=24)` and `timedelta(hours=24)` (the magnitude of the offset must be less than one day). Most implementations of *utcoffset()* will probably look like one of these two:

```
return CONSTANT                # fixed-offset class
return CONSTANT + self.dst(dt) # daylight-aware class
```

If *utcoffset()* does not return *None*, *dst()* should not return *None* either.

The default implementation of *utcoffset()* raises *NotImplementedError*.

在 3.7 版的變更: The UTC offset is not restricted to a whole number of minutes.

tzinfo.dst(dt)

Return the daylight saving time (DST) adjustment, as a *timedelta* object or *None* if DST information isn't known.

Return `timedelta(0)` if DST is not in effect. If DST is in effect, return the offset as a *timedelta* object (see *utcoffset()* for details). Note that DST offset, if applicable, has already been added to the UTC offset returned by *utcoffset()*, so there's no need to consult *dst()* unless you're interested in obtaining DST info separately. For example, *datetime.timetuple()* calls its *tzinfo* attribute's *dst()* method to determine how the `tm_isdst` flag should be set, and *tzinfo.fromutc()* calls *dst()* to account for DST changes when crossing time zones.

An instance *tz* of a *tzinfo* subclass that models both standard and daylight times must be consistent in this sense:

```
tz.utcoffset(dt) - tz.dst(dt)
```

must return the same result for every *datetime dt* with `dt.tzinfo == tz`. For sane *tzinfo* subclasses, this expression yields the time zone's "standard offset", which should not depend on the date or the time, but only on geographic location. The implementation of *datetime.astimezone()* relies on this, but cannot detect violations; it's the programmer's responsibility to ensure it. If a *tzinfo* subclass cannot guarantee this, it may be able to override the default implementation of *tzinfo.fromutc()* to work correctly with *astimezone()* regardless.

Most implementations of `dst()` will probably look like one of these two:

```
def dst(self, dt):
    # a fixed-offset class: doesn't account for DST
    return timedelta(0)
```

或是：

```
def dst(self, dt):
    # Code to set dston and dstoff to the time zone's DST
    # transition times based on the input dt.year, and expressed
    # in standard local time.

    if dston <= dt.replace(tzinfo=None) < dstoff:
        return timedelta(hours=1)
    else:
        return timedelta(0)
```

The default implementation of `dst()` raises `NotImplementedError`.

在 3.7 版的變更: The DST offset is not restricted to a whole number of minutes.

`tzinfo.tzname(dt)`

Return the time zone name corresponding to the `datetime` object `dt`, as a string. Nothing about string names is defined by the `datetime` module, and there's no requirement that it mean anything in particular. For example, "GMT", "UTC", "-500", "-5:00", "EDT", "US/Eastern", "America/New York" are all valid replies. Return `None` if a string name isn't known. Note that this is a method rather than a fixed string primarily because some `tzinfo` subclasses will wish to return different names depending on the specific value of `dt` passed, especially if the `tzinfo` class is accounting for daylight time.

The default implementation of `tzname()` raises `NotImplementedError`.

These methods are called by a `datetime` or `time` object, in response to their methods of the same names. A `datetime` object passes itself as the argument, and a `time` object passes `None` as the argument. A `tzinfo` subclass's methods should therefore be prepared to accept a `dt` argument of `None`, or of class `datetime`.

When `None` is passed, it's up to the class designer to decide the best response. For example, returning `None` is appropriate if the class wishes to say that time objects don't participate in the `tzinfo` protocols. It may be more useful for `utcoffset(None)` to return the standard UTC offset, as there is no other convention for discovering the standard offset.

When a `datetime` object is passed in response to a `datetime` method, `dt.tzinfo` is the same object as `self.tzinfo` methods can rely on this, unless user code calls `tzinfo` methods directly. The intent is that the `tzinfo` methods interpret `dt` as being in local time, and not need worry about objects in other timezones.

There is one more `tzinfo` method that a subclass may wish to override:

`tzinfo.fromutc(dt)`

This is called from the default `datetime.astimezone()` implementation. When called from that, `dt.tzinfo` is `self`, and `dt`'s date and time data are to be viewed as expressing a UTC time. The purpose of `fromutc()` is to adjust the date and time data, returning an equivalent datetime in `self`'s local time.

Most `tzinfo` subclasses should be able to inherit the default `fromutc()` implementation without problems. It's strong enough to handle fixed-offset time zones, and time zones accounting for both standard and daylight time, and the latter even if the DST transition times differ in different years. An example of a time zone the default `fromutc()` implementation may not handle correctly in all cases is one where the standard offset (from UTC) depends on the specific date and time passed, which can happen for political reasons. The default implementations of `astimezone()` and `fromutc()` may not produce the result you want if the result is one of the hours straddling the moment the standard offset changes.

Skipping code for error cases, the default `fromutc()` implementation acts like:

```

def fromutc(self, dt):
    # raise ValueError error if dt.tzinfo is not self
    dtoff = dt.utcoffset()
    dtdst = dt.dst()
    # raise ValueError if dtoff is None or dtdst is None
    delta = dtoff - dtdst # this is self's standard offset
    if delta:
        dt += delta # convert to standard local time
        dtdst = dt.dst()
        # raise ValueError if dtdst is None
    if dtdst:
        return dt + dtdst
    else:
        return dt

```

In the following `tzinfo_examples.py` file there are some examples of `tzinfo` classes:

```

from datetime import tzinfo, timedelta, datetime

ZERO = timedelta(0)
HOUR = timedelta(hours=1)
SECOND = timedelta(seconds=1)

# A class capturing the platform's idea of local time.
# (May result in wrong values on historical times in
# timezones where UTC offset and/or the DST rules had
# changed in the past.)
import time as _time

STDOFFSET = timedelta(seconds = -_time.timezone)
if _time.daylight:
    DSTOFFSET = timedelta(seconds = -_time.altzone)
else:
    DSTOFFSET = STDOFFSET

DSTDIFF = DSTOFFSET - STDOFFSET

class LocalTimezone(tzinfo):

    def fromutc(self, dt):
        assert dt.tzinfo is self
        stamp = (dt - datetime(1970, 1, 1, tzinfo=self)) // SECOND
        args = _time.localtime(stamp)[:6]
        dst_diff = DSTDIFF // SECOND
        # Detect fold
        fold = (args == _time.localtime(stamp - dst_diff))
        return datetime(*args, microsecond=dt.microsecond,
                        tzinfo=self, fold=fold)

    def utcoffset(self, dt):
        if self._isdst(dt):
            return DSTOFFSET
        else:
            return STDOFFSET

    def dst(self, dt):
        if self._isdst(dt):
            return DSTDIFF
        else:
            return ZERO

    def tzname(self, dt):

```

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```

        return _time.tzname[self._isdst(dt)]

    def _isdst(self, dt):
        tt = (dt.year, dt.month, dt.day,
              dt.hour, dt.minute, dt.second,
              dt.weekday(), 0, 0)
        stamp = _time.mktime(tt)
        tt = _time.localtime(stamp)
        return tt.tm_isdst > 0

Local = LocalTimezone()

# A complete implementation of current DST rules for major US time zones.

def first_sunday_on_or_after(dt):
    days_to_go = 6 - dt.weekday()
    if days_to_go:
        dt += timedelta(days_to_go)
    return dt

# US DST Rules
#
# This is a simplified (i.e., wrong for a few cases) set of rules for US
# DST start and end times. For a complete and up-to-date set of DST rules
# and timezone definitions, visit the Olson Database (or try pytz):
# http://www.twinsun.com/tz/tz-link.htm
# https://sourceforge.net/projects/pytz/ (might not be up-to-date)
#
# In the US, since 2007, DST starts at 2am (standard time) on the second
# Sunday in March, which is the first Sunday on or after Mar 8.
DSTSTART_2007 = datetime(1, 3, 8, 2)
# and ends at 2am (DST time) on the first Sunday of Nov.
DSTEND_2007 = datetime(1, 11, 1, 2)
# From 1987 to 2006, DST used to start at 2am (standard time) on the first
# Sunday in April and to end at 2am (DST time) on the last
# Sunday of October, which is the first Sunday on or after Oct 25.
DSTSTART_1987_2006 = datetime(1, 4, 1, 2)
DSTEND_1987_2006 = datetime(1, 10, 25, 2)
# From 1967 to 1986, DST used to start at 2am (standard time) on the last
# Sunday in April (the one on or after April 24) and to end at 2am (DST time)
# on the last Sunday of October, which is the first Sunday
# on or after Oct 25.
DSTSTART_1967_1986 = datetime(1, 4, 24, 2)
DSTEND_1967_1986 = DSTEND_1987_2006

def us_dst_range(year):
    # Find start and end times for US DST. For years before 1967, return
    # start = end for no DST.
    if 2006 < year:
        dststart, dstend = DSTSTART_2007, DSTEND_2007
    elif 1986 < year < 2007:
        dststart, dstend = DSTSTART_1987_2006, DSTEND_1987_2006
    elif 1966 < year < 1987:
        dststart, dstend = DSTSTART_1967_1986, DSTEND_1967_1986
    else:
        return (datetime(year, 1, 1), ) * 2

    start = first_sunday_on_or_after(dststart.replace(year=year))
    end = first_sunday_on_or_after(dstend.replace(year=year))

```

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```

    return start, end

class USTimeZone(tzinfo):

    def __init__(self, hours, reprname, stdname, dstname):
        self.stdoffset = timedelta(hours=hours)
        self.reprname = reprname
        self.stdname = stdname
        self.dstname = dstname

    def __repr__(self):
        return self.reprname

    def tzname(self, dt):
        if self.dst(dt):
            return self.dstname
        else:
            return self.stdname

    def utcoffset(self, dt):
        return self.stdoffset + self.dst(dt)

    def dst(self, dt):
        if dt is None or dt.tzinfo is None:
            # An exception may be sensible here, in one or both cases.
            # It depends on how you want to treat them. The default
            # fromutc() implementation (called by the default astimezone()
            # implementation) passes a datetime with dt.tzinfo is self.
            return ZERO
        assert dt.tzinfo is self
        start, end = us_dst_range(dt.year)
        # Can't compare naive to aware objects, so strip the timezone from
        # dt first.
        dt = dt.replace(tzinfo=None)
        if start + HOUR <= dt < end - HOUR:
            # DST is in effect.
            return HOUR
        if end - HOUR <= dt < end:
            # Fold (an ambiguous hour): use dt.fold to disambiguate.
            return ZERO if dt.fold else HOUR
        if start <= dt < start + HOUR:
            # Gap (a non-existent hour): reverse the fold rule.
            return HOUR if dt.fold else ZERO
        # DST is off.
        return ZERO

    def fromutc(self, dt):
        assert dt.tzinfo is self
        start, end = us_dst_range(dt.year)
        start = start.replace(tzinfo=self)
        end = end.replace(tzinfo=self)
        std_time = dt + self.stdoffset
        dst_time = std_time + HOUR
        if end <= dst_time < end + HOUR:
            # Repeated hour
            return std_time.replace(fold=1)
        if std_time < start or dst_time >= end:
            # Standard time
            return std_time
        if start <= std_time < end - HOUR:

```

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```

    # Daylight saving time
    return dst_time

Eastern = USTimeZone(-5, "Eastern", "EST", "EDT")
Central = USTimeZone(-6, "Central", "CST", "CDT")
Mountain = USTimeZone(-7, "Mountain", "MST", "MDT")
Pacific = USTimeZone(-8, "Pacific", "PST", "PDT")

```

Note that there are unavoidable subtleties twice per year in a *tzinfo* subclass accounting for both standard and daylight time, at the DST transition points. For concreteness, consider US Eastern (UTC -0500), where EDT begins the minute after 1:59 (EST) on the second Sunday in March, and ends the minute after 1:59 (EDT) on the first Sunday in November:

```

UTC      3:MM  4:MM  5:MM  6:MM  7:MM  8:MM
EST      22:MM 23:MM  0:MM  1:MM  2:MM  3:MM
EDT      23:MM  0:MM  1:MM  2:MM  3:MM  4:MM

start    22:MM 23:MM  0:MM  1:MM  3:MM  4:MM

end      23:MM  0:MM  1:MM  1:MM  2:MM  3:MM

```

When DST starts (the "start" line), the local wall clock leaps from 1:59 to 3:00. A wall time of the form 2:MM doesn't really make sense on that day, so *astimezone*(Eastern) won't deliver a result with `hour == 2` on the day DST begins. For example, at the Spring forward transition of 2016, we get:

```

>>> from datetime import datetime, timezone
>>> from tzinfo_examples import HOUR, Eastern
>>> u0 = datetime(2016, 3, 13, 5, tzinfo=timezone.utc)
>>> for i in range(4):
...     u = u0 + i*HOUR
...     t = u.astimezone(Eastern)
...     print(u.time(), 'UTC =', t.time(), t.tzname())
...
05:00:00 UTC = 00:00:00 EST
06:00:00 UTC = 01:00:00 EST
07:00:00 UTC = 03:00:00 EDT
08:00:00 UTC = 04:00:00 EDT

```

When DST ends (the "end" line), there's a potentially worse problem: there's an hour that can't be spelled unambiguously in local wall time: the last hour of daylight time. In Eastern, that's times of the form 5:MM UTC on the day daylight time ends. The local wall clock leaps from 1:59 (daylight time) back to 1:00 (standard time) again. Local times of the form 1:MM are ambiguous. *astimezone*() mimics the local clock's behavior by mapping two adjacent UTC hours into the same local hour then. In the Eastern example, UTC times of the form 5:MM and 6:MM both map to 1:MM when converted to Eastern, but earlier times have the *fold* attribute set to 0 and the later times have it set to 1. For example, at the Fall back transition of 2016, we get:

```

>>> u0 = datetime(2016, 11, 6, 4, tzinfo=timezone.utc)
>>> for i in range(4):
...     u = u0 + i*HOUR
...     t = u.astimezone(Eastern)
...     print(u.time(), 'UTC =', t.time(), t.tzname(), t.fold)
...
04:00:00 UTC = 00:00:00 EDT 0
05:00:00 UTC = 01:00:00 EDT 0
06:00:00 UTC = 01:00:00 EST 1
07:00:00 UTC = 02:00:00 EST 0

```

Note that the *datetime* instances that differ only by the value of the *fold* attribute are considered equal in comparisons.

Applications that can't bear wall-time ambiguities should explicitly check the value of the `fold` attribute or avoid using hybrid `tzinfo` subclasses; there are no ambiguities when using `timezone`, or any other fixed-offset `tzinfo` subclass (such as a class representing only EST (fixed offset -5 hours), or only EDT (fixed offset -4 hours)).

也參考:

`zoneinfo`

The `datetime` module has a basic `timezone` class (for handling arbitrary fixed offsets from UTC) and its `timezone.utc` attribute (a UTC `timezone` instance).

`zoneinfo` brings the *IANA timezone database* (also known as the Olson database) to Python, and its usage is recommended.

IANA 時區資料庫

The Time Zone Database (often called tz, tzdata or zoneinfo) contains code and data that represent the history of local time for many representative locations around the globe. It is updated periodically to reflect changes made by political bodies to time zone boundaries, UTC offsets, and daylight-saving rules.

8.1.9 `timezone` 物件

The `timezone` class is a subclass of `tzinfo`, each instance of which represents a timezone defined by a fixed offset from UTC.

Objects of this class cannot be used to represent timezone information in the locations where different offsets are used in different days of the year or where historical changes have been made to civil time.

class `datetime.timezone` (*offset*, *name=None*)

The *offset* argument must be specified as a `timedelta` object representing the difference between the local time and UTC. It must be strictly between `-timedelta(hours=24)` and `timedelta(hours=24)`, otherwise `ValueError` is raised.

The *name* argument is optional. If specified it must be a string that will be used as the value returned by the `datetime.tzname()` method.

在 3.2 版新加入.

在 3.7 版的變更: The UTC offset is not restricted to a whole number of minutes.

`timezone.utcoffset(dt)`

Return the fixed value specified when the `timezone` instance is constructed.

The *dt* argument is ignored. The return value is a `timedelta` instance equal to the difference between the local time and UTC.

在 3.7 版的變更: The UTC offset is not restricted to a whole number of minutes.

`timezone.tzname(dt)`

Return the fixed value specified when the `timezone` instance is constructed.

If *name* is not provided in the constructor, the name returned by `tzname(dt)` is generated from the value of the *offset* as follows. If *offset* is `timedelta(0)`, the name is "UTC", otherwise it is a string in the format `UTC±HH:MM`, where \pm is the sign of *offset*, HH and MM are two digits of `offset.hours` and `offset.minutes` respectively.

在 3.6 版的變更: Name generated from `offset=timedelta(0)` is now plain 'UTC', not 'UTC+00:00'.

`timezone.dst(dt)`

Always returns None.

`timezone.fromutc(dt)`

Return `dt + offset`. The *dt* argument must be an aware `datetime` instance, with `tzinfo` set to `self`.

類 F 屬性:

`timezone.utc`
The UTC timezone, `timezone(timedelta(0))`.

8.1.10 `strftime()` and `strptime()` Behavior

`date`, `datetime`, and `time` objects all support a `strftime(format)` method, to create a string representing the time under the control of an explicit format string.

Conversely, the `datetime.strptime()` class method creates a `datetime` object from a string representing a date and time and a corresponding format string.

The table below provides a high-level comparison of `strftime()` versus `strptime()`:

	<code>strftime</code>	<code>strptime</code>
用法	Convert object to a string according to a given format	Parse a string into a <code>datetime</code> object given a corresponding format
Type of method	實例方法	類F方法
Method of	<code>date</code> ; <code>datetime</code> ; <code>time</code>	<code>datetime</code>
Signature	<code>strftime(format)</code>	<code>strptime(date_string, format)</code>

`strftime()` and `strptime()` Format Codes

These methods accept format codes that can be used to parse and format dates:

```
>>> datetime.strptime('31/01/22 23:59:59.999999',
...                   '%d/%m/%y %H:%M:%S.%f')
datetime.datetime(2022, 1, 31, 23, 59, 59, 999999)
>>> _.strftime('%a %d %b %Y, %I:%M%p')
'Mon 31 Jan 2022, 11:59PM'
```

The following is a list of all the format codes that the 1989 C standard requires, and these work on all platforms with a standard C implementation.

Directive	Meaning	範例	解
%a	Weekday as locale's abbreviated name.	Sun, Mon, ..., Sat (en_US); So, Mo, ..., Sa (de_DE)	(1)
%A	Weekday as locale's full name.	Sunday, Monday, ..., Saturday (en_US); Sonntag, Montag, ..., Samstag (de_DE)	(1)
%w	Weekday as a decimal number, where 0 is Sunday and 6 is Saturday.	0, 1, ..., 6	
%d	Day of the month as a zero-padded decimal number.	01, 02, ..., 31	(9)
%b	Month as locale's abbreviated name.	Jan, Feb, ..., Dec (en_US); Jan, Feb, ..., Dez (de_DE)	(1)
%B	Month as locale's full name.	January, February, ..., December (en_US); Januar, Februar, ..., Dezember (de_DE)	(1)
%m	Month as a zero-padded decimal number.	01, 02, ..., 12	(9)
%y	Year without century as a zero-padded decimal number.	00, 01, ..., 99	(9)
%Y	Year with century as a decimal number.	0001, 0002, ..., 2013, 2014, ..., 9998, 9999	(2)
%H	Hour (24-hour clock) as a zero-padded decimal number.	00, 01, ..., 23	(9)
%I	Hour (12-hour clock) as a zero-padded decimal number.	01, 02, ..., 12	(9)
%p	Locale's equivalent of either AM or PM.	AM, PM (en_US); am, pm (de_DE)	(1), (3)
%M	Minute as a zero-padded decimal number.	00, 01, ..., 59	(9)
%S	Second as a zero-padded decimal number.	00, 01, ..., 59	(4), (9)
%f	Microsecond as a decimal number, zero-padded to 6 digits.	000000, 000001, ..., 999999	(5)
%z	UTC offset in the form ±HHMM[SS[.ffffff]] (empty string if the object is naive).	(empty), +0000, - 0400, +1030, +063415, -030712.345216	(6)

Several additional directives not required by the C89 standard are included for convenience. These parameters all correspond to ISO 8601 date values.

Di- rec- tive	Meaning	範例	解
%G	ISO 8601 year with century representing the year that contains the greater part of the ISO week (%V).	0001, 0002, ..., 2013, 2014, ..., 9998, 9999	(8)
%u	ISO 8601 weekday as a decimal number where 1 is Monday.	1, 2, ..., 7	
%V	ISO 8601 week as a decimal number with Monday as the first day of the week. Week 01 is the week containing Jan 4.	01, 02, ..., 53	(8), (9)

These may not be available on all platforms when used with the `strptime()` method. The ISO 8601 year and ISO 8601 week directives are not interchangeable with the year and week number directives above. Calling `strptime()` with incomplete or ambiguous ISO 8601 directives will raise a `ValueError`.

The full set of format codes supported varies across platforms, because Python calls the platform C library's `strptime()` function, and platform variations are common. To see the full set of format codes supported on your platform, consult the `strptime(3)` documentation. There are also differences between platforms in handling of unsupported format specifiers.

在 3.6 版新加入: 新增 %G、%u 與 %V。

Technical Detail

Broadly speaking, `d.strptime(fmt)` acts like the `time` module's `time.strptime(fmt, d.timetuple())` although not all objects support a `timetuple()` method.

For the `datetime.strptime()` class method, the default value is `1900-01-01T00:00:00.000`: any components not specified in the format string will be pulled from the default value.⁴

Using `datetime.strptime(date_string, format)` is equivalent to:

```
datetime(*(time.strptime(date_string, format)[0:6]))
```

except when the format includes sub-second components or timezone offset information, which are supported in `datetime.strptime` but are discarded by `time.strptime`.

For `time` objects, the format codes for year, month, and day should not be used, as `time` objects have no such values. If they're used anyway, 1900 is substituted for the year, and 1 for the month and day.

For `date` objects, the format codes for hours, minutes, seconds, and microseconds should not be used, as `date` objects have no such values. If they're used anyway, 0 is substituted for them.

For the same reason, handling of format strings containing Unicode code points that can't be represented in the charset of the current locale is also platform-dependent. On some platforms such code points are preserved intact in the output, while on others `strptime` may raise `UnicodeError` or return an empty string instead.

解:

- (1) Because the format depends on the current locale, care should be taken when making assumptions about the output value. Field orderings will vary (for example, "month/day/year" versus "day/month/year"), and the output may contain non-ASCII characters.
- (2) The `strptime()` method can parse years in the full [1, 9999] range, but years < 1000 must be zero-filled to 4-digit width.

在 3.2 版的變更: In previous versions, `strptime()` method was restricted to years \geq 1900.

在 3.3 版的變更: In version 3.2, `strptime()` method was restricted to years \geq 1000.

⁴ Passing `datetime.strptime('Feb 29', '%b %d')` will fail since 1900 is not a leap year.

- (3) When used with the `strptime()` method, the `%p` directive only affects the output hour field if the `%I` directive is used to parse the hour.
- (4) Unlike the `time` module, the `datetime` module does not support leap seconds.
- (5) When used with the `strptime()` method, the `%f` directive accepts from one to six digits and zero pads on the right. `%f` is an extension to the set of format characters in the C standard (but implemented separately in `datetime` objects, and therefore always available).
- (6) For a naive object, the `%z` and `%Z` format codes are replaced by empty strings.

For an aware object:

%z

`utcoffset()` is transformed into a string of the form `±HHMM[SS[.ffffff]]`, where `HH` is a 2-digit string giving the number of UTC offset hours, `MM` is a 2-digit string giving the number of UTC offset minutes, `SS` is a 2-digit string giving the number of UTC offset seconds and `ffffff` is a 6-digit string giving the number of UTC offset microseconds. The `ffffff` part is omitted when the offset is a whole number of seconds and both the `ffffff` and the `SS` part is omitted when the offset is a whole number of minutes. For example, if `utcoffset()` returns `timedelta(hours=-3, minutes=-30)`, `%z` is replaced with the string `'-0330'`.

在 3.7 版的變更: The UTC offset is not restricted to a whole number of minutes.

在 3.7 版的變更: When the `%z` directive is provided to the `strptime()` method, the UTC offsets can have a colon as a separator between hours, minutes and seconds. For example, `'+01:00:00'` will be parsed as an offset of one hour. In addition, providing `'Z'` is identical to `'+00:00'`.

%Z

In `strptime()`, `%Z` is replaced by an empty string if `tzname()` returns `None`; otherwise `%Z` is replaced by the returned value, which must be a string.

`strptime()` only accepts certain values for `%Z`:

1. any value in `time.tzname` for your machine's locale
2. the hard-coded values `UTC` and `GMT`

So someone living in Japan may have `JST`, `UTC`, and `GMT` as valid values, but probably not `EST`. It will raise `ValueError` for invalid values.

在 3.2 版的變更: When the `%z` directive is provided to the `strptime()` method, an aware `datetime` object will be produced. The `tzinfo` of the result will be set to a `timezone` instance.

- (7) When used with the `strptime()` method, `%U` and `%W` are only used in calculations when the day of the week and the calendar year (`%Y`) are specified.
- (8) Similar to `%U` and `%W`, `%V` is only used in calculations when the day of the week and the ISO year (`%G`) are specified in a `strptime()` format string. Also note that `%G` and `%Y` are not interchangeable.
- (9) When used with the `strptime()` method, the leading zero is optional for formats `%d`, `%m`, `%H`, `%I`, `%M`, `%S`, `%j`, `%U`, `%W`, and `%V`. Format `%y` does require a leading zero.

F 解

8.2 zoneinfo --- IANA 時區支援

在 3.9 版新加入.

原始碼: [Lib/zoneinfo](#)

The `zoneinfo` module provides a concrete time zone implementation to support the IANA time zone database as originally specified in [PEP 615](#). By default, `zoneinfo` uses the system's time zone data if available; if no system time zone data is available, the library will fall back to using the first-party `tzdata` package available on PyPI.

也參考:

`datetime` 模組

Provides the `time` and `datetime` types with which the `ZoneInfo` class is designed to be used.

Package `tzdata`

First-party package maintained by the CPython core developers to supply time zone data via PyPI.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

8.2.1 Using `ZoneInfo`

`ZoneInfo` is a concrete implementation of the `datetime.tzinfo` abstract base class, and is intended to be attached to `tzinfo`, either via the constructor, the `datetime.replace` method or `datetime.astimezone`:

```
>>> from zoneinfo import ZoneInfo
>>> from datetime import datetime, timedelta

>>> dt = datetime(2020, 10, 31, 12, tzinfo=ZoneInfo("America/Los_Angeles"))
>>> print(dt)
2020-10-31 12:00:00-07:00

>>> dt.tzname()
'PDT'
```

Datetimes constructed in this way are compatible with datetime arithmetic and handle daylight saving time transitions with no further intervention:

```
>>> dt_add = dt + timedelta(days=1)

>>> print(dt_add)
2020-11-01 12:00:00-08:00

>>> dt_add.tzname()
'PST'
```

These time zones also support the `fold` attribute introduced in [PEP 495](#). During offset transitions which induce ambiguous times (such as a daylight saving time to standard time transition), the offset from *before* the transition is used when `fold=0`, and the offset *after* the transition is used when `fold=1`, for example:

```
>>> dt = datetime(2020, 11, 1, 1, tzinfo=ZoneInfo("America/Los_Angeles"))
>>> print(dt)
2020-11-01 01:00:00-07:00

>>> print(dt.replace(fold=1))
2020-11-01 01:00:00-08:00
```

When converting from another time zone, the `fold` will be set to the correct value:

```
>>> from datetime import timezone
>>> LOS_ANGELES = ZoneInfo("America/Los_Angeles")
>>> dt_utc = datetime(2020, 11, 1, 8, tzinfo=timezone.utc)

>>> # Before the PDT -> PST transition
>>> print(dt_utc.astimezone(LOS_ANGELES))
2020-11-01 01:00:00-07:00

>>> # After the PDT -> PST transition
```

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```
>>> print((dt_utc + timedelta(hours=1)).astimezone(LOS_ANGELES))
2020-11-01 01:00:00-08:00
```

8.2.2 Data sources

The `zoneinfo` module does not directly provide time zone data, and instead pulls time zone information from the system time zone database or the first-party PyPI package `tzdata`, if available. Some systems, including notably Windows systems, do not have an IANA database available, and so for projects targeting cross-platform compatibility that require time zone data, it is recommended to declare a dependency on `tzdata`. If neither system data nor `tzdata` are available, all calls to `ZoneInfo` will raise `ZoneInfoNotFoundError`.

Configuring the data sources

When `ZoneInfo(key)` is called, the constructor first searches the directories specified in `TZPATH` for a file matching `key`, and on failure looks for a match in the `tzdata` package. This behavior can be configured in three ways:

1. The default `TZPATH` when not otherwise specified can be configured at *compile time*.
2. `TZPATH` can be configured using *an environment variable*.
3. At *runtime*, the search path can be manipulated using the `reset_tzpath()` function.

Compile-time configuration

The default `TZPATH` includes several common deployment locations for the time zone database (except on Windows, where there are no “well-known” locations for time zone data). On POSIX systems, downstream distributors and those building Python from source who know where their system time zone data is deployed may change the default time zone path by specifying the compile-time option `TZPATH` (or, more likely, the configure flag `--with-tzpath`), which should be a string delimited by `os.pathsep`.

On all platforms, the configured value is available as the `TZPATH` key in `sysconfig.get_config_var()`.

Environment configuration

When initializing `TZPATH` (either at import time or whenever `reset_tzpath()` is called with no arguments), the `zoneinfo` module will use the environment variable `PYTHONTZPATH`, if it exists, to set the search path.

PYTHONTZPATH

This is an `os.pathsep`-separated string containing the time zone search path to use. It must consist of only absolute rather than relative paths. Relative components specified in `PYTHONTZPATH` will not be used, but otherwise the behavior when a relative path is specified is implementation-defined; CPython will raise `InvalidTZPathWarning`, but other implementations are free to silently ignore the erroneous component or raise an exception.

To set the system to ignore the system data and use the `tzdata` package instead, set `PYTHONTZPATH=""`.

Runtime configuration

The TZ search path can also be configured at runtime using the `reset_tzpath()` function. This is generally not an advisable operation, though it is reasonable to use it in test functions that require the use of a specific time zone path (or require disabling access to the system time zones).

8.2.3 The `ZoneInfo` class

class `zoneinfo.ZoneInfo(key)`

A concrete `datetime.tzinfo` subclass that represents an IANA time zone specified by the string `key`. Calls to the primary constructor will always return objects that compare identically; put another way, barring cache invalidation via `ZoneInfo.clear_cache()`, for all values of `key`, the following assertion will always be true:

```
a = ZoneInfo(key)
b = ZoneInfo(key)
assert a is b
```

`key` must be in the form of a relative, normalized POSIX path, with no up-level references. The constructor will raise `ValueError` if a non-conforming key is passed.

If no file matching `key` is found, the constructor will raise `ZoneInfoNotFoundError`.

The `ZoneInfo` class has two alternate constructors:

classmethod `ZoneInfo.from_file(fobj, /, key=None)`

Constructs a `ZoneInfo` object from a file-like object returning bytes (e.g. a file opened in binary mode or an `io.BytesIO` object). Unlike the primary constructor, this always constructs a new object.

The `key` parameter sets the name of the zone for the purposes of `__str__()` and `__repr__()`.

Objects created via this constructor cannot be pickled (see [pickling](#)).

classmethod `ZoneInfo.no_cache(key)`

An alternate constructor that bypasses the constructor's cache. It is identical to the primary constructor, but returns a new object on each call. This is most likely to be useful for testing or demonstration purposes, but it can also be used to create a system with a different cache invalidation strategy.

Objects created via this constructor will also bypass the cache of a deserializing process when unpickled.

警告: Using this constructor may change the semantics of your datetimes in surprising ways, only use it if you know that you need to.

The following class methods are also available:

classmethod `ZoneInfo.clear_cache(*, only_keys=None)`

A method for invalidating the cache on the `ZoneInfo` class. If no arguments are passed, all caches are invalidated and the next call to the primary constructor for each key will return a new instance.

If an iterable of key names is passed to the `only_keys` parameter, only the specified keys will be removed from the cache. Keys passed to `only_keys` but not found in the cache are ignored.

警告: Invoking this function may change the semantics of datetimes using `ZoneInfo` in surprising ways; this modifies process-wide global state and thus may have wide-ranging effects. Only use it if you know that you need to.

The class has one attribute:

ZoneInfo.key

This is a read-only *attribute* that returns the value of *key* passed to the constructor, which should be a lookup key in the IANA time zone database (e.g. `America/New_York`, `Europe/Paris` or `Asia/Tokyo`).

For zones constructed from file without specifying a *key* parameter, this will be set to `None`.

備: Although it is a somewhat common practice to expose these to end users, these values are designed to be primary keys for representing the relevant zones and not necessarily user-facing elements. Projects like CLDR (the Unicode Common Locale Data Repository) can be used to get more user-friendly strings from these keys.

String representations

The string representation returned when calling `str` on a `ZoneInfo` object defaults to using the `ZoneInfo.key` attribute (see the note on usage in the attribute documentation):

```
>>> zone = ZoneInfo("Pacific/Kwajalein")
>>> str(zone)
'Pacific/Kwajalein'

>>> dt = datetime(2020, 4, 1, 3, 15, tzinfo=zone)
>>> f"{dt.isoformat()} [{dt.tzinfo}]"
'2020-04-01T03:15:00+12:00 [Pacific/Kwajalein]'
```

For objects constructed from a file without specifying a *key* parameter, `str` falls back to calling `repr()`. `ZoneInfo`'s `repr` is implementation-defined and not necessarily stable between versions, but it is guaranteed not to be a valid `ZoneInfo` key.

Pickle serialization

Rather than serializing all transition data, `ZoneInfo` objects are serialized by key, and `ZoneInfo` objects constructed from files (even those with a value for *key* specified) cannot be pickled.

The behavior of a `ZoneInfo` file depends on how it was constructed:

1. `ZoneInfo(key)`: When constructed with the primary constructor, a `ZoneInfo` object is serialized by key, and when deserialized, the deserializing process uses the primary and thus it is expected that these are expected to be the same object as other references to the same time zone. For example, if `europe_berlin_pkl` is a string containing a pickle constructed from `ZoneInfo("Europe/Berlin")`, one would expect the following behavior:

```
>>> a = ZoneInfo("Europe/Berlin")
>>> b = pickle.loads(europe_berlin_pkl)
>>> a is b
True
```

2. `ZoneInfo.no_cache(key)`: When constructed from the cache-bypassing constructor, the `ZoneInfo` object is also serialized by key, but when deserialized, the deserializing process uses the cache bypassing constructor. If `europe_berlin_pkl_nc` is a string containing a pickle constructed from `ZoneInfo.no_cache("Europe/Berlin")`, one would expect the following behavior:

```
>>> a = ZoneInfo("Europe/Berlin")
>>> b = pickle.loads(europe_berlin_pkl_nc)
>>> a is b
False
```

3. `ZoneInfo.from_file(fobj, /, key=None)`: When constructed from a file, the `ZoneInfo` object raises an exception on pickling. If an end user wants to pickle a `ZoneInfo` constructed from a file, it

is recommended that they use a wrapper type or a custom serialization function: either serializing by key or storing the contents of the file object and serializing that.

This method of serialization requires that the time zone data for the required key be available on both the serializing and deserializing side, similar to the way that references to classes and functions are expected to exist in both the serializing and deserializing environments. It also means that no guarantees are made about the consistency of results when unpickling a `ZoneInfo` pickled in an environment with a different version of the time zone data.

8.2.4 函式

`zoneinfo.available_timezones()`

Get a set containing all the valid keys for IANA time zones available anywhere on the time zone path. This is recalculated on every call to the function.

This function only includes canonical zone names and does not include "special" zones such as those under the `posix/` and `right/` directories, or the `posixrules` zone.

警告: This function may open a large number of files, as the best way to determine if a file on the time zone path is a valid time zone is to read the "magic string" at the beginning.

備註: These values are not designed to be exposed to end-users; for user facing elements, applications should use something like CLDR (the Unicode Common Locale Data Repository) to get more user-friendly strings. See also the cautionary note on `ZoneInfo.key`.

`zoneinfo.reset_tzpath(to=None)`

Sets or resets the time zone search path (`TZPATH`) for the module. When called with no arguments, `TZPATH` is set to the default value.

Calling `reset_tzpath` will not invalidate the `ZoneInfo` cache, and so calls to the primary `ZoneInfo` constructor will only use the new `TZPATH` in the case of a cache miss.

The `to` parameter must be a *sequence* of strings or `os.PathLike` and not a string, all of which must be absolute paths. `ValueError` will be raised if something other than an absolute path is passed.

8.2.5 Globals

`zoneinfo.TZPATH`

A read-only sequence representing the time zone search path -- when constructing a `ZoneInfo` from a key, the key is joined to each entry in the `TZPATH`, and the first file found is used.

`TZPATH` may contain only absolute paths, never relative paths, regardless of how it is configured.

The object that `zoneinfo.TZPATH` points to may change in response to a call to `reset_tzpath()`, so it is recommended to use `zoneinfo.TZPATH` rather than importing `TZPATH` from `zoneinfo` or assigning a long-lived variable to `zoneinfo.TZPATH`.

For more information on configuring the time zone search path, see *Configuring the data sources*.

8.2.6 Exceptions and warnings

exception `zoneinfo.ZoneInfoNotFoundError`

Raised when construction of a `ZoneInfo` object fails because the specified key could not be found on the system. This is a subclass of `KeyError`.

exception `zoneinfo.InvalidTZPathWarning`

Raised when `PYTHONTZPATH` contains an invalid component that will be filtered out, such as a relative path.

8.3 `calendar` --- General calendar-related functions

原始碼: [Lib/calendar.py](#)

This module allows you to output calendars like the Unix `cal` program, and provides additional useful functions related to the calendar. By default, these calendars have Monday as the first day of the week, and Sunday as the last (the European convention). Use `setfirstweekday()` to set the first day of the week to Sunday (6) or to any other weekday. Parameters that specify dates are given as integers. For related functionality, see also the `datetime` and `time` modules.

The functions and classes defined in this module use an idealized calendar, the current Gregorian calendar extended indefinitely in both directions. This matches the definition of the “proleptic Gregorian” calendar in Dershowitz and Reingold’s book “Calendrical Calculations”, where it’s the base calendar for all computations. Zero and negative years are interpreted as prescribed by the ISO 8601 standard. Year 0 is 1 BC, year -1 is 2 BC, and so on.

class `calendar.Calendar` (*firstweekday=0*)

Creates a `Calendar` object. *firstweekday* is an integer specifying the first day of the week. `MONDAY` is 0 (the default), `SUNDAY` is 6.

A `Calendar` object provides several methods that can be used for preparing the calendar data for formatting. This class doesn’t do any formatting itself. This is the job of subclasses.

`Calendar` instances have the following methods:

iterweekdays ()

Return an iterator for the week day numbers that will be used for one week. The first value from the iterator will be the same as the value of the *firstweekday* property.

itermonthdates (*year*, *month*)

Return an iterator for the month *month* (1--12) in the year *year*. This iterator will return all days (as `datetime.date` objects) for the month and all days before the start of the month or after the end of the month that are required to get a complete week.

itermonthdays (*year*, *month*)

Return an iterator for the month *month* in the year *year* similar to `itermonthdates()`, but not restricted by the `datetime.date` range. Days returned will simply be day of the month numbers. For the days outside of the specified month, the day number is 0.

itermonthdays2 (*year*, *month*)

Return an iterator for the month *month* in the year *year* similar to `itermonthdates()`, but not restricted by the `datetime.date` range. Days returned will be tuples consisting of a day of the month number and a week day number.

itermonthdays3 (*year*, *month*)

Return an iterator for the month *month* in the year *year* similar to `itermonthdates()`, but not restricted by the `datetime.date` range. Days returned will be tuples consisting of a year, a month and a day of the month numbers.

在 3.7 版新加入。

itermonthdays4 (*year, month*)

Return an iterator for the month *month* in the year *year* similar to *itermonthdates()*, but not restricted by the *datetime.date* range. Days returned will be tuples consisting of a year, a month, a day of the month, and a day of the week numbers.

在 3.7 版新加入。

monthdatescalendar (*year, month*)

Return a list of the weeks in the month *month* of the *year* as full weeks. Weeks are lists of seven *datetime.date* objects.

monthdays2calendar (*year, month*)

Return a list of the weeks in the month *month* of the *year* as full weeks. Weeks are lists of seven tuples of day numbers and weekday numbers.

monthdayscalendar (*year, month*)

Return a list of the weeks in the month *month* of the *year* as full weeks. Weeks are lists of seven day numbers.

yeardatescalendar (*year, width=3*)

Return the data for the specified year ready for formatting. The return value is a list of month rows. Each month row contains up to *width* months (defaulting to 3). Each month contains between 4 and 6 weeks and each week contains 1--7 days. Days are *datetime.date* objects.

yeardays2calendar (*year, width=3*)

Return the data for the specified year ready for formatting (similar to *yeardatescalendar()*). Entries in the week lists are tuples of day numbers and weekday numbers. Day numbers outside this month are zero.

yeardayscalendar (*year, width=3*)

Return the data for the specified year ready for formatting (similar to *yeardatescalendar()*). Entries in the week lists are day numbers. Day numbers outside this month are zero.

class `calendar.TextCalendar` (*firstweekday=0*)

This class can be used to generate plain text calendars.

TextCalendar instances have the following methods:

formatmonth (*theyear, themonth, w=0, l=0*)

Return a month's calendar in a multi-line string. If *w* is provided, it specifies the width of the date columns, which are centered. If *l* is given, it specifies the number of lines that each week will use. Depends on the first weekday as specified in the constructor or set by the *setfirstweekday()* method.

prmonth (*theyear, themonth, w=0, l=0*)

Print a month's calendar as returned by *formatmonth()*.

formatyear (*theyear, w=2, l=1, c=6, m=3*)

Return a *m*-column calendar for an entire year as a multi-line string. Optional parameters *w*, *l*, and *c* are for date column width, lines per week, and number of spaces between month columns, respectively. Depends on the first weekday as specified in the constructor or set by the *setfirstweekday()* method. The earliest year for which a calendar can be generated is platform-dependent.

pryear (*theyear, w=2, l=1, c=6, m=3*)

Print the calendar for an entire year as returned by *formatyear()*.

class `calendar.HTMLCalendar` (*firstweekday=0*)

This class can be used to generate HTML calendars.

HTMLCalendar instances have the following methods:

formatmonth (*theyear, themonth, withyear=True*)

Return a month's calendar as an HTML table. If *withyear* is true the year will be included in the header, otherwise just the month name will be used.

formatyear (*theyear*, *width*=3)

Return a year's calendar as an HTML table. *width* (defaulting to 3) specifies the number of months per row.

formatyearpage (*theyear*, *width*=3, *css*='calendar.css', *encoding*=None)

Return a year's calendar as a complete HTML page. *width* (defaulting to 3) specifies the number of months per row. *css* is the name for the cascading style sheet to be used. *None* can be passed if no style sheet should be used. *encoding* specifies the encoding to be used for the output (defaulting to the system default encoding).

formatmonthname (*theyear*, *themoth*, *withyear*=True)

Return a month name as an HTML table row. If *withyear* is true the year will be included in the row, otherwise just the month name will be used.

HTMLCalendar has the following attributes you can override to customize the CSS classes used by the calendar:

cssclasses

A list of CSS classes used for each weekday. The default class list is:

```
cssclasses = ["mon", "tue", "wed", "thu", "fri", "sat", "sun"]
```

more styles can be added for each day:

```
cssclasses = ["mon text-bold", "tue", "wed", "thu", "fri", "sat", "sun red  
↪"]
```

Note that the length of this list must be seven items.

cssclass_noday

The CSS class for a weekday occurring in the previous or coming month.

在 3.7 版新加入.

cssclasses_weekday_head

A list of CSS classes used for weekday names in the header row. The default is the same as *cssclasses*.

在 3.7 版新加入.

cssclass_month_head

The month's head CSS class (used by *formatmonthname()*). The default value is "month".

在 3.7 版新加入.

cssclass_month

The CSS class for the whole month's table (used by *formatmonth()*). The default value is "month".

在 3.7 版新加入.

cssclass_year

The CSS class for the whole year's table of tables (used by *formatyear()*). The default value is "year".

在 3.7 版新加入.

cssclass_year_head

The CSS class for the table head for the whole year (used by *formatyear()*). The default value is "year".

在 3.7 版新加入.

Note that although the naming for the above described class attributes is singular (e.g. *cssclass_month*, *cssclass_noday*), one can replace the single CSS class with a space separated list of CSS classes, for example:

```
"text-bold text-red"
```

以下是客化 HTMLCalendar 的範例：

```
class CustomHTMLCal(calendar.HTMLCalendar):
    cssclasses = [style + " text-nowrap" for style in
                  calendar.HTMLCalendar.cssclasses]
    cssclass_month_head = "text-center month-head"
    cssclass_month = "text-center month"
    cssclass_year = "text-italic lead"
```

class `calendar.LocaleTextCalendar` (*firstweekday=0, locale=None*)

This subclass of `TextCalendar` can be passed a locale name in the constructor and will return month and weekday names in the specified locale.

class `calendar.LocaleHTMLCalendar` (*firstweekday=0, locale=None*)

This subclass of `HTMLCalendar` can be passed a locale name in the constructor and will return month and weekday names in the specified locale.

備註： The constructor, `formatweekday()` and `formatmonthname()` methods of these two classes temporarily change the `LC_TIME` locale to the given *locale*. Because the current locale is a process-wide setting, they are not thread-safe.

For simple text calendars this module provides the following functions.

`calendar.setfirstweekday` (*weekday*)

Sets the weekday (0 is Monday, 6 is Sunday) to start each week. The values `MONDAY`, `TUESDAY`, `WEDNESDAY`, `THURSDAY`, `FRIDAY`, `SATURDAY`, and `SUNDAY` are provided for convenience. For example, to set the first weekday to Sunday:

```
import calendar
calendar.setfirstweekday(calendar.SUNDAY)
```

`calendar.firstweekday` ()

Returns the current setting for the weekday to start each week.

`calendar.isleap` (*year*)

Returns `True` if *year* is a leap year, otherwise `False`.

`calendar.leapdays` (*y1, y2*)

Returns the number of leap years in the range from *y1* to *y2* (exclusive), where *y1* and *y2* are years.

This function works for ranges spanning a century change.

`calendar.weekday` (*year, month, day*)

Returns the day of the week (0 is Monday) for *year* (1970--...), *month* (1--12), *day* (1--31).

`calendar.weekheader` (*n*)

Return a header containing abbreviated weekday names. *n* specifies the width in characters for one weekday.

`calendar.monthrange` (*year, month*)

Returns weekday of first day of the month and number of days in month, for the specified *year* and *month*.

`calendar.monthcalendar` (*year, month*)

Returns a matrix representing a month's calendar. Each row represents a week; days outside of the month are represented by zeros. Each week begins with Monday unless set by `setfirstweekday()`.

`calendar.prmnth` (*theyear, themonth, w=0, l=0*)

Prints a month's calendar as returned by `month()`.

`calendar.month(theyear, themonth, w=0, l=0)`

Returns a month's calendar in a multi-line string using the `formatmonth()` of the `TextCalendar` class.

`calendar.prcal(year, w=0, l=0, c=6, m=3)`

Prints the calendar for an entire year as returned by `calendar()`.

`calendar.calendar(year, w=2, l=1, c=6, m=3)`

Returns a 3-column calendar for an entire year as a multi-line string using the `formatyear()` of the `TextCalendar` class.

`calendar.timegm(tuple)`

An unrelated but handy function that takes a time tuple such as returned by the `gmtime()` function in the `time` module, and returns the corresponding Unix timestamp value, assuming an epoch of 1970, and the POSIX encoding. In fact, `time.gmtime()` and `timegm()` are each others' inverse.

The `calendar` module exports the following data attributes:

`calendar.day_name`

An array that represents the days of the week in the current locale.

`calendar.day_abbr`

An array that represents the abbreviated days of the week in the current locale.

`calendar.month_name`

An array that represents the months of the year in the current locale. This follows normal convention of January being month number 1, so it has a length of 13 and `month_name[0]` is the empty string.

`calendar.month_abbr`

An array that represents the abbreviated months of the year in the current locale. This follows normal convention of January being month number 1, so it has a length of 13 and `month_abbr[0]` is the empty string.

`calendar.MONDAY`

`calendar.TUESDAY`

`calendar.WEDNESDAY`

`calendar.THURSDAY`

`calendar.FRIDAY`

`calendar.SATURDAY`

`calendar.SUNDAY`

Aliases for day numbers, where MONDAY is 0 and SUNDAY is 6.

The `calendar` module defines the following exceptions:

exception `calendar.IllegalMonthError(month)`

A subclass of `ValueError`, raised when the given month number is outside of the range 1-12 (inclusive).

month

The invalid month number.

exception `calendar.IllegalWeekdayError(weekday)`

A subclass of `ValueError`, raised when the given weekday number is outside of the range 0-6 (inclusive).

weekday

The invalid weekday number.

也參考:

`datetime` 模組

Object-oriented interface to dates and times with similar functionality to the `time` module.

`time` 模組

Low-level time related functions.

8.3.1 Command-Line Usage

在 2.5 版新加入.

The `calendar` module can be executed as a script from the command line to interactively print a calendar.

```
python -m calendar [-h] [-L LOCALE] [-e ENCODING] [-t {text,html}]
                  [-w WIDTH] [-l LINES] [-s SPACING] [-m MONTHS] [-c CSS]
                  [year] [month]
```

For example, to print a calendar for the year 2000:

```
$ python -m calendar 2000

                2000

    January                February                March
Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su
                        1  2                        1  2  3  4  5
  3  4  5  6  7  8  9    7  8  9 10 11 12 13    6  7  8  9 10 11 12
10 11 12 13 14 15 16    14 15 16 17 18 19 20    13 14 15 16 17 18 19
17 18 19 20 21 22 23    21 22 23 24 25 26 27    20 21 22 23 24 25 26
24 25 26 27 28 29 30    28 29                    27 28 29 30 31
31

    April                May                June
Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su
                        1  2                        1  2  3  4
  3  4  5  6  7  8  9    1  2  3  4  5  6  7    5  6  7  8  9 10 11
10 11 12 13 14 15 16    8  9 10 11 12 13 14    12 13 14 15 16 17 18
17 18 19 20 21 22 23    15 16 17 18 19 20 21    19 20 21 22 23 24 25
24 25 26 27 28 29 30    22 23 24 25 26 27 28    26 27 28 29 30
29 30 31

    July                August                September
Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su
                        1  2                        1  2  3
  3  4  5  6  7  8  9    1  2  3  4  5  6    4  5  6  7  8  9 10
10 11 12 13 14 15 16    7  8  9 10 11 12 13    11 12 13 14 15 16 17
17 18 19 20 21 22 23    14 15 16 17 18 19 20    18 19 20 21 22 23 24
24 25 26 27 28 29 30    21 22 23 24 25 26 27    25 26 27 28 29 30
31

    October                November                December
Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su    Mo Tu We Th Fr Sa Su
                        1                        1  2  3  4  5
  2  3  4  5  6  7  8    6  7  8  9 10 11 12    4  5  6  7  8  9 10
  9 10 11 12 13 14 15    13 14 15 16 17 18 19    11 12 13 14 15 16 17
16 17 18 19 20 21 22    20 21 22 23 24 25 26    18 19 20 21 22 23 24
23 24 25 26 27 28 29    27 28 29 30                25 26 27 28 29 30 31
30 31
```

The following options are accepted:

--help, -h

Show the help message and exit.

--locale LOCALE, -L LOCALE

The locale to use for month and weekday names. Defaults to English.

--encoding ENCODING, -e ENCODING

The encoding to use for output. `--encoding` is required if `--locale` is set.

--type {text,html}, -t {text,html}

Print the calendar to the terminal as text, or as an HTML document.

year

The year to print the calendar for. Must be a number between 1 and 9999. Defaults to the current year.

month

The month of the specified *year* to print the calendar for. Must be a number between 1 and 12, and may only be used in text mode. Defaults to printing a calendar for the full year.

Text-mode options:

--width WIDTH, **-w** WIDTH

The width of the date column in terminal columns. The date is printed centred in the column. Any value lower than 2 is ignored. Defaults to 2.

--lines LINES, **-l** LINES

The number of lines for each week in terminal rows. The date is printed top-aligned. Any value lower than 1 is ignored. Defaults to 1.

--spacing SPACING, **-s** SPACING

The space between months in columns. Any value lower than 2 is ignored. Defaults to 6.

--months MONTHS, **-m** MONTHS

The number of months printed per row. Defaults to 3.

HTML-mode options:

--css CSS, **-c** CSS

The path of a CSS stylesheet to use for the calendar. This must either be relative to the generated HTML, or an absolute HTTP or `file:///` URL.

8.4 collections --- 容器資料型態

原始碼: [Lib/collections/__init__.py](#)

這個模組實作了一些特 F 的容器資料型態，用來替代 Python 一般 F 建的容器，例如 *dict* (字典)、*list* (串列)、*set* (集合) 和 *tuple* (元組)。

<i>namedtuple()</i>	用來建立具名欄位的 <i>tuple</i> 子類 F 的工廠函式
<i>deque</i>	一個類似 <i>list</i> 的容器，可以快速的在頭尾加入 (<i>append</i>) 元素與移除 (<i>pop</i>) 元素
<i>ChainMap</i>	一個類似 <i>dict</i> 的類 F，用來 F 多個對映 (<i>mapping</i>) 建立單一的視圖 (<i>view</i>)
<i>Counter</i>	<i>dict</i> 的子類 F，用來計算可雜 F 物件的數量
<i>OrderedDict</i>	<i>dict</i> 的子類 F，會記 F 物件被加入的順序
<i>defaultdict</i>	<i>dict</i> 的子類 F，當值不存在 <i>dict</i> 中時會呼叫一個提供預設值的工廠函式
<i>UserDict</i>	<i>dict</i> 物件的包裝器 (<i>wrapper</i>)，簡化了 <i>dict</i> 的子類 F 化過程
<i>UserList</i>	<i>list</i> 物件的包裝器，簡化了 <i>list</i> 的子類 F 化過程
<i>UserString</i>	字串物件的包裝器，簡化了字串的子類 F 化過程

8.4.1 ChainMap 物件

在 3.3 版新加入。

ChainMap (對映鏈結) 類 F 的目的是快速將數個對映連結在一起，讓它們可以被當作一個單元來處理。它通常會比建立一個新的字典 F 多次呼叫 *update()* 來得更快。

這個類 F 可用於模擬巢狀作用域 (*nested scopes*)，且在模板化 (*templating*) 時能派上用場。


```
class collections.ChainMap(*maps)
```

一個 *ChainMap* 將多個 *dict* 或其他對映組合在一起，建立一個獨立、可更新的視圖。如果 *maps* 有指定，預設會提供一個空字典讓每個新鏈結都至少有一個對映。

底層的對映儲存於一個 *list* 中，這個 *list* 是公開的且可透過 *maps* 屬性存取或更新，*ChainMap* 有其他狀態 (*state*)。

檢索 (*lookup*) 陸續查詢底層對映，直到鍵被找到，然而讀取、更新和 *del* 就只會對第一個對映操作。

ChainMap 透過參照將底層對映合併，所以當一個底層對映被更新，這些改變也會反映到 *ChainMap*。

所有常見的字典方法都有支援。此外，還有一個 *maps* 屬性 (*attribute*)、一個建立子上下文 (*subcontext*) 的方法、和一個能 *del* 存取除了第一個以外其他所有對映的特性 (*property*)：

maps

一個可被更新的對映列表，這個列表是按照被搜索的順序來排列，在 *ChainMap* 中它是唯一被儲存的狀態，可被修改來變更搜索順序。回傳的列表都至少包含一個對映。

```
new_child(m=None, **kwargs)
```

回傳包含一個新對映的 *ChainMap*，新對映後面接著當前實例的所有現存對映。如果有給定 *m*，*m* 會成 *ChainMap* 那個最前面的新對映；若 *maps* 有指定，則會加上一個空 *dict*，如此一來呼叫 *d.new_child()* 就等同於 *ChainMap({}, *d.maps)*。這個方法用於建立子上下文，而保持父對映的不變。

在 3.4 版的變更：加入可選參數 *m*。

在 3.10 版的變更：增加了對關鍵字引數的支援。

parents

回傳一個包含除了第一個以外所有其他對映的新 *ChainMap* 的特性，可用於需要跳過第一個對映的搜索。使用情境類似於在巢狀作用域當中使用 *nonlocal* 關鍵字，也可與 *super()* 做類比。引用 *d.parents* 等同於 *ChainMap(*d.maps[1:])*。

注意，一個 *ChainMap()* 的 *del* 順序是透過由後往前掃描對映而定：

```
>>> baseline = {'music': 'bach', 'art': 'rembrandt'}
>>> adjustments = {'art': 'van gogh', 'opera': 'carmen'}
>>> list(ChainMap(adjustments, baseline))
['music', 'art', 'opera']
```

這和呼叫 *dict.update()* 結果的順序一樣是從最後一個對映開始：

```
>>> combined = baseline.copy()
>>> combined.update(adjustments)
>>> list(combined)
['music', 'art', 'opera']
```

在 3.9 版的變更：支援 *|* 和 *|=* 運算子，詳見 [PEP 584](#)。

也參考：

- Enthought *CodeTools package* 中的 *MultiContext class* 支援在鏈中選定任意對映寫入。
- Django 中用於模板的 *Context class* 是唯讀的對映鏈，也具有加入 (*push*) 和移除 (*pop*) 上下文的功能，與 *new_child()* 方法和 *parents* 特性類似。
- *Nested Contexts recipe* 提供了控制是否只對鏈中第一個或其他對映做寫入或其他操作的選項。
- 一個極度簡化、維護版本的 *Chainmap*。

ChainMap 范例和用法

此章節提供了多種操作 ChainMap 的案例。

模擬 Python 內部檢索鏈結的例子：

```
import builtins
pylookup = ChainMap(locals(), globals(), vars(builtins))
```

讓使用者指定的命令列引數優先於環境變數、再優先於預設值的範例：

```
import os, argparse

defaults = {'color': 'red', 'user': 'guest'}

parser = argparse.ArgumentParser()
parser.add_argument('-u', '--user')
parser.add_argument('-c', '--color')
namespace = parser.parse_args()
command_line_args = {k: v for k, v in vars(namespace).items() if v is not None}

combined = ChainMap(command_line_args, os.environ, defaults)
print(combined['color'])
print(combined['user'])
```

用 ChainMap 類模擬巢狀上下文的範例模式：

```
c = ChainMap()           # Create root context
d = c.new_child()        # Create nested child context
e = c.new_child()        # Child of c, independent from d
e.maps[0]                # Current context dictionary -- like Python's locals()
e.maps[-1]               # Root context -- like Python's globals()
e.parents                # Enclosing context chain -- like Python's nonlocals

d['x'] = 1                # Set value in current context
d['x']                   # Get first key in the chain of contexts
del d['x']                # Delete from current context
list(d)                  # All nested values
k in d                   # Check all nested values
len(d)                   # Number of nested values
d.items()                # All nested items
dict(d)                  # Flatten into a regular dictionary
```

ChainMap 類只對鏈結中第一個對映來做寫入或刪除，但檢索則會掃過整個鏈結。但如果需要對更深層的鍵寫入或刪除，透過定義一個子類來實作也不困難：

```
class DeepChainMap(ChainMap):
    'Variant of ChainMap that allows direct updates to inner scopes'

    def __setitem__(self, key, value):
        for mapping in self.maps:
            if key in mapping:
                mapping[key] = value
                return
        self.maps[0][key] = value

    def __delitem__(self, key):
        for mapping in self.maps:
            if key in mapping:
                del mapping[key]
                return
        raise KeyError(key)
```

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```
>>> d = DeepChainMap({'zebra': 'black'}, {'elephant': 'blue'}, {'lion': 'yellow'})
>>> d['lion'] = 'orange'           # update an existing key two levels down
>>> d['snake'] = 'red'             # new keys get added to the topmost dict
>>> del d['elephant']              # remove an existing key one level down
>>> d                             # display result
DeepChainMap({'zebra': 'black', 'snake': 'red'}, {}, {'lion': 'orange'})
```

8.4.2 Counter 物件

提供一個支援方便且快速計數的計數器工具，例如：

```
>>> # Tally occurrences of words in a list
>>> cnt = Counter()
>>> for word in ['red', 'blue', 'red', 'green', 'blue', 'blue']:
...     cnt[word] += 1
>>> cnt
Counter({'blue': 3, 'red': 2, 'green': 1})

>>> # Find the ten most common words in Hamlet
>>> import re
>>> words = re.findall(r'\w+', open('hamlet.txt').read().lower())
>>> Counter(words).most_common(10)
[('the', 1143), ('and', 966), ('to', 762), ('of', 669), ('i', 631),
 ('you', 554), ('a', 546), ('my', 514), ('hamlet', 471), ('in', 451)]
```

class collections.Counter ([iterable-or-mapping])

Counter 是 *dict* 的子類，用來計算可雜物件的數量。它是將物件與其計數作字典的鍵值對儲存的集合容器。計數可以是包含 0 與負數的任何整數值。*Counter* 類似其他程式語言中的 *bags* 或 *multisets*。

被計數的元素來自一個 *iterable* 或是被其他的 *mapping* (或 *Counter*) 初始化：

```
>>> c = Counter()                # a new, empty counter
>>> c = Counter('gallahad')      # a new counter from an iterable
>>> c = Counter({'red': 4, 'blue': 2}) # a new counter from a mapping
>>> c = Counter(cats=4, dogs=8)   # a new counter from keyword args
```

Counter 物件擁有一個字典的使用介面，除了遇到 *Counter* 中有的值時會回傳計數 0 取代 *KeyError* 這點不同：

```
>>> c = Counter(['eggs', 'ham'])
>>> c['bacon']                    # count of a missing element is
↪ zero
0
```

將一個值的計數設 0 不會真的從 *Counter* 中除這個元素，要使用 *del* 來將其除：

```
>>> c['sausage'] = 0              # counter entry with a zero count
>>> del c['sausage']              # del actually removes the entry
```

在 3.1 版新加入。

在 3.7 版的變更：作 *dict* 的子類，*Counter* 繼承了記憶插入順序的功能。對 *Counter* 做數學運算後同樣保留順序性，其結果是依照各個元素在運算元左邊出現的時間先後、再按照運算元右邊出現的時間先後來排列。

除了字典原本就有的方法外，*Counter* 物件額外支援數個新方法：

elements()

回傳每個元素都重現出現計算次數的 `iterator` (迭代器) 物件，其中元素的回傳順序是依照各元素首次出現的時間先後。如果元素的出現次數小於 1，`elements()` 方法會忽略這些元素。

```
>>> c = Counter(a=4, b=2, c=0, d=-2)
>>> sorted(c.elements())
['a', 'a', 'a', 'a', 'b', 'b']
```

most_common([n])

回傳一個 `list`，包含出現最多次的 n 個元素及其出現次數，按照出現次數排序。如果 n 被省略或者 `None`，`most_common()` 會回傳所有 `counter` 中的元素。出現次數相同的元素會按照首次出現的時間先後來排列：

```
>>> Counter('abracadabra').most_common(3)
[('a', 5), ('b', 2), ('r', 2)]
```

subtract([iterable-or-mapping])

去自一個 `iterable` 或另一個對映 (或 `Counter`) 中的計數元素，行類似 `dict.update()` 但是是去計數而非取代其值。輸入和輸出都可以是 0 或是負數。

```
>>> c = Counter(a=4, b=2, c=0, d=-2)
>>> d = Counter(a=1, b=2, c=3, d=4)
>>> c.subtract(d)
>>> c
Counter({'a': 3, 'b': 0, 'c': -3, 'd': -6})
```

在 3.2 版新加入。

total()

計算總計數值。

```
>>> c = Counter(a=10, b=5, c=0)
>>> c.total()
15
```

在 3.10 版新加入。

通常來字典方法也可以用於 `Counter` 物件，除了以下兩個作用方式與計數器不同。

fromkeys(iterable)

此類方法有被實作於 `Counter` 物件中。

update([iterable-or-mapping])

加上自一個 `iterable` 計算出的計數或加上另一個 `mapping` (或 `Counter`) 中的計數，行類似 `dict.update()` 但是是加上計數而非取代其值。另外，`iterable` 需要是一串將被計算個數元素的序列，而非元素 (key, value) 形式的序列。

`Counter` 支援相等性、子集和超集關係的 `rich comparison` 運算子：`==`、`!=`、`<`、`<=`、`>`、`>=`。這些檢測會將不存在的元素之計數值當作零，因此 `Counter(a=1) == Counter(a=1, b=0)` 將回傳真值。

在 3.10 版的變更：增加了 `rich comparison` 運算。

在 3.10 版的變更：在相等性運算中，不存在的元素之計數值會被當作零。在此之前，`Counter(a=3)` 和 `Counter(a=3, b=0)` 被視為不同。

使用 `Counter` 物件的常見使用模式：

```
c.total()           # total of all counts
c.clear()           # reset all counts
list(c)             # list unique elements
set(c)              # convert to a set
dict(c)             # convert to a regular dictionary
```

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```

c.items()                # convert to a list of (elem, cnt) pairs
Counter(dict(list_of_pairs)) # convert from a list of (elem, cnt) pairs
c.most_common()[:n-1:-1]  # n least common elements
+c                        # remove zero and negative counts

```

結合多個 `Counter` 物件以生成 `multiset` (多重集合, 擁有大於 0 計數元素的計數器), 有提供了幾種數學操作。加法和減法是根據各個對應元素分別將 `Counter` 加上和減去計數, 交集和聯集分別回傳各個元素最小和最大計數, 相等性與包含性運算則會比較對應的計數。每一個操作都可以接受輸入帶有正負號的計數, 但輸出的 `Counter` 則會將擁有小於或等於 0 計數的元素剔除。

```

>>> c = Counter(a=3, b=1)
>>> d = Counter(a=1, b=2)
>>> c + d                                # add two counters together: c[x] + d[x]
Counter({'a': 4, 'b': 3})
>>> c - d                                # subtract (keeping only positive counts)
Counter({'a': 2})
>>> c & d                                # intersection: min(c[x], d[x])
Counter({'a': 1, 'b': 1})
>>> c | d                                # union: max(c[x], d[x])
Counter({'a': 3, 'b': 2})
>>> c == d                               # equality: c[x] == d[x]
False
>>> c <= d                               # inclusion: c[x] <= d[x]
False

```

加減法的一元運算子分別是加上空的 `Counter` 和從空 `Counter` 減去的簡寫。

```

>>> c = Counter(a=2, b=-4)
>>> +c
Counter({'a': 2})
>>> -c
Counter({'b': 4})

```

在 3.3 版新加入: 開始支援加減一元運算子和 `multiset` 的原地 (in-place) 操作。

備註: `Counter` 主要是被設計來操作正整數以當作使用中的計數, 但除了某些會用到計數之值為負數或除其他型別的案例中, `Counter` 也小心地被設計成不會預先排除這些特殊元素。除了輔助使用於上述案例, 這一小節記述了最小範圍和型別限制。

- `Counter` 類別本身是字典的子類別, 且不限制其鍵與值。值被用來表示計數, 但實際上你可以儲存任何值。
- 使用 `most_common()` 方法的唯一條件是其值要是可被排序的。
- 像是 `c[key] += 1` 的原地操作中, 其值之型別只必須支援加減, 所以分數、浮點數、十進位數與其負值都可以使用。同理, `update()` 和 `subtract()` 也都允許 0 或負值輸入或輸出。
- `Multiset` 相關方法只為了處理正值而設計, 其輸入允許是 0 或負值但只有正值會被輸出。無型別限制, 但其值的型別須支援加、減及比較運算。
- `elements()` 方法需要其計數為正值, 如 0 或負值則忽略。

也參考:

- `Smalltalk` 中的 `Bag class`。
- 維基百科上的 [多重集合](#) 條目。
- `C++ multisets` 教學與範例。
- `Multiset` 的數學運算及其使用時機, 參考 *Knuth, Donald. The Art of Computer Programming Volume II, Section 4.6.3, Exercise 19.*

- 若要根據給定的元素集合來列舉出所有不重且擁有指定元素數量的 `multiset`，請見 `itertools.combinations_with_replacement()`：

```
map(Counter, combinations_with_replacement('ABC', 2)) # --> AA AB AC BB BC CC
```

8.4.3 deque 物件

class `collections.deque([iterable[, maxlen]])`

回傳一個新的 `deque`（雙端列）物件，將 `iterable` 中的資料由左至右（使用 `append()`）加入來做初始化。如果 `iterable` 未給定，回傳的則是一個空的 `deque`。

Dequeues are a generalization of stacks and queues (the name is pronounced "deck" and is short for "double-ended queue"). Deques support thread-safe, memory efficient appends and pops from either side of the deque with approximately the same $O(1)$ performance in either direction.

Though `list` objects support similar operations, they are optimized for fast fixed-length operations and incur $O(n)$ memory movement costs for `pop(0)` and `insert(0, v)` operations which change both the size and position of the underlying data representation.

如果 `maxlen` 有給定或者 `None`，`deque` 可以增長到任意長度；但若有給定的話，`deque` 的最大長度就會被限制。一個被限制長度的 `deque` 一但滿了，若在一端加入數個新元素，則同時會在另一端移除相同數量的元素。限定長度的 `deque` 提供了和 Unix `tail filter` 類似的功能，可用於追蹤使用者在意的那些最新執行事項或數據源。

Deque 物件支援以下方法：

append(*x*)

將 *x* 自 `deque` 的右側加入。

appendleft(*x*)

將 *x* 自 `deque` 的左側加入。

clear()

將所有元素從 `deque` 中移除，使其長度為 0。

copy()

建立一個 `deque` 的淺（shallow copy）。

在 3.5 版新加入。

count(*x*)

計算 `deque` 中元素 *x* 的個數。

在 3.2 版新加入。

extend(*iterable*)

將 `iterable` 引數加入 `deque` 的右側。

extendleft(*iterable*)

將 `iterable` 引數加入 `deque` 的左側。要注意的是，加入後的元素順序和 `iterable` 參數是相反的。

index(*x*[, *start*[, *stop*]])

回傳 `deque` 中 *x* 的位置（或在索引 *start* 之後、索引 *stop* 之前的位置）。回傳第一個匹配的位置，如果找到就引發 `ValueError`。

在 3.5 版新加入。

insert(*i*, *x*)

在 `deque` 位置 *i* 中插入 *x*。

如果此插入操作導致 `deque` 超過其長度上限 `maxlen` 的話，會引發 `IndexError` 例外。

在 3.5 版新加入。

pop()

移除回傳 deque 的最右側元素，若本來就沒有任何元素，則會引發 `IndexError`。

popleft()

移除回傳 deque 的最左側元素，若本來就沒有任何元素，則會引發 `IndexError`。

remove(value)

移除第一個出現的 `value`，如果找到的話就引發一個 `ValueError`。

reverse()

將 deque 中的元素原地 (in-place) 倒序排列回傳 `None`。

在 3.2 版新加入。

rotate(n=1)

將 deque 向右輪轉 `n` 步。若 `n` 負值則向左輪轉。

當 deque 不是空的，向右輪轉一步和 `d.appendleft(d.pop())` 有相同意義，而向左輪轉亦等價於 `d.append(d.popleft())`。

Deque 物件也提供了一個唯讀屬性：

maxlen

Deque 的最大長度，如果不限制長度的話則回傳 `None`。

在 3.1 版新加入。

In addition to the above, deques support iteration, pickling, `len(d)`, `reversed(d)`, `copy.copy(d)`, `copy.deepcopy(d)`, membership testing with the `in` operator, and subscript references such as `d[0]` to access the first element. Indexed access is $O(1)$ at both ends but slows to $O(n)$ in the middle. For fast random access, use lists instead.

自從 3.5 版本起，deque 開始支援 `__add__()`、`__mul__()` 和 `__imul__()`。

範例：

```
>>> from collections import deque
>>> d = deque('ghi')           # make a new deque with three items
>>> for elem in d:             # iterate over the deque's elements
...     print(elem.upper())
G
H
I

>>> d.append('j')              # add a new entry to the right side
>>> d.appendleft('f')          # add a new entry to the left side
>>> d                          # show the representation of the deque
deque(['f', 'g', 'h', 'i', 'j'])

>>> d.pop()                    # return and remove the rightmost item
'j'
>>> d.popleft()                # return and remove the leftmost item
'f'
>>> list(d)                    # list the contents of the deque
['g', 'h', 'i']
>>> d[0]                       # peek at leftmost item
'g'
>>> d[-1]                      # peek at rightmost item
'i'

>>> list(reversed(d))          # list the contents of a deque in reverse
['i', 'h', 'g']
>>> 'h' in d                   # search the deque
True
>>> d.extend('jkl')           # add multiple elements at once
>>> d
```

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```

deque(['g', 'h', 'i', 'j', 'k', 'l'])
>>> d.rotate(1)                                # right rotation
>>> d
deque(['l', 'g', 'h', 'i', 'j', 'k'])
>>> d.rotate(-1)                               # left rotation
>>> d
deque(['g', 'h', 'i', 'j', 'k', 'l'])

>>> deque(reversed(d))                         # make a new deque in reverse order
deque(['l', 'k', 'j', 'i', 'h', 'g'])
>>> d.clear()                                  # empty the deque
>>> d.pop()                                    # cannot pop from an empty deque
Traceback (most recent call last):
  File "<pyshell#6>", line 1, in <code>-
    d.pop()
IndexError: pop from an empty deque

>>> d.extendleft('abc')                       # extendleft() reverses the input order
>>> d
deque(['c', 'b', 'a'])

```

deque 用法

這一章節提供了多種操作 deque 的案例。

被限制長度的 deque 功能類似 Unix 中的 tail filter:

```

def tail(filename, n=10):
    'Return the last n lines of a file'
    with open(filename) as f:
        return deque(f, n)

```

另一用法是透過從右邊加入、從左邊移除來維護最近加入元素的 list:

```

def moving_average(iterable, n=3):
    # moving_average([40, 30, 50, 46, 39, 44]) --> 40.0 42.0 45.0 43.0
    # https://en.wikipedia.org/wiki/Moving_average
    it = iter(iterable)
    d = deque(itertools.islice(it, n-1))
    d.appendleft(0)
    s = sum(d)
    for elem in it:
        s += elem - d.popleft()
        d.append(elem)
        yield s / n

```

一個輪詢調度器可以透過在 deque 中放入 iterator 來實現，值自當前 iterator 的位置 0 取出，如果 iterator 已經消耗完畢就用 popleft() 將其從队列中移除，否則利用 rotate() 來將其移至队列尾端：

```

def roundrobin(*iterables):
    "roundrobin('ABC', 'D', 'EF') --> A D E B F C"
    iterators = deque(map(iter, iterables))
    while iterators:
        try:
            while True:
                yield next(iterators[0])
                iterators.rotate(-1)
        except StopIteration:
            # Remove an exhausted iterator.
            iterators.popleft()

```


`rotate()` 提供了可以用來實作 *deque* 切片和刪除的方法。舉例來說，用純 Python 實作 `del d[n]` 需要用 `rotate()` 來定位要被移除的元素：

```
def delete_nth(d, n):
    d.rotate(-n)
    d.popleft()
    d.rotate(n)
```

要實現 *deque* 切片，可使用近似以下方法：使用 `rotate()` 來將目標元素移動到 *deque* 最左側，用 `popleft()` 移除舊元素，用 `extend()` 加入新元素，最後再反向 `rotate`。在這個方法上做小小的更動就能簡單地實現 Forth 風格的 *stack* 操作，例如 `dup`、`drop`、`swap`、`over`、`pick`、`rot` 和 `roll`。

8.4.4 defaultdict 物件

class `collections.defaultdict` (*default_factory=None*, *[, ...]*)

回傳一個新的類似字典的物件。`defaultdict` 是 `dict` 的子類。它覆蓋掉了一個方法，添加了一個可寫入的實例變數。其餘功能與 `dict` 相同，此文件不再述。

第一個引數 `default_factory` 屬性提供了初始值，他被預設為 `None`，所有其他的引數（包括關鍵字引數）都會被傳遞給 `dict` 的建構函式（constructor）。

`defaultdict` 物件支援以下 `dict` 所擁有的方法：

`__missing__(key)`

如果 `default_factory` 屬性為 `None`，呼叫此方法會引發一個附帶引數 `key` 的 `KeyError` 例外。

如果 `default_factory` 不為 `None`，它會不帶引數地被呼叫來給定的 `key` 提供一個預設值，這個值和 `key` 被作鍵值對來插入到字典中，且被此方法所回傳。

如果呼叫 `default_factory` 時發生例外，則該例外將會保持不變地向外傳遞。

This method is called by the `__getitem__()` method of the `dict` class when the requested key is not found; whatever it returns or raises is then returned or raised by `__getitem__()`.

Note that `__missing__()` is *not* called for any operations besides `__getitem__()`. This means that `get()` will, like normal dictionaries, return `None` as a default rather than using `default_factory`.

`defaultdict` 物件支援以下實例變數：

`default_factory`

此屬性為 `__missing__()` 方法所使用。如果有引數被傳入建構函式，則此屬性會被初始化成第一個引數，如未提供引數則被初始化為 `None`。

在 3.9 版的變更：新增合 (`|`) 和更新 (`|=`) 運算子，請見 [PEP 584](#)。

defaultdict 范例

使用 `list` 作為 `default_factory` 可以很輕鬆地將鍵值對序列轉為包含 `list` 之字典：

```
>>> s = [('yellow', 1), ('blue', 2), ('yellow', 3), ('blue', 4), ('red', 1)]
>>> d = defaultdict(list)
>>> for k, v in s:
...     d[k].append(v)
...
>>> sorted(d.items())
[('blue', [2, 4]), ('red', [1]), ('yellow', [1, 3])]
```

當每個鍵第一次被存取時，它還不存在於對映中，所以會自動呼叫 `default_factory` 方法來回傳一個空的 `list` 以建立一個條目，`list.append()` 操作後續會再新增值到這個新的列表。當再次存取

該鍵時，就如普通字典般操作（回傳該鍵所對應到的 list），`list.append()` 也會新增另一個值到 list 中。和使用與其等價的 `dict.setdefault()` 相比，這個技巧更加快速和簡單：

```
>>> d = {}
>>> for k, v in s:
...     d.setdefault(k, []).append(v)
...
>>> sorted(d.items())
[('blue', [2, 4]), ('red', [1]), ('yellow', [1, 3])]
```

設定 `default_factory` 使得 `defaultdict` 可被用於計數（類似其他語言中的 bag 或 multiset）：

```
>>> s = 'mississippi'
>>> d = defaultdict(int)
>>> for k in s:
...     d[k] += 1
...
>>> sorted(d.items())
[('i', 4), ('m', 1), ('p', 2), ('s', 4)]
```

當一個字母首次被存取時，它不存在於對映中，則 `default_factory` 函式會呼叫 `int()` 來提供一個整數 0 作預設值。後續的增加操作繼續對每個字母做計數。

函式 `int()` 總是回傳 0，這是常數函式的特殊情況。一個更快、更有彈性的方法是使用 `lambda` 函式來提供任何常數值（不用一定要是 0）：

```
>>> def constant_factory(value):
...     return lambda: value
>>> d = defaultdict(constant_factory('<missing>'))
>>> d.update(name='John', action='ran')
>>> '%(name)s %(action)s to %(object)s' % d
'John ran to <missing>'
```

將 `default_factory` 設為 `set` 使 `defaultdict` 可用於構建一個值為 set 的字典：

```
>>> s = [('red', 1), ('blue', 2), ('red', 3), ('blue', 4), ('red', 1), ('blue', 4)]
>>> d = defaultdict(set)
>>> for k, v in s:
...     d[k].add(v)
...
>>> sorted(d.items())
[('blue', {2, 4}), ('red', {1, 3})]
```

8.4.5 namedtuple() 擁有具名欄位之 tuple 的工廠函式

Named tuple（具名元組）賦予 tuple 中各個位置意義，使程式碼更有可讀性與自我文件性。它們可以用於任何普通 tuple 可使用的場合，賦予其透過名稱（而非位置索引）來存取欄位的能力。

`collections.namedtuple` (`typename`, `field_names`, *, `rename=False`, `defaults=None`, `module=None`)

回傳一個名為 `typename` 的新 tuple 子類。這個新的子類被用於建立類似 tuple 的物件，可以透過屬性名稱來存取欄位，它同時也是可索引 (indexable) 和可迭代的 (iterable)。子類實例同樣有文件字串 (docstring) (有類名 `typename` 和欄位名 `field_names`) 和一個好用的 `__repr__()` 方法，可將 tuple 內容以 `name=value` 格式列出。

`field_names` 是一個像 `['x', 'y']` 一樣的字串序列。`field_names` 也可以是一個用空白或逗號分隔各個欄位名稱的字串，比如 `'x y'` 或者 `'x, y'`。

除了底端開頭以外的其他任何有效 Python 識別字 (identifier) 都可以作欄位名稱，有效識別字由字母、數字、底端所組成，但不能是數字或底端開頭，也不能是關鍵詞 `keyword`，例如 `class`、`for`、`return`、`global`、`pass` 或 `raise`。

如果 `rename` 為真值，無效的欄位名稱會自動被位置名稱取代。比如 `['abc', 'def', 'ghi', 'abc']` 會被轉成 `['abc', '_1', 'ghi', '_3']`，移除了關鍵字 `def` 和重欄位名 `abc`。

`defaults` 可以是 `None` 或者是一個預設值的 *iterable*。因有預設值的欄位必須出現在那些有預設值的欄位之後，`defaults` 是被應用在右側的引數。例如 `fieldnames` 為 `['x', 'y', 'z']` 且 `defaults` 為 `(1, 2)`，那 `x` 就必須被給定一個引數，`y` 被預設為 1，`z` 則被預設為 2。

如果 `module` 值有被定義，`named tuple` 的 `__module__` 屬性就被設定為該值。

`Named tuple` 實例中有字典，所以它們更加輕量，且和一般 `tuple` 相比用更少記憶體。

要支援 `pickle`，應將 `named tuple` 類賦值給一個符合 *typename* 的變數。

在 3.1 版的變更：新增對於 `rename` 的支援。

在 3.6 版的變更：`verbose` 和 `rename` 參數成為僅限關鍵字引數。

在 3.6 版的變更：新增 `module` 參數。

在 3.7 版的變更：移除 `verbose` 參數和 `__source__` 屬性。

在 3.7 版的變更：新增 `defaults` 參數和 `__field_defaults` 屬性。

```
>>> # Basic example
>>> Point = namedtuple('Point', ['x', 'y'])
>>> p = Point(11, y=22)      # instantiate with positional or keyword arguments
>>> p[0] + p[1]              # indexable like the plain tuple (11, 22)
33
>>> x, y = p                 # unpack like a regular tuple
>>> x, y
(11, 22)
>>> p.x + p.y                # fields also accessible by name
33
>>> p                        # readable __repr__ with a name=value style
Point(x=11, y=22)
```

`Named tuple` 在賦予欄位名稱於 `csv` 或 `sqlite3` 模組回傳之 `tuple` 時相當有用：

```
EmployeeRecord = namedtuple('EmployeeRecord', 'name, age, title, department, \
    ↳paygrade')

import csv
for emp in map(EmployeeRecord._make, csv.reader(open("employees.csv", "rb"))):
    print(emp.name, emp.title)

import sqlite3
conn = sqlite3.connect('/companydata')
cursor = conn.cursor()
cursor.execute('SELECT name, age, title, department, paygrade FROM employees')
for emp in map(EmployeeRecord._make, cursor.fetchall()):
    print(emp.name, emp.title)
```

除了繼承自 `tuple` 的方法，`named tuple` 還支援三個額外的方法和兩個屬性。為了防止欄位名稱有衝突，方法和屬性的名稱以底開頭。

classmethod `somenamedtuple._make(iterable)`

從已存在的序列或可迭代物件建立一個新實例的類方法。

```
>>> t = [11, 22]
>>> Point._make(t)
Point(x=11, y=22)
```

`somenamedtuple._asdict()`

回傳一個將欄位名稱對映至對應值的 *dict*：

```
>>> p = Point(x=11, y=22)
>>> p._asdict()
{'x': 11, 'y': 22}
```

在 3.1 版的變更: 回傳一個 `OrderedDict` 而非 `dict`。

在 3.8 版的變更: 回傳一個常規 `dict` 而非 `OrderedDict`, 自從 Python 3.7 開始, `dict` 已經保證有順序性, 如果需要 `OrderedDict` 所專屬的特性, 推薦的解法是將結果專成所需的類型: `OrderedDict(nt._asdict())`。

`somenamedtuple._replace(**kwargs)`

回傳一個新的 `named tuple` 實例, 將指定欄位替新的值:

```
>>> p = Point(x=11, y=22)
>>> p._replace(x=33)
Point(x=33, y=22)

>>> for partnum, record in inventory.items():
...     inventory[partnum] = record._replace(price=newprices[partnum],
... timestamp=time.now())
```

`somenamedtuple._fields`

列出 `tuple` 欄位名稱的字串, 用於自我檢查或是從現有 `named tuple` 建立一個新的 `named tuple` 型。

```
>>> p._fields          # view the field names
('x', 'y')

>>> Color = namedtuple('Color', 'red green blue')
>>> Pixel = namedtuple('Pixel', Point._fields + Color._fields)
>>> Pixel(11, 22, 128, 255, 0)
Pixel(x=11, y=22, red=128, green=255, blue=0)
```

`somenamedtuple._field_defaults`

將欄位名稱對映至預設值的字典。

```
>>> Account = namedtuple('Account', ['type', 'balance'], defaults=[0])
>>> Account._field_defaults
{'balance': 0}
>>> Account('premium')
Account(type='premium', balance=0)
```

要取得這個名稱存於字串的欄位, 要使用 `getattr()` 函式:

```
>>> getattr(p, 'x')
11
```

(如 `tut-unpacking-arguments` 所述) 將一個字典轉成 `named tuple`, 要使用 `**` 雙星號運算子:

```
>>> d = {'x': 11, 'y': 22}
>>> Point(**d)
Point(x=11, y=22)
```

因一個 `named tuple` 是一個常規的 Python 類, 我們可以很容易的透過子類來新增或更改功能, 以下是如何新增一個計算得到的欄位和固定寬度的輸出列印格式:

```
>>> class Point(namedtuple('Point', ['x', 'y'])):
...     __slots__ = ()
...     @property
...     def hypot(self):
...         return (self.x ** 2 + self.y ** 2) ** 0.5
...     def __str__(self):
```

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```

...         return 'Point: x=%6.3f y=%6.3f hypot=%6.3f' % (self.x, self.y, self.
↪hypot)

>>> for p in Point(3, 4), Point(14, 5/7):
...     print(p)
Point: x= 3.000 y= 4.000 hypot= 5.000
Point: x=14.000 y= 0.714 hypot=14.018

```

上面的子類將 `__slots__` 設定為空 tuple，這樣一來就防止了字典實例被建立，因而保持了較低的記憶體用量。

子類無法用於增加新的、已被儲存的欄位，應當透過 `_fields` 屬性以建立一個新的 named tuple 來實現：

```
>>> Point3D = namedtuple('Point3D', Point._fields + ('z',))
```

透過直接賦值給 `__doc__`，可以自訂明文件字串：

```

>>> Book = namedtuple('Book', ['id', 'title', 'authors'])
>>> Book.__doc__ += ': Hardcover book in active collection'
>>> Book.id.__doc__ = '13-digit ISBN'
>>> Book.title.__doc__ = 'Title of first printing'
>>> Book.authors.__doc__ = 'List of authors sorted by last name'

```

在 3.5 版的變更：文件字串屬性變成可寫入。

也參考：

- 關於 named tuple 新增型提示的方法，請參 `typing.NamedTuple`，它運用 `class` 關鍵字以提供了一個簡潔的表示法：

```

class Component(NamedTuple):
    part_number: int
    weight: float
    description: Optional[str] = None

```

- 關於以 dict 而非 tuple 為底層的可變命名空間，請參考 `types.SimpleNamespace()`。
- `dataclasses` 模組提供了一個裝飾器和一些函式，用於自動將被生成的特殊方法新增到使用者定義的類中。

8.4.6 OrderedDict 物件

Ordered dictionary（有序字典）就像常規字典一樣，但有一些與排序操作相關的額外功能，但由於建立的 `dict` 類現在已經有記憶插入順序的能力（Python 3.7 中確保了這種新行），它們變得不那麼重要了。

仍存在一些與 `dict` 的不同之處：

- 常規的 `dict` 被設計成非常擅長於對映相關操作，追蹤插入的順序為次要目標。
- `OrderedDict` 則被設計成擅長於重新排序相關的操作，空間效率、迭代速度和更新操作的效能則為次要設計目標。
- `OrderedDict` 比起 `dict` 更適合處理頻繁的重新排序操作，如在下方法中所示，這讓它適合用於多種 LRU cache 的實作中。
- `OrderedDict` 之相等性運算會檢查順序是否相同。

一個一般的 `dict` 可以用 `p == q and all(k1 == k2 for k1, k2 in zip(p, q))` 來效仿有檢查順序的相等性運算。

- `OrderedDict` 類 的 `popitem()` 方法有不同的函式簽名 (signature)，它接受傳入一個選擇性引數來指定要移除哪個元素。

一個一般的 `dict` 可以用 `d.popitem()` 來效仿 `OrderedDict` 的 `od.popitem(last=True)`，這保證會移除最右邊（最後一個）的元素。

一個一般的 `dict` 可以用 `(k := next(iter(d)), d.pop(k))` 來效仿 `OrderedDict` 的 `od.popitem(last=False)`，若最左邊（第一個）的元素存在，則將其回傳 移除。

- `OrderedDict` 有個 `move_to_end()` 方法可有效率地將一個元素重新排列到任一端。

一個一般的 `dict` 可以用 `d[k] = d.pop(k)` 來效仿 `OrderedDict` 的 `od.move_to_end(k, last=True)`，這會將該鍵與其對應到的值移動至最右（最後面）的位置。

一個一般的 `dict` 有和 `OrderedDict` 的 `od.move_to_end(k, last=False)` 等價的有效方式，這是將鍵與其對應到的值移動至最左（最前面）位置的方法。

- 在 Python 3.8 之前，`dict` 有 `__reversed__()` 方法。

class `collections.OrderedDict` (`[items]`)

回傳一個 `dict` 子類 的實例，它具有專門用於重新排列字典順序的方法。

在 3.1 版新加入。

popitem (`last=True`)

`Ordered dictionary` 的 `popitem()` 方法移除 回傳一個鍵值 (key, value) 對。如果 `last` 真值，則按 LIFO 後進先出的順序回傳鍵值對，否則就按 FIFO (first-in, first-out) 先進先出的順序回傳鍵值對。

move_to_end (`key`, `last=True`)

將現有的 `key` 移動到 `ordered dictionary` 的任一端。如果 `last` 真值（此 預設值）則將元素移至右端；如果 `last` 假值則將元素移至左端。如果 `key` 不存在則會引發 `KeyError`：

```
>>> d = OrderedDict.fromkeys('abcde')
>>> d.move_to_end('b')
>>> ''.join(d)
'acdeb'
>>> d.move_to_end('b', last=False)
>>> ''.join(d)
'bacde'
```

在 3.2 版新加入。

除了普通的對映方法，`ordered dictionary` 還支援了透過 `reversed()` 來做倒序 代。

`OrderedDict` 物件之間的相等性運算是會檢查順序是否相同的，是透過 `list(od1.items())==list(od2.items())` 來實現。`OrderedDict` 物件和其他 `Mapping` 物件間的相等性運算則像普通字典一樣不考慮順序性，這使得 `OrderedDict` 可於任何字典可使用的時機中被替 掉。

在 3.5 版的變更：`OrderedDict` 的項 (item)、鍵與值之視圖現在可透過 `reversed()` 來倒序 代。

在 3.6 版的變更：隨著 **PEP 468** 被核可，被傳入給 `OrderedDict` 建構函式與其 `update()` 方法的關鍵字引數之順序被保留了下來。

在 3.9 版的變更：新增合 (|) 和更新 (|=) 運算子，請見 **PEP 584**。

OrderedDict 范例與用法

建立一個能記住鍵最後插入順序的 `ordered dictionary` 變體很簡單。如果新條目覆蓋了現有條目，則原本插入位置會被更改並移動至末端：

```
class LastUpdatedOrderedDict(OrderedDict):
    'Store items in the order the keys were last added'

    def __setitem__(self, key, value):
        super().__setitem__(key, value)
        self.move_to_end(key)
```

`OrderedDict` 在實現一個 `functools.lru_cache()` 的變形版本時也非常有用：

```
from time import time

class TimeBoundedLRU:
    "LRU Cache that invalidates and refreshes old entries."

    def __init__(self, func, maxsize=128, maxage=30):
        self.cache = OrderedDict() # { args : (timestamp, result) }
        self.func = func
        self.maxsize = maxsize
        self.maxage = maxage

    def __call__(self, *args):
        if args in self.cache:
            self.cache.move_to_end(args)
            timestamp, result = self.cache[args]
            if time() - timestamp <= self.maxage:
                return result
        result = self.func(*args)
        self.cache[args] = time(), result
        if len(self.cache) > self.maxsize:
            self.cache.popitem(0)
        return result

class MultiHitLRUCache:
    """ LRU cache that defers caching a result until
        it has been requested multiple times.

        To avoid flushing the LRU cache with one-time requests,
        we don't cache until a request has been made more than once.

    """

    def __init__(self, func, maxsize=128, maxrequests=4096, cache_after=1):
        self.requests = OrderedDict() # { uncached_key : request_count }
        self.cache = OrderedDict() # { cached_key : function_result }
        self.func = func
        self.maxrequests = maxrequests # max number of uncached requests
        self.maxsize = maxsize # max number of stored return values
        self.cache_after = cache_after

    def __call__(self, *args):
        if args in self.cache:
            self.cache.move_to_end(args)
            return self.cache[args]
        result = self.func(*args)
        self.requests[args] = self.requests.get(args, 0) + 1
        if self.requests[args] <= self.cache_after:
            self.requests.move_to_end(args)
```

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```

        if len(self.requests) > self.maxrequests:
            self.requests.popitem(0)
        else:
            self.requests.pop(args, None)
            self.cache[args] = result
            if len(self.cache) > self.maxsize:
                self.cache.popitem(0)
        return result

```

8.4.7 UserDict 物件

UserDict 類是作 *dict* 物件的包裝器。因已經可以直接自 *dict* 建立子類，這個類的需求已部分被滿足，不過這個類使用起來更方便，因被包裝的字典可以作其屬性來存取。

```
class collections.UserDict ([initialdata])
```

模擬字典的類。實例的內容被存於一個字典，可透過 *UserDict* 的 *data* 屬性來做存取。如果有提供 *initialdata*，*data* 屬性會被初始化其值；要注意指到 *initialdata* 的參照不會被保留，使其可被用於其他目的。

除了支援作對映所需的方法與操作，*UserDict* 實例提供了以下屬性：

data

一個真實的字典，用於儲存 *UserDict* 類的資料內容。

8.4.8 UserList 物件

此類是 *list* 物件的包裝器。它是個方便的基礎類，可繼承它覆寫現有方法或加入新方法來定義你所需的一個類似於 *list* 的類。如此一來，我們可以 *list* 加入新的特性。

因已經可以直接自 *list* 建立子類，這個類的需求已部分被滿足，不過這個類使用起來更方便，因被包裝的 *list* 可以作其屬性來存取。

```
class collections.UserList ([list])
```

模擬 *list* 的類。實例的內容被存於一個 *list*，可透過 *UserList* 的 *data* 屬性來做存取。實例內容被初始化 *list* 的內容，預設一個空的 *list* []。*list* 可以是任何 *iterable*，例如一個真實的 Python *list* 或是一個 *UserList* 物件。

除了支援可變序列的方法與操作，*UserList* 實例提供了以下屬性：

data

一個真實的 *list* 物件，用於儲存 *UserList* 類的資料內容。

子類化的條件：*UserList* 的子類應該要提供一個不需要引數或一個引數的建構函式。回傳一個新序列的 *list* 操作會從那些實作出來的類建立一個實例，了達成上述目的，它假設建構函式可傳入單一參數來呼叫，該參數即是做數據來源的一個序列物件。

如果希望一個自此獲得的子類不遵從上述要求，那所有該類支援的特殊方法則必須被覆寫；請參考原始碼來理解在這情況下哪些方法是必須提供的。

8.4.9 `UserString` 物件

`UserString` 類別是字串物件的包裝器，因為已經可以從 `str` 直接建立子類別，這個類別的需求已經部分被滿足，不過這個類別使用起來更方便，因為被包裝的字串可以作為其屬性來存取。

```
class collections.UserString(seq)
```

模擬字串物件的類別。實例的內容被存於一個字串物件，可透過 `UserString` 的 `data` 屬性來做存取。實例內容被初始化為 `seq` 的內容，`seq` 引數可以是任何可被建構函式 `str()` 轉成字串的物件。

除了支援字串的方法和操作以外，`UserString` 實例也提供了以下屬性：

data

一個真實的 `str` 物件，用來儲存 `UserString` 類別的資料內容。

在 3.5 版的變更：新增方法 `__getnewargs__`、`__rmod__`、`casefold`、`format_map`、`isprintable` 以及 `maketrans`。

8.5 `collections.abc` --- Abstract Base Classes for Containers

在 3.3 版新加入：Formerly, this module was part of the `collections` module.

原始碼： `Lib/_collections_abc.py`

This module provides *abstract base classes* that can be used to test whether a class provides a particular interface; for example, whether it is *hashable* or whether it is a *mapping*.

An `issubclass()` or `isinstance()` test for an interface works in one of three ways.

1) A newly written class can inherit directly from one of the abstract base classes. The class must supply the required abstract methods. The remaining mixin methods come from inheritance and can be overridden if desired. Other methods may be added as needed:

```
class C(Sequence):
    def __init__(self): ...           # Direct inheritance
    def __getitem__(self, index): ... # Extra method not required by the ABC
    def __len__(self): ...           # Required abstract method
    def count(self, value): ...       # Required abstract method
                                     # Optionally override a mixin method
```

```
>>> issubclass(C, Sequence)
True
>>> isinstance(C(), Sequence)
True
```

2) Existing classes and built-in classes can be registered as "virtual subclasses" of the ABCs. Those classes should define the full API including all of the abstract methods and all of the mixin methods. This lets users rely on `issubclass()` or `isinstance()` tests to determine whether the full interface is supported. The exception to this rule is for methods that are automatically inferred from the rest of the API:

```
class D:
    def __init__(self): ...           # No inheritance
    def __getitem__(self, index): ... # Extra method not required by the ABC
    def __len__(self): ...           # Abstract method
    def count(self, value): ...       # Abstract method
    def index(self, value): ...       # Mixin method
                                     # Mixin method

Sequence.register(D)                # Register instead of inherit
```

```
>>> isinstance(D, Sequence)
True
>>> isinstance(D(), Sequence)
True
```

In this example, class `D` does not need to define `__contains__`, `__iter__`, and `__reversed__` because the in-operator, the *iteration* logic, and the `reversed()` function automatically fall back to using `__getitem__` and `__len__`.

3) Some simple interfaces are directly recognizable by the presence of the required methods (unless those methods have been set to *None*):

```
class E:
    def __iter__(self): ...
    def __next__(self): ...
```

```
>>> isinstance(E, Iterable)
True
>>> isinstance(E(), Iterable)
True
```

Complex interfaces do not support this last technique because an interface is more than just the presence of method names. Interfaces specify semantics and relationships between methods that cannot be inferred solely from the presence of specific method names. For example, knowing that a class supplies `__getitem__`, `__len__`, and `__iter__` is insufficient for distinguishing a *Sequence* from a *Mapping*.

在 3.9 版新加入: These abstract classes now support []. See *Generic Alias Type* and **PEP 585**.

8.5.1 Collections Abstract Base Classes

The collections module offers the following *ABCs*:

ABC	Inherits from	Abstract Methods	Mixin Methods
<i>Container</i> ¹		<code>__contains__</code>	
<i>Hashable</i> ^{Page 259, 1}		<code>__hash__</code>	
<i>Iterable</i> ¹²		<code>__iter__</code>	
<i>Iterator</i> ¹	<i>Iterable</i>	<code>__next__</code>	<code>__iter__</code>
<i>Reversible</i> ¹	<i>Iterable</i>	<code>__reversed__</code>	
<i>Generator</i> ¹	<i>Iterator</i>	<code>send</code> , <code>throw</code>	<code>close</code> , <code>__iter__</code> , <code>__next__</code>
<i>Sized</i> ¹		<code>__len__</code>	
<i>Callable</i> ¹		<code>__call__</code>	
<i>Collection</i> ¹	<i>Sized</i> , <i>Iterable</i>	<code>__contains__</code> , <code>__iter__</code> , <code>__len__</code>	
<i>Sequence</i>	<i>Reversible</i> , <i>Collection</i>	<code>__getitem__</code> , <code>__len__</code>	<code>__contains__</code> , <code>__iter__</code> , <code>__reversed__</code> , <code>index</code> 和 <code>count</code>
<i>MutableSequence</i>	<i>Sequence</i>	<code>__getitem__</code> , <code>__setitem__</code> , <code>__delitem__</code> , <code>__len__</code> , <code>insert</code>	Inherited <i>Sequence</i> methods and <code>append</code> , <code>clear</code> , <code>reverse</code> , <code>extend</code> , <code>pop</code> , <code>remove</code> , and <code>__iadd__</code>
<i>ByteString</i>	<i>Sequence</i>	<code>__getitem__</code> , <code>__len__</code>	Inherited <i>Sequence</i> methods
<i>Set</i>	<i>Collection</i>	<code>__contains__</code> , <code>__iter__</code> , <code>__len__</code>	<code>__le__</code> , <code>__lt__</code> , <code>__eq__</code> , <code>__ne__</code> , <code>__gt__</code> , <code>__ge__</code> , <code>__and__</code> , <code>__or__</code> , <code>__sub__</code> , <code>__xor__</code> 與 <code>isdisjoint</code>
<i>MutableSet</i>	<i>Set</i>	<code>__contains__</code> , <code>__iter__</code> , <code>__len__</code> , <code>add</code> , <code>discard</code>	Inherited <i>Set</i> methods and <code>clear</code> , <code>pop</code> , <code>remove</code> , <code>__ior__</code> , <code>__iand__</code> , <code>__ixor__</code> , and <code>__isub__</code>
<i>Mapping</i>	<i>Collection</i>	<code>__getitem__</code> , <code>__iter__</code> , <code>__len__</code>	<code>__contains__</code> , <code>keys</code> , <code>items</code> , <code>values</code> , <code>get</code> , <code>__eq__</code> 和 <code>__ne__</code>
<i>MutableMapping</i>	<i>Mapping</i>	<code>__getitem__</code> , <code>__setitem__</code> , <code>__delitem__</code> , <code>__iter__</code> , <code>__len__</code>	Inherited <i>Mapping</i> methods and <code>pop</code> , <code>popitem</code> , <code>clear</code> , <code>update</code> , and <code>setdefault</code>
<i>MappingView</i>	<i>Sized</i>		<code>__len__</code>
<i>ItemsView</i>	<i>MappingView</i> , <i>Set</i>		<code>__contains__</code> , <code>__iter__</code>
<i>KeysView</i>	<i>MappingView</i> , <i>Set</i>		<code>__contains__</code> , <code>__iter__</code>
<i>ValuesView</i>	<i>MappingView</i> , <i>Collection</i>		<code>__contains__</code> , <code>__iter__</code>
<i>Awaitable</i> ¹		<code>__await__</code>	
<i>Coroutine</i> ¹	<i>Awaitable</i>	<code>send</code> , <code>throw</code>	<code>close</code>
<i>AsyncIterable</i> ¹		<code>__aiter__</code>	
<i>AsyncIterator</i> ¹	<i>AsyncIterable</i>	<code>__anext__</code>	<code>__aiter__</code>
<i>AsyncGenerator</i> ¹	<i>AsyncIterator</i>	<code>asend</code> , <code>athrow</code>	<code>aclose</code> , <code>__aiter__</code> , <code>__anext__</code>

¹ These ABCs override `__subclasshook__()` to support testing an interface by verifying the required methods are present and have not been set to `None`. This only works for simple interfaces. More complex interfaces require registration or direct subclassing.

² Checking `isinstance(obj, Iterable)` detects classes that are registered as *Iterable* or that have an `__iter__()` method, but it does not detect classes that iterate with the `__getitem__()` method. The only reliable way to determine whether an object is *iterable* is to call `iter(obj)`.

F 解

8.5.2 Collections Abstract Base Classes -- Detailed Descriptions

class `collections.abc.Container`ABC for classes that provide the `__contains__()` method.**class** `collections.abc.Hashable`ABC for classes that provide the `__hash__()` method.**class** `collections.abc.Sized`ABC for classes that provide the `__len__()` method.**class** `collections.abc.Callable`ABC for classes that provide the `__call__()` method.**class** `collections.abc.Iterable`ABC for classes that provide the `__iter__()` method.

Checking `isinstance(obj, Iterable)` detects classes that are registered as *Iterable* or that have an `__iter__()` method, but it does not detect classes that iterate with the `__getitem__()` method. The only reliable way to determine whether an object is *iterable* is to call `iter(obj)`.

class `collections.abc.Collection`

ABC for sized iterable container classes.

在 3.6 版新加入.

class `collections.abc.Iterator`ABC for classes that provide the `__iter__()` and `__next__()` methods. See also the definition of *iterator*.**class** `collections.abc.Reversible`ABC for iterable classes that also provide the `__reversed__()` method.

在 3.6 版新加入.

class `collections.abc.Generator`ABC for *generator* classes that implement the protocol defined in **PEP 342** that extends *iterators* with the `send()`, `throw()` and `close()` methods.

在 3.5 版新加入.

class `collections.abc.Sequence`**class** `collections.abc.MutableSequence`**class** `collections.abc.ByteString`ABCs for read-only and mutable *sequences*.

Implementation note: Some of the mixin methods, such as `__iter__()`, `__reversed__()` and `index()`, make repeated calls to the underlying `__getitem__()` method. Consequently, if `__getitem__()` is implemented with constant access speed, the mixin methods will have linear performance; however, if the underlying method is linear (as it would be with a linked list), the mixins will have quadratic performance and will likely need to be overridden.

在 3.5 版的變更: The `index()` method added support for *stop* and *start* arguments.**class** `collections.abc.Set`**class** `collections.abc.MutableSet`ABCs for read-only and mutable *sets*.**class** `collections.abc.Mapping`

class `collections.abc.MutableMapping`

ABCs for read-only and mutable *mappings*.

class `collections.abc.MappingView`

class `collections.abc.ItemsView`

class `collections.abc.KeysView`

class `collections.abc.ValuesView`

ABCs for mapping, items, keys, and values *views*.

class `collections.abc.Awaitable`

ABC for *awaitable* objects, which can be used in `await` expressions. Custom implementations must provide the `__await__()` method.

Coroutine objects and instances of the *Coroutine* ABC are all instances of this ABC.

備 注: In CPython, generator-based coroutines (*generators* decorated with `@types.coroutine`) are *awaitables*, even though they do not have an `__await__()` method. Using `isinstance(gencoro, Awaitable)` for them will return `False`. Use `inspect.isawaitable()` to detect them.

在 3.5 版新加入.

class `collections.abc.Coroutine`

ABC for *coroutine* compatible classes. These implement the following methods, defined in coroutine-objects: `send()`, `throw()`, and `close()`. Custom implementations must also implement `__await__()`. All *Coroutine* instances are also instances of *Awaitable*.

備 注: In CPython, generator-based coroutines (*generators* decorated with `@types.coroutine`) are *awaitables*, even though they do not have an `__await__()` method. Using `isinstance(gencoro, Coroutine)` for them will return `False`. Use `inspect.isawaitable()` to detect them.

在 3.5 版新加入.

class `collections.abc.AsyncIterable`

ABC for classes that provide an `__aiter__` method. See also the definition of *asynchronous iterable*.

在 3.5 版新加入.

class `collections.abc.AsyncIterator`

ABC for classes that provide `__aiter__` and `__anext__` methods. See also the definition of *asynchronous iterator*.

在 3.5 版新加入.

class `collections.abc.AsyncGenerator`

ABC for *asynchronous generator* classes that implement the protocol defined in **PEP 525** and **PEP 492**.

在 3.6 版新加入.

8.5.3 Examples and Recipes

ABCs allow us to ask classes or instances if they provide particular functionality, for example:

```
size = None
if isinstance(myvar, collections.abc.Sized):
    size = len(myvar)
```

Several of the ABCs are also useful as mixins that make it easier to develop classes supporting container APIs. For example, to write a class supporting the full `Set` API, it is only necessary to supply the three underlying abstract methods: `__contains__()`, `__iter__()`, and `__len__()`. The ABC supplies the remaining methods such as `__and__()` and `isdisjoint()`:

```
class ListBasedSet(collections.abc.Set):
    ''' Alternate set implementation favoring space over speed
        and not requiring the set elements to be hashable. '''
    def __init__(self, iterable):
        self.elements = lst = []
        for value in iterable:
            if value not in lst:
                lst.append(value)

    def __iter__(self):
        return iter(self.elements)

    def __contains__(self, value):
        return value in self.elements

    def __len__(self):
        return len(self.elements)

s1 = ListBasedSet('abcdef')
s2 = ListBasedSet('defghi')
overlap = s1 & s2           # The __and__() method is supported automatically
```

Notes on using `Set` and `MutableSet` as a mixin:

- (1) Since some set operations create new sets, the default mixin methods need a way to create new instances from an *iterable*. The class constructor is assumed to have a signature in the form `ClassName(iterable)`. That assumption is factored-out to an internal *classmethod* called `_from_iterable()` which calls `cls(iterable)` to produce a new set. If the `Set` mixin is being used in a class with a different constructor signature, you will need to override `_from_iterable()` with a classmethod or regular method that can construct new instances from an iterable argument.
- (2) To override the comparisons (presumably for speed, as the semantics are fixed), redefine `__le__()` and `__ge__()`, then the other operations will automatically follow suit.
- (3) The `Set` mixin provides a `__hash__()` method to compute a hash value for the set; however, `__hash__()` is not defined because not all sets are *hashable* or immutable. To add set hashability using mixins, inherit from both `Set()` and `Hashable()`, then define `__hash__ = Set._hash`.

也參考:

- [OrderedSet recipe](#) for an example built on `MutableSet`.
- 關於 ABC 的更多資訊請見 [abc module](#) 和 [PEP 3119](#)。

8.6 heapq --- 堆積列 (heap queue) 演算法

原始碼: [Lib/heapq.py](#)

這個模組實作了堆積列 (heap queue) 演算法，亦被稱優先列 (priority queue) 演算法。

Heap (堆積) 是一顆二元樹，樹上所有父節點的值都小於等於他的子節點的值。使用陣列實作，對於所有從 0 開始的 k 都滿足 $\text{heap}[k] \leq \text{heap}[2*k+1]$ 和 $\text{heap}[k] \leq \text{heap}[2*k+2]$ 。為了比較節點的值，不存在的元素被視為無限大。heap 存在一個有趣的性質：樹上最小的元素永遠會在根節點 $\text{heap}[0]$ 上。

下方的 API 跟一般教科書的 heap queue 演算法有兩個方面不同：第一，我們的索引從 0 開始計算，這會父節點與子節點之間的關係產生很微小的差別，但更符合 Python 從 0 開始索引的設計。第二，我們的 pop 方法會回傳最小的元素而不是最大的元素（在教科書中被稱作“min heap”，而“max heap”因為他很適合做原地排序，所以更常出現在教科書中）。

這兩個特性使得把 heap 當作一個標準的 Python list 檢視時不會出現意外： $\text{heap}[0]$ 是最小的物件， $\text{heap.sort}()$ 能保持 heap 的性質不變！

建立一個 heap 可以使用 list 初始化 $[]$ ，或者使用函式 `heapify()` 將一個已經有元素的 list 轉成一個 heap。

此模組提供下面的函式

`heapq.heappush(heap, item)`

把 *item* 放進 *heap*，保持 heap 性質不變。

`heapq.heappop(heap)`

從 *heap* 取出回傳最小的元素，同時保持 heap 性質不變。如果 *heap* 是空的會產生 `IndexError` 錯誤。只存取最小元素但不取出可以使用 $\text{heap}[0]$ 。

`heapq.heappushpop(heap, item)`

將 *item* 放入 *heap*，接著從 *heap* 取出回傳最小的元素。這個組合函式比呼叫 `heappush()` 之後呼叫 `heappop()` 更有效率。

`heapq.heapify(x)`

在時間上將 list *x* 轉成 heap，且過程不會申請額外記憶體。

`heapq.heapreplace(heap, item)`

從 *heap* 取出回傳最小的元素，接著將新的 *item* 放進 *heap*。*heap* 的大小不會改變。如果 *heap* 是空的會產生 `IndexError` 錯誤。

這個一次完成的操作會比呼叫 `heappop()` 之後呼叫 `heappush()` 更有效率，在維護 *heap* 的大小不變時更適當，取出/放入的組合函式一定會從 *heap* 回傳一個元素用 *item* 取代他。

函式的回傳值可能會大於被加入的 *item*。如果這不是你期望發生的，可以考慮使用 `heappushpop()` 替代，他會回傳 *heap* 的最小值和 *item* 兩個當中比較小的那個，將大的留在 *heap*。

這個模組也提供三個利用 heap 實作的一般用途函式

`heapq.merge(*iterables, key=None, reverse=False)`

合併多個已排序的輸入產生單一旦已排序的輸出（舉例：合併來自多個 log 檔中有時間戳記的項目）。回傳一個 *iterator* 包含已經排序的值。

和 `sorted(itertools.chain(*iterables))` 類似但回傳值是一個 *iterable*，不會一次把所有資料都放進記憶體中，且假設每一個輸入都已經（由小到大）排序過了。

有兩個選用參數，指定時必須被當作關鍵字參數指定。

key 參數指定了一個 *key function* 引數，用來從每一個輸入的元素中選定一個比較的依據。預設的值是 `None`（直接比較元素）。

`reverse` 是一個布林值，如果設定為 `True`，則輸入的元素將以相反的比較順序進行合併。為了達成類似 `sorted(itertools.chain(*iterables), reverse=True)` 的行，所有 `iterables` 必須由大到小排序。

在 3.5 版的變更：加入選用參數 `key` 和 `reverse`。

`heapq.nlargest(n, iterable, key=None)`

回傳一個包含資料 `iterable` 中前 `n` 大元素的 list。如果有指定 `key` 引數，`key` 會是只有一個引數的函式，用來從每一個在 `iterable` 中的元素提取一個比較的依據（例如 `key=str.lower`）。效果相當於 `sorted(iterable, key=key, reverse=True)[:n]`。

`heapq.nsmallest(n, iterable, key=None)`

回傳一個包含資料 `iterable` 中前 `n` 小元素的 list。如果有指定 `key` 引數，`key` 會是只有一個引數的函式，用來從每一個在 `iterable` 中的元素提取一個比較的依據（例如 `key=str.lower`）。效果相當於 `sorted(iterable, key=key)[:n]`。

後兩個函式在 `n` 值比較小時有最好的表現。對於較大的 `n` 值，只用 `sorted()` 函式會更有效率。同樣地，當 `n=1` 時，使用內建函式 `min()` 和 `max()` 會有更好的效率。如果需要重複使用這些函式，可以考慮將 `iterable` 轉成真正的 heap。

8.6.1 基礎范例

堆積排序 (heapsort) 可以透過將所有的值推入一個 heap，且從 heap 中一個接一個彈出最小元素來實作：

```
>>> def heapsort(iterable):
...     h = []
...     for value in iterable:
...         heappush(h, value)
...     return [heappop(h) for i in range(len(h))]
...
>>> heapsort([1, 3, 5, 7, 9, 2, 4, 6, 8, 0])
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

雖然類似 `sorted(iterable)`，但跟 `sorted()` 不同的是，這個實作不是 `stable` 的排序。

Heap 中的元素可以是 tuple。這有利於將要比較的值（例如一個 task 的優先度）和主要資料放在一起排序。

```
>>> h = []
>>> heappush(h, (5, 'write code'))
>>> heappush(h, (7, 'release product'))
>>> heappush(h, (1, 'write spec'))
>>> heappush(h, (3, 'create tests'))
>>> heappop(h)
(1, 'write spec')
```

8.6.2 優先列實作細節

優先列 (priority queue) 是 heap 的常見用途之一，實作優先列伴隨著下列挑戰：

- 排序的穩定性：如何將兩個擁有相同優先次序 (priority) 的 task 按照他們被加入的順序回傳？
- Tuple 的排序在某些情況下會壞掉，例如當 Tuple (priority, task) 的 priorities 相等且 tasks 有一個預設的排序時。
- 當一個 heap 中 task 的 priority 改變時，如何將它移到 heap 正確的位置上？
- 或者一個還未被解鎖的 task 需要被刪除時，要如何從列中找到要刪除指定的 task？

一個針對前兩個問題的解法是：儲存一個包含 priority、entry count 和 task 三個元素的 tuple。兩個 task 有相同 priority 時，entry count 會讓兩個 task 能根據加入的順序排序。因為沒有任何兩個 task 擁有相同的 entry count，所以永遠不會直接使用 task 做比較。

task 無法比較的另一個解方案是建立一個包裝器類，該類忽略 task 項目，只比較優先等級：

```
from dataclasses import dataclass, field
from typing import Any

@dataclass(order=True)
class PrioritizedItem:
    priority: int
    item: Any=field(compare=False)
```

剩下的問題可以藉由找到要除的 task 更改它的 priority 或者直接將它移除。尋找一個 task 可以使用一個 dictionary 指向列當中的 entry。

移除 entry 或更改它的 priority 更困難，因這會破壞 heap 的性質。所以一個可行的方案是將原本的 entry 做一個標記表示它已經被除，新增一個擁有新的 priority 的 entry。

```
pq = []                                # list of entries arranged in a heap
entry_finder = {}                     # mapping of tasks to entries
REMOVED = '<removed-task>'            # placeholder for a removed task
counter = itertools.count()           # unique sequence count

def add_task(task, priority=0):
    'Add a new task or update the priority of an existing task'
    if task in entry_finder:
        remove_task(task)
    count = next(counter)
    entry = [priority, count, task]
    entry_finder[task] = entry
    heappush(pq, entry)

def remove_task(task):
    'Mark an existing task as REMOVED. Raise KeyError if not found.'
    entry = entry_finder.pop(task)
    entry[-1] = REMOVED

def pop_task():
    'Remove and return the lowest priority task. Raise KeyError if empty.'
    while pq:
        priority, count, task = heappop(pq)
        if task is not REMOVED:
            del entry_finder[task]
            return task
    raise KeyError('pop from an empty priority queue')
```

8.6.3 原理

Heap 是一個陣列對於所有從 0 開始的 index k 都存在性質 $a[k] \leq a[2k+1]$ 和 $a[k] \leq a[2k+2]$ 。方便比較，不存在的元素被視無限大。Heap 的一個有趣的性質是： $a[0]$ 永遠是最小的元素。

上述乍看之下有些奇怪的不變式，是為了實作一個對記憶體來有效率的方法，其表示方式如同錦標賽一般。下列的數字 k ，而不是 $a[k]$ ：

```

              0
            1         2
          3         4         5         6
        7         8         9        10        11        12        13        14
      15 16    17 18    19 20    21 22    23 24    25 26    27 28    29 30
```

在上面的樹當中，每個單元 k 都會位在 $2*k+1$ 與 $2*k+2$ 上方。如同體育賽事常見的錦標賽般，每個單元可視為其下方兩個單元當中的贏家，我們可以透過追溯整棵樹來找到該贏家曾經對戰過的所有對手。然而，在許多電腦應用中，我們不需要追溯贏家的完整對戰歷史。為了能更有效率地使用記憶體，當一個贏家級勝出時，我們用下方較低層級的另一個項目來取代它，至此規則變成一個單元以及它下方兩個單元，包含三個不同項目，但是最上方的單元「勝過」下方兩個單元。

If this heap invariant is protected at all time, index 0 is clearly the overall winner. The simplest algorithmic way to remove it and find the "next" winner is to move some loser (let's say cell 30 in the diagram above) into the 0 position, and then percolate this new 0 down the tree, exchanging values, until the invariant is re-established. This is clearly logarithmic on the total number of items in the tree. By iterating over all items, you get an $O(n \log n)$ sort.

這種排序有個好處，只要插入的項目有「贏過」你最後提取、索引 0 的元素，你就可以在排序進行的同時有效率地插入新項目。這在模擬情境當中特別有用，其中樹能保存所有輸入事件，而「贏」意味著最小排程時間。當一個事件排程其它事件的執行時，因這些事件仍在等待進行，所以很容易將它們插入 heap 當中。因此，heap 是一個實現排程器的優秀資料結構（這就是我用以實作 MIDI 編曲器的方法:-）。

多種用於實作排程器的結構現今已被廣泛研究，heap 對此非常有用，因它們速度相當快，且速度幾乎不受其他因素影響，最壞情況與平均狀況差無幾。也有其它整體來更有效率的方法，然而它們的最壞情況可能會非常糟糕。

Heap 在儲存於硬碟上的大量資料進行排序也非常有用。你可能已經知道，大量資料排序涉及“runs”的生成（也就是預先排序的序列，其大小通常與 CPU 記憶體的大小有關），之後再對這些 run 合併，而這些合併的過程通常相當巧妙¹。很重要的一點是，初始排序生成的 run 越長越好。錦標賽是達成這一點的好方法，若你用所有可用記憶體來舉行一場錦標賽，透過替換與向下交換來處理所有適配當前 run 的值，那麼對於隨機生成的輸入，將可以生成長度兩倍於記憶體大小的 run。對於已模糊排序過的輸入，效果更好。

此外，若你將索引 0 的項目輸出至磁碟，取得一個無法適配當前錦標賽的輸入（因該值「勝過」最後的輸出值），則該輸入值就無法插入至 heap 當中，因此 heap 的大小會變小。釋放出來的記憶體可以巧妙地立即再被運用，逐步建構出第二個 heap，其大小增加的速度會與第一個 heap 變少的速度一致。當第一個 heap 完全消失時，你可以切換至第二個 heap 開一個新 run。這真是個聰明且相當有效率的做法！

總結來說，heap 是值得了解的有用記憶體結構。我在一些應用中使用它們，我認為能有一個‘heap’模組是很棒的。:-)

解

8.7 bisect --- 陣列二分演算法 (Array bisection algorithm)

原始碼：[Lib/bisect.py](#)

這個模組維護一個已經排序過的 list，當我們每次做完插入後不需要再次排序整個 list。一個很長的 list 的比較操作很花費時間，為了改進這點，這個模組是其中一個常用的方法。這個模組被命名為 `bisect` 來自他使用一個基礎的 `bisection` 演算法實作。模組的原始碼是這個演算法的一個完善的實作（邊界條件已經是正確的了）。

此模組提供下面的函式：

`bisect.bisect_left(a, x, lo=0, hi=len(a), *, key=None)`

在 a 當中找到一個位置，讓 x 插入後 a 仍然是排序好的。參數 lo 和 hi 用來指定 list 中應該被考慮的子區間，預設是考慮整個 list。如果 a 裡面已經有 x 出現，插入的位置會在所有 x 的前面（左邊）。回傳值可以被當作 `list.insert()` 的第一個參數，但列表 a 必須先排序過。

回傳的插入位置 i 將陣列 a 分兩半，使得 `all(val < x for val in a[lo : i])` 都在左側且 `all(val >= x for val in a[i : hi])` 都在右側。

¹ 現今的磁碟平衡演算法因硬碟查找能力而更加複雜難解。在有查找功能的裝置如大型磁帶機，狀況又不一样了，人們必須機智地確保（遠遠提前）每次於磁帶上移動都盡可能是最有效率的（也就是盡可能更好地「推進」合併的過程）。有些磁帶甚至能向後讀取，這也被用來避免倒轉的時間。相信我，真正優秀的磁帶排序看起來相當壯觀！排序一直以來都是一門偉大的藝術！:-)

`key` 可指定一個單一參數的 *key function*。函式將套用此 `function` 在陣列所有元素以得到比較值來計算順位。注意此 `function` 只會套用在陣列中的元素，不會套用在 `x`。

若 `key` 為 `None`，則排序順位將直接以陣列中元素值決定。

在 3.10 版的變更: 新增 `key` 參數。

```
bisect.bisect_right(a, x, lo=0, hi=len(a), *, key=None)
```

```
bisect.bisect(a, x, lo=0, hi=len(a), *, key=None)
```

類似 `bisect_left()`，但回傳的插入位置會在所有 `a` 當中的 `x` 的後面（右邊）。

回傳的插入位置 `i` 將陣列 `a` 分成兩半，使得 `all(val <= x for val in a[lo : i])` 都在左側且 `all(val > x for val in a[i : hi])` 都在右側。

`key` 可指定一個單一參數的 *key function*。函式將套用此 `function` 在陣列所有元素以得到比較值來計算順位。注意此 `function` 只會套用在陣列中的元素，不會套用在 `x`。

若 `key` 為 `None`，則排序順位將直接以陣列中元素值決定。

在 3.10 版的變更: 新增 `key` 參數。

```
bisect.insort_left(a, x, lo=0, hi=len(a), *, key=None)
```

將元素 `x` 插入 list `a`，維持順序。

This function first runs `bisect_left()` to locate an insertion point. Next, it runs the `insert()` method on `a` to insert `x` at the appropriate position to maintain sort order.

此函式只有在搜索時會使用 `key` 函式，插入時不會。

Keep in mind that the $O(\log n)$ search is dominated by the slow $O(n)$ insertion step.

在 3.10 版的變更: 新增 `key` 參數。

```
bisect.insort_right(a, x, lo=0, hi=len(a), *, key=None)
```

```
bisect.insort(a, x, lo=0, hi=len(a), *, key=None)
```

類似 `insort_left()`，但插入的位置會在所有 `a` 當中的 `x` 的後面（右邊）。

This function first runs `bisect_right()` to locate an insertion point. Next, it runs the `insert()` method on `a` to insert `x` at the appropriate position to maintain sort order.

此函式只有在搜索時會使用 `key` 函式，插入時不會。

Keep in mind that the $O(\log n)$ search is dominated by the slow $O(n)$ insertion step.

在 3.10 版的變更: 新增 `key` 參數。

8.7.1 效能考量

若需要在需要關注寫入時間的程式當中使用 `bisect()` 和 `insort()`，請特別注意幾個事項：

- 二分法在一段範圍的數值中做搜索的效率較佳，但若是需要存取特定數值，使用字典的表現還是比較好。
- The `insort()` functions are $O(n)$ because the logarithmic search step is dominated by the linear time insertion step.
- 搜索函式是無狀態的 (stateless)，且鍵函式會在使用過後被回收。因此，如果搜索函式被使用於循環當中，鍵函式會不斷被重調用於相同的 list 元素。如果鍵函式執行速度不快，請考慮將其以 `functools.cache()` 包裝起來以減少重調用的計算。另外，也可以透過搜尋預先計算好的鍵列表 (array of precomputed keys) 來定位插入點（如下方範例所示）。

也參考：

- 有序容器 (Sorted Collections) 是一個使用 `bisect` 來管理資料之有序集合的高效能模組。
- SortedCollection recipe 使用二分法來建立一個功能完整的集合類 (collection class) 帶有符合直覺的搜索方法 (search methods) 與支援鍵函式。鍵會預先被計算好，以減少搜索過程中多余的鍵函式調用。

8.7.2 搜尋一個已排序的 list

上面的 *bisect functions* 在找到數值插入點上很有用，但一般的數值搜尋任務上就不是那麼的方便。以下的五個函式展示了如何將其轉成標準的有序列表查找函式：

```
def index(a, x):
    'Locate the leftmost value exactly equal to x'
    i = bisect_left(a, x)
    if i != len(a) and a[i] == x:
        return i
    raise ValueError

def find_lt(a, x):
    'Find rightmost value less than x'
    i = bisect_left(a, x)
    if i:
        return a[i-1]
    raise ValueError

def find_le(a, x):
    'Find rightmost value less than or equal to x'
    i = bisect_right(a, x)
    if i:
        return a[i-1]
    raise ValueError

def find_gt(a, x):
    'Find leftmost value greater than x'
    i = bisect_right(a, x)
    if i != len(a):
        return a[i]
    raise ValueError

def find_ge(a, x):
    'Find leftmost item greater than or equal to x'
    i = bisect_left(a, x)
    if i != len(a):
        return a[i]
    raise ValueError
```

8.7.3 范例

bisect() 函式可用於數值表中的查找 (numeric table lookup)，這個範例使用 *bisect()* 以基於一組有序的數值分界點來一個考試成績找到相對應的字母等級：90 以上是 'A'、80 到 89 是 'B'，依此類推：

```
>>> def grade(score, breakpoints=[60, 70, 80, 90], grades='FDCBA'):
...     i = bisect(breakpoints, score)
...     return grades[i]
...
>>> [grade(score) for score in [33, 99, 77, 70, 89, 90, 100]]
['F', 'A', 'C', 'C', 'B', 'A', 'A']
```

bisect() 與 *insort()* 函式也適用於包含 tuples (元組) 的 lists，key 引數可被用以取出在數值表中作排序依據的欄位：

```
>>> from collections import namedtuple
>>> from operator import attrgetter
>>> from bisect import bisect, insort
>>> from pprint import pprint
```

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(繼續上一頁)

```
>>> Movie = namedtuple('Movie', ('name', 'released', 'director'))

>>> movies = [
...     Movie('Jaws', 1975, 'Spielberg'),
...     Movie('Titanic', 1997, 'Cameron'),
...     Movie('The Birds', 1963, 'Hitchcock'),
...     Movie('Aliens', 1986, 'Cameron')
... ]

>>> # Find the first movie released after 1960
>>> by_year = attrgetter('released')
>>> movies.sort(key=by_year)
>>> movies[bisect(movies, 1960, key=by_year)]
Movie(name='The Birds', released=1963, director='Hitchcock')

>>> # Insert a movie while maintaining sort order
>>> romance = Movie('Love Story', 1970, 'Hiller')
>>> insort(movies, romance, key=by_year)
>>> pprint(movies)
[Movie(name='The Birds', released=1963, director='Hitchcock'),
 Movie(name='Love Story', released=1970, director='Hiller'),
 Movie(name='Jaws', released=1975, director='Spielberg'),
 Movie(name='Aliens', released=1986, director='Cameron'),
 Movie(name='Titanic', released=1997, director='Cameron')]
```

如果鍵函式會消耗較多運算資源，那可以在預先計算好的鍵列表中搜索該紀元的索引值，以減少重覆的函式呼叫：

```
>>> data = [('red', 5), ('blue', 1), ('yellow', 8), ('black', 0)]
>>> data.sort(key=lambda r: r[1])           # Or use operator.itemgetter(1).
>>> keys = [r[1] for r in data]             # Precompute a list of keys.
>>> data[bisect_left(keys, 0)]
('black', 0)
>>> data[bisect_left(keys, 1)]
('blue', 1)
>>> data[bisect_left(keys, 5)]
('red', 5)
>>> data[bisect_left(keys, 8)]
('yellow', 8)
```

8.8 array --- 高效率的數值型陣列

這個模組定義了一個物件型，可以簡潔的表達一個包含基本數值的陣列：字元、整數、浮點數。陣列是一個非常類似 list（串列）的序列型，除了陣列會限制儲存的物件型。在建立陣列時可以使用一個字元的 *type code* 來指定儲存的資料型。以下有被定義的 type codes：

Type code	C Type	Python Type	所需的最小位元組 (bytes)	解
'b'	signed char	int	1	
'B'	unsigned char	int	1	
'u'	wchar_t	Unicode character	2	(1)
'h'	signed short	int	2	
'H'	unsigned short	int	2	
'i'	signed int	int	2	
'I'	unsigned int	int	2	
'l'	signed long	int	4	
'L'	unsigned long	int	4	
'q'	signed long long	int	8	
'Q'	unsigned long long	int	8	
'f'	float	float	4	
'd'	double	float	8	

解：

(1) 根據平台的不同，它有可能是 16 位元或者 32 位元。

在 3.9 版的變更: `array('u')` now uses `wchar_t` as C type instead of deprecated `Py_UNICODE`. This change doesn't affect its behavior because `Py_UNICODE` is alias of `wchar_t` since Python 3.3.

自從版本 3.3 後不推薦使用，將會自版本 4.0 中移除。

實際上數值的表示方法是被機器的架構所固定（更精準地，被 C 的實作方法固定）。實際的大小可以透過 `array.itemsize` 屬性存取。

這個模組定義了以下項目：

array.typecodes

一個包含所有可用的 type codes 的字串。

這個模組定義了下方的型：

class `array.array` (*typecode* [, *initializer*])

A new array whose items are restricted by *typecode*, and initialized from the optional *initializer* value, which must be a *bytes* or *bytearray* object, a Unicode string, or iterable over elements of the appropriate type.

If given a *bytes* or *bytearray* object, the initializer is passed to the new array's *frombytes()* method; if given a Unicode string, the initializer is passed to the *fromunicode()* method; otherwise, the initializer's iterator is passed to the *extend()* method to add initial items to the array.

陣列支援常見的序列操作，包含索引 (indexing)、切片 (slicing)、串接 (concatenation)、相乘 (multiplication) 等。當使用切片進行賦值時，賦值的陣列必須具備相同的 type code，其他型的數值將導致 *TypeError*。陣列同時也實作了緩衝區介面，可以在任何支援 *bytes-like objects* 的地方使用。

引發稽核事件 (*auditing event*) `array.__new__` 帶入引數 *typecode*、*initializer*。

typecode

typecode 字元被用在建立陣列時。

itemsize

陣列當中的一個元素在部需要的位元組長度。

append (*x*)

新增一個元素 *x* 到陣列的最尾端。

buffer_info ()

回傳一個 tuple (*address*, *length*) 表示當前的記憶體位置和陣列儲存元素的緩衝區記憶體長度。緩衝區的長度單位是位元組，可以用 `array.buffer_info()[1] * array.itemsize` 計算得到。這偶爾會在底層操作需要記憶體位置的輸出輸入時很有用，例如 `ioctl()` 指令。只要陣列存在且有使用任何更改長度的操作時，回傳的數值就有效。

備註：當使用來自 C 或 C++ 程式碼（這是唯一使得這個資訊有效的途徑）的陣列物件時，更適當的做法是使用陣列物件支援的緩衝區介面。這個方法維護了向後兼容性，`array` 應該在新的程式碼中避免。關於緩衝區介面的文件在 `bufferobjects`。

`byteswap()`

“Byteswap”所有陣列中的物件。這只有支援物件長度 1、2、4 或 8 位元組的陣列，其他型的值會導致 `RuntimeError`。這在從機器讀取位元順序不同的檔案時很有用。

`count(x)`

回傳 `x` 在陣列中出現了幾次。

`extend(iterable)`

從 `iterable` 中新增元素到陣列的尾端，如果 `iterable` 是另一個陣列，它必須有完全相同的 type code，如果不同會導致 `TypeError`。如果 `iterable` 不是一個陣列，它必須可以被 `iterable` 代且其中的元素必須是可以被加入陣列中的正確型。

`frombytes(buffer)`

Appends items from the *bytes-like object*, interpreting its content as an array of machine values (as if it had been read from a file using the `fromfile()` method).

在 3.2 版新加入：將 `fromstring()` 更名 `frombytes()`，使其更加清晰易懂。

`fromfile(f, n)`

從 *file object* `f` 讀取 `n` 個元素（作機器數值），接著將這些元素加入陣列的最尾端。如果只有少於 `n` 個有效的元素會導致 `EOFError`，但有效的元素仍然會被加入陣列中。

`fromlist(list)`

從 `list` 中新增元素。這等價於 `for x in list: a.append(x)`，除了有型錯誤發生時，陣列會保持原狀不會被更改。

`fromunicode(s)`

Extends this array with data from the given Unicode string. The array must have type code 'u'; otherwise a `ValueError` is raised. Use `array.frombytes(unicodestring.encode(enc))` to append Unicode data to an array of some other type.

`index(x[, start[, stop]])`

回傳 `i` 的最小數值，使得 `i` 成陣列之中第一次出現 `x` 的索引。選擇性的引數 `start` 及 `stop` 則可以被用來在指定的陣列空間中搜尋 `x`。如果 `x` 不存在將導致 `ValueError`。

在 3.10 版的變更：新增選擇性的參數 `start` 及 `stop`。

`insert(i, x)`

在位置 `i` 之前插入一個元素 `x`。負數的索引值會從陣列尾端開始數。

`pop([i])`

移除回傳陣列索引值 `i` 的元素。選擇性的引數 `i` 預設 `-1`，所以預設會除回傳最後一個元素。

`remove(x)`

從陣列中除第一個出現的 `x`。

`reverse()`

反轉陣列中元素的順序。

`tobytes()`

將陣列轉另一個機器數值組成的陣列回傳它的位元組表示（跟用 `tofile()` 方法寫入檔案時的位元序列相同）。

在 3.2 版新加入：為了明確性，過去的 `tostring()` 已更名 `tobytes()`。

tofile (*f*)

將所有元素（作 F 機器數值）寫入 *file object* *f*。

tolist ()

不更改元素，將陣列轉 F 一般的 list。

tounicode ()

Convert the array to a Unicode string. The array must have a type 'u'; otherwise a *ValueError* is raised. Use `array.tobytes().decode(enc)` to obtain a Unicode string from an array of some other type.

The string representation of array objects has the form `array(typecode, initializer)`. The *initializer* is omitted if the array is empty, otherwise it is a Unicode string if the *typecode* is 'u', otherwise it is a list of numbers. The string representation is guaranteed to be able to be converted back to an array with the same type and value using `eval()`, so long as the `array` class has been imported using `from array import array`. Variables `inf` and `nan` must also be defined if it contains corresponding floating point values. Examples:

```
array('l')
array('u', 'hello \u2641')
array('l', [1, 2, 3, 4, 5])
array('d', [1.0, 2.0, 3.14, -inf, nan])
```

也參考:

struct 模組

將包含不同資料類型的二進位資料包裝與解開包裝。

xdrlib 模組

將 External Data Representation (XDR) 的資料包裝與解開包裝，這用在一些遠端操作的系統 (remote procedure call systems)。

NumPy

NumPy 套件定義了另一個陣列型 F

8.9 weakref --- Weak references

原始碼: [Lib/weakref.py](#)

The *weakref* module allows the Python programmer to create *weak references* to objects.

In the following, the term *referent* means the object which is referred to by a weak reference.

A weak reference to an object is not enough to keep the object alive: when the only remaining references to a referent are weak references, *garbage collection* is free to destroy the referent and reuse its memory for something else. However, until the object is actually destroyed the weak reference may return the object even if there are no strong references to it.

A primary use for weak references is to implement caches or mappings holding large objects, where it's desired that a large object not be kept alive solely because it appears in a cache or mapping.

For example, if you have a number of large binary image objects, you may wish to associate a name with each. If you used a Python dictionary to map names to images, or images to names, the image objects would remain alive just because they appeared as values or keys in the dictionaries. The *WeakKeyDictionary* and *WeakValueDictionary* classes supplied by the *weakref* module are an alternative, using weak references to construct mappings that don't keep objects alive solely because they appear in the mapping objects. If, for example, an image object is a value in a *WeakValueDictionary*, then when the last remaining references to that image object are the weak references held by weak mappings, garbage collection can reclaim the object, and its corresponding entries in weak mappings are simply deleted.

WeakKeyDictionary and *WeakValueDictionary* use weak references in their implementation, setting up callback functions on the weak references that notify the weak dictionaries when a key or value has been reclaimed

by garbage collection. `WeakSet` implements the `set` interface, but keeps weak references to its elements, just like a `WeakKeyDictionary` does.

`finalize` provides a straight forward way to register a cleanup function to be called when an object is garbage collected. This is simpler to use than setting up a callback function on a raw weak reference, since the module automatically ensures that the finalizer remains alive until the object is collected.

Most programs should find that using one of these weak container types or `finalize` is all they need -- it's not usually necessary to create your own weak references directly. The low-level machinery is exposed by the `weakref` module for the benefit of advanced uses.

Not all objects can be weakly referenced. Objects which support weak references include class instances, functions written in Python (but not in C), instance methods, sets, frozensets, some *file objects*, *generators*, type objects, sockets, arrays, deques, regular expression pattern objects, and code objects.

在 3.2 版的變更: Added support for `thread.lock`, `threading.Lock`, and code objects.

Several built-in types such as `list` and `dict` do not directly support weak references but can add support through subclassing:

```
class Dict(dict):
    pass

obj = Dict(red=1, green=2, blue=3)  # this object is weak referenceable
```

CPython 實作細節: Other built-in types such as `tuple` and `int` do not support weak references even when subclassed.

Extension types can easily be made to support weak references; see `weakref-support`.

When `__slots__` are defined for a given type, weak reference support is disabled unless a `'__weakref__'` string is also present in the sequence of strings in the `__slots__` declaration. See `__slots__` documentation for details.

class `weakref.ref(object[, callback])`

Return a weak reference to *object*. The original object can be retrieved by calling the reference object if the referent is still alive; if the referent is no longer alive, calling the reference object will cause `None` to be returned. If *callback* is provided and not `None`, and the returned weakref object is still alive, the callback will be called when the object is about to be finalized; the weak reference object will be passed as the only parameter to the callback; the referent will no longer be available.

It is allowable for many weak references to be constructed for the same object. Callbacks registered for each weak reference will be called from the most recently registered callback to the oldest registered callback.

Exceptions raised by the callback will be noted on the standard error output, but cannot be propagated; they are handled in exactly the same way as exceptions raised from an object's `__del__()` method.

Weak references are *hashable* if the *object* is hashable. They will maintain their hash value even after the *object* was deleted. If `hash()` is called the first time only after the *object* was deleted, the call will raise `TypeError`.

Weak references support tests for equality, but not ordering. If the referents are still alive, two references have the same equality relationship as their referents (regardless of the *callback*). If either referent has been deleted, the references are equal only if the reference objects are the same object.

This is a subclassable type rather than a factory function.

__callback__

This read-only attribute returns the callback currently associated to the weakref. If there is no callback or if the referent of the weakref is no longer alive then this attribute will have value `None`.

在 3.4 版的變更: 新增 `__callback__` 屬性。

weakref.proxy(object[, callback])

Return a proxy to *object* which uses a weak reference. This supports use of the proxy in most contexts instead of requiring the explicit dereferencing used with weak reference objects. The returned object will have a type

of either `ProxyType` or `CallableProxyType`, depending on whether *object* is callable. Proxy objects are not *hashable* regardless of the referent; this avoids a number of problems related to their fundamentally mutable nature, and prevents their use as dictionary keys. *callback* is the same as the parameter of the same name to the `ref()` function.

Accessing an attribute of the proxy object after the referent is garbage collected raises `ReferenceError`.

在 3.8 版的變更: Extended the operator support on proxy objects to include the matrix multiplication operators `@` and `@=`.

`weakref.getweakrefcount(object)`

Return the number of weak references and proxies which refer to *object*.

`weakref.getweakrefs(object)`

Return a list of all weak reference and proxy objects which refer to *object*.

class `weakref.WeakKeyDictionary([dict])`

Mapping class that references keys weakly. Entries in the dictionary will be discarded when there is no longer a strong reference to the key. This can be used to associate additional data with an object owned by other parts of an application without adding attributes to those objects. This can be especially useful with objects that override attribute accesses.

Note that when a key with equal value to an existing key (but not equal identity) is inserted into the dictionary, it replaces the value but does not replace the existing key. Due to this, when the reference to the original key is deleted, it also deletes the entry in the dictionary:

```
>>> class T(str): pass
...
>>> k1, k2 = T(), T()
>>> d = weakref.WeakKeyDictionary()
>>> d[k1] = 1      # d = {k1: 1}
>>> d[k2] = 2      # d = {k1: 2}
>>> del k1         # d = {}
```

A workaround would be to remove the key prior to reassignment:

```
>>> class T(str): pass
...
>>> k1, k2 = T(), T()
>>> d = weakref.WeakKeyDictionary()
>>> d[k1] = 1      # d = {k1: 1}
>>> del d[k1]
>>> d[k2] = 2      # d = {k2: 2}
>>> del k1         # d = {k2: 2}
```

在 3.9 版的變更: 新增 **PEP 584** 所述對於 `|` 與 `|=` 運算子的支援。

`WeakKeyDictionary` objects have an additional method that exposes the internal references directly. The references are not guaranteed to be "live" at the time they are used, so the result of calling the references needs to be checked before being used. This can be used to avoid creating references that will cause the garbage collector to keep the keys around longer than needed.

`WeakKeyDictionary.keyrefs()`

Return an iterable of the weak references to the keys.

class `weakref.WeakValueDictionary([dict])`

Mapping class that references values weakly. Entries in the dictionary will be discarded when no strong reference to the value exists any more.

在 3.9 版的變更: Added support for `|` and `|=` operators, as specified in **PEP 584**.

`WeakValueDictionary` objects have an additional method that has the same issues as the `WeakKeyDictionary.keyrefs()` method.

`WeakValueDictionary.valuerefs()`

Return an iterable of the weak references to the values.

class `weakref.WeakSet([elements])`

Set class that keeps weak references to its elements. An element will be discarded when no strong reference to it exists any more.

class `weakref.WeakMethod(method[, callback])`

A custom *ref* subclass which simulates a weak reference to a bound method (i.e., a method defined on a class and looked up on an instance). Since a bound method is ephemeral, a standard weak reference cannot keep hold of it. *WeakMethod* has special code to recreate the bound method until either the object or the original function dies:

```
>>> class C:
...     def method(self):
...         print("method called!")
...
>>> c = C()
>>> r = weakref.ref(c.method)
>>> r()
>>> r = weakref.WeakMethod(c.method)
>>> r()
<bound method C.method of <__main__.C object at 0x7fc859830220>>
>>> r() ()
method called!
>>> del c
>>> gc.collect()
0
>>> r()
>>>
```

callback is the same as the parameter of the same name to the *ref()* function.

在 3.4 版新加入.

class `weakref.finalize(obj, func, /, *args, **kwargs)`

Return a callable finalizer object which will be called when *obj* is garbage collected. Unlike an ordinary weak reference, a finalizer will always survive until the reference object is collected, greatly simplifying lifecycle management.

A finalizer is considered *alive* until it is called (either explicitly or at garbage collection), and after that it is *dead*. Calling a live finalizer returns the result of evaluating `func(*arg, **kwargs)`, whereas calling a dead finalizer returns *None*.

Exceptions raised by finalizer callbacks during garbage collection will be shown on the standard error output, but cannot be propagated. They are handled in the same way as exceptions raised from an object's `__del__()` method or a weak reference's callback.

When the program exits, each remaining live finalizer is called unless its *atexit* attribute has been set to false. They are called in reverse order of creation.

A finalizer will never invoke its callback during the later part of the *interpreter shutdown* when module globals are liable to have been replaced by *None*.

`__call__()`

If *self* is alive then mark it as dead and return the result of calling `func(*args, **kwargs)`. If *self* is dead then return *None*.

`detach()`

If *self* is alive then mark it as dead and return the tuple `(obj, func, args, kwargs)`. If *self* is dead then return *None*.

peek()

If *self* is alive then return the tuple (*obj*, *func*, *args*, *kwargs*). If *self* is dead then return *None*.

alive

Property which is true if the finalizer is alive, false otherwise.

atexit

A writable boolean property which by default is true. When the program exits, it calls all remaining live finalizers for which *atexit* is true. They are called in reverse order of creation.

備 F: It is important to ensure that *func*, *args* and *kwargs* do not own any references to *obj*, either directly or indirectly, since otherwise *obj* will never be garbage collected. In particular, *func* should not be a bound method of *obj*.

在 3.4 版新加入.

weakref.ReferenceType

The type object for weak references objects.

weakref.ProxyType

The type object for proxies of objects which are not callable.

weakref.CallableProxyType

The type object for proxies of callable objects.

weakref.ProxyTypes

Sequence containing all the type objects for proxies. This can make it simpler to test if an object is a proxy without being dependent on naming both proxy types.

也參考:**PEP 205 - Weak References**

The proposal and rationale for this feature, including links to earlier implementations and information about similar features in other languages.

8.9.1 Weak Reference Objects

Weak reference objects have no methods and no attributes besides *ref.__callback__*. A weak reference object allows the referent to be obtained, if it still exists, by calling it:

```
>>> import weakref
>>> class Object:
...     pass
...
>>> o = Object()
>>> r = weakref.ref(o)
>>> o2 = r()
>>> o is o2
True
```

If the referent no longer exists, calling the reference object returns *None*:

```
>>> del o, o2
>>> print(r())
None
```

Testing that a weak reference object is still live should be done using the expression *ref() is not None*. Normally, application code that needs to use a reference object should follow this pattern:

```
# r is a weak reference object
o = r()
if o is None:
    # referent has been garbage collected
    print("Object has been deallocated; can't frobnicate.")
else:
    print("Object is still live!")
    o.do_something_useful()
```

Using a separate test for “liveness” creates race conditions in threaded applications; another thread can cause a weak reference to become invalidated before the weak reference is called; the idiom shown above is safe in threaded applications as well as single-threaded applications.

Specialized versions of `ref` objects can be created through subclassing. This is used in the implementation of the `WeakValueDictionary` to reduce the memory overhead for each entry in the mapping. This may be most useful to associate additional information with a reference, but could also be used to insert additional processing on calls to retrieve the referent.

This example shows how a subclass of `ref` can be used to store additional information about an object and affect the value that’s returned when the referent is accessed:

```
import weakref

class ExtendedRef(weakref.ref):
    def __init__(self, ob, callback=None, /, **annotations):
        super().__init__(ob, callback)
        self.__counter = 0
        for k, v in annotations.items():
            setattr(self, k, v)

    def __call__(self):
        """Return a pair containing the referent and the number of
        times the reference has been called.
        """
        ob = super().__call__()
        if ob is not None:
            self.__counter += 1
            ob = (ob, self.__counter)
        return ob
```

8.9.2 范例

This simple example shows how an application can use object IDs to retrieve objects that it has seen before. The IDs of the objects can then be used in other data structures without forcing the objects to remain alive, but the objects can still be retrieved by ID if they do.

```
import weakref

_id2obj_dict = weakref.WeakValueDictionary()

def remember(obj):
    oid = id(obj)
    _id2obj_dict[oid] = obj
    return oid

def id2obj(oid):
    return _id2obj_dict[oid]
```

8.9.3 Finalizer Objects

The main benefit of using `finalize` is that it makes it simple to register a callback without needing to preserve the returned finalizer object. For instance

```
>>> import weakref
>>> class Object:
...     pass
...
>>> kenny = Object()
>>> weakref.finalize(kenny, print, "You killed Kenny!")
<finalize object at ...; for 'Object' at ...>
>>> del kenny
You killed Kenny!
```

The finalizer can be called directly as well. However the finalizer will invoke the callback at most once.

```
>>> def callback(x, y, z):
...     print("CALLBACK")
...     return x + y + z
...
>>> obj = Object()
>>> f = weakref.finalize(obj, callback, 1, 2, z=3)
>>> assert f.alive
>>> assert f() == 6
CALLBACK
>>> assert not f.alive
>>> f()                                     # callback not called because finalizer dead
>>> del obj                                # callback not called because finalizer dead
```

You can unregister a finalizer using its `detach()` method. This kills the finalizer and returns the arguments passed to the constructor when it was created.

```
>>> obj = Object()
>>> f = weakref.finalize(obj, callback, 1, 2, z=3)
>>> f.detach()
(<...Object object ...>, <function callback ...>, (1, 2), {'z': 3})
>>> newobj, func, args, kwargs = _
>>> assert not f.alive
>>> assert newobj is obj
>>> assert func(*args, **kwargs) == 6
CALLBACK
```

Unless you set the `atexit` attribute to `False`, a finalizer will be called when the program exits if it is still alive. For instance

```
>>> obj = Object()
>>> weakref.finalize(obj, print, "obj dead or exiting")
<finalize object at ...; for 'Object' at ...>
>>> exit()
obj dead or exiting
```

8.9.4 Comparing finalizers with `__del__()` methods

Suppose we want to create a class whose instances represent temporary directories. The directories should be deleted with their contents when the first of the following events occurs:

- the object is garbage collected,
- the object's `remove()` method is called, or
- the program exits.

We might try to implement the class using a `__del__()` method as follows:

```
class TempDir:
    def __init__(self):
        self.name = tempfile.mkdtemp()

    def remove(self):
        if self.name is not None:
            shutil.rmtree(self.name)
            self.name = None

    @property
    def removed(self):
        return self.name is None

    def __del__(self):
        self.remove()
```

Starting with Python 3.4, `__del__()` methods no longer prevent reference cycles from being garbage collected, and module globals are no longer forced to `None` during *interpreter shutdown*. So this code should work without any issues on CPython.

However, handling of `__del__()` methods is notoriously implementation specific, since it depends on internal details of the interpreter's garbage collector implementation.

A more robust alternative can be to define a finalizer which only references the specific functions and objects that it needs, rather than having access to the full state of the object:

```
class TempDir:
    def __init__(self):
        self.name = tempfile.mkdtemp()
        self._finalizer = weakref.finalize(self, shutil.rmtree, self.name)

    def remove(self):
        self._finalizer()

    @property
    def removed(self):
        return not self._finalizer.alive
```

Defined like this, our finalizer only receives a reference to the details it needs to clean up the directory appropriately. If the object never gets garbage collected the finalizer will still be called at exit.

The other advantage of `weakref` based finalizers is that they can be used to register finalizers for classes where the definition is controlled by a third party, such as running code when a module is unloaded:

```
import weakref, sys
def unloading_module():
    # implicit reference to the module globals from the function body
    weakref.finalize(sys.modules[__name__], unloading_module)
```

備註: If you create a finalizer object in a daemon thread just as the program exits then there is the possibility that the finalizer does not get called at exit. However, in a daemon thread `atexit.register()`, try: ...

`finally:` ... and `with:` ... do not guarantee that cleanup occurs either.

8.10 types --- Dynamic type creation and names for built-in types

原始碼: [Lib/types.py](#)

This module defines utility functions to assist in dynamic creation of new types.

It also defines names for some object types that are used by the standard Python interpreter, but not exposed as builtins like `int` or `str` are.

Finally, it provides some additional type-related utility classes and functions that are not fundamental enough to be builtins.

8.10.1 Dynamic Type Creation

`types.new_class` (*name*, *bases*=(), *kws*=None, *exec_body*=None)

Creates a class object dynamically using the appropriate metaclass.

The first three arguments are the components that make up a class definition header: the class name, the base classes (in order), the keyword arguments (such as `metaclass`).

The *exec_body* argument is a callback that is used to populate the freshly created class namespace. It should accept the class namespace as its sole argument and update the namespace directly with the class contents. If no callback is provided, it has the same effect as passing in `lambda ns: None`.

在 3.3 版新加入.

`types.prepare_class` (*name*, *bases*=(), *kws*=None)

Calculates the appropriate metaclass and creates the class namespace.

The arguments are the components that make up a class definition header: the class name, the base classes (in order) and the keyword arguments (such as `metaclass`).

The return value is a 3-tuple: `metaclass`, `namespace`, `kws`

metaclass is the appropriate metaclass, *namespace* is the prepared class namespace and *kws* is an updated copy of the passed in *kws* argument with any 'metaclass' entry removed. If no *kws* argument is passed in, this will be an empty dict.

在 3.3 版新加入.

在 3.6 版的變更: The default value for the `namespace` element of the returned tuple has changed. Now an insertion-order-preserving mapping is used when the metaclass does not have a `__prepare__` method.

也參考:

metaclasses

Full details of the class creation process supported by these functions

PEP 3115 - Metaclasses in Python 3000

Introduced the `__prepare__` namespace hook

`types.resolve_bases` (*bases*)

Resolve MRO entries dynamically as specified by [PEP 560](#).

This function looks for items in *bases* that are not instances of `type`, and returns a tuple where each such object that has an `__mro_entries__()` method is replaced with an unpacked result of calling this method. If a *bases* item is an instance of `type`, or it doesn't have an `__mro_entries__()` method, then it is included in the return tuple unchanged.

在 3.7 版新加入.

也參考:

PEP 560 - Core support for typing module and generic types

8.10.2 Standard Interpreter Types

This module provides names for many of the types that are required to implement a Python interpreter. It deliberately avoids including some of the types that arise only incidentally during processing such as the `listiterator` type.

Typical use of these names is for `isinstance()` or `issubclass()` checks.

If you instantiate any of these types, note that signatures may vary between Python versions.

Standard names are defined for the following types:

`types.NoneType`

The type of `None`.

在 3.10 版新加入.

`types.FunctionType`

`types.LambdaType`

The type of user-defined functions and functions created by `lambda` expressions.

引發一個附帶引數 `code` 的稽核事件 `function.__new__`。

The audit event only occurs for direct instantiation of function objects, and is not raised for normal compilation.

`types.GeneratorType`

The type of *generator*-iterator objects, created by generator functions.

`types.CoroutineType`

The type of *coroutine* objects, created by `async def` functions.

在 3.5 版新加入.

`types.AsyncGeneratorType`

The type of *asynchronous generator*-iterator objects, created by asynchronous generator functions.

在 3.6 版新加入.

class `types.CodeType` (***kwargs*)

The type of code objects such as returned by `compile()`.

引發一個附帶引數 `code`、`filename`、`name`、`argcount`、`posonlyargcount`、`kwnonlyargcount`、`nlocals`、`stacksize`、`flags` 的稽核事件 `code.__new__`。

Note that the audited arguments may not match the names or positions required by the initializer. The audit event only occurs for direct instantiation of code objects, and is not raised for normal compilation.

`types.CellType`

The type for cell objects: such objects are used as containers for a function's free variables.

在 3.8 版新加入.

`types.MethodType`

The type of methods of user-defined class instances.

`types.BuiltinFunctionType`

`types.BuiltinMethodType`

The type of built-in functions like `len()` or `sys.exit()`, and methods of built-in classes. (Here, the term "built-in" means "written in C".)

types.WrapperDescriptorType

The type of methods of some built-in data types and base classes such as `object.__init__()` or `object.__lt__()`.

在 3.7 版新加入.

types.MethodWrapperType

The type of *bound* methods of some built-in data types and base classes. For example it is the type of `object().__str__`.

在 3.7 版新加入.

types.NotImplementedType

The type of *NotImplemented*.

在 3.10 版新加入.

types.MethodDescriptorType

The type of methods of some built-in data types such as `str.join()`.

在 3.7 版新加入.

types.ClassMethodDescriptorType

The type of *unbound* class methods of some built-in data types such as `dict.__dict__['fromkeys']`.

在 3.7 版新加入.

class types.ModuleType (name, doc=None)

The type of *modules*. The constructor takes the name of the module to be created and optionally its *docstring*.

備 F: Use `importlib.util.module_from_spec()` to create a new module if you wish to set the various import-controlled attributes.

__doc__

The *docstring* of the module. Defaults to `None`.

__loader__

The *loader* which loaded the module. Defaults to `None`.

This attribute is to match `importlib.machinery.ModuleSpec.loader` as stored in the `__spec__` object.

備 F: A future version of Python may stop setting this attribute by default. To guard against this potential change, preferably read from the `__spec__` attribute instead or use `getattr(module, "__loader__", None)` if you explicitly need to use this attribute.

在 3.4 版的變更: Defaults to `None`. Previously the attribute was optional.

__name__

The name of the module. Expected to match `importlib.machinery.ModuleSpec.name`.

__package__

Which *package* a module belongs to. If the module is top-level (i.e. not a part of any specific package) then the attribute should be set to `' '`, else it should be set to the name of the package (which can be `__name__` if the module is a package itself). Defaults to `None`.

This attribute is to match `importlib.machinery.ModuleSpec.parent` as stored in the `__spec__` object.

備 F: A future version of Python may stop setting this attribute by default. To guard against this potential change, preferably read from the `__spec__` attribute instead or use `getattr(module, "__package__", None)` if you explicitly need to use this attribute.

在 3.4 版的變更: Defaults to `None`. Previously the attribute was optional.

`__spec__`

A record of the module's import-system-related state. Expected to be an instance of `importlib.machinery.ModuleSpec`.

在 3.4 版新加入.

`types.EllipsisType`

The type of `Ellipsis`.

在 3.10 版新加入.

`class types.GenericAlias (t_origin, t_args)`

The type of *parameterized generics* such as `list[int]`.

`t_origin` should be a non-parameterized generic class, such as `list`, `tuple` or `dict`. `t_args` should be a *tuple* (possibly of length 1) of types which parameterize `t_origin`:

```
>>> from types import GenericAlias
>>> list[int] == GenericAlias(list, (int,))
True
>>> dict[str, int] == GenericAlias(dict, (str, int))
True
```

在 3.9 版新加入.

在 3.9.2 版的變更: This type can now be subclassed.

也參考:

Generic Alias Types

In-depth documentation on instances of `types.GenericAlias`

PEP 585 - Type Hinting Generics In Standard Collections

Introducing the `types.GenericAlias` class

`class types.UnionType`

The type of *union type expressions*.

在 3.10 版新加入.

`class types.TracebackType (tb_next, tb_frame, tb_lasti, tb_lineno)`

The type of traceback objects such as found in `sys.exception().__traceback__`.

See the language reference for details of the available attributes and operations, and guidance on creating tracebacks dynamically.

`types.FrameType`

The type of frame objects such as found in `tb.tb_frame` if `tb` is a traceback object.

`types.GetSetDescriptorType`

The type of objects defined in extension modules with `PyGetSetDef`, such as `FrameType.f_locals` or `array.array.typecode`. This type is used as descriptor for object attributes; it has the same purpose as the *property* type, but for classes defined in extension modules.

types.MemberDescriptorType

The type of objects defined in extension modules with `PyMemberDef`, such as `datetime.timedelta.days`. This type is used as descriptor for simple C data members which use standard conversion functions; it has the same purpose as the *property* type, but for classes defined in extension modules.

In addition, when a class is defined with a `__slots__` attribute, then for each slot, an instance of `MemberDescriptorType` will be added as an attribute on the class. This allows the slot to appear in the class's `__dict__`.

CPython 實作細節: In other implementations of Python, this type may be identical to `GetSetDescriptorType`.

class types.MappingProxyType(mapping)

Read-only proxy of a mapping. It provides a dynamic view on the mapping's entries, which means that when the mapping changes, the view reflects these changes.

在 3.3 版新加入。

在 3.9 版的變更: Updated to support the new union (`|`) operator from **PEP 584**, which simply delegates to the underlying mapping.

key in proxy

Return `True` if the underlying mapping has a key *key*, else `False`.

proxy[key]

Return the item of the underlying mapping with key *key*. Raises a *KeyError* if *key* is not in the underlying mapping.

iter(proxy)

Return an iterator over the keys of the underlying mapping. This is a shortcut for `iter(proxy.keys())`.

len(proxy)

Return the number of items in the underlying mapping.

copy()

Return a shallow copy of the underlying mapping.

get(key[, default])

Return the value for *key* if *key* is in the underlying mapping, else *default*. If *default* is not given, it defaults to `None`, so that this method never raises a *KeyError*.

items()

Return a new view of the underlying mapping's items (`(key, value)` pairs).

keys()

Return a new view of the underlying mapping's keys.

values()

Return a new view of the underlying mapping's values.

reversed(proxy)

Return a reverse iterator over the keys of the underlying mapping.

在 3.9 版新加入。

8.10.3 Additional Utility Classes and Functions

`class types.SimpleNamespace`

A simple *object* subclass that provides attribute access to its namespace, as well as a meaningful repr.

Unlike *object*, with `SimpleNamespace` you can add and remove attributes. If a `SimpleNamespace` object is initialized with keyword arguments, those are directly added to the underlying namespace.

The type is roughly equivalent to the following code:

```
class SimpleNamespace:
    def __init__(self, /, **kwargs):
        self.__dict__.update(kwargs)

    def __repr__(self):
        items = (f"{k}={v!r}" for k, v in self.__dict__.items())
        return "{}({})".format(type(self).__name__, ", ".join(items))

    def __eq__(self, other):
        if isinstance(self, SimpleNamespace) and isinstance(other, SimpleNamespace):
            return self.__dict__ == other.__dict__
        return NotImplemented
```

`SimpleNamespace` may be useful as a replacement for `class NS: pass`. However, for a structured record type use `namedtuple()` instead.

在 3.3 版新加入.

在 3.9 版的變更: Attribute order in the repr changed from alphabetical to insertion (like dict).

`types.DynamicClassAttribute (fget=None, fset=None, fdel=None, doc=None)`

Route attribute access on a class to `__getattr__`.

This is a descriptor, used to define attributes that act differently when accessed through an instance and through a class. Instance access remains normal, but access to an attribute through a class will be routed to the class's `__getattr__` method; this is done by raising `AttributeError`.

This allows one to have properties active on an instance, and have virtual attributes on the class with the same name (see `enum.Enum` for an example).

在 3.4 版新加入.

8.10.4 Coroutine Utility Functions

`types.coroutine (gen_func)`

This function transforms a *generator* function into a *coroutine function* which returns a generator-based coroutine. The generator-based coroutine is still a *generator iterator*, but is also considered to be a *coroutine* object and is *awaitable*. However, it may not necessarily implement the `__await__()` method.

If `gen_func` is a generator function, it will be modified in-place.

If `gen_func` is not a generator function, it will be wrapped. If it returns an instance of `collections.abc.Generator`, the instance will be wrapped in an *awaitable* proxy object. All other types of objects will be returned as is.

在 3.5 版新加入.

8.11 copy --- 淺層 (shallow) 和深層 (deep) 操作

原始碼: [Lib/copy.py](#)

Python 的賦值陳述式不建立物件，而是建立目標和物件的結 (binding) 關係。對於可變 (mutable) 或包含可變項目 (mutable item) 的集合，有時會需要一份副本來改變特定副本，而不必改變其他副本。本模組提供了通用的淺層和深層操作（如下所述）。

介面摘要：

`copy.copy(x)`

回傳 `x` 的淺層副本。

`copy.deepcopy(x[, memo])`

回傳 `x` 的深層副本。

exception `copy.Error`

引發針對特定模組的錯誤。

淺層與深層的區別僅與複合物件（即包含 `list` 或類型的實例等其他物件的物件）相關：

- 淺層建構一個新的複合物件，然後（在可能的範圍內）將原始物件中找到的物件的參照插入其中。
- 深層建構一個新的複合物件，然後遞迴地將在原始物件中找到的物件的副本插入其中。

深層操作通常存在兩個問題，而淺層操作不存在這些問題：

- 遞迴物件（直接或間接包含對自身參照的複合物件）可能會導致遞迴圈。
- 由於深層會複製所有內容，因此可能會有過多副本（例如應該在副本之間共享的資料）。

`deepcopy()` 函式用以下方式避免了這些問題：

- 保留在當前複製過程中已複製的物件的 `memo` 字典；以及
- 允許使用者定義的類覆寫 (override) 複製操作或複製的元件集合。

該模組不依賴模組、方法、堆棧追蹤 (stack trace)、堆棧框 (stack frame)、檔案、socket、視窗、陣列以及任何類型的型別。它透過不變更原始物件將其回傳來（淺層或深層地）”複製”函式和類；這與 `pickle` 模組處理這類問題的方式是相似的。

字典的淺層複製可以使用 `dict.copy()`，而 `list` 的淺層複製可以透過賦值整個 `list` 的切片 (slice) 完成，例如，`copied_list = original_list[:]`。

類可以使用與操作 `pickle` 相同的介面來控制複製操作，關於這些方法的描述資訊請參考 `pickle` 模組。實際上，`copy` 模組使用的正是從 `copyreg` 模組中複製的 `pickle` 函式。

想要一個類定義它自己的複製操作實作，可以透過定義特殊方法 `__copy__()` 和 `__deepcopy__()`。呼叫前者以實現淺層複製操作；不必傳入額外引數。呼叫後者以實現深層複製操作；它應傳入一個引數，即 `memo` 字典。如果 `__deepcopy__()` 實現需要建立一個元件的深層複製，它應當呼叫 `deepcopy()` 函式以該元件作第一個引數、以該 `memo` 字典作第二個引數。`memo` 字典應當被當作不透明物件 (opaque object) 來處理。

也參考：

`pickle` 模組

支援物件之狀態檢索 (state retrieval) 和恢復 (restoration) 相關特殊方法的討論。

8.12 pprint --- Data pretty printer

原始碼: [Lib/pprint.py](#)

The `pprint` module provides a capability to “pretty-print” arbitrary Python data structures in a form which can be used as input to the interpreter. If the formatted structures include objects which are not fundamental Python types, the representation may not be loadable. This may be the case if objects such as files, sockets or classes are included, as well as many other objects which are not representable as Python literals.

The formatted representation keeps objects on a single line if it can, and breaks them onto multiple lines if they don't fit within the allowed width. Construct `PrettyPrinter` objects explicitly if you need to adjust the width constraint.

Dictionaries are sorted by key before the display is computed.

在 3.9 版的變更: Added support for pretty-printing `types.SimpleNamespace`.

在 3.10 版的變更: Added support for pretty-printing `dataclasses.dataclass`.

8.12.1 Functions

`pprint.pp(object, *args, sort_dicts=False, **kwargs)`

Prints the formatted representation of `object` followed by a newline. If `sort_dicts` is false (the default), dictionaries will be displayed with their keys in insertion order, otherwise the dict keys will be sorted. `args` and `kwargs` will be passed to `pprint()` as formatting parameters.

```
>>> import pprint
>>> stuff = ['spam', 'eggs', 'lumberjack', 'knights', 'ni']
>>> stuff.insert(0, stuff)
>>> pprint.pp(stuff)
[<Recursion on list with id=...>,
 'spam',
 'eggs',
 'lumberjack',
 'knights',
 'ni']
```

在 3.8 版新加入.

`pprint.pprint(object, stream=None, indent=1, width=80, depth=None, *, compact=False, sort_dicts=True, underscore_numbers=False)`

Prints the formatted representation of `object` on `stream`, followed by a newline. If `stream` is None, `sys.stdout` is used. This may be used in the interactive interpreter instead of the `print()` function for inspecting values (you can even reassign `print = pprint.pprint` for use within a scope).

The configuration parameters `stream`, `indent`, `width`, `depth`, `compact`, `sort_dicts` and `underscore_numbers` are passed to the `PrettyPrinter` constructor and their meanings are as described in its documentation below.

Note that `sort_dicts` is True by default and you might want to use `pp()` instead where it is False by default.

`pprint.pformat(object, indent=1, width=80, depth=None, *, compact=False, sort_dicts=True, underscore_numbers=False)`

Return the formatted representation of `object` as a string. `indent`, `width`, `depth`, `compact`, `sort_dicts` and `underscore_numbers` are passed to the `PrettyPrinter` constructor as formatting parameters and their meanings are as described in its documentation below.

`pprint.isreadable(object)`

Determine if the formatted representation of `object` is “readable”, or can be used to reconstruct the value using `eval()`. This always returns False for recursive objects.

```
>>> pprint.isreadable(stuff)
False
```

`pprint.isrecursive(object)`

Determine if *object* requires a recursive representation.

`pprint.saferepr(object)`

Return a string representation of *object*, protected against recursive data structures. If the representation of *object* exposes a recursive entry, the recursive reference will be represented as `<Recursion on typename with id=number>`. The representation is not otherwise formatted.

```
>>> pprint.saferepr(stuff)
" [<Recursion on list with id=...>, 'spam', 'eggs', 'lumberjack', 'knights', 'ni
↪ ' ] "
```

8.12.2 PrettyPrinter 物件

This module defines one class:

```
class pprint.PrettyPrinter (indent=1, width=80, depth=None, stream=None, *, compact=False,
                             sort_dicts=True, underscore_numbers=False)
```

Construct a *PrettyPrinter* instance. This constructor understands several keyword parameters.

stream (default `sys.stdout`) is a *file-like object* to which the output will be written by calling its `write()` method. If both *stream* and `sys.stdout` are `None`, then `pprint()` silently returns.

Other values configure the manner in which nesting of complex data structures is displayed.

indent (default 1) specifies the amount of indentation added for each nesting level.

depth controls the number of nesting levels which may be printed; if the data structure being printed is too deep, the next contained level is replaced by `. . .`. By default, there is no constraint on the depth of the objects being formatted.

width (default 80) specifies the desired maximum number of characters per line in the output. If a structure cannot be formatted within the width constraint, a best effort will be made.

compact impacts the way that long sequences (lists, tuples, sets, etc) are formatted. If *compact* is false (the default) then each item of a sequence will be formatted on a separate line. If *compact* is true, as many items as will fit within the *width* will be formatted on each output line.

If *sort_dicts* is true (the default), dictionaries will be formatted with their keys sorted, otherwise they will display in insertion order.

If *underscore_numbers* is true, integers will be formatted with the `_` character for a thousands separator, otherwise underscores are not displayed (the default).

在 3.4 版的變更: 新增 *compact* 參數。

在 3.8 版的變更: 新增 *sort_dicts* 參數。

在 3.10 版的變更: 新增 *underscore_numbers* 參數。

在 3.11 版的變更: No longer attempts to write to `sys.stdout` if it is `None`.

```
>>> import pprint
>>> stuff = ['spam', 'eggs', 'lumberjack', 'knights', 'ni']
>>> stuff.insert(0, stuff[:])
>>> pp = pprint.PrettyPrinter(indent=4)
>>> pp.pprint(stuff)
[
    ['spam', 'eggs', 'lumberjack', 'knights', 'ni'],
    'spam',
    'eggs',
```

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```

    'lumberjack',
    'knights',
    'ni']
>>> pp = pprint.PrettyPrinter(width=41, compact=True)
>>> pp.pprint(stuff)
[['spam', 'eggs', 'lumberjack',
  'knights', 'ni'],
 'spam', 'eggs', 'lumberjack', 'knights',
 'ni']
>>> tup = ('spam', ('eggs', ('lumberjack', ('knights', ('ni', ('dead',
... ('parrot', ('fresh fruit',)))))))
>>> pp = pprint.PrettyPrinter(depth=6)
>>> pp.pprint(tup)
('spam', ('eggs', ('lumberjack', ('knights', ('ni', ('dead', (...)))))))

```

`PrettyPrinter` instances have the following methods:

`PrettyPrinter.pformat(object)`

Return the formatted representation of *object*. This takes into account the options passed to the `PrettyPrinter` constructor.

`PrettyPrinter.pprint(object)`

Print the formatted representation of *object* on the configured stream, followed by a newline.

The following methods provide the implementations for the corresponding functions of the same names. Using these methods on an instance is slightly more efficient since new `PrettyPrinter` objects don't need to be created.

`PrettyPrinter.isreadable(object)`

Determine if the formatted representation of the object is "readable," or can be used to reconstruct the value using `eval()`. Note that this returns `False` for recursive objects. If the `depth` parameter of the `PrettyPrinter` is set and the object is deeper than allowed, this returns `False`.

`PrettyPrinter.isrecursive(object)`

Determine if the object requires a recursive representation.

This method is provided as a hook to allow subclasses to modify the way objects are converted to strings. The default implementation uses the internals of the `saferepr()` implementation.

`PrettyPrinter.format(object, context, maxlevels, level)`

Returns three values: the formatted version of *object* as a string, a flag indicating whether the result is readable, and a flag indicating whether recursion was detected. The first argument is the object to be presented. The second is a dictionary which contains the `id()` of objects that are part of the current presentation context (direct and indirect containers for *object* that are affecting the presentation) as the keys; if an object needs to be presented which is already represented in *context*, the third return value should be `True`. Recursive calls to the `format()` method should add additional entries for containers to this dictionary. The third argument, *maxlevels*, gives the requested limit to recursion; this will be 0 if there is no requested limit. This argument should be passed unmodified to recursive calls. The fourth argument, *level*, gives the current level; recursive calls should be passed a value less than that of the current call.

8.12.3 范例

To demonstrate several uses of the `pp()` function and its parameters, let's fetch information about a project from PyPI:

```

>>> import json
>>> import pprint
>>> from urllib.request import urlopen
>>> with urlopen('https://pypi.org/pypi/sampleproject/json') as resp:
...     project_info = json.load(resp)['info']

```

In its basic form, `pp()` shows the whole object:

```
>>> pprint.pp(project_info)
{'author': 'The Python Packaging Authority',
 'author_email': 'pypa-dev@googlegroups.com',
 'bugtrack_url': None,
 'classifiers': ['Development Status :: 3 - Alpha',
                 'Intended Audience :: Developers',
                 'License :: OSI Approved :: MIT License',
                 'Programming Language :: Python :: 2',
                 'Programming Language :: Python :: 2.6',
                 'Programming Language :: Python :: 2.7',
                 'Programming Language :: Python :: 3',
                 'Programming Language :: Python :: 3.2',
                 'Programming Language :: Python :: 3.3',
                 'Programming Language :: Python :: 3.4',
                 'Topic :: Software Development :: Build Tools'],
 'description': 'A sample Python project\n'
               '=====\n'
               '\n'
               'This is the description file for the project.\n'
               '\n'
               'The file should use UTF-8 encoding and be written using '
               'ReStructured Text. It\n'
               'will be used to generate the project webpage on PyPI, and '
               'should be written for\n'
               'that purpose.\n'
               '\n'
               'Typical contents for this file would include an overview of '
               'the project, basic\n'
               'usage examples, etc. Generally, including the project '
               'changelog in here is not\n'
               'a good idea, although a simple "What\'s New" section for the '
               'most recent version\n'
               'may be appropriate.',
 'description_content_type': None,
 'docs_url': None,
 'download_url': 'UNKNOWN',
 'downloads': {'last_day': -1, 'last_month': -1, 'last_week': -1},
 'home_page': 'https://github.com/pypa/sampleproject',
 'keywords': 'sample setuptools development',
 'license': 'MIT',
 'maintainer': None,
 'maintainer_email': None,
 'name': 'sampleproject',
 'package_url': 'https://pypi.org/project/sampleproject/',
 'platform': 'UNKNOWN',
 'project_url': 'https://pypi.org/project/sampleproject/',
 'project_urls': {'Download': 'UNKNOWN',
                  'Homepage': 'https://github.com/pypa/sampleproject'},
 'release_url': 'https://pypi.org/project/sampleproject/1.2.0/',
 'requires_dist': None,
 'requires_python': None,
 'summary': 'A sample Python project',
 'version': '1.2.0'}
```

The result can be limited to a certain *depth* (ellipsis is used for deeper contents):

```
>>> pprint.pp(project_info, depth=1)
{'author': 'The Python Packaging Authority',
 'author_email': 'pypa-dev@googlegroups.com',
 'bugtrack_url': None,
 'classifiers': [...],
```

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```
'description': 'A sample Python project\n'
                '=====\n'
                '\n'
                'This is the description file for the project.\n'
                '\n'
                'The file should use UTF-8 encoding and be written using '
                'ReStructured Text. It\n'
                'will be used to generate the project webpage on PyPI, and '
                'should be written for\n'
                'that purpose.\n'
                '\n'
                'Typical contents for this file would include an overview of '
                'the project, basic\n'
                'usage examples, etc. Generally, including the project '
                'changelog in here is not\n'
                'a good idea, although a simple "What\'s New" section for the '
                'most recent version\n'
                'may be appropriate.',
'description_content_type': None,
'docs_url': None,
'download_url': 'UNKNOWN',
'downloads': {...},
'home_page': 'https://github.com/pypa/sampleproject',
'keywords': 'sample setuptools development',
'license': 'MIT',
'maintainer': None,
'maintainer_email': None,
'name': 'sampleproject',
'package_url': 'https://pypi.org/project/sampleproject/',
'platform': 'UNKNOWN',
'project_url': 'https://pypi.org/project/sampleproject/',
'project_urls': {...},
'release_url': 'https://pypi.org/project/sampleproject/1.2.0/',
'requires_dist': None,
'requires_python': None,
'summary': 'A sample Python project',
'version': '1.2.0'}
```

Additionally, maximum character *width* can be suggested. If a long object cannot be split, the specified width will be exceeded:

```
>>> pprint.pprint(project_info, depth=1, width=60)
{'author': 'The Python Packaging Authority',
 'author_email': 'pypa-dev@googlegroups.com',
 'bugtrack_url': None,
 'classifiers': [...],
 'description': 'A sample Python project\n'
               '=====\n'
               '\n'
               'This is the description file for the '
               'project.\n'
               '\n'
               'The file should use UTF-8 encoding and be '
               'written using ReStructured Text. It\n'
               'will be used to generate the project '
               'webpage on PyPI, and should be written '
               'for\n'
               'that purpose.\n'
               '\n'
               'Typical contents for this file would '
               'include an overview of the project, '}
```

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```

        'basic\n'
        'usage examples, etc. Generally, including '
        'the project changelog in here is not\n'
        'a good idea, although a simple "What\'s '
        'New" section for the most recent version\n'
        'may be appropriate.',
'description_content_type': None,
'docs_url': None,
'download_url': 'UNKNOWN',
'downloads': {...},
'home_page': 'https://github.com/pypa/sampleproject',
'keywords': 'sample setuptools development',
'license': 'MIT',
'maintainer': None,
'maintainer_email': None,
'name': 'sampleproject',
'package_url': 'https://pypi.org/project/sampleproject/',
'platform': 'UNKNOWN',
'project_url': 'https://pypi.org/project/sampleproject/',
'project_urls': {...},
'release_url': 'https://pypi.org/project/sampleproject/1.2.0/',
'requires_dist': None,
'requires_python': None,
'summary': 'A sample Python project',
'version': '1.2.0'}

```

8.13 reprlib --- Alternate repr() implementation

原始碼: [Lib/reprlib.py](#)

The `reprlib` module provides a means for producing object representations with limits on the size of the resulting strings. This is used in the Python debugger and may be useful in other contexts as well.

This module provides a class, an instance, and a function:

class `reprlib.Repr`

Class which provides formatting services useful in implementing functions similar to the built-in `repr()`; size limits for different object types are added to avoid the generation of representations which are excessively long.

`reprlib.aRepr`

This is an instance of `Repr` which is used to provide the `repr()` function described below. Changing the attributes of this object will affect the size limits used by `repr()` and the Python debugger.

`reprlib.repr(obj)`

This is the `repr()` method of `aRepr`. It returns a string similar to that returned by the built-in function of the same name, but with limits on most sizes.

In addition to size-limiting tools, the module also provides a decorator for detecting recursive calls to `__repr__()` and substituting a placeholder string instead.

@`reprlib.recursive_repr(fillvalue='...')`

Decorator for `__repr__()` methods to detect recursive calls within the same thread. If a recursive call is made, the `fillvalue` is returned, otherwise, the usual `__repr__()` call is made. For example:

```

>>> from reprlib import recursive_repr
>>> class MyList(list):
...     @recursive_repr()

```

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```

...     def __repr__(self):
...         return '<' + '|'.join(map(repr, self)) + '>'
...
>>> m = MyList('abc')
>>> m.append(m)
>>> m.append('x')
>>> print(m)
<'a'|'b'|'c'|...|'x'>

```

在 3.2 版新加入。

8.13.1 Repr 物件

Repr instances provide several attributes which can be used to provide size limits for the representations of different object types, and methods which format specific object types.

Repr.fillvalue

This string is displayed for recursive references. It defaults to ...

在 3.11 版新加入。

Repr.maxlevel

Depth limit on the creation of recursive representations. The default is 6.

Repr.maxdict

Repr.maxlist

Repr.maxtuple

Repr.maxset

Repr.maxfrozenset

Repr.maxdeque

Repr.maxarray

Limits on the number of entries represented for the named object type. The default is 4 for *maxdict*, 5 for *maxarray*, and 6 for the others.

Repr.maxlong

Maximum number of characters in the representation for an integer. Digits are dropped from the middle. The default is 40.

Repr.maxstring

Limit on the number of characters in the representation of the string. Note that the "normal" representation of the string is used as the character source: if escape sequences are needed in the representation, these may be mangled when the representation is shortened. The default is 30.

Repr.maxother

This limit is used to control the size of object types for which no specific formatting method is available on the *Repr* object. It is applied in a similar manner as *maxstring*. The default is 20.

Repr.repr(obj)

The equivalent to the built-in *repr()* that uses the formatting imposed by the instance.

Repr.repr1(obj, level)

Recursive implementation used by *repr()*. This uses the type of *obj* to determine which formatting method to call, passing it *obj* and *level*. The type-specific methods should call *repr1()* to perform recursive formatting, with *level - 1* for the value of *level* in the recursive call.

`Repr.repr_TYPE(obj, level)`

Formatting methods for specific types are implemented as methods with a name based on the type name. In the method name, **TYPE** is replaced by `'_'.join(type(obj).__name__.split())`. Dispatch to these methods is handled by `repr1()`. Type-specific methods which need to recursively format a value should call `self.repr1(subobj, level - 1)`.

8.13.2 Subclassing Repr Objects

The use of dynamic dispatching by `Repr.repr1()` allows subclasses of `Repr` to add support for additional built-in object types or to modify the handling of types already supported. This example shows how special support for file objects could be added:

```
import reprlib
import sys

class MyRepr(reprlib.Repr):

    def repr_TextIOWrapper(self, obj, level):
        if obj.name in {'<stdin>', '<stdout>', '<stderr>'}:
            return obj.name
        return repr(obj)

aRepr = MyRepr()
print(aRepr.repr(sys.stdin))           # prints '<stdin>'
```

```
<stdin>
```

8.14 enum --- Support for enumerations

在 3.4 版新加入.

原始碼: [Lib/enum.py](#)

Important

This page contains the API reference information. For tutorial information and discussion of more advanced topics, see

- Basic Tutorial
- Advanced Tutorial
- Enum Cookbook

An enumeration:

- is a set of symbolic names (members) bound to unique values
- can be iterated over to return its canonical (i.e. non-alias) members in definition order
- uses *call* syntax to return members by value
- uses *index* syntax to return members by name

Enumerations are created either by using `class` syntax, or by using function-call syntax:

```
>>> from enum import Enum

>>> # class syntax
>>> class Color(Enum):
...     RED = 1
...     GREEN = 2
...     BLUE = 3

>>> # functional syntax
>>> Color = Enum('Color', ['RED', 'GREEN', 'BLUE'])
```

Even though we can use `class` syntax to create Enums, Enums are not normal Python classes. See [How are Enums different?](#) for more details.

備 註: Nomenclature

- The class `Color` is an *enumeration* (or *enum*)
 - The attributes `Color.RED`, `Color.GREEN`, etc., are *enumeration members* (or *members*) and are functionally constants.
 - The enum members have *names* and *values* (the name of `Color.RED` is `RED`, the value of `Color.BLUE` is 3, etc.)
-

8.14.1 模 組 內 容

`EnumType`

The type for Enum and its subclasses.

`Enum`

Base class for creating enumerated constants.

`IntEnum`

Base class for creating enumerated constants that are also subclasses of `int`. (Notes)

`StrEnum`

Base class for creating enumerated constants that are also subclasses of `str`. (Notes)

`Flag`

Base class for creating enumerated constants that can be combined using the bitwise operations without losing their *Flag* membership.

`IntFlag`

Base class for creating enumerated constants that can be combined using the bitwise operators without losing their *IntFlag* membership. *IntFlag* members are also subclasses of `int`. (Notes)

`ReprEnum`

Used by *IntEnum*, *StrEnum*, and *IntFlag* to keep the `str()` of the mixed-in type.

`EnumCheck`

An enumeration with the values `CONTINUOUS`, `NAMED_FLAGS`, and `UNIQUE`, for use with `verify()` to ensure various constraints are met by a given enumeration.

`FlagBoundary`

An enumeration with the values `STRICT`, `CONFORM`, `EJECT`, and `KEEP` which allows for more fine-grained control over how invalid values are dealt with in an enumeration.

`auto`

Instances are replaced with an appropriate value for Enum members. `StrEnum` defaults to the lower-cased version of the member name, while other Enums default to 1 and increase from there.

`property()`

Allows `Enum` members to have attributes without conflicting with member names.

`unique()`

Enum class decorator that ensures only one name is bound to any one value.

`verify()`

Enum class decorator that checks user-selectable constraints on an enumeration.

`member()`

Make `obj` a member. Can be used as a decorator.

`nonmember()`

Do not make `obj` a member. Can be used as a decorator.

`global_enum()`

Modify the `str()` and `repr()` of an enum to show its members as belonging to the module instead of its class, and export the enum members to the global namespace.

`show_flag_values()`

Return a list of all power-of-two integers contained in a flag.

在 3.6 版新加入: `Flag`, `IntFlag`, `auto`

在 3.11 版新加入: `StrEnum`, `EnumCheck`, `ReprEnum`, `FlagBoundary`, `property`, `member`, `nonmember`, `global_enum`, `show_flag_values`

8.14.2 Data Types

class `enum.EnumType`

`EnumType` is the *metaclass* for *enum* enumerations. It is possible to subclass `EnumType` -- see Subclassing `EnumType` for details.

`EnumType` is responsible for setting the correct `__repr__()`, `__str__()`, `__format__()`, and `__reduce__()` methods on the final *enum*, as well as creating the enum members, properly handling duplicates, providing iteration over the enum class, etc.

__call__ (*cls*, *value*, *names=None*, *, *module=None*, *qualname=None*, *type=None*, *start=1*, *boundary=None*)

This method is called in two different ways:

- to look up an existing member:

cls

The enum class being called.

value

The value to lookup.

- to use the `cls` enum to create a new enum (only if the existing enum does not have any members):

cls

The enum class being called.

value

The name of the new Enum to create.

names

The names/values of the members for the new Enum.

模組

The name of the module the new Enum is created in.

qualname

The actual location in the module where this Enum can be found.

type

A mix-in type for the new Enum.

start

The first integer value for the Enum (used by *auto*).

boundary

How to handle out-of-range values from bit operations (*Flag* only).

__contains__(*cls, member*)

Returns True if member belongs to the *cls*:

```
>>> some_var = Color.RED
>>> some_var in Color
True
```

備F: In Python 3.12 it will be possible to check for member values and not just members; until then, a *TypeError* will be raised if a non-Enum-member is used in a containment check.

__dir__(*cls*)

Returns `['__class__', '__doc__', '__members__', '__module__']` and the names of the members in *cls*:

```
>>> dir(Color)
['BLUE', 'GREEN', 'RED', '__class__', '__contains__', '__doc__', '__
→getitem__', '__init_subclass__', '__iter__', '__len__', '__members__', '__
→module__', '__name__', '__qualname__']
```

__getattr__(*cls, name*)

Returns the Enum member in *cls* matching *name*, or raises an *AttributeError*:

```
>>> Color.GREEN
<Color.GREEN: 2>
```

__getitem__(*cls, name*)

Returns the Enum member in *cls* matching *name*, or raises a *KeyError*:

```
>>> Color['BLUE']
<Color.BLUE: 3>
```

__iter__(*cls*)

Returns each member in *cls* in definition order:

```
>>> list(Color)
[<Color.RED: 1>, <Color.GREEN: 2>, <Color.BLUE: 3>]
```

__len__ (*cls*)Returns the number of member in *cls*:

```
>>> len(Color)
3
```

__reversed__ (*cls*)Returns each member in *cls* in reverse definition order:

```
>>> list(reversed(Color))
[<Color.BLUE: 3>, <Color.GREEN: 2>, <Color.RED: 1>]
```

在 3.11 版新加入: Before 3.11 `enum` used `EnumMeta` type, which is kept as an alias.

class `enum.Enum`*Enum* is the base class for all *enum* enumerations.**name**

The name used to define the Enum member:

```
>>> Color.BLUE.name
'BLUE'
```

value

The value given to the Enum member:

```
>>> Color.RED.value
1
```

Value of the member, can be set in `__new__()`.

備 F: Enum member values

Member values can be anything: *int*, *str*, etc. If the exact value is unimportant you may use *auto* instances and an appropriate value will be chosen for you. See *auto* for the details.

While mutable/unhashable values, such as *dict*, *list* or a mutable *dataclass*, can be used, they will have a quadratic performance impact during creation relative to the total number of mutable/unhashable values in the enum.

__name__

Name of the member.

__value__Value of the member, can be set in `__new__()`.**__order__**

No longer used, kept for backward compatibility. (class attribute, removed during class creation).

__ignore__`__ignore__` is only used during creation and is removed from the enumeration once creation is complete.`__ignore__` is a list of names that will not become members, and whose names will also be removed from the completed enumeration. See *TimePeriod* for an example.**__dir__** (*self*)Returns `['__class__', '__doc__', '__module__', 'name', 'value']` and any public methods defined on *self.__class__*:

```

>>> from datetime import date
>>> class Weekday(Enum):
...     MONDAY = 1
...     TUESDAY = 2
...     WEDNESDAY = 3
...     THURSDAY = 4
...     FRIDAY = 5
...     SATURDAY = 6
...     SUNDAY = 7
...     @classmethod
...     def today(cls):
...         print('today is %s' % cls(date.today().isoweekday()).name)
>>> dir(Weekday.SATURDAY)
['__class__', '__doc__', '__eq__', '__hash__', '__module__', 'name', 'today',
↪ 'value']

```

`_generate_next_value_(name, start, count, last_values)`

name

The name of the member being defined (e.g. 'RED').

start

The start value for the Enum; the default is 1.

count

The number of members currently defined, not including this one.

last_values

A list of the previous values.

A *staticmethod* that is used to determine the next value returned by *auto*:

```

>>> from enum import auto
>>> class PowersOfThree(Enum):
...     @staticmethod
...     def _generate_next_value_(name, start, count, last_values):
...         return 3 ** (count + 1)
...     FIRST = auto()
...     SECOND = auto()
>>> PowersOfThree.SECOND.value
9

```

`__init_subclass__(cls, **kws)`

A *classmethod* that is used to further configure subsequent subclasses. By default, does nothing.

`_missing_(cls, value)`

A *classmethod* for looking up values not found in *cls*. By default it does nothing, but can be overridden to implement custom search behavior:

```

>>> from enum import StrEnum
>>> class Build(StrEnum):
...     DEBUG = auto()
...     OPTIMIZED = auto()
...     @classmethod
...     def _missing_(cls, value):
...         value = value.lower()
...         for member in cls:
...             if member.value == value:
...                 return member
...         return None
>>> Build.DEBUG.value
'debug'

```

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```
>>> Build('deBUG')
<Build.DEBUG: 'debug'>
```

__repr__(self)

Returns the string used for *repr()* calls. By default, returns the *Enum* name, member name, and value, but can be overridden:

```
>>> class OtherStyle(Enum):
...     ALTERNATE = auto()
...     OTHER = auto()
...     SOMETHING_ELSE = auto()
...     def __repr__(self):
...         cls_name = self.__class__.__name__
...         return f'{cls_name}.{self.name}'
>>> OtherStyle.ALTERNATE, str(OtherStyle.ALTERNATE), f'{OtherStyle.
↪ALTERNATE}'
(OtherStyle.ALTERNATE, 'OtherStyle.ALTERNATE', 'OtherStyle.ALTERNATE')
```

__str__(self)

Returns the string used for *str()* calls. By default, returns the *Enum* name and member name, but can be overridden:

```
>>> class OtherStyle(Enum):
...     ALTERNATE = auto()
...     OTHER = auto()
...     SOMETHING_ELSE = auto()
...     def __str__(self):
...         return f'{self.name}'
>>> OtherStyle.ALTERNATE, str(OtherStyle.ALTERNATE), f'{OtherStyle.
↪ALTERNATE}'
(<OtherStyle.ALTERNATE: 1>, 'ALTERNATE', 'ALTERNATE')
```

__format__(self)

Returns the string used for *format()* and *f-string* calls. By default, returns *__str__()* return value, but can be overridden:

```
>>> class OtherStyle(Enum):
...     ALTERNATE = auto()
...     OTHER = auto()
...     SOMETHING_ELSE = auto()
...     def __format__(self, spec):
...         return f'{self.name}'
>>> OtherStyle.ALTERNATE, str(OtherStyle.ALTERNATE), f'{OtherStyle.
↪ALTERNATE}'
(<OtherStyle.ALTERNATE: 1>, 'OtherStyle.ALTERNATE', 'ALTERNATE')
```

備 F: Using *auto* with *Enum* results in integers of increasing value, starting with 1.

class enum.IntEnum

IntEnum is the same as *Enum*, but its members are also integers and can be used anywhere that an integer can be used. If any integer operation is performed with an *IntEnum* member, the resulting value loses its enumeration status.

```
>>> from enum import IntEnum
>>> class Number(IntEnum):
...     ONE = 1
...     TWO = 2
```

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(繼續上一頁)

```

...     THREE = 3
...
>>> Number.THREE
<Number.THREE: 3>
>>> Number.ONE + Number.TWO
3
>>> Number.THREE + 5
8
>>> Number.THREE == 3
True

```

備 備: Using `auto` with `IntEnum` results in integers of increasing value, starting with 1.

在 3.11 版的變更: `__str__()` is now `int.__str__()` to better support the *replacement of existing constants* use-case. `__format__()` was already `int.__format__()` for that same reason.

`class enum.StrEnum`

StrEnum is the same as *Enum*, but its members are also strings and can be used in most of the same places that a string can be used. The result of any string operation performed on or with a *StrEnum* member is not part of the enumeration.

備 備: There are places in the stdlib that check for an exact `str` instead of a `str` subclass (i.e. `type(unknown) == str` instead of `isinstance(unknown, str)`), and in those locations you will need to use `str(StrEnum.member)`.

備 備: Using `auto` with `StrEnum` results in the lower-cased member name as the value.

備 備: `__str__()` is `str.__str__()` to better support the *replacement of existing constants* use-case. `__format__()` is likewise `str.__format__()` for that same reason.

在 3.11 版新加入.

`class enum.Flag`

Flag members support the bitwise operators `&` (AND), `|` (OR), `^` (XOR), and `~` (INVERT); the results of those operators are members of the enumeration.

`__contains__(self, value)`

Returns *True* if value is in self:

```

>>> from enum import Flag, auto
>>> class Color(Flag):
...     RED = auto()
...     GREEN = auto()
...     BLUE = auto()
>>> purple = Color.RED | Color.BLUE
>>> white = Color.RED | Color.GREEN | Color.BLUE
>>> Color.GREEN in purple
False
>>> Color.GREEN in white
True
>>> purple in white
True
>>> white in purple
False

```

__iter__(self):

Returns all contained non-alias members:

```
>>> list(Color.RED)
[<Color.RED: 1>]
>>> list(purple)
[<Color.RED: 1>, <Color.BLUE: 4>]
```

在 3.11 版新加入.

__len__(self):

Returns number of members in flag:

```
>>> len(Color.GREEN)
1
>>> len(white)
3
```

__bool__(self):Returns *True* if any members in flag, *False* otherwise:

```
>>> bool(Color.GREEN)
True
>>> bool(white)
True
>>> black = Color(0)
>>> bool(black)
False
```

__or__(self, other)

Returns current flag binary or'ed with other:

```
>>> Color.RED | Color.GREEN
<Color.RED|GREEN: 3>
```

__and__(self, other)

Returns current flag binary and'ed with other:

```
>>> purple & white
<Color.RED|BLUE: 5>
>>> purple & Color.GREEN
<Color: 0>
```

__xor__(self, other)

Returns current flag binary xor'ed with other:

```
>>> purple ^ white
<Color.GREEN: 2>
>>> purple ^ Color.GREEN
<Color.RED|GREEN|BLUE: 7>
```

__invert__(self):Returns all the flags in *type(self)* that are not in self:

```
>>> ~white
<Color: 0>
>>> ~purple
<Color.GREEN: 2>
>>> ~Color.RED
<Color.GREEN|BLUE: 6>
```

`__numeric_repr__()`

Function used to format any remaining unnamed numeric values. Default is the value's repr; common choices are `hex()` and `oct()`.

備註: Using `auto` with `Flag` results in integers that are powers of two, starting with 1.

在 3.11 版的變更: The `repr()` of zero-valued flags has changed. It is now::

```
>>> Color(0)
<Color: 0>
```

`class enum.IntFlag`

`IntFlag` is the same as `Flag`, but its members are also integers and can be used anywhere that an integer can be used.

```
>>> from enum import IntFlag, auto
>>> class Color(IntFlag):
...     RED = auto()
...     GREEN = auto()
...     BLUE = auto()
>>> Color.RED & 2
<Color: 0>
>>> Color.RED | 2
<Color.RED|GREEN: 3>
```

If any integer operation is performed with an `IntFlag` member, the result is not an `IntFlag`:

```
>>> Color.RED + 2
3
```

If a `Flag` operation is performed with an `IntFlag` member and:

- the result is a valid `IntFlag`: an `IntFlag` is returned
- the result is not a valid `IntFlag`: the result depends on the `FlagBoundary` setting

The `repr()` of unnamed zero-valued flags has changed. It is now:

```
>>> Color(0)
<Color: 0>
```

備註: Using `auto` with `IntFlag` results in integers that are powers of two, starting with 1.

在 3.11 版的變更: `__str__()` is now `int.__str__()` to better support the replacement of existing constants use-case. `__format__()` was already `int.__format__()` for that same reason.

Inversion of an `IntFlag` now returns a positive value that is the union of all flags not in the given flag, rather than a negative value. This matches the existing `Flag` behavior.

`class enum.ReprEnum`

`ReprEnum` uses the `repr()` of `Enum`, but the `str()` of the mixed-in data type:

- `int.__str__()` for `IntEnum` and `IntFlag`
- `str.__str__()` for `StrEnum`

Inherit from `ReprEnum` to keep the `str()` / `format()` of the mixed-in data type instead of using the `Enum`-default `str()`.

在 3.11 版新加入.

class `enum.EnumCheck`

EnumCheck contains the options used by the *verify()* decorator to ensure various constraints; failed constraints result in a *ValueError*.

UNIQUE

Ensure that each value has only one name:

```
>>> from enum import Enum, verify, UNIQUE
>>> @verify(UNIQUE)
... class Color(Enum):
...     RED = 1
...     GREEN = 2
...     BLUE = 3
...     CRIMSON = 1
Traceback (most recent call last):
...
ValueError: aliases found in <enum 'Color': CRIMSON -> RED
```

CONTINUOUS

Ensure that there are no missing values between the lowest-valued member and the highest-valued member:

```
>>> from enum import Enum, verify, CONTINUOUS
>>> @verify(CONTINUOUS)
... class Color(Enum):
...     RED = 1
...     GREEN = 2
...     BLUE = 5
Traceback (most recent call last):
...
ValueError: invalid enum 'Color': missing values 3, 4
```

NAMED_FLAGS

Ensure that any flag groups/masks contain only named flags -- useful when values are specified instead of being generated by *auto()*:

```
>>> from enum import Flag, verify, NAMED_FLAGS
>>> @verify(NAMED_FLAGS)
... class Color(Flag):
...     RED = 1
...     GREEN = 2
...     BLUE = 4
...     WHITE = 15
...     NEON = 31
Traceback (most recent call last):
...
ValueError: invalid Flag 'Color': aliases WHITE and NEON are missing_
↳ combined values of 0x18 [use enum.show_flag_values(value) for details]
```

備 F: CONTINUOUS and NAMED_FLAGS are designed to work with integer-valued members.

在 3.11 版新加入.

class `enum.FlagBoundary`

FlagBoundary controls how out-of-range values are handled in *Flag* and its subclasses.

STRICT

Out-of-range values cause a *ValueError* to be raised. This is the default for *Flag*:


```
>>> from enum import Flag, STRICT, auto
>>> class StrictFlag(Flag, boundary=STRICT):
...     RED = auto()
...     GREEN = auto()
...     BLUE = auto()
>>> StrictFlag(2**2 + 2**4)
Traceback (most recent call last):
...
ValueError: <flag 'StrictFlag'> invalid value 20
        given 0b0 10100
        allowed 0b0 00111
```

CONFORM

Out-of-range values have invalid values removed, leaving a valid *Flag* value:

```
>>> from enum import Flag, CONFORM, auto
>>> class ConformFlag(Flag, boundary=CONFORM):
...     RED = auto()
...     GREEN = auto()
...     BLUE = auto()
>>> ConformFlag(2**2 + 2**4)
<ConformFlag.BLUE: 4>
```

EJECT

Out-of-range values lose their *Flag* membership and revert to *int*.

```
>>> from enum import Flag, EJECT, auto
>>> class EjectFlag(Flag, boundary=EJECT):
...     RED = auto()
...     GREEN = auto()
...     BLUE = auto()
>>> EjectFlag(2**2 + 2**4)
20
```

KEEP

Out-of-range values are kept, and the *Flag* membership is kept. This is the default for *IntFlag*:

```
>>> from enum import Flag, KEEP, auto
>>> class KeepFlag(Flag, boundary=KEEP):
...     RED = auto()
...     GREEN = auto()
...     BLUE = auto()
>>> KeepFlag(2**2 + 2**4)
<KeepFlag.BLUE|16: 20>
```

在 3.11 版新加入.

Supported `__dunder__` names

`__members__` is a read-only ordered mapping of `member_name:member` items. It is only available on the class.

`__new__()`, if specified, must create and return the enum members; it is also a very good idea to set the member's `__value__` appropriately. Once all the members are created it is no longer used.

Supported `_sunder_` names

- `_name_` -- name of the member
- `_value_` -- value of the member; can be set in `__new__`
- `_missing_()` -- a lookup function used when a value is not found; may be overridden
- `_ignore_` -- a list of names, either as a *list* or a *str*, that will not be transformed into members, and will be removed from the final class
- `_order_` -- no longer used, kept for backward compatibility (class attribute, removed during class creation)
- `_generate_next_value_()` -- used to get an appropriate value for an enum member; may be overridden

備 F: For standard *Enum* classes the next value chosen is the last value seen incremented by one.

For *Flag* classes the next value chosen will be the next highest power-of-two, regardless of the last value seen.

在 3.6 版新加入: `_missing_`、`_order_`、`_generate_next_value_`

在 3.7 版新加入: `_ignore_`

8.14.3 Utilities and Decorators

`class enum.auto`

auto can be used in place of a value. If used, the *Enum* machinery will call an *Enum*'s `_generate_next_value_()` to get an appropriate value. For *Enum* and *IntEnum* that appropriate value will be the last value plus one; for *Flag* and *IntFlag* it will be the first power-of-two greater than the highest value; for *StrEnum* it will be the lower-cased version of the member's name. Care must be taken if mixing *auto()* with manually specified values.

auto instances are only resolved when at the top level of an assignment:

- `FIRST = auto()` will work (*auto()* is replaced with 1);
- `SECOND = auto(), -2` will work (*auto* is replaced with 2, so 2, -2 is used to create the *SECOND* enum member);
- `THREE = [auto(), -3]` will *not* work (`<auto instance>`, -3 is used to create the *THREE* enum member)

在 3.11.1 版的變更: In prior versions, `auto()` had to be the only thing on the assignment line to work properly.

`_generate_next_value_` can be overridden to customize the values used by *auto*.

備 F: in 3.13 the default `_generate_next_value_` will always return the highest member value incremented by 1, and will fail if any member is an incompatible type.

`@enum.property`

A decorator similar to the built-in *property*, but specifically for enumerations. It allows member attributes to have the same names as members themselves.

備 F: the *property* and the member must be defined in separate classes; for example, the *value* and *name* attributes are defined in the *Enum* class, and *Enum* subclasses can define members with the names *value* and *name*.

在 3.11 版新加入.

@enum.unique

A class decorator specifically for enumerations. It searches an enumeration's `__members__`, gathering any aliases it finds; if any are found `ValueError` is raised with the details:

```
>>> from enum import Enum, unique
>>> @unique
... class Mistake(Enum):
...     ONE = 1
...     TWO = 2
...     THREE = 3
...     FOUR = 3
...
Traceback (most recent call last):
...
ValueError: duplicate values found in <enum 'Mistake': FOUR -> THREE
```

@enum.verify

A class decorator specifically for enumerations. Members from `EnumCheck` are used to specify which constraints should be checked on the decorated enumeration.

在 3.11 版新加入.

@enum.member

A decorator for use in enums: its target will become a member.

在 3.11 版新加入.

@enum.nonmember

A decorator for use in enums: its target will not become a member.

在 3.11 版新加入.

@enum.global_enum

A decorator to change the `str()` and `repr()` of an enum to show its members as belonging to the module instead of its class. Should only be used when the enum members are exported to the module global namespace (see `re.RegexFlag` for an example).

在 3.11 版新加入.

enum.show_flag_values (value)

Return a list of all power-of-two integers contained in a flag *value*.

在 3.11 版新加入.

8.14.4 Notes

IntEnum, *StrEnum*, and *IntFlag*

These three enum types are designed to be drop-in replacements for existing integer- and string-based values; as such, they have extra limitations:

- `__str__` uses the value and not the name of the enum member
- `__format__`, because it uses `__str__`, will also use the value of the enum member instead of its name

If you do not need/want those limitations, you can either create your own base class by mixing in the `int` or `str` type yourself:

```
>>> from enum import Enum
>>> class MyIntEnum(int, Enum):
...     pass
```

or you can reassign the appropriate `str()`, etc., in your enum:

```
>>> from enum import Enum, IntEnum
>>> class MyIntEnum(IntEnum):
...     __str__ = Enum.__str__
```

8.15 graphlib — 使用類圖 (graph-like) 結構進行操作的功能

原始碼: [Lib/graphlib.py](#)

class `graphlib.TopologicalSorter` (`graph=None`)

提供對包含可雜 (*hashable*) 節點之圖 (`graph`) 進行拓撲排序 (topologically sort) 的功能。

拓撲排序是圖中頂點 (vertex) 的性排序，使得對於從頂點 `u` 到頂點 `v` 的每條有向邊 (directed edge) `u -> v`，頂點 `u` 在排序中會位於頂點 `v` 之前。例如，圖的頂點可能代表要執行的任務，而邊可能代表一個任務必須在另一個任務之前執行的限制；在此範例中，拓撲排序只是任務的一種有效序列。若且唯若 (if and only if) 圖有有向環 (directed cycle) 時，即如果它是個有向無環圖 (directed acyclic graph)，則完整的拓撲排序才是可行的。

如果提供了可選的 `graph` 引數，它必須是表示有向無環圖的字典，其中鍵是節點，值是圖中該節點的包含所有前驅節點 (predecessor) 之可代物件（這些前驅節點具有指向以鍵表示之節點的邊）。可以使用 `add()` 方法將其他節點新增到圖中。

在一般情況下，對給定的圖執行排序所需的步驟如下：

- 以選用的初始圖建立 `TopologicalSorter` 的實例。
- 在圖中新增其他節點。
- 呼叫圖的 `prepare()`。
- 當 `is_active()` 為 `True` 時，代 `get_ready()` 回傳的節點處理它們。在每個節點完成處理時呼叫 `done()`。

如果只需要立即對圖中的節點進行排序且不涉及平行性 (parallelism)，則可以直接使用便捷方法 `TopologicalSorter.static_order()`：

```
>>> graph = {"D": {"B", "C"}, "C": {"A"}, "B": {"A"}}
>>> ts = TopologicalSorter(graph)
>>> tuple(ts.static_order())
('A', 'C', 'B', 'D')
```

該類設計在節點準備就緒時，簡單支援節點的平行處理。例如：

```
topological_sorter = TopologicalSorter()

# Add nodes to 'topological_sorter'...

topological_sorter.prepare()
while topological_sorter.is_active():
    for node in topological_sorter.get_ready():
        # Worker threads or processes take nodes to work on off the
        # 'task_queue' queue.
        task_queue.put(node)

    # When the work for a node is done, workers put the node in
    # 'finalized_tasks_queue' so we can get more nodes to work on.
    # The definition of 'is_active()' guarantees that, at this point, at
    # least one node has been placed on 'task_queue' that hasn't yet
    # been passed to 'done()', so this blocking 'get()' must (eventually)
```

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```
# succeed. After calling 'done()', we loop back to call 'get_ready()'
# again, so put newly freed nodes on 'task_queue' as soon as
# logically possible.
node = finalized_tasks_queue.get()
topological_sorter.done(node)
```

add(node, *predecessors)

向圖中新增新節點及其前驅節點。node 和 predecessors 中的所有元素都必須是可雜的。

如果以相同節點引數多次呼叫，則依賴項的集合將會是傳入的所有依賴項的聯集。

可以新增一個有依賴關的節點 (predecessors 未提供) 或提供兩次依賴關。如果有之前未曾提供的節點被包含在 predecessors 中，它將自動新增到有前驅節點的圖中。

如果在 prepare() 之後呼叫，則引發 ValueError。

prepare()

將圖標記為已完成檢查圖中的循環。如果檢測到任何循環，將引發 CycleError，但 get_ready() 仍可用於盡可能獲得更多的節點，直到循環阻塞了進度。呼叫此函式後就無法修改圖，因此無法使用 add() 來新增更多節點。

is_active()

如果可以有更多進度則回傳 True，否則回傳 False。如果循環不阻塞解析 (resolution) 且仍有節點準備就緒但尚未由 TopologicalSorter.get_ready() 回傳或標記 TopologicalSorter.done() 的節點數量較 TopologicalSorter.get_ready() 所回傳的少，則可以繼續取得進度。

The __bool__() method of this class defers to this function, so instead of:

```
if ts.is_active():
    ...
```

可以簡單地用以下方式替：

```
if ts:
    ...
```

如果呼叫之前有先呼叫 prepare() 則引發 ValueError。

done(*nodes)

將 TopologicalSorter.get_ready() 回傳的一組節點標記為已處理，停止阻塞 nodes 中每個節點的任何後繼節點 (successor)，以便將來通過呼叫 TopologicalSorter.get_ready() 回傳。

若有和該呼叫一起呼叫 prepare() 或節點還未被 get_ready() 回傳，且如果 nodes 中有任何節點已被先前對此方法的呼叫標記為已處理、或者未使用 TopologicalSorter.add() 將節點新增到圖中，則引發 ValueError。

get_ready()

回傳一個包含所有準備就緒節點的 tuple。最初它回傳有前驅節點的所有節點，一旦通過呼叫 TopologicalSorter.done() 來將這些節點標記為已處理後，進一步的呼叫將回傳所有其全部前驅節點都已被處理的新節點。若無法取得更多進度，將回傳空 tuple。

如果呼叫之前有先呼叫 prepare() 則引發 ValueError。

static_order()

回傳一個可迭代物件，它將按拓撲排序迭代節點。使用此方法時，不應呼叫 prepare() 和 done()。此方法等效於：

```
def static_order(self):
    self.prepare()
    while self.is_active():
```

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```
node_group = self.get_ready()
yield from node_group
self.done(*node_group)
```

回傳的特定順序可能取於將項目插入圖中的特定順序。例如：

```
>>> ts = TopologicalSorter()
>>> ts.add(3, 2, 1)
>>> ts.add(1, 0)
>>> print(*ts.static_order())
[2, 0, 1, 3]

>>> ts2 = TopologicalSorter()
>>> ts2.add(1, 0)
>>> ts2.add(3, 2, 1)
>>> print(*ts2.static_order())
[0, 2, 1, 3]
```

這是因“0”和“2”在圖中處於同一級（它們將在對`get_ready()`的同一呼叫中回傳）且它們之間的順序取於插入順序。

如果檢測到任何循環，則引發`CycleError`。

在 3.9 版新加入。

8.15.1 例外

`graphlib` 模組定義了以下例外類：

exception `graphlib.CycleError`

`ValueError` 的子類，如果作用的圖中存在循環則由`TopologicalSorter.prepare()`引發。如果存在多個循環，則只會報告未定義的其中一個包含在例外中。

The detected cycle can be accessed via the second element in the `args` attribute of the exception instance and consists in a list of nodes, such that each node is, in the graph, an immediate predecessor of the next node in the list. In the reported list, the first and the last node will be the same, to make it clear that it is cyclic.

數值與數學模組

The modules described in this chapter provide numeric and math-related functions and data types. The `numbers` module defines an abstract hierarchy of numeric types. The `math` and `cmath` modules contain various mathematical functions for floating-point and complex numbers. The `decimal` module supports exact representations of decimal numbers, using arbitrary precision arithmetic.

The following modules are documented in this chapter:

9.1 numbers --- 數值的抽象基底類 \mathbb{F}

原始碼: [Lib/numbers.py](#)

The `numbers` module ([PEP 3141](#)) defines a hierarchy of numeric *abstract base classes* which progressively define more operations. None of the types defined in this module are intended to be instantiated.

class `numbers.Number`

數值階層結構的基礎。如果你只想確認引數 x 是不是數值、 \mathbb{F} 不關心其型 \mathbb{F} ，請使用 `isinstance(x, Number)`。

9.1.1 數值的階層

class `numbers.Complex`

這個型 \mathbb{F} 的子類 \mathbb{F} 描述了 \mathbb{F} 數 \mathbb{F} 包含適用於 \mathbb{F} 建 `complex` 型 \mathbb{F} 的操作。這些操作有: `complex` 和 `bool` 的轉 \mathbb{F} 、`real`、`imag`、`+`、`-`、`*`、`/`、`**`、`abs()`、`conjugate()`、`==` 以及 `!=`。除 `-` 和 `!=` 之外所有操作都是抽象的。

real

\mathbb{F} 抽象的。取得該數值的實數部分。

imag

\mathbb{F} 抽象的。取得該數值的 \mathbb{F} 數部分。

abstractmethod `conjugate()`

\mathbb{F} 抽象的。回傳共 \mathbb{F} \mathbb{F} 數，例如 `(1+3j).conjugate() == (1-3j)`。

class numbers.Real

To *Complex*, Real adds the operations that work on real numbers.

簡單的 \mathbb{R} ，有 *float* 的轉 \mathbb{R} 、*math.trunc()*、*round()*、*math.floor()*、*math.ceil()*、*divmod()*、*//*、*%*、*<*、*<=*、*>*、和 *>=*。

實數同樣提供 *complex()*、*real*、*imag* 和 *conjugate()* 的預設值。

class numbers.Rational

Real 的子型 \mathbb{R} ， \mathbb{R} 增加了 *numerator* 和 *denominator* 這兩種特性。它也會提供 *float()* 的預設值。

numerator 和 *denominator* 的值必須是 *Integral* 的實例且 *denominator* 要是正數。

numerator

\mathbb{R} 抽象的。

denominator

\mathbb{R} 抽象的。

class numbers.Integral

Rational 的子型 \mathbb{R} ， \mathbb{R} 增加了 *int* 的轉 \mathbb{R} 操作。 \mathbb{R} *float()*、*numerator* 和 *denominator* 提供了預設值。 \mathbb{R} *pow()* 方法增加了求余 (modulus) 和位元字串運算 (bit-string operations) 的抽象方法：*<<*、*>>*、*&*、*^*、*|*、*~*。

9.1.2 給型 \mathbb{R} 實作者的 \mathbb{R} 記

實作者需注意，相等的數值除了大小相等外，還必須擁有同樣的雜 \mathbb{R} 值。當使用兩個不同的實數擴充時，這可能是很微妙的。例如，*fractions.Fraction* 底下的 *hash()* 實作如下：

```
def __hash__(self):
    if self.denominator == 1:
        # Get integers right.
        return hash(self.numerator)
    # Expensive check, but definitely correct.
    if self == float(self):
        return hash(float(self))
    else:
        # Use tuple's hash to avoid a high collision rate on
        # simple fractions.
        return hash((self.numerator, self.denominator))
```

加入更多數值 ABC

當然，還有更多用於數值的 ABC，如果不加入它們就不會有健全的階層。你可以在 *Complex* 和 *Real* 中加入 *MyFoo*，像是：

```
class MyFoo(Complex): ...
MyFoo.register(Real)
```


實作算術操作

We want to implement the arithmetic operations so that mixed-mode operations either call an implementation whose author knew about the types of both arguments, or convert both to the nearest built in type and do the operation there. For subtypes of *Integral*, this means that `__add__()` and `__radd__()` should be defined as:

```
class MyIntegral(Integral):

    def __add__(self, other):
        if isinstance(other, MyIntegral):
            return do_my_adding_stuff(self, other)
        elif isinstance(other, OtherTypeIKnowAbout):
            return do_my_other_adding_stuff(self, other)
        else:
            return NotImplemented

    def __radd__(self, other):
        if isinstance(other, MyIntegral):
            return do_my_adding_stuff(other, self)
        elif isinstance(other, OtherTypeIKnowAbout):
            return do_my_other_adding_stuff(other, self)
        elif isinstance(other, Integral):
            return int(other) + int(self)
        elif isinstance(other, Real):
            return float(other) + float(self)
        elif isinstance(other, Complex):
            return complex(other) + complex(self)
        else:
            return NotImplemented
```

Complex 的子類有 5 種不同的混合型操作。我將上面提到所有不涉及 *MyIntegral* 和 *OtherTypeIKnowAbout* 的程式碼稱作「模板 (boilerplate)」。*a* 是 *Complex* 之子型 *A* 的實例 (*a* : *A* <: *Complex*)，同時 *b* : *B* <: *Complex*。我將要計算 *a* + *b*：

1. If *A* defines an `__add__()` which accepts *b*, all is well.
2. If *A* falls back to the boilerplate code, and it were to return a value from `__add__()`, we'd miss the possibility that *B* defines a more intelligent `__radd__()`, so the boilerplate should return *NotImplemented* from `__add__()`. (Or *A* may not implement `__add__()` at all.)
3. Then *B*'s `__radd__()` gets a chance. If it accepts *a*, all is well.
4. 如果 *A* 有成功回退到模板，就 *A* 有更多的方法可以去嘗試，因此這 *A* 將使用預設的實作。
5. 如果 *B* <: *A*，Python 會在 *A*.`__add__` 之前嘗試 *B*.`__radd__`。這是可行的，因為它是透過對 *A* 的理解而實作的，所以這可以在交給 *Complex* 之前處理好這些實例。

If *A* <: *Complex* and *B* <: *Real* without sharing any other knowledge, then the appropriate shared operation is the one involving the built in *complex*, and both `__radd__()` s land there, so *a*+*b* == *b*+*a*.

由於大部分對任意給定類型的操作都十分相似的，定義一個任意給定運算子生成向前 (forward) 與向後 (reverse) 實例的輔助函式可能會非常有用。例如，*fractions.Fraction* 使用了：

```
def _operator_fallbacks(monomorphic_operator, fallback_operator):
    def forward(a, b):
        if isinstance(b, (int, Fraction)):
            return monomorphic_operator(a, b)
        elif isinstance(b, float):
            return fallback_operator(float(a), b)
        elif isinstance(b, complex):
            return fallback_operator(complex(a), b)
        else:
            return NotImplemented
    forward.__name__ = '__' + fallback_operator.__name__ + '__'
```

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(繼續上一頁)

```

forward.__doc__ = monomorphic_operator.__doc__

def reverse(b, a):
    if isinstance(a, Rational):
        # Includes ints.
        return monomorphic_operator(a, b)
    elif isinstance(a, Real):
        return fallback_operator(float(a), float(b))
    elif isinstance(a, Complex):
        return fallback_operator(complex(a), complex(b))
    else:
        return NotImplemented
reverse.__name__ = '__r' + fallback_operator.__name__ + '__'
reverse.__doc__ = monomorphic_operator.__doc__

return forward, reverse

def _add(a, b):
    """a + b"""
    return Fraction(a.numerator * b.denominator +
                    b.numerator * a.denominator,
                    a.denominator * b.denominator)

__add__, __radd__ = _operator_fallbacks(_add, operator.add)

# ...

```

9.2 math --- 數學函式

This module provides access to the mathematical functions defined by the C standard.

These functions cannot be used with complex numbers; use the functions of the same name from the `cmath` module if you require support for complex numbers. The distinction between functions which support complex numbers and those which don't is made since most users do not want to learn quite as much mathematics as required to understand complex numbers. Receiving an exception instead of a complex result allows earlier detection of the unexpected complex number used as a parameter, so that the programmer can determine how and why it was generated in the first place.

The following functions are provided by this module. Except when explicitly noted otherwise, all return values are floats.

9.2.1 Number-theoretic and representation functions

`math.ceil(x)`

Return the ceiling of x , the smallest integer greater than or equal to x . If x is not a float, delegates to `x.__ceil__`, which should return an *Integral* value.

`math.comb(n, k)`

Return the number of ways to choose k items from n items without repetition and without order.

Evaluates to $n! / (k! * (n - k)!)$ when $k \leq n$ and evaluates to zero when $k > n$.

Also called the binomial coefficient because it is equivalent to the coefficient of k -th term in polynomial expansion of $(1 + x)^n$.

Raises `TypeError` if either of the arguments are not integers. Raises `ValueError` if either of the arguments are negative.

在 3.8 版新加入。

`math.copysign(x, y)`

Return a float with the magnitude (absolute value) of *x* but the sign of *y*. On platforms that support signed zeros, `copysign(1.0, -0.0)` returns `-1.0`.

`math.fabs(x)`

Return the absolute value of *x*.

`math.factorial(n)`

Return *n* factorial as an integer. Raises `ValueError` if *n* is not integral or is negative.

在 3.9 版之後被Ⓔ用: Accepting floats with integral values (like `5.0`) is deprecated.

`math.floor(x)`

Return the floor of *x*, the largest integer less than or equal to *x*. If *x* is not a float, delegates to `x.__floor__`, which should return an *Integral* value.

`math.fmod(x, y)`

Return `fmod(x, y)`, as defined by the platform C library. Note that the Python expression `x % y` may not return the same result. The intent of the C standard is that `fmod(x, y)` be exactly (mathematically; to infinite precision) equal to `x - n*y` for some integer *n* such that the result has the same sign as *x* and magnitude less than `abs(y)`. Python's `x % y` returns a result with the sign of *y* instead, and may not be exactly computable for float arguments. For example, `fmod(-1e-100, 1e100)` is `-1e-100`, but the result of Python's `-1e-100 % 1e100` is `1e100-1e-100`, which cannot be represented exactly as a float, and rounds to the surprising `1e100`. For this reason, function `fmod()` is generally preferred when working with floats, while Python's `x % y` is preferred when working with integers.

`math.frexp(x)`

Return the mantissa and exponent of *x* as the pair `(m, e)`. *m* is a float and *e* is an integer such that `x == m * 2**e` exactly. If *x* is zero, returns `(0.0, 0)`, otherwise `0.5 <= abs(m) < 1`. This is used to “pick apart” the internal representation of a float in a portable way.

`math.fsum(iterable)`

Return an accurate floating point sum of values in the iterable. Avoids loss of precision by tracking multiple intermediate partial sums:

```
>>> sum([.1, .1, .1, .1, .1, .1, .1, .1, .1, .1])
0.9999999999999999
>>> fsum([.1, .1, .1, .1, .1, .1, .1, .1, .1, .1])
1.0
```

The algorithm's accuracy depends on IEEE-754 arithmetic guarantees and the typical case where the rounding mode is half-even. On some non-Windows builds, the underlying C library uses extended precision addition and may occasionally double-round an intermediate sum causing it to be off in its least significant bit.

For further discussion and two alternative approaches, see the [ASPN cookbook recipes for accurate floating point summation](#).

`math.gcd(*integers)`

Return the greatest common divisor of the specified integer arguments. If any of the arguments is nonzero, then the returned value is the largest positive integer that is a divisor of all arguments. If all arguments are zero, then the returned value is 0. `gcd()` without arguments returns 0.

在 3.5 版新加入。

在 3.9 版的變更: Added support for an arbitrary number of arguments. Formerly, only two arguments were supported.

`math.isclose(a, b, *, rel_tol=1e-09, abs_tol=0.0)`

Return `True` if the values *a* and *b* are close to each other and `False` otherwise.

Whether or not two values are considered close is determined according to given absolute and relative tolerances.

rel_tol is the relative tolerance -- it is the maximum allowed difference between *a* and *b*, relative to the larger absolute value of *a* or *b*. For example, to set a tolerance of 5%, pass `rel_tol=0.05`. The default tolerance is `1e-09`, which assures that the two values are the same within about 9 decimal digits. *rel_tol* must be greater than zero.

abs_tol is the minimum absolute tolerance -- useful for comparisons near zero. *abs_tol* must be at least zero.

If no errors occur, the result will be: `abs(a-b) <= max(rel_tol * max(abs(a), abs(b)), abs_tol)`.

The IEEE 754 special values of NaN, `inf`, and `-inf` will be handled according to IEEE rules. Specifically, NaN is not considered close to any other value, including NaN. `inf` and `-inf` are only considered close to themselves.

在 3.5 版新加入。

也參考：

PEP 485 -- A function for testing approximate equality

`math.isfinite(x)`

Return True if *x* is neither an infinity nor a NaN, and False otherwise. (Note that `0.0` is considered finite.)

在 3.2 版新加入。

`math.isinf(x)`

Return True if *x* is a positive or negative infinity, and False otherwise.

`math.isnan(x)`

Return True if *x* is a NaN (not a number), and False otherwise.

`math.isqrt(n)`

Return the integer square root of the nonnegative integer *n*. This is the floor of the exact square root of *n*, or equivalently the greatest integer *a* such that $a^2 \leq n$.

For some applications, it may be more convenient to have the least integer *a* such that $n \leq a^2$, or in other words the ceiling of the exact square root of *n*. For positive *n*, this can be computed using `a = 1 + isqrt(n - 1)`.

在 3.8 版新加入。

`math.lcm(*integers)`

Return the least common multiple of the specified integer arguments. If all arguments are nonzero, then the returned value is the smallest positive integer that is a multiple of all arguments. If any of the arguments is zero, then the returned value is 0. `lcm()` without arguments returns 1.

在 3.9 版新加入。

`math.ldexp(x, i)`

Return `x * (2**i)`. This is essentially the inverse of function `frexp()`.

`math.modf(x)`

Return the fractional and integer parts of *x*. Both results carry the sign of *x* and are floats.

`math.nextafter(x, y)`

Return the next floating-point value after *x* towards *y*.

If *x* is equal to *y*, return *y*.

範例：

- `math.nextafter(x, math.inf)` goes up: towards positive infinity.
- `math.nextafter(x, -math.inf)` goes down: towards minus infinity.
- `math.nextafter(x, 0.0)` goes towards zero.
- `math.nextafter(x, math.copysign(math.inf, x))` goes away from zero.

另請參 `math.ulp()`。

在 3.9 版新加入。

`math.perm(n, k=None)`

Return the number of ways to choose k items from n items without repetition and with order.

Evaluates to $n! / (n - k)!$ when $k \leq n$ and evaluates to zero when $k > n$.

If k is not specified or is `None`, then k defaults to n and the function returns $n!$.

Raises `TypeError` if either of the arguments are not integers. Raises `ValueError` if either of the arguments are negative.

在 3.8 版新加入。

`math.prod(iterable, *, start=1)`

Calculate the product of all the elements in the input *iterable*. The default *start* value for the product is 1.

When the iterable is empty, return the start value. This function is intended specifically for use with numeric values and may reject non-numeric types.

在 3.8 版新加入。

`math.remainder(x, y)`

Return the IEEE 754-style remainder of x with respect to y . For finite x and finite nonzero y , this is the difference $x - n*y$, where n is the closest integer to the exact value of the quotient x / y . If x / y is exactly halfway between two consecutive integers, the nearest *even* integer is used for n . The remainder $r = \text{remainder}(x, y)$ thus always satisfies $\text{abs}(r) \leq 0.5 * \text{abs}(y)$.

Special cases follow IEEE 754: in particular, `remainder(x, math.inf)` is x for any finite x , and `remainder(x, 0)` and `remainder(math.inf, x)` raise `ValueError` for any non-NaN x . If the result of the remainder operation is zero, that zero will have the same sign as x .

On platforms using IEEE 754 binary floating-point, the result of this operation is always exactly representable: no rounding error is introduced.

在 3.7 版新加入。

`math.trunc(x)`

Return x with the fractional part removed, leaving the integer part. This rounds toward 0: `trunc()` is equivalent to `floor()` for positive x , and equivalent to `ceil()` for negative x . If x is not a float, delegates to `x.__trunc__`, which should return an *Integral* value.

`math.ulp(x)`

Return the value of the least significant bit of the float x :

- If x is a NaN (not a number), return x .
- If x is negative, return `ulp(-x)`.
- If x is a positive infinity, return x .
- If x is equal to zero, return the smallest positive *denormalized* representable float (smaller than the minimum positive *normalized* float, `sys.float_info.min`).
- If x is equal to the largest positive representable float, return the value of the least significant bit of x , such that the first float smaller than x is $x - \text{ulp}(x)$.
- Otherwise (x is a positive finite number), return the value of the least significant bit of x , such that the first float bigger than x is $x + \text{ulp}(x)$.

ULP stands for "Unit in the Last Place".

See also `math.nextafter()` and `sys.float_info.epsilon`.

在 3.9 版新加入。

Note that `frexp()` and `modf()` have a different call/return pattern than their C equivalents: they take a single argument and return a pair of values, rather than returning their second return value through an 'output parameter' (there is no such thing in Python).

For the `ceil()`, `floor()`, and `modf()` functions, note that *all* floating-point numbers of sufficiently large magnitude are exact integers. Python floats typically carry no more than 53 bits of precision (the same as the platform C double type), in which case any float x with `abs(x) >= 2**52` necessarily has no fractional bits.

9.2.2 Power and logarithmic functions

`math.cbrt(x)`

Return the cube root of x .

在 3.11 版新加入。

`math.exp(x)`

Return e raised to the power x , where $e = 2.718281\dots$ is the base of natural logarithms. This is usually more accurate than `math.e ** x` or `pow(math.e, x)`.

`math.exp2(x)`

Return 2 raised to the power x .

在 3.11 版新加入。

`math.expm1(x)`

Return e raised to the power x , minus 1. Here e is the base of natural logarithms. For small floats x , the subtraction in `exp(x) - 1` can result in a **significant loss of precision**; the `expm1()` function provides a way to compute this quantity to full precision:

```
>>> from math import exp, expm1
>>> exp(1e-5) - 1 # gives result accurate to 11 places
1.0000050000069649e-05
>>> expm1(1e-5) # result accurate to full precision
1.0000050000166668e-05
```

在 3.2 版新加入。

`math.log(x[, base])`

With one argument, return the natural logarithm of x (to base e).

With two arguments, return the logarithm of x to the given *base*, calculated as `log(x) / log(base)`.

`math.log1p(x)`

Return the natural logarithm of $1+x$ (base e). The result is calculated in a way which is accurate for x near zero.

`math.log2(x)`

Return the base-2 logarithm of x . This is usually more accurate than `log(x, 2)`.

在 3.3 版新加入。

也參考：

`int.bit_length()` returns the number of bits necessary to represent an integer in binary, excluding the sign and leading zeros.

`math.log10(x)`

Return the base-10 logarithm of x . This is usually more accurate than `log(x, 10)`.

`math.pow(x, y)`

Return x raised to the power y . Exceptional cases follow the IEEE 754 standard as far as possible. In particular, `pow(1.0, x)` and `pow(x, 0.0)` always return `1.0`, even when x is a zero or a NaN. If both x and y are finite, x is negative, and y is not an integer then `pow(x, y)` is undefined, and raises `ValueError`.

Unlike the built-in `**` operator, `math.pow()` converts both its arguments to type `float`. Use `**` or the built-in `pow()` function for computing exact integer powers.

在 3.11 版的變更: The special cases `pow(0.0, -inf)` and `pow(-0.0, -inf)` were changed to return `inf` instead of raising `ValueError`, for consistency with IEEE 754.

`math.sqrt(x)`

Return the square root of x .

9.2.3 Trigonometric functions

`math.acos(x)`

Return the arc cosine of x , in radians. The result is between 0 and π .

`math.asin(x)`

Return the arc sine of x , in radians. The result is between $-\pi/2$ and $\pi/2$.

`math.atan(x)`

Return the arc tangent of x , in radians. The result is between $-\pi/2$ and $\pi/2$.

`math.atan2(y, x)`

Return `atan(y / x)`, in radians. The result is between $-\pi$ and π . The vector in the plane from the origin to point (x, y) makes this angle with the positive X axis. The point of `atan2()` is that the signs of both inputs are known to it, so it can compute the correct quadrant for the angle. For example, `atan(1)` and `atan2(1, 1)` are both $\pi/4$, but `atan2(-1, -1)` is $-3\pi/4$.

`math.cos(x)`

Return the cosine of x radians.

`math.dist(p, q)`

Return the Euclidean distance between two points p and q , each given as a sequence (or iterable) of coordinates. The two points must have the same dimension.

Roughly equivalent to:

```
sqrt(sum((px - qx) ** 2.0 for px, qx in zip(p, q)))
```

在 3.8 版新加入.

`math.hypot(*coordinates)`

Return the Euclidean norm, `sqrt(sum(x**2 for x in coordinates))`. This is the length of the vector from the origin to the point given by the coordinates.

For a two dimensional point (x, y) , this is equivalent to computing the hypotenuse of a right triangle using the Pythagorean theorem, `sqrt(x*x + y*y)`.

在 3.8 版的變更: Added support for n-dimensional points. Formerly, only the two dimensional case was supported.

在 3.10 版的變更: Improved the algorithm's accuracy so that the maximum error is under 1 ulp (unit in the last place). More typically, the result is almost always correctly rounded to within 1/2 ulp.

`math.sin(x)`

Return the sine of x radians.

`math.tan(x)`

Return the tangent of x radians.

9.2.4 Angular conversion

`math.degrees(x)`

Convert angle x from radians to degrees.

`math.radians(x)`

Convert angle x from degrees to radians.

9.2.5 Hyperbolic functions

Hyperbolic functions are analogs of trigonometric functions that are based on hyperbolas instead of circles.

`math.acosh(x)`

Return the inverse hyperbolic cosine of x .

`math.asinh(x)`

Return the inverse hyperbolic sine of x .

`math.atanh(x)`

Return the inverse hyperbolic tangent of x .

`math.cosh(x)`

Return the hyperbolic cosine of x .

`math.sinh(x)`

Return the hyperbolic sine of x .

`math.tanh(x)`

Return the hyperbolic tangent of x .

9.2.6 Special functions

`math.erf(x)`

Return the error function at x .

The `erf()` function can be used to compute traditional statistical functions such as the cumulative standard normal distribution:

```
def phi(x):  
    'Cumulative distribution function for the standard normal distribution'  
    return (1.0 + erf(x / sqrt(2.0))) / 2.0
```

在 3.2 版新加入.

`math.erfc(x)`

Return the complementary error function at x . The complementary error function is defined as $1.0 - \text{erf}(x)$. It is used for large values of x where a subtraction from one would cause a loss of significance.

在 3.2 版新加入.

`math.gamma(x)`

Return the Gamma function at x .

在 3.2 版新加入.

`math.lgamma(x)`

Return the natural logarithm of the absolute value of the Gamma function at x .

在 3.2 版新加入.

9.2.7 常數

`math.pi`

The mathematical constant $\pi = 3.141592\dots$, to available precision.

`math.e`

The mathematical constant $e = 2.718281\dots$, to available precision.

`math.tau`

The mathematical constant $\tau = 6.283185\dots$, to available precision. Tau is a circle constant equal to 2π , the ratio of a circle's circumference to its radius. To learn more about Tau, check out Vi Hart's video [Pi is \(still\) Wrong](#), and start celebrating [Tau day](#) by eating twice as much pie!

在 3.6 版新加入。

`math.inf`

A floating-point positive infinity. (For negative infinity, use `-math.inf`.) Equivalent to the output of `float('inf')`.

在 3.5 版新加入。

`math.nan`

A floating-point "not a number" (NaN) value. Equivalent to the output of `float('nan')`. Due to the requirements of the [IEEE-754 standard](#), `math.nan` and `float('nan')` are not considered to equal to any other numeric value, including themselves. To check whether a number is a NaN, use the `isnan()` function to test for NaNs instead of `is` or `==`. Example:

```
>>> import math
>>> math.nan == math.nan
False
>>> float('nan') == float('nan')
False
>>> math.isnan(math.nan)
True
>>> math.isnan(float('nan'))
True
```

在 3.5 版新加入。

在 3.11 版的變更: It is now always available.

CPython 實作細節: The `math` module consists mostly of thin wrappers around the platform C math library functions. Behavior in exceptional cases follows Annex F of the C99 standard where appropriate. The current implementation will raise `ValueError` for invalid operations like `sqrt(-1.0)` or `log(0.0)` (where C99 Annex F recommends signaling invalid operation or divide-by-zero), and `OverflowError` for results that overflow (for example, `exp(1000.0)`). A NaN will not be returned from any of the functions above unless one or more of the input arguments was a NaN; in that case, most functions will return a NaN, but (again following C99 Annex F) there are some exceptions to this rule, for example `pow(float('nan'), 0.0)` or `hypot(float('nan'), float('inf'))`.

Note that Python makes no effort to distinguish signaling NaNs from quiet NaNs, and behavior for signaling NaNs remains unspecified. Typical behavior is to treat all NaNs as though they were quiet.

也參考:

`cmath` 模組

Complex number versions of many of these functions.

9.3 cmath --- Mathematical functions for complex numbers

This module provides access to mathematical functions for complex numbers. The functions in this module accept integers, floating-point numbers or complex numbers as arguments. They will also accept any Python object that has either a `__complex__()` or a `__float__()` method: these methods are used to convert the object to a complex or floating-point number, respectively, and the function is then applied to the result of the conversion.

備F: For functions involving branch cuts, we have the problem of deciding how to define those functions on the cut itself. Following Kahan’s “Branch cuts for complex elementary functions” paper, as well as Annex G of C99 and later C standards, we use the sign of zero to distinguish one side of the branch cut from the other: for a branch cut along (a portion of) the real axis we look at the sign of the imaginary part, while for a branch cut along the imaginary axis we look at the sign of the real part.

For example, the `cmath.sqrt()` function has a branch cut along the negative real axis. An argument of `complex(-2.0, -0.0)` is treated as though it lies *below* the branch cut, and so gives a result on the negative imaginary axis:

```
>>> cmath.sqrt(complex(-2.0, -0.0))
-1.4142135623730951j
```

But an argument of `complex(-2.0, 0.0)` is treated as though it lies above the branch cut:

```
>>> cmath.sqrt(complex(-2.0, 0.0))
1.4142135623730951j
```

9.3.1 Conversions to and from polar coordinates

A Python complex number `z` is stored internally using *rectangular* or *Cartesian* coordinates. It is completely determined by its *real part* `z.real` and its *imaginary part* `z.imag`. In other words:

```
z == z.real + z.imag*1j
```

Polar coordinates give an alternative way to represent a complex number. In polar coordinates, a complex number `z` is defined by the modulus *r* and the phase angle *phi*. The modulus *r* is the distance from `z` to the origin, while the phase *phi* is the counterclockwise angle, measured in radians, from the positive x-axis to the line segment that joins the origin to `z`.

The following functions can be used to convert from the native rectangular coordinates to polar coordinates and back.

`cmath.phase(x)`

Return the phase of `x` (also known as the *argument* of `x`), as a float. `phase(x)` is equivalent to `math.atan2(x.imag, x.real)`. The result lies in the range $[-\pi, \pi]$, and the branch cut for this operation lies along the negative real axis. The sign of the result is the same as the sign of `x.imag`, even when `x.imag` is zero:

```
>>> phase(complex(-1.0, 0.0))
3.141592653589793
>>> phase(complex(-1.0, -0.0))
-3.141592653589793
```

備F: The modulus (absolute value) of a complex number `x` can be computed using the built-in `abs()` function. There is no separate `cmath` module function for this operation.

`cmath.polar(x)`

Return the representation of x in polar coordinates. Returns a pair (r, phi) where r is the modulus of x and phi is the phase of x . `polar(x)` is equivalent to `(abs(x), phase(x))`.

`cmath.rect(r, phi)`

Return the complex number x with polar coordinates r and phi . Equivalent to $r * (\text{math.cos(phi)} + \text{math.sin(phi)} * 1j)$.

9.3.2 Power and logarithmic functions

`cmath.exp(x)`

Return e raised to the power x , where e is the base of natural logarithms.

`cmath.log(x[, base])`

Returns the logarithm of x to the given *base*. If the *base* is not specified, returns the natural logarithm of x . There is one branch cut, from 0 along the negative real axis to $-\infty$.

`cmath.log10(x)`

Return the base-10 logarithm of x . This has the same branch cut as `log()`.

`cmath.sqrt(x)`

Return the square root of x . This has the same branch cut as `log()`.

9.3.3 Trigonometric functions

`cmath.acos(x)`

Return the arc cosine of x . There are two branch cuts: One extends right from 1 along the real axis to ∞ . The other extends left from -1 along the real axis to $-\infty$.

`cmath.asin(x)`

Return the arc sine of x . This has the same branch cuts as `acos()`.

`cmath.atan(x)`

Return the arc tangent of x . There are two branch cuts: One extends from $1j$ along the imaginary axis to ∞j . The other extends from $-1j$ along the imaginary axis to $-\infty j$.

`cmath.cos(x)`

Return the cosine of x .

`cmath.sin(x)`

Return the sine of x .

`cmath.tan(x)`

Return the tangent of x .

9.3.4 Hyperbolic functions

`cmath.acosh(x)`

Return the inverse hyperbolic cosine of x . There is one branch cut, extending left from 1 along the real axis to $-\infty$.

`cmath.asinh(x)`

Return the inverse hyperbolic sine of x . There are two branch cuts: One extends from $1j$ along the imaginary axis to ∞j . The other extends from $-1j$ along the imaginary axis to $-\infty j$.

`cmath.atanh(x)`

Return the inverse hyperbolic tangent of x . There are two branch cuts: One extends from 1 along the real axis to ∞ . The other extends from -1 along the real axis to $-\infty$.

`cmath.cosh(x)`

Return the hyperbolic cosine of x .

`cmath.sinh(x)`

Return the hyperbolic sine of x .

`cmath.tanh(x)`

Return the hyperbolic tangent of x .

9.3.5 Classification functions

`cmath.isfinite(x)`

Return `True` if both the real and imaginary parts of x are finite, and `False` otherwise.

在 3.2 版新加入.

`cmath.isinf(x)`

Return `True` if either the real or the imaginary part of x is an infinity, and `False` otherwise.

`cmath.isnan(x)`

Return `True` if either the real or the imaginary part of x is a NaN, and `False` otherwise.

`cmath.isclose(a, b, *, rel_tol=1e-09, abs_tol=0.0)`

Return `True` if the values a and b are close to each other and `False` otherwise.

Whether or not two values are considered close is determined according to given absolute and relative tolerances.

rel_tol is the relative tolerance -- it is the maximum allowed difference between a and b , relative to the larger absolute value of a or b . For example, to set a tolerance of 5%, pass *rel_tol*=0.05. The default tolerance is $1e-09$, which assures that the two values are the same within about 9 decimal digits. *rel_tol* must be greater than zero.

abs_tol is the minimum absolute tolerance -- useful for comparisons near zero. *abs_tol* must be at least zero.

If no errors occur, the result will be: `abs(a-b) <= max(rel_tol * max(abs(a), abs(b)), abs_tol)`.

The IEEE 754 special values of NaN, `inf`, and `-inf` will be handled according to IEEE rules. Specifically, NaN is not considered close to any other value, including NaN. `inf` and `-inf` are only considered close to themselves.

在 3.5 版新加入.

也參考:

PEP 485 -- A function for testing approximate equality

9.3.6 常數

`cmath.pi`

The mathematical constant π , as a float.

`cmath.e`

The mathematical constant e , as a float.

`cmath.tau`

The mathematical constant τ , as a float.

在 3.6 版新加入.

`cmath.inf`

Floating-point positive infinity. Equivalent to `float('inf')`.

在 3.6 版新加入.

`cmath.infj`

Complex number with zero real part and positive infinity imaginary part. Equivalent to `complex(0.0, float('inf'))`.

在 3.6 版新加入.

`cmath.nan`

A floating-point "not a number" (NaN) value. Equivalent to `float('nan')`.

在 3.6 版新加入.

`cmath.nanj`

Complex number with zero real part and NaN imaginary part. Equivalent to `complex(0.0, float('nan'))`.

在 3.6 版新加入.

Note that the selection of functions is similar, but not identical, to that in module `math`. The reason for having two modules is that some users aren't interested in complex numbers, and perhaps don't even know what they are. They would rather have `math.sqrt(-1)` raise an exception than return a complex number. Also note that the functions defined in `cmath` always return a complex number, even if the answer can be expressed as a real number (in which case the complex number has an imaginary part of zero).

A note on branch cuts: They are curves along which the given function fails to be continuous. They are a necessary feature of many complex functions. It is assumed that if you need to compute with complex functions, you will understand about branch cuts. Consult almost any (not too elementary) book on complex variables for enlightenment. For information of the proper choice of branch cuts for numerical purposes, a good reference should be the following:

也參考:

Kahan, W: Branch cuts for complex elementary functions; or, Much ado about nothing's sign bit. In Iserles, A., and Powell, M. (eds.), The state of the art in numerical analysis. Clarendon Press (1987) pp165--211.

9.4 decimal --- Decimal fixed point and floating point arithmetic

原始碼: [Lib/decimal.py](#)

The `decimal` module provides support for fast correctly rounded decimal floating point arithmetic. It offers several advantages over the `float` datatype:

- Decimal "is based on a floating-point model which was designed with people in mind, and necessarily has a paramount guiding principle -- computers must provide an arithmetic that works in the same way as the arithmetic that people learn at school." -- excerpt from the decimal arithmetic specification.

- Decimal numbers can be represented exactly. In contrast, numbers like 1.1 and 2.2 do not have exact representations in binary floating point. End users typically would not expect $1.1 + 2.2$ to display as 3.3000000000000003 as it does with binary floating point.
- The exactness carries over into arithmetic. In decimal floating point, $0.1 + 0.1 + 0.1 - 0.3$ is exactly equal to zero. In binary floating point, the result is $5.5511151231257827e-017$. While near to zero, the differences prevent reliable equality testing and differences can accumulate. For this reason, decimal is preferred in accounting applications which have strict equality invariants.
- The decimal module incorporates a notion of significant places so that $1.30 + 1.20$ is 2.50. The trailing zero is kept to indicate significance. This is the customary presentation for monetary applications. For multiplication, the “schoolbook” approach uses all the figures in the multiplicands. For instance, $1.3 * 1.2$ gives 1.56 while $1.30 * 1.20$ gives 1.5600.
- Unlike hardware based binary floating point, the decimal module has a user alterable precision (defaulting to 28 places) which can be as large as needed for a given problem:

```
>>> from decimal import *
>>> getcontext().prec = 6
>>> Decimal(1) / Decimal(7)
Decimal('0.142857')
>>> getcontext().prec = 28
>>> Decimal(1) / Decimal(7)
Decimal('0.1428571428571428571428571429')
```

- Both binary and decimal floating point are implemented in terms of published standards. While the built-in float type exposes only a modest portion of its capabilities, the decimal module exposes all required parts of the standard. When needed, the programmer has full control over rounding and signal handling. This includes an option to enforce exact arithmetic by using exceptions to block any inexact operations.
- The decimal module was designed to support “without prejudice, both exact unrounded decimal arithmetic (sometimes called fixed-point arithmetic) and rounded floating-point arithmetic.” -- excerpt from the decimal arithmetic specification.

The module design is centered around three concepts: the decimal number, the context for arithmetic, and signals.

A decimal number is immutable. It has a sign, coefficient digits, and an exponent. To preserve significance, the coefficient digits do not truncate trailing zeros. Decimals also include special values such as *Infinity*, *-Infinity*, and *NaN*. The standard also differentiates *-0* from *+0*.

The context for arithmetic is an environment specifying precision, rounding rules, limits on exponents, flags indicating the results of operations, and trap enablers which determine whether signals are treated as exceptions. Rounding options include *ROUND_CEILING*, *ROUND_DOWN*, *ROUND_FLOOR*, *ROUND_HALF_DOWN*, *ROUND_HALF_EVEN*, *ROUND_HALF_UP*, *ROUND_UP*, and *ROUND_05UP*.

Signals are groups of exceptional conditions arising during the course of computation. Depending on the needs of the application, signals may be ignored, considered as informational, or treated as exceptions. The signals in the decimal module are: *Clamped*, *InvalidOperation*, *DivisionByZero*, *Inexact*, *Rounded*, *Subnormal*, *Overflow*, *Underflow* and *FloatOperation*.

For each signal there is a flag and a trap enabler. When a signal is encountered, its flag is set to one, then, if the trap enabler is set to one, an exception is raised. Flags are sticky, so the user needs to reset them before monitoring a calculation.

也參考:

- IBM’s General Decimal Arithmetic Specification, [The General Decimal Arithmetic Specification](#).

9.4.1 Quick-start Tutorial

The usual start to using decimals is importing the module, viewing the current context with `getcontext()` and, if necessary, setting new values for precision, rounding, or enabled traps:

```
>>> from decimal import *
>>> getcontext()
Context(prec=28, rounding=ROUND_HALF_EVEN, Emin=-999999, Emax=999999,
        capitals=1, clamp=0, flags=[], traps=[Overflow, DivisionByZero,
        InvalidOperation])
>>> getcontext().prec = 7           # Set a new precision
```

Decimal instances can be constructed from integers, strings, floats, or tuples. Construction from an integer or a float performs an exact conversion of the value of that integer or float. Decimal numbers include special values such as NaN which stands for "Not a number", positive and negative Infinity, and -0:

```
>>> getcontext().prec = 28
>>> Decimal(10)
Decimal('10')
>>> Decimal('3.14')
Decimal('3.14')
>>> Decimal(3.14)
Decimal('3.140000000000000124344978758017532527446746826171875')
>>> Decimal((0, (3, 1, 4), -2))
Decimal('3.14')
>>> Decimal(str(2.0 ** 0.5))
Decimal('1.4142135623730951')
>>> Decimal(2) ** Decimal('0.5')
Decimal('1.414213562373095048801688724')
>>> Decimal('NaN')
Decimal('NaN')
>>> Decimal('-Infinity')
Decimal('-Infinity')
```

If the `FloatOperation` signal is trapped, accidental mixing of decimals and floats in constructors or ordering comparisons raises an exception:

```
>>> c = getcontext()
>>> c.traps[FloatOperation] = True
>>> Decimal(3.14)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
decimal.FloatOperation: [<class 'decimal.FloatOperation'>]
>>> Decimal('3.5') < 3.7
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
decimal.FloatOperation: [<class 'decimal.FloatOperation'>]
>>> Decimal('3.5') == 3.5
True
```

在 3.3 版新加入。

The significance of a new Decimal is determined solely by the number of digits input. Context precision and rounding only come into play during arithmetic operations.

```
>>> getcontext().prec = 6
>>> Decimal('3.0')
Decimal('3.0')
>>> Decimal('3.1415926535')
Decimal('3.1415926535')
>>> Decimal('3.1415926535') + Decimal('2.7182818285')
```

(繼續下一頁)

As shown above, the `getcontext()` function accesses the current context and allows the settings to be changed. This approach meets the needs of most applications.

For more advanced work, it may be useful to create alternate contexts using the `Context()` constructor. To make an alternate active, use the `setcontext()` function.

In accordance with the standard, the `decimal` module provides two ready to use standard contexts, `BasicContext` and `ExtendedContext`. The former is especially useful for debugging because many of the traps are enabled:

```
>>> myothercontext = Context(prec=60, rounding=ROUND_HALF_DOWN)
>>> setcontext(myothercontext)
>>> Decimal(1) / Decimal(7)
Decimal('0.142857142857142857142857142857142857142857142857142857')

>>> ExtendedContext
Context(prec=9, rounding=ROUND_HALF_EVEN, Emin=-999999, Emax=999999,
        capitals=1, clamp=0, flags=[], traps=[])
>>> setcontext(ExtendedContext)
>>> Decimal(1) / Decimal(7)
Decimal('0.142857143')
>>> Decimal(42) / Decimal(0)
Decimal('Infinity')

>>> setcontext(BasicContext)
>>> Decimal(42) / Decimal(0)
Traceback (most recent call last):
  File "<pyshell#143>", line 1, in -toplevel-
    Decimal(42) / Decimal(0)
DivisionByZero: x / 0
```

Contexts also have signal flags for monitoring exceptional conditions encountered during computations. The flags remain set until explicitly cleared, so it is best to clear the flags before each set of monitored computations by using the `clear_flags()` method.

```
>>> setcontext(ExtendedContext)
>>> getcontext().clear_flags()
>>> Decimal(355) / Decimal(113)
Decimal('3.14159292')
>>> getcontext()
Context(prec=9, rounding=ROUND_HALF_EVEN, Emin=-999999, Emax=999999,
        capitals=1, clamp=0, flags=[Inexact, Rounded], traps=[])
```

The `flags` entry shows that the rational approximation to pi was rounded (digits beyond the context precision were thrown away) and that the result is inexact (some of the discarded digits were non-zero).

Individual traps are set using the dictionary in the `traps` attribute of a context:

```
>>> setcontext(ExtendedContext)
>>> Decimal(1) / Decimal(0)
Decimal('Infinity')
>>> getcontext().traps[DivisionByZero] = 1
>>> Decimal(1) / Decimal(0)
Traceback (most recent call last):
  File "<pyshell#112>", line 1, in -toplevel-
    Decimal(1) / Decimal(0)
DivisionByZero: x / 0
```

Most programs adjust the current context only once, at the beginning of the program. And, in many applications, data is converted to `Decimal` with a single cast inside a loop. With context set and decimals created, the bulk of the program manipulates the data no differently than with other Python numeric types.

9.4.2 Decimal objects

class `decimal.Decimal` (*value*='0', *context*=None)

Construct a new *Decimal* object based from *value*.

value can be an integer, string, tuple, *float*, or another *Decimal* object. If no *value* is given, returns `Decimal('0')`. If *value* is a string, it should conform to the decimal numeric string syntax after leading and trailing whitespace characters, as well as underscores throughout, are removed:

```
sign          ::= '+' | '-'
digit         ::= '0' | '1' | '2' | '3' | '4' | '5' | '6' | '7' | '8' | '9'
indicator     ::= 'e' | 'E'
digits        ::= digit [digit]...
decimal-part  ::= digits '.' [digits] | ['.'] digits
exponent-part ::= indicator [sign] digits
infinity      ::= 'Infinity' | 'Inf'
nan           ::= 'NaN' [digits] | 'sNaN' [digits]
numeric-value ::= decimal-part [exponent-part] | infinity
numeric-string ::= [sign] numeric-value | [sign] nan
```

Other Unicode decimal digits are also permitted where *digit* appears above. These include decimal digits from various other alphabets (for example, Arabic-Indic and Devanāgarī digits) along with the fullwidth digits '\uff10' through '\uff19'.

If *value* is a *tuple*, it should have three components, a sign (0 for positive or 1 for negative), a *tuple* of digits, and an integer exponent. For example, `Decimal((0, (1, 4, 1, 4), -3))` returns `Decimal('1.414')`.

If *value* is a *float*, the binary floating point value is losslessly converted to its exact decimal equivalent. This conversion can often require 53 or more digits of precision. For example, `Decimal(float('1.1'))` converts to `Decimal('1.100000000000000088817841970012523233890533447265625')`.

The *context* precision does not affect how many digits are stored. That is determined exclusively by the number of digits in *value*. For example, `Decimal('3.00000')` records all five zeros even if the context precision is only three.

The purpose of the *context* argument is determining what to do if *value* is a malformed string. If the context traps *InvalidOperation*, an exception is raised; otherwise, the constructor returns a new *Decimal* with the value of NaN.

Once constructed, *Decimal* objects are immutable.

在 3.2 版的變更: The argument to the constructor is now permitted to be a *float* instance.

在 3.3 版的變更: *float* arguments raise an exception if the *FloatOperation* trap is set. By default the trap is off.

在 3.6 版的變更: Underscores are allowed for grouping, as with integral and floating-point literals in code.

Decimal floating point objects share many properties with the other built-in numeric types such as *float* and *int*. All of the usual math operations and special methods apply. Likewise, decimal objects can be copied, pickled, printed, used as dictionary keys, used as set elements, compared, sorted, and coerced to another type (such as *float* or *int*).

There are some small differences between arithmetic on *Decimal* objects and arithmetic on integers and floats. When the remainder operator `%` is applied to *Decimal* objects, the sign of the result is the sign of the *dividend* rather than the sign of the divisor:

```
>>> (-7) % 4
1
>>> Decimal(-7) % Decimal(4)
Decimal('-3')
```

The integer division operator `//` behaves analogously, returning the integer part of the true quotient (truncating towards zero) rather than its floor, so as to preserve the usual identity $x == (x // y) * y + x \% y$:

```
>>> -7 // 4
-2
>>> Decimal(-7) // Decimal(4)
Decimal('-1')
```

The `%` and `//` operators implement the remainder and divide-integer operations (respectively) as described in the specification.

Decimal objects cannot generally be combined with floats or instances of `fractions.Fraction` in arithmetic operations: an attempt to add a `Decimal` to a `float`, for example, will raise a `TypeError`. However, it is possible to use Python's comparison operators to compare a `Decimal` instance `x` with another number `y`. This avoids confusing results when doing equality comparisons between numbers of different types.

在 3.2 版的變更: Mixed-type comparisons between `Decimal` instances and other numeric types are now fully supported.

In addition to the standard numeric properties, decimal floating point objects also have a number of specialized methods:

adjusted()

Return the adjusted exponent after shifting out the coefficient's rightmost digits until only the lead digit remains: `Decimal('321e+5').adjusted()` returns seven. Used for determining the position of the most significant digit with respect to the decimal point.

as_integer_ratio()

Return a pair `(n, d)` of integers that represent the given `Decimal` instance as a fraction, in lowest terms and with a positive denominator:

```
>>> Decimal('-3.14').as_integer_ratio()
(-157, 50)
```

The conversion is exact. Raise `OverflowError` on infinities and `ValueError` on NaNs.

在 3.6 版新加入.

as_tuple()

Return a *named tuple* representation of the number: `DecimalTuple(sign, digits, exponent)`.

canonical()

Return the canonical encoding of the argument. Currently, the encoding of a `Decimal` instance is always canonical, so this operation returns its argument unchanged.

compare(other, context=None)

Compare the values of two `Decimal` instances. `compare()` returns a `Decimal` instance, and if either operand is a NaN then the result is a NaN:

```
a or b is a NaN ==> Decimal('NaN')
a < b           ==> Decimal('-1')
a == b          ==> Decimal('0')
a > b           ==> Decimal('1')
```

compare_signal(other, context=None)

This operation is identical to the `compare()` method, except that all NaNs signal. That is, if neither operand is a signaling NaN then any quiet NaN operand is treated as though it were a signaling NaN.

compare_total(other, context=None)

Compare two operands using their abstract representation rather than their numerical value. Similar to the `compare()` method, but the result gives a total ordering on `Decimal` instances. Two `Decimal` instances with the same numeric value but different representations compare unequal in this ordering:

```
>>> Decimal('12.0').compare_total(Decimal('12'))
Decimal('-1')
```

Quiet and signaling NaNs are also included in the total ordering. The result of this function is `Decimal('0')` if both operands have the same representation, `Decimal('-1')` if the first operand is lower in the total order than the second, and `Decimal('1')` if the first operand is higher in the total order than the second operand. See the specification for details of the total order.

This operation is unaffected by context and is quiet: no flags are changed and no rounding is performed. As an exception, the C version may raise `InvalidOperation` if the second operand cannot be converted exactly.

compare_total_mag(*other*, *context=None*)

Compare two operands using their abstract representation rather than their value as in `compare_total()`, but ignoring the sign of each operand. `x.compare_total_mag(y)` is equivalent to `x.copy_abs().compare_total(y.copy_abs())`.

This operation is unaffected by context and is quiet: no flags are changed and no rounding is performed. As an exception, the C version may raise `InvalidOperation` if the second operand cannot be converted exactly.

conjugate()

Just returns self, this method is only to comply with the Decimal Specification.

copy_abs()

Return the absolute value of the argument. This operation is unaffected by the context and is quiet: no flags are changed and no rounding is performed.

copy_negate()

Return the negation of the argument. This operation is unaffected by the context and is quiet: no flags are changed and no rounding is performed.

copy_sign(*other*, *context=None*)

Return a copy of the first operand with the sign set to be the same as the sign of the second operand. For example:

```
>>> Decimal('2.3').copy_sign(Decimal('-1.5'))
Decimal('-2.3')
```

This operation is unaffected by context and is quiet: no flags are changed and no rounding is performed. As an exception, the C version may raise `InvalidOperation` if the second operand cannot be converted exactly.

exp(*context=None*)

Return the value of the (natural) exponential function e^{**x} at the given number. The result is correctly rounded using the `ROUND_HALF_EVEN` rounding mode.

```
>>> Decimal(1).exp()
Decimal('2.718281828459045235360287471')
>>> Decimal(321).exp()
Decimal('2.561702493119680037517373933E+139')
```

classmethod from_float(*f*)

Alternative constructor that only accepts instances of `float` or `int`.

Note `Decimal.from_float(0.1)` is not the same as `Decimal('0.1')`. Since 0.1 is not exactly representable in binary floating point, the value is stored as the nearest representable value which is $0 \times 1.9999999999999999 \text{ap-4}$. That equivalent value in decimal is 0.1000000000000000055511151231257827021181583404541015625.

備F: From Python 3.2 onwards, a `Decimal` instance can also be constructed directly from a `float`.

```
>>> Decimal.from_float(0.1)
Decimal('0.1000000000000000055511151231257827021181583404541015625')
>>> Decimal.from_float(float('nan'))
Decimal('NaN')
>>> Decimal.from_float(float('inf'))
Decimal('Infinity')
>>> Decimal.from_float(float('-inf'))
Decimal('-Infinity')
```

在 3.1 版新加入.

fma (*other, third, context=None*)

Fused multiply-add. Return `self*other+third` with no rounding of the intermediate product `self*other`.

```
>>> Decimal(2).fma(3, 5)
Decimal('11')
```

is_canonical ()

Return *True* if the argument is canonical and *False* otherwise. Currently, a *Decimal* instance is always canonical, so this operation always returns *True*.

is_finite ()

Return *True* if the argument is a finite number, and *False* if the argument is an infinity or a NaN.

is_infinite ()

Return *True* if the argument is either positive or negative infinity and *False* otherwise.

is_nan ()

Return *True* if the argument is a (quiet or signaling) NaN and *False* otherwise.

is_normal (*context=None*)

Return *True* if the argument is a *normal* finite number. Return *False* if the argument is zero, subnormal, infinite or a NaN.

is_qnan ()

Return *True* if the argument is a quiet NaN, and *False* otherwise.

is_signed ()

Return *True* if the argument has a negative sign and *False* otherwise. Note that zeros and NaNs can both carry signs.

is_snan ()

Return *True* if the argument is a signaling NaN and *False* otherwise.

is_subnormal (*context=None*)

Return *True* if the argument is subnormal, and *False* otherwise.

is_zero ()

Return *True* if the argument is a (positive or negative) zero and *False* otherwise.

ln (*context=None*)

Return the natural (base e) logarithm of the operand. The result is correctly rounded using the *ROUND_HALF_EVEN* rounding mode.

log10 (*context=None*)

Return the base ten logarithm of the operand. The result is correctly rounded using the *ROUND_HALF_EVEN* rounding mode.

logb (*context=None*)

For a nonzero number, return the adjusted exponent of its operand as a *Decimal* instance. If the operand is a zero then `Decimal('-Infinity')` is returned and the *DivisionByZero* flag is raised. If the operand is an infinity then `Decimal('Infinity')` is returned.

logical_and (*other*, *context=None*)

logical_and() is a logical operation which takes two *logical operands* (see *Logical operands*). The result is the digit-wise and of the two operands.

logical_invert (*context=None*)

logical_invert() is a logical operation. The result is the digit-wise inversion of the operand.

logical_or (*other*, *context=None*)

logical_or() is a logical operation which takes two *logical operands* (see *Logical operands*). The result is the digit-wise or of the two operands.

logical_xor (*other*, *context=None*)

logical_xor() is a logical operation which takes two *logical operands* (see *Logical operands*). The result is the digit-wise exclusive or of the two operands.

max (*other*, *context=None*)

Like `max(self, other)` except that the context rounding rule is applied before returning and that NaN values are either signaled or ignored (depending on the context and whether they are signaling or quiet).

max_mag (*other*, *context=None*)

Similar to the *max()* method, but the comparison is done using the absolute values of the operands.

min (*other*, *context=None*)

Like `min(self, other)` except that the context rounding rule is applied before returning and that NaN values are either signaled or ignored (depending on the context and whether they are signaling or quiet).

min_mag (*other*, *context=None*)

Similar to the *min()* method, but the comparison is done using the absolute values of the operands.

next_minus (*context=None*)

Return the largest number representable in the given context (or in the current thread's context if no context is given) that is smaller than the given operand.

next_plus (*context=None*)

Return the smallest number representable in the given context (or in the current thread's context if no context is given) that is larger than the given operand.

next_toward (*other*, *context=None*)

If the two operands are unequal, return the number closest to the first operand in the direction of the second operand. If both operands are numerically equal, return a copy of the first operand with the sign set to be the same as the sign of the second operand.

normalize (*context=None*)

Used for producing canonical values of an equivalence class within either the current context or the specified context.

This has the same semantics as the unary plus operation, except that if the final result is finite it is reduced to its simplest form, with all trailing zeros removed and its sign preserved. That is, while the coefficient is non-zero and a multiple of ten the coefficient is divided by ten and the exponent is incremented by 1. Otherwise (the coefficient is zero) the exponent is set to 0. In all cases the sign is unchanged.

For example, `Decimal('32.100')` and `Decimal('0.321000e+2')` both normalize to the equivalent value `Decimal('32.1')`.

Note that rounding is applied *before* reducing to simplest form.

In the latest versions of the specification, this operation is also known as *reduce*.

number_class (*context=None*)

Return a string describing the *class* of the operand. The returned value is one of the following ten strings.

- `"-Infinity"`, indicating that the operand is negative infinity.

- `"-Normal"`, indicating that the operand is a negative normal number.
- `"-Subnormal"`, indicating that the operand is negative and subnormal.
- `"-Zero"`, indicating that the operand is a negative zero.
- `"+Zero"`, indicating that the operand is a positive zero.
- `"+Subnormal"`, indicating that the operand is positive and subnormal.
- `"+Normal"`, indicating that the operand is a positive normal number.
- `"+Infinity"`, indicating that the operand is positive infinity.
- `"NaN"`, indicating that the operand is a quiet NaN (Not a Number).
- `"sNaN"`, indicating that the operand is a signaling NaN.

quantize (*exp*, *rounding=None*, *context=None*)

Return a value equal to the first operand after rounding and having the exponent of the second operand.

```
>>> Decimal('1.41421356').quantize(Decimal('1.000'))
Decimal('1.414')
```

Unlike other operations, if the length of the coefficient after the quantize operation would be greater than precision, then an *InvalidOperation* is signaled. This guarantees that, unless there is an error condition, the quantized exponent is always equal to that of the right-hand operand.

Also unlike other operations, quantize never signals Underflow, even if the result is subnormal and inexact.

If the exponent of the second operand is larger than that of the first then rounding may be necessary. In this case, the rounding mode is determined by the *rounding* argument if given, else by the given *context* argument; if neither argument is given the rounding mode of the current thread's context is used.

An error is returned whenever the resulting exponent is greater than *E_{max}* or less than *E_{tiny}*().

radix()

Return `Decimal(10)`, the radix (base) in which the *Decimal* class does all its arithmetic. Included for compatibility with the specification.

remainder_near (*other*, *context=None*)

Return the remainder from dividing *self* by *other*. This differs from `self % other` in that the sign of the remainder is chosen so as to minimize its absolute value. More precisely, the return value is `self - n * other` where *n* is the integer nearest to the exact value of `self / other`, and if two integers are equally near then the even one is chosen.

If the result is zero then its sign will be the sign of *self*.

```
>>> Decimal(18).remainder_near(Decimal(10))
Decimal('-2')
>>> Decimal(25).remainder_near(Decimal(10))
Decimal('5')
>>> Decimal(35).remainder_near(Decimal(10))
Decimal('-5')
```

rotate (*other*, *context=None*)

Return the result of rotating the digits of the first operand by an amount specified by the second operand. The second operand must be an integer in the range `-precision` through `precision`. The absolute value of the second operand gives the number of places to rotate. If the second operand is positive then rotation is to the left; otherwise rotation is to the right. The coefficient of the first operand is padded on the left with zeros to length `precision` if necessary. The sign and exponent of the first operand are unchanged.

same_quantum (*other*, *context=None*)

Test whether self and other have the same exponent or whether both are NaN.

This operation is unaffected by context and is quiet: no flags are changed and no rounding is performed. As an exception, the C version may raise `InvalidOperation` if the second operand cannot be converted exactly.

scaleb (*other*, *context=None*)

Return the first operand with exponent adjusted by the second. Equivalently, return the first operand multiplied by $10^{**other}$. The second operand must be an integer.

shift (*other*, *context=None*)

Return the result of shifting the digits of the first operand by an amount specified by the second operand. The second operand must be an integer in the range `-precision` through `precision`. The absolute value of the second operand gives the number of places to shift. If the second operand is positive then the shift is to the left; otherwise the shift is to the right. Digits shifted into the coefficient are zeros. The sign and exponent of the first operand are unchanged.

sqrt (*context=None*)

Return the square root of the argument to full precision.

to_eng_string (*context=None*)

Convert to a string, using engineering notation if an exponent is needed.

Engineering notation has an exponent which is a multiple of 3. This can leave up to 3 digits to the left of the decimal place and may require the addition of either one or two trailing zeros.

For example, this converts `Decimal('123E+1')` to `Decimal('1.23E+3')`.

to_integral (*rounding=None*, *context=None*)

Identical to the `to_integral_value()` method. The `to_integral` name has been kept for compatibility with older versions.

to_integral_exact (*rounding=None*, *context=None*)

Round to the nearest integer, signaling *Inexact* or *Rounded* as appropriate if rounding occurs. The rounding mode is determined by the *rounding* parameter if given, else by the given *context*. If neither parameter is given then the rounding mode of the current context is used.

to_integral_value (*rounding=None*, *context=None*)

Round to the nearest integer without signaling *Inexact* or *Rounded*. If given, applies *rounding*; otherwise, uses the rounding method in either the supplied *context* or the current context.

Logical operands

The `logical_and()`, `logical_invert()`, `logical_or()`, and `logical_xor()` methods expect their arguments to be *logical operands*. A *logical operand* is a *Decimal* instance whose exponent and sign are both zero, and whose digits are all either 0 or 1.

9.4.3 Context objects

Contexts are environments for arithmetic operations. They govern precision, set rules for rounding, determine which signals are treated as exceptions, and limit the range for exponents.

Each thread has its own current context which is accessed or changed using the `getcontext()` and `setcontext()` functions:

`decimal.getcontext()`

Return the current context for the active thread.

`decimal.setcontext(c)`

Set the current context for the active thread to *c*.

You can also use the `with` statement and the `localcontext()` function to temporarily change the active context.

`decimal.localcontext(ctx=None, **kwargs)`

Return a context manager that will set the current context for the active thread to a copy of *ctx* on entry to the `with`-statement and restore the previous context when exiting the `with`-statement. If no context is specified, a copy of the current context is used. The *kwargs* argument is used to set the attributes of the new context.

For example, the following code sets the current decimal precision to 42 places, performs a calculation, and then automatically restores the previous context:

```
from decimal import localcontext

with localcontext() as ctx:
    ctx.prec = 42    # Perform a high precision calculation
    s = calculate_something()
s = +s    # Round the final result back to the default precision
```

Using keyword arguments, the code would be the following:

```
from decimal import localcontext

with localcontext(prec=42) as ctx:
    s = calculate_something()
s = +s
```

Raises `TypeError` if *kwargs* supplies an attribute that `Context` doesn't support. Raises either `TypeError` or `ValueError` if *kwargs* supplies an invalid value for an attribute.

在 3.11 版的變更: `localcontext()` now supports setting context attributes through the use of keyword arguments.

New contexts can also be created using the `Context` constructor described below. In addition, the module provides three pre-made contexts:

class `decimal.BasicContext`

This is a standard context defined by the General Decimal Arithmetic Specification. Precision is set to nine. Rounding is set to `ROUND_HALF_UP`. All flags are cleared. All traps are enabled (treated as exceptions) except `Inexact`, `Rounded`, and `Subnormal`.

Because many of the traps are enabled, this context is useful for debugging.

class `decimal.ExtendedContext`

This is a standard context defined by the General Decimal Arithmetic Specification. Precision is set to nine. Rounding is set to `ROUND_HALF_EVEN`. All flags are cleared. No traps are enabled (so that exceptions are not raised during computations).

Because the traps are disabled, this context is useful for applications that prefer to have result value of NaN or Infinity instead of raising exceptions. This allows an application to complete a run in the presence of conditions that would otherwise halt the program.

class `decimal.DefaultContext`

This context is used by the `Context` constructor as a prototype for new contexts. Changing a field (such a precision) has the effect of changing the default for new contexts created by the `Context` constructor.

This context is most useful in multi-threaded environments. Changing one of the fields before threads are started has the effect of setting system-wide defaults. Changing the fields after threads have started is not recommended as it would require thread synchronization to prevent race conditions.

In single threaded environments, it is preferable to not use this context at all. Instead, simply create contexts explicitly as described below.

The default values are `Context.prec=28`, `Context.rounding=ROUND_HALF_EVEN`, and enabled traps for *Overflow*, *InvalidOperation*, and *DivisionByZero*.

In addition to the three supplied contexts, new contexts can be created with the *Context* constructor.

```
class decimal.Context (prec=None, rounding=None, Emin=None, Emax=None, capitals=None,
                        clamp=None, flags=None, traps=None)
```

Creates a new context. If a field is not specified or is *None*, the default values are copied from the *DefaultContext*. If the *flags* field is not specified or is *None*, all flags are cleared.

prec is an integer in the range [1, *MAX_PREC*] that sets the precision for arithmetic operations in the context.

The *rounding* option is one of the constants listed in the section *Rounding Modes*.

The *traps* and *flags* fields list any signals to be set. Generally, new contexts should only set traps and leave the flags clear.

The *Emin* and *Emax* fields are integers specifying the outer limits allowable for exponents. *Emin* must be in the range [*MIN_EMIN*, 0], *Emax* in the range [0, *MAX_EMAX*].

The *capitals* field is either 0 or 1 (the default). If set to 1, exponents are printed with a capital E; otherwise, a lowercase e is used: `Decimal('6.02e+23')`.

The *clamp* field is either 0 (the default) or 1. If set to 1, the exponent *e* of a *Decimal* instance representable in this context is strictly limited to the range $Emin - prec + 1 \leq e \leq Emax - prec + 1$. If *clamp* is 0 then a weaker condition holds: the adjusted exponent of the *Decimal* instance is at most *Emax*. When *clamp* is 1, a large normal number will, where possible, have its exponent reduced and a corresponding number of zeros added to its coefficient, in order to fit the exponent constraints; this preserves the value of the number but loses information about significant trailing zeros. For example:

```
>>> Context(prec=6, Emax=999, clamp=1).create_decimal('1.23e999')
Decimal('1.23000E+999')
```

A *clamp* value of 1 allows compatibility with the fixed-width decimal interchange formats specified in IEEE 754.

The *Context* class defines several general purpose methods as well as a large number of methods for doing arithmetic directly in a given context. In addition, for each of the *Decimal* methods described above (with the exception of the *adjusted()* and *as_tuple()* methods) there is a corresponding *Context* method. For example, for a *Context* instance *C* and *Decimal* instance *x*, *C.exp(x)* is equivalent to *x.exp(context=C)*. Each *Context* method accepts a Python integer (an instance of *int*) anywhere that a *Decimal* instance is accepted.

clear_flags()

Resets all of the flags to 0.

clear_traps()

Resets all of the traps to 0.

在 3.3 版新加入。

copy()

Return a duplicate of the context.

copy_decimal(num)

Return a copy of the *Decimal* instance *num*.

create_decimal(num)

Creates a new *Decimal* instance from *num* but using *self* as context. Unlike the *Decimal* constructor, the context precision, rounding method, flags, and traps are applied to the conversion.

This is useful because constants are often given to a greater precision than is needed by the application. Another benefit is that rounding immediately eliminates unintended effects from digits beyond the current precision. In the following example, using unrounded inputs means that adding zero to a sum can change the result:

```
>>> getcontext().prec = 3
>>> Decimal('3.4445') + Decimal('1.0023')
Decimal('4.45')
>>> Decimal('3.4445') + Decimal(0) + Decimal('1.0023')
Decimal('4.44')
```

This method implements the to-number operation of the IBM specification. If the argument is a string, no leading or trailing whitespace or underscores are permitted.

create_decimal_from_float(*f*)

Creates a new `Decimal` instance from a float *f* but rounding using *self* as the context. Unlike the `Decimal.from_float()` class method, the context precision, rounding method, flags, and traps are applied to the conversion.

```
>>> context = Context(prec=5, rounding=ROUND_DOWN)
>>> context.create_decimal_from_float(math.pi)
Decimal('3.1415')
>>> context = Context(prec=5, traps=[Inexact])
>>> context.create_decimal_from_float(math.pi)
Traceback (most recent call last):
...
decimal.Inexact: None
```

在 3.1 版新加入.

Etiny()

Returns a value equal to $E_{\min} - \text{prec} + 1$ which is the minimum exponent value for subnormal results. When underflow occurs, the exponent is set to *Etiny*.

Etop()

Returns a value equal to $E_{\max} - \text{prec} + 1$.

The usual approach to working with decimals is to create `Decimal` instances and then apply arithmetic operations which take place within the current context for the active thread. An alternative approach is to use context methods for calculating within a specific context. The methods are similar to those for the `Decimal` class and are only briefly recounted here.

abs(*x*)

Returns the absolute value of *x*.

add(*x*, *y*)

Return the sum of *x* and *y*.

canonical(*x*)

Returns the same `Decimal` object *x*.

compare(*x*, *y*)

Compares *x* and *y* numerically.

compare_signal(*x*, *y*)

Compares the values of the two operands numerically.

compare_total(*x*, *y*)

Compares two operands using their abstract representation.

compare_total_mag(*x*, *y*)

Compares two operands using their abstract representation, ignoring sign.

copy_abs(*x*)

Returns a copy of *x* with the sign set to 0.

copy_negate (*x*)
Returns a copy of *x* with the sign inverted.

copy_sign (*x*, *y*)
Copies the sign from *y* to *x*.

divide (*x*, *y*)
Return *x* divided by *y*.

divide_int (*x*, *y*)
Return *x* divided by *y*, truncated to an integer.

divmod (*x*, *y*)
Divides two numbers and returns the integer part of the result.

exp (*x*)
Returns e^{**x} .

fma (*x*, *y*, *z*)
Returns *x* multiplied by *y*, plus *z*.

is_canonical (*x*)
Returns `True` if *x* is canonical; otherwise returns `False`.

is_finite (*x*)
Returns `True` if *x* is finite; otherwise returns `False`.

is_infinite (*x*)
Returns `True` if *x* is infinite; otherwise returns `False`.

is_nan (*x*)
Returns `True` if *x* is a qNaN or sNaN; otherwise returns `False`.

is_normal (*x*)
Returns `True` if *x* is a normal number; otherwise returns `False`.

is_qnan (*x*)
Returns `True` if *x* is a quiet NaN; otherwise returns `False`.

is_signed (*x*)
Returns `True` if *x* is negative; otherwise returns `False`.

is_snan (*x*)
Returns `True` if *x* is a signaling NaN; otherwise returns `False`.

is_subnormal (*x*)
Returns `True` if *x* is subnormal; otherwise returns `False`.

is_zero (*x*)
Returns `True` if *x* is a zero; otherwise returns `False`.

ln (*x*)
Returns the natural (base *e*) logarithm of *x*.

log10 (*x*)
Returns the base 10 logarithm of *x*.

logb (*x*)
Returns the exponent of the magnitude of the operand's MSD.

logical_and (*x*, *y*)
Applies the logical operation *and* between each operand's digits.

logical_invert (*x*)

Invert all the digits in *x*.

logical_or (*x*, *y*)

Applies the logical operation *or* between each operand's digits.

logical_xor (*x*, *y*)

Applies the logical operation *xor* between each operand's digits.

max (*x*, *y*)

Compares two values numerically and returns the maximum.

max_mag (*x*, *y*)

Compares the values numerically with their sign ignored.

min (*x*, *y*)

Compares two values numerically and returns the minimum.

min_mag (*x*, *y*)

Compares the values numerically with their sign ignored.

minus (*x*)

Minus corresponds to the unary prefix minus operator in Python.

multiply (*x*, *y*)

Return the product of *x* and *y*.

next_minus (*x*)

Returns the largest representable number smaller than *x*.

next_plus (*x*)

Returns the smallest representable number larger than *x*.

next_toward (*x*, *y*)

Returns the number closest to *x*, in direction towards *y*.

normalize (*x*)

Reduces *x* to its simplest form.

number_class (*x*)

Returns an indication of the class of *x*.

plus (*x*)

Plus corresponds to the unary prefix plus operator in Python. This operation applies the context precision and rounding, so it is *not* an identity operation.

power (*x*, *y*, *modulo*=None)

Return *x* to the power of *y*, reduced modulo *modulo* if given.

With two arguments, compute $x^{**}y$. If *x* is negative then *y* must be integral. The result will be inexact unless *y* is integral and the result is finite and can be expressed exactly in 'precision' digits. The rounding mode of the context is used. Results are always correctly rounded in the Python version.

`Decimal(0) ** Decimal(0)` results in `InvalidOperation`, and if `InvalidOperation` is not trapped, then results in `Decimal('NaN')`.

在 3.3 版的變更: The C module computes `power()` in terms of the correctly rounded `exp()` and `ln()` functions. The result is well-defined but only "almost always correctly rounded".

With three arguments, compute $(x^{**}y) \% modulo$. For the three argument form, the following restrictions on the arguments hold:

- all three arguments must be integral
- *y* must be nonnegative

- at least one of `x` or `y` must be nonzero
- `modulo` must be nonzero and have at most 'precision' digits

The value resulting from `Context.power(x, y, modulo)` is equal to the value that would be obtained by computing `(x**y) % modulo` with unbounded precision, but is computed more efficiently. The exponent of the result is zero, regardless of the exponents of `x`, `y` and `modulo`. The result is always exact.

quantize (`x`, `y`)

Returns a value equal to `x` (rounded), having the exponent of `y`.

radix ()

Just returns 10, as this is Decimal, :)

remainder (`x`, `y`)

Returns the remainder from integer division.

The sign of the result, if non-zero, is the same as that of the original dividend.

remainder_near (`x`, `y`)

Returns `x - y * n`, where `n` is the integer nearest the exact value of `x / y` (if the result is 0 then its sign will be the sign of `x`).

rotate (`x`, `y`)

Returns a rotated copy of `x`, `y` times.

same_quantum (`x`, `y`)

Returns `True` if the two operands have the same exponent.

scaleb (`x`, `y`)

Returns the first operand after adding the second value its exp.

shift (`x`, `y`)

Returns a shifted copy of `x`, `y` times.

sqrt (`x`)

Square root of a non-negative number to context precision.

subtract (`x`, `y`)

Return the difference between `x` and `y`.

to_eng_string (`x`)

Convert to a string, using engineering notation if an exponent is needed.

Engineering notation has an exponent which is a multiple of 3. This can leave up to 3 digits to the left of the decimal place and may require the addition of either one or two trailing zeros.

to_integral_exact (`x`)

Rounds to an integer.

to_sci_string (`x`)

Converts a number to a string using scientific notation.

9.4.4 常數

The constants in this section are only relevant for the C module. They are also included in the pure Python version for compatibility.

	32-bit	64-bit
<code>decimal.MAX_PREC</code>	425000000	999999999999999999
<code>decimal.MAX_EMAX</code>	425000000	999999999999999999
<code>decimal.MIN_EMIN</code>	-425000000	-999999999999999999
<code>decimal.MIN_ETINY</code>	-849999999	-1999999999999999997

`decimal.HAVE_THREADS`

The value is `True`. Deprecated, because Python now always has threads.

在 3.9 版之後被禁用。

`decimal.HAVE_CONTEXTVAR`

The default value is `True`. If Python is configured using the `--without-decimal-contextvar` option, the C version uses a thread-local rather than a coroutine-local context and the value is `False`. This is slightly faster in some nested context scenarios.

在 3.8.3 版新加入。

9.4.5 Rounding modes

`decimal.ROUND_CEILING`

Round towards Infinity.

`decimal.ROUND_DOWN`

Round towards zero.

`decimal.ROUND_FLOOR`

Round towards -Infinity.

`decimal.ROUND_HALF_DOWN`

Round to nearest with ties going towards zero.

`decimal.ROUND_HALF_EVEN`

Round to nearest with ties going to nearest even integer.

`decimal.ROUND_HALF_UP`

Round to nearest with ties going away from zero.

`decimal.ROUND_UP`

Round away from zero.

`decimal.ROUND_05UP`

Round away from zero if last digit after rounding towards zero would have been 0 or 5; otherwise round towards zero.

9.4.6 Signals

Signals represent conditions that arise during computation. Each corresponds to one context flag and one context trap enabler.

The context flag is set whenever the condition is encountered. After the computation, flags may be checked for informational purposes (for instance, to determine whether a computation was exact). After checking the flags, be sure to clear all flags before starting the next computation.

If the context's trap enabler is set for the signal, then the condition causes a Python exception to be raised. For example, if the *DivisionByZero* trap is set, then a *DivisionByZero* exception is raised upon encountering the condition.

class `decimal.Clamped`

Altered an exponent to fit representation constraints.

Typically, clamping occurs when an exponent falls outside the context's `Emin` and `Emax` limits. If possible, the exponent is reduced to fit by adding zeros to the coefficient.

class `decimal.DecimalException`

Base class for other signals and a subclass of *ArithmeticError*.

class `decimal.DivisionByZero`

Signals the division of a non-infinite number by zero.

Can occur with division, modulo division, or when raising a number to a negative power. If this signal is not trapped, returns `Infinity` or `-Infinity` with the sign determined by the inputs to the calculation.

class `decimal.Inexact`

Indicates that rounding occurred and the result is not exact.

Signals when non-zero digits were discarded during rounding. The rounded result is returned. The signal flag or trap is used to detect when results are inexact.

class `decimal.InvalidOperation`

An invalid operation was performed.

Indicates that an operation was requested that does not make sense. If not trapped, returns `NaN`. Possible causes include:

```
Infinity - Infinity
0 * Infinity
Infinity / Infinity
x % 0
Infinity % x
sqrt(-x) and x > 0
0 ** 0
x ** (non-integer)
x ** Infinity
```

class `decimal.Overflow`

Numerical overflow.

Indicates the exponent is larger than `Context.Emax` after rounding has occurred. If not trapped, the result depends on the rounding mode, either pulling inward to the largest representable finite number or rounding outward to `Infinity`. In either case, *Inexact* and *Rounded* are also signaled.

class `decimal.Rounded`

Rounding occurred though possibly no information was lost.

Signaled whenever rounding discards digits; even if those digits are zero (such as rounding `5.00` to `5.0`). If not trapped, returns the result unchanged. This signal is used to detect loss of significant digits.

class decimal.Subnormal

Exponent was lower than *Emin* prior to rounding.

Occurs when an operation result is subnormal (the exponent is too small). If not trapped, returns the result unchanged.

class decimal.Underflow

Numerical underflow with result rounded to zero.

Occurs when a subnormal result is pushed to zero by rounding. *Inexact* and *Subnormal* are also signaled.

class decimal.FloatOperation

Enable stricter semantics for mixing floats and Decimals.

If the signal is not trapped (default), mixing floats and Decimals is permitted in the *Decimal* constructor, *create_decimal()* and all comparison operators. Both conversion and comparisons are exact. Any occurrence of a mixed operation is silently recorded by setting *FloatOperation* in the context flags. Explicit conversions with *from_float()* or *create_decimal_from_float()* do not set the flag.

Otherwise (the signal is trapped), only equality comparisons and explicit conversions are silent. All other mixed operations raise *FloatOperation*.

The following table summarizes the hierarchy of signals:

```
exceptions.ArithmeticError(exceptions.Exception)
  DecimalException
    Clamped
    DivisionByZero(DecimalException, exceptions.ZeroDivisionError)
    Inexact
      Overflow(Inexact, Rounded)
      Underflow(Inexact, Rounded, Subnormal)
    InvalidOperation
    Rounded
    Subnormal
    FloatOperation(DecimalException, exceptions.TypeError)
```

9.4.7 Floating Point Notes

Mitigating round-off error with increased precision

The use of decimal floating point eliminates decimal representation error (making it possible to represent 0.1 exactly); however, some operations can still incur round-off error when non-zero digits exceed the fixed precision.

The effects of round-off error can be amplified by the addition or subtraction of nearly offsetting quantities resulting in loss of significance. Knuth provides two instructive examples where rounded floating point arithmetic with insufficient precision causes the breakdown of the associative and distributive properties of addition:

```
# Examples from Seminumerical Algorithms, Section 4.2.2.
>>> from decimal import Decimal, getcontext
>>> getcontext().prec = 8

>>> u, v, w = Decimal(11111113), Decimal(-11111111), Decimal('7.51111111')
>>> (u + v) + w
Decimal('9.5111111')
>>> u + (v + w)
Decimal('10')

>>> u, v, w = Decimal(20000), Decimal(-6), Decimal('6.0000003')
>>> (u*v) + (u*w)
Decimal('0.01')
>>> u * (v+w)
Decimal('0.0060000')
```

The `decimal` module makes it possible to restore the identities by expanding the precision sufficiently to avoid loss of significance:

```
>>> getcontext().prec = 20
>>> u, v, w = Decimal(11111113), Decimal(-11111111), Decimal('7.51111111')
>>> (u + v) + w
Decimal('9.51111111')
>>> u + (v + w)
Decimal('9.51111111')
>>>
>>> u, v, w = Decimal(20000), Decimal(-6), Decimal('6.0000003')
>>> (u*v) + (u*w)
Decimal('0.0060000')
>>> u * (v+w)
Decimal('0.0060000')
```

Special values

The number system for the `decimal` module provides special values including NaN, sNaN, -Infinity, Infinity, and two zeros, +0 and -0.

Infinities can be constructed directly with: `Decimal('Infinity')`. Also, they can arise from dividing by zero when the `DivisionByZero` signal is not trapped. Likewise, when the `Overflow` signal is not trapped, infinity can result from rounding beyond the limits of the largest representable number.

The infinities are signed (affine) and can be used in arithmetic operations where they get treated as very large, indeterminate numbers. For instance, adding a constant to infinity gives another infinite result.

Some operations are indeterminate and return NaN, or if the `InvalidOperation` signal is trapped, raise an exception. For example, `0/0` returns NaN which means “not a number”. This variety of NaN is quiet and, once created, will flow through other computations always resulting in another NaN. This behavior can be useful for a series of computations that occasionally have missing inputs --- it allows the calculation to proceed while flagging specific results as invalid.

A variant is sNaN which signals rather than remaining quiet after every operation. This is a useful return value when an invalid result needs to interrupt a calculation for special handling.

The behavior of Python’s comparison operators can be a little surprising where a NaN is involved. A test for equality where one of the operands is a quiet or signaling NaN always returns `False` (even when doing `Decimal('NaN')==Decimal('NaN')`), while a test for inequality always returns `True`. An attempt to compare two Decimals using any of the `<`, `<=`, `>` or `>=` operators will raise the `InvalidOperation` signal if either operand is a NaN, and return `False` if this signal is not trapped. Note that the General Decimal Arithmetic specification does not specify the behavior of direct comparisons; these rules for comparisons involving a NaN were taken from the IEEE 854 standard (see Table 3 in section 5.7). To ensure strict standards-compliance, use the `compare()` and `compare_signal()` methods instead.

The signed zeros can result from calculations that underflow. They keep the sign that would have resulted if the calculation had been carried out to greater precision. Since their magnitude is zero, both positive and negative zeros are treated as equal and their sign is informational.

In addition to the two signed zeros which are distinct yet equal, there are various representations of zero with differing precisions yet equivalent in value. This takes a bit of getting used to. For an eye accustomed to normalized floating point representations, it is not immediately obvious that the following calculation returns a value equal to zero:

```
>>> 1 / Decimal('Infinity')
Decimal('0E-1000026')
```

9.4.8 Working with threads

The `getcontext()` function accesses a different `Context` object for each thread. Having separate thread contexts means that threads may make changes (such as `getcontext().prec=10`) without interfering with other threads.

Likewise, the `setcontext()` function automatically assigns its target to the current thread.

If `setcontext()` has not been called before `getcontext()`, then `getcontext()` will automatically create a new context for use in the current thread.

The new context is copied from a prototype context called `DefaultContext`. To control the defaults so that each thread will use the same values throughout the application, directly modify the `DefaultContext` object. This should be done *before* any threads are started so that there won't be a race condition between threads calling `getcontext()`. For example:

```
# Set applicationwide defaults for all threads about to be launched
DefaultContext.prec = 12
DefaultContext.rounding = ROUND_DOWN
DefaultContext.traps = ExtendedContext.traps.copy()
DefaultContext.traps[InvalidOperation] = 1
setcontext(DefaultContext)

# Afterwards, the threads can be started
t1.start()
t2.start()
t3.start()
. . .
```

9.4.9 Recipes

Here are a few recipes that serve as utility functions and that demonstrate ways to work with the `Decimal` class:

```
def moneyfmt(value, places=2, curr='', sep=',', dp='.',
             pos='', neg='-', trailneg=''):
    """Convert Decimal to a money formatted string.

    places:  required number of places after the decimal point
    curr:    optional currency symbol before the sign (may be blank)
    sep:     optional grouping separator (comma, period, space, or blank)
    dp:      decimal point indicator (comma or period)
             only specify as blank when places is zero
    pos:     optional sign for positive numbers: '+', space or blank
    neg:     optional sign for negative numbers: '-', '(', space or blank
    trailneg: optional trailing minus indicator: '-', ')', space or blank

    >>> d = Decimal('-1234567.8901')
    >>> moneyfmt(d, curr='$')
    '-$1,234,567.89'
    >>> moneyfmt(d, places=0, sep='.', dp='', neg='', trailneg='-')
    '1.234.568-'
    >>> moneyfmt(d, curr='$', neg='(', trailneg=')')
    '($1,234,567.89)'
    >>> moneyfmt(Decimal(123456789), sep=' ')
    '123 456 789.00'
    >>> moneyfmt(Decimal('-0.02'), neg='<', trailneg='>')
    '<0.02>'

    """
    q = Decimal(10) ** -places          # 2 places --> '0.01'
    sign, digits, exp = value.quantize(q).as_tuple()
```

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```

result = []
digits = list(map(str, digits))
build, next = result.append, digits.pop
if sign:
    build(trailneg)
for i in range(places):
    build(next() if digits else '0')
if places:
    build(dp)
if not digits:
    build('0')
i = 0
while digits:
    build(next())
    i += 1
    if i == 3 and digits:
        i = 0
    build(sep)
build(curr)
build(neg if sign else pos)
return ''.join(reversed(result))

def pi():
    """Compute Pi to the current precision.

    >>> print(pi())
    3.141592653589793238462643383

    """
    getcontext().prec += 2 # extra digits for intermediate steps
    three = Decimal(3) # substitute "three=3.0" for regular floats
    lasts, t, s, n, na, d, da = 0, three, 3, 1, 0, 0, 24
    while s != lasts:
        lasts = s
        n, na = n+na, na+8
        d, da = d+da, da+32
        t = (t * n) / d
        s += t
    getcontext().prec -= 2
    return +s # unary plus applies the new precision

def exp(x):
    """Return e raised to the power of x. Result type matches input type.

    >>> print(exp(Decimal(1)))
    2.718281828459045235360287471
    >>> print(exp(Decimal(2)))
    7.389056098930650227230427461
    >>> print(exp(2.0))
    7.38905609893
    >>> print(exp(2+0j))
    (7.38905609893+0j)

    """
    getcontext().prec += 2
    i, lasts, s, fact, num = 0, 0, 1, 1, 1
    while s != lasts:
        lasts = s
        i += 1
        fact *= i
        num *= x

```

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```

        s += num / fact
    getcontext().prec -= 2
    return +s

def cos(x):
    """Return the cosine of x as measured in radians.

    The Taylor series approximation works best for a small value of x.
    For larger values, first compute x = x % (2 * pi).

    >>> print(cos(Decimal('0.5')))
    0.8775825618903727161162815826
    >>> print(cos(0.5))
    0.87758256189
    >>> print(cos(0.5+0j))
    (0.87758256189+0j)

    """
    getcontext().prec += 2
    i, lasts, s, fact, num, sign = 0, 0, 1, 1, 1, 1
    while s != lasts:
        lasts = s
        i += 2
        fact *= i * (i-1)
        num *= x * x
        sign *= -1
        s += num / fact * sign
    getcontext().prec -= 2
    return +s

def sin(x):
    """Return the sine of x as measured in radians.

    The Taylor series approximation works best for a small value of x.
    For larger values, first compute x = x % (2 * pi).

    >>> print(sin(Decimal('0.5')))
    0.4794255386042030002732879352
    >>> print(sin(0.5))
    0.479425538604
    >>> print(sin(0.5+0j))
    (0.479425538604+0j)

    """
    getcontext().prec += 2
    i, lasts, s, fact, num, sign = 1, 0, x, 1, x, 1
    while s != lasts:
        lasts = s
        i += 2
        fact *= i * (i-1)
        num *= x * x
        sign *= -1
        s += num / fact * sign
    getcontext().prec -= 2
    return +s

```

9.4.10 Decimal FAQ

Q. It is cumbersome to type `decimal.Decimal('1234.5')`. Is there a way to minimize typing when using the interactive interpreter?

A. Some users abbreviate the constructor to just a single letter:

```
>>> D = decimal.Decimal
>>> D('1.23') + D('3.45')
Decimal('4.68')
```

Q. In a fixed-point application with two decimal places, some inputs have many places and need to be rounded. Others are not supposed to have excess digits and need to be validated. What methods should be used?

A. The `quantize()` method rounds to a fixed number of decimal places. If the `Inexact` trap is set, it is also useful for validation:

```
>>> TWOPLACES = Decimal(10) ** -2           # same as Decimal('0.01')
```

```
>>> # Round to two places
>>> Decimal('3.214').quantize(TWOPLACES)
Decimal('3.21')
```

```
>>> # Validate that a number does not exceed two places
>>> Decimal('3.21').quantize(TWOPLACES, context=Context(traps=[Inexact]))
Decimal('3.21')
```

```
>>> Decimal('3.214').quantize(TWOPLACES, context=Context(traps=[Inexact]))
Traceback (most recent call last):
...
Inexact: None
```

Q. Once I have valid two place inputs, how do I maintain that invariant throughout an application?

A. Some operations like addition, subtraction, and multiplication by an integer will automatically preserve fixed point. Others operations, like division and non-integer multiplication, will change the number of decimal places and need to be followed-up with a `quantize()` step:

```
>>> a = Decimal('102.72')           # Initial fixed-point values
>>> b = Decimal('3.17')
>>> a + b                           # Addition preserves fixed-point
Decimal('105.89')
>>> a - b
Decimal('99.55')
>>> a * 42                          # So does integer multiplication
Decimal('4314.24')
>>> (a * b).quantize(TWOPLACES)     # Must quantize non-integer multiplication
Decimal('325.62')
>>> (b / a).quantize(TWOPLACES)     # And quantize division
Decimal('0.03')
```

In developing fixed-point applications, it is convenient to define functions to handle the `quantize()` step:

```
>>> def mul(x, y, fp=TWOPLACES):
...     return (x * y).quantize(fp)
>>> def div(x, y, fp=TWOPLACES):
...     return (x / y).quantize(fp)
```

```
>>> mul(a, b)                       # Automatically preserve fixed-point
Decimal('325.62')
>>> div(b, a)
Decimal('0.03')
```

Q. There are many ways to express the same value. The numbers 200, 200.000, 2E2, and .02E+4 all have the same value at various precisions. Is there a way to transform them to a single recognizable canonical value?

A. The `normalize()` method maps all equivalent values to a single representative:

```
>>> values = map(Decimal, '200 200.000 2E2 .02E+4'.split())
>>> [v.normalize() for v in values]
[Decimal('2E+2'), Decimal('2E+2'), Decimal('2E+2'), Decimal('2E+2')]
```

Q. When does rounding occur in a computation?

A. It occurs *after* the computation. The philosophy of the decimal specification is that numbers are considered exact and are created independent of the current context. They can even have greater precision than current context. Computations process with those exact inputs and then rounding (or other context operations) is applied to the *result* of the computation:

```
>>> getcontext().prec = 5
>>> pi = Decimal('3.1415926535')    # More than 5 digits
>>> pi                               # All digits are retained
Decimal('3.1415926535')
>>> pi + 0                          # Rounded after an addition
Decimal('3.1416')
>>> pi - Decimal('0.00005')         # Subtract unrounded numbers, then round
Decimal('3.1415')
>>> pi + 0 - Decimal('0.00005')     # Intermediate values are rounded
Decimal('3.1416')
```

Q. Some decimal values always print with exponential notation. Is there a way to get a non-exponential representation?

A. For some values, exponential notation is the only way to express the number of significant places in the coefficient. For example, expressing 5.0E+3 as 5000 keeps the value constant but cannot show the original's two-place significance.

If an application does not care about tracking significance, it is easy to remove the exponent and trailing zeroes, losing significance, but keeping the value unchanged:

```
>>> def remove_exponent(d):
...     return d.quantize(Decimal(1)) if d == d.to_integral() else d.normalize()
```

```
>>> remove_exponent(Decimal('5E+3'))
Decimal('5000')
```

Q. Is there a way to convert a regular float to a `Decimal`?

A. Yes, any binary floating point number can be exactly expressed as a `Decimal` though an exact conversion may take more precision than intuition would suggest:

```
>>> Decimal(math.pi)
Decimal('3.141592653589793115997963468544185161590576171875')
```

Q. Within a complex calculation, how can I make sure that I haven't gotten a spurious result because of insufficient precision or rounding anomalies.

A. The decimal module makes it easy to test results. A best practice is to re-run calculations using greater precision and with various rounding modes. Widely differing results indicate insufficient precision, rounding mode issues, ill-conditioned inputs, or a numerically unstable algorithm.

Q. I noticed that context precision is applied to the results of operations but not to the inputs. Is there anything to watch out for when mixing values of different precisions?

A. Yes. The principle is that all values are considered to be exact and so is the arithmetic on those values. Only the results are rounded. The advantage for inputs is that "what you type is what you get". A disadvantage is that the results can look odd if you forget that the inputs haven't been rounded:

```
>>> getcontext().prec = 3
>>> Decimal('3.104') + Decimal('2.104')
Decimal('5.21')
>>> Decimal('3.104') + Decimal('0.000') + Decimal('2.104')
Decimal('5.20')
```

The solution is either to increase precision or to force rounding of inputs using the unary plus operation:

```
>>> getcontext().prec = 3
>>> +Decimal('1.23456789')      # unary plus triggers rounding
Decimal('1.23')
```

Alternatively, inputs can be rounded upon creation using the `Context.create_decimal()` method:

```
>>> Context(prec=5, rounding=ROUND_DOWN).create_decimal('1.2345678')
Decimal('1.2345')
```

Q. Is the CPython implementation fast for large numbers?

A. Yes. In the CPython and PyPy3 implementations, the C/CFFI versions of the decimal module integrate the high speed `libmpdec` library for arbitrary precision correctly rounded decimal floating point arithmetic¹. `libmpdec` uses [Karatsuba multiplication](#) for medium-sized numbers and the [Number Theoretic Transform](#) for very large numbers.

The context must be adapted for exact arbitrary precision arithmetic. `Emin` and `Emax` should always be set to the maximum values, `clamp` should always be 0 (the default). Setting `prec` requires some care.

The easiest approach for trying out bignum arithmetic is to use the maximum value for `prec` as well²:

```
>>> setcontext(Context(prec=MAX_PREC, Emax=MAX_EMAX, Emin=MIN_EMIN))
>>> x = Decimal(2) ** 256
>>> x / 128
Decimal(
↳ '904625697166532776746648320380374280103671755200316906558262375061821325312')
```

For inexact results, `MAX_PREC` is far too large on 64-bit platforms and the available memory will be insufficient:

```
>>> Decimal(1) / 3
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
MemoryError
```

On systems with overallocation (e.g. Linux), a more sophisticated approach is to adjust `prec` to the amount of available RAM. Suppose that you have 8GB of RAM and expect 10 simultaneous operands using a maximum of 500MB each:

```
>>> import sys
>>>
>>> # Maximum number of digits for a single operand using 500MB in 8-byte words
>>> # with 19 digits per word (4-byte and 9 digits for the 32-bit build):
>>> maxdigits = 19 * ((500 * 1024**2) // 8)
>>>
>>> # Check that this works:
>>> c = Context(prec=maxdigits, Emax=MAX_EMAX, Emin=MIN_EMIN)
>>> c.traps[Inexact] = True
>>> setcontext(c)
>>>
>>> # Fill the available precision with nines:
>>> x = Decimal(0).logical_invert() * 9
```

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¹
在 3.3 版新加入。

²
在 3.9 版的變更: This approach now works for all exact results except for non-integer powers.

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```
>>> sys.getsizeof(x)
524288112
>>> x + 2
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
decimal.Inexact: [<class 'decimal.Inexact'>]
```

In general (and especially on systems without overallocation), it is recommended to estimate even tighter bounds and set the *Inexact* trap if all calculations are expected to be exact.

9.5 fractions --- Rational numbers

原始碼: [Lib/fractions.py](#)

The *fractions* module provides support for rational number arithmetic.

A *Fraction* instance can be constructed from a pair of integers, from another rational number, or from a string.

```
class fractions.Fraction (numerator=0, denominator=1)
class fractions.Fraction (other_fraction)
class fractions.Fraction (float)
class fractions.Fraction (decimal)
class fractions.Fraction (string)
```

The first version requires that *numerator* and *denominator* are instances of *numbers.Rational* and returns a new *Fraction* instance with value *numerator*/*denominator*. If *denominator* is 0, it raises a *ZeroDivisionError*. The second version requires that *other_fraction* is an instance of *numbers.Rational* and returns a *Fraction* instance with the same value. The next two versions accept either a *float* or a *decimal.Decimal* instance, and return a *Fraction* instance with exactly the same value. Note that due to the usual issues with binary floating-point (see *tut-fp-issues*), the argument to *Fraction*(1.1) is not exactly equal to 11/10, and so *Fraction*(1.1) does *not* return *Fraction*(11, 10) as one might expect. (But see the documentation for the *limit_denominator()* method below.) The last version of the constructor expects a string or unicode instance. The usual form for this instance is:

```
[sign] numerator ['/' denominator]
```

where the optional *sign* may be either '+' or '-' and *numerator* and *denominator* (if present) are strings of decimal digits (underscores may be used to delimit digits as with integral literals in code). In addition, any string that represents a finite value and is accepted by the *float* constructor is also accepted by the *Fraction* constructor. In either form the input string may also have leading and/or trailing whitespace. Here are some examples:

```
>>> from fractions import Fraction
>>> Fraction(16, -10)
Fraction(-8, 5)
>>> Fraction(123)
Fraction(123, 1)
>>> Fraction()
Fraction(0, 1)
>>> Fraction('3/7')
Fraction(3, 7)
>>> Fraction(' -3/7 ')
Fraction(-3, 7)
>>> Fraction('1.414213 \t\n')
Fraction(1414213, 1000000)
>>> Fraction('-.125')
```

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```

Fraction(-1, 8)
>>> Fraction('7e-6')
Fraction(7, 1000000)
>>> Fraction(2.25)
Fraction(9, 4)
>>> Fraction(1.1)
Fraction(2476979795053773, 2251799813685248)
>>> from decimal import Decimal
>>> Fraction(Decimal('1.1'))
Fraction(11, 10)

```

The `Fraction` class inherits from the abstract base class `numbers.Rational`, and implements all of the methods and operations from that class. `Fraction` instances are *hashable*, and should be treated as immutable. In addition, `Fraction` has the following properties and methods:

在 3.2 版的變更: The `Fraction` constructor now accepts `float` and `decimal.Decimal` instances.

在 3.9 版的變更: The `math.gcd()` function is now used to normalize the *numerator* and *denominator*. `math.gcd()` always return a `int` type. Previously, the GCD type depended on *numerator* and *denominator*.

在 3.11 版的變更: Underscores are now permitted when creating a `Fraction` instance from a string, following **PEP 515** rules.

在 3.11 版的變更: `Fraction` implements `__int__` now to satisfy `typing.SupportsInt` instance checks.

numerator

Numerator of the Fraction in lowest term.

denominator

Denominator of the Fraction in lowest term.

as_integer_ratio()

Return a tuple of two integers, whose ratio is equal to the Fraction and with a positive denominator.

在 3.8 版新加入.

classmethod from_float (flt)

Alternative constructor which only accepts instances of `float` or `numbers.Integral`. Beware that `Fraction.from_float(0.3)` is not the same value as `Fraction(3, 10)`.

備 F: From Python 3.2 onwards, you can also construct a `Fraction` instance directly from a `float`.

classmethod from_decimal (dec)

Alternative constructor which only accepts instances of `decimal.Decimal` or `numbers.Integral`.

備 F: From Python 3.2 onwards, you can also construct a `Fraction` instance directly from a `decimal.Decimal` instance.

limit_denominator (max_denominator=1000000)

Finds and returns the closest `Fraction` to self that has denominator at most `max_denominator`. This method is useful for finding rational approximations to a given floating-point number:

```

>>> from fractions import Fraction
>>> Fraction('3.1415926535897932').limit_denominator(1000)
Fraction(355, 113)

```

or for recovering a rational number that's represented as a float:

```
>>> from math import pi, cos
>>> Fraction(cos(pi/3))
Fraction(4503599627370497, 9007199254740992)
>>> Fraction(cos(pi/3)).limit_denominator()
Fraction(1, 2)
>>> Fraction(1.1).limit_denominator()
Fraction(11, 10)
```

`__floor__()`

Returns the greatest `int` \leq `self`. This method can also be accessed through the `math.floor()` function:

```
>>> from math import floor
>>> floor(Fraction(355, 113))
3
```

`__ceil__()`

Returns the least `int` \geq `self`. This method can also be accessed through the `math.ceil()` function.

`__round__()`

`__round__(ndigits)`

The first version returns the nearest `int` to `self`, rounding half to even. The second version rounds `self` to the nearest multiple of `Fraction(1, 10**ndigits)` (logically, if `ndigits` is negative), again rounding half toward even. This method can also be accessed through the `round()` function.

也參考:

`numbers` 模組

The abstract base classes making up the numeric tower.

9.6 random --- 生成 F 隨機數

原始碼: [Lib/random.py](#)

本章中所提及的 module (模組) 用來實現各種分 F 的 F 擬隨機數 F 生器。

對於整數, 可以從範圍中進行均 F 選擇。對於序列, 有一個隨機元素的均 F 選擇, 一個用來原地 (in-place) F 生隨機排列清單的函式, 以及一個用來隨機 F 樣不替 F 的函式。

在實數 F 上, 有一些函式用於處理均 F 分 F、常態分 F (高斯分 F)、對數常態分 F、負指數分 F、gamma 分 F 和 Beta 分 F。對於生成角度分 F, 可以使用馮·米塞斯分 F (von Mises distribution)。

幾乎所有 module 函式都相依於基本函式 `random()`, 此函式在半開放範圍 $0.0 \leq x < 1.0$ F 均 F 地生成一個隨機 float (浮點數)。Python 使用 Mersenne Twister (梅森旋轉演算法) 作 F 核心的 F 生器, 它 F 生 53 位元精度 float, 其 F 期 F $2^{19937}-1$, 透過 C 語言進行底層的實作既快速又支援執行緒安全 (threadsafe)。Mersenne Twister 是現存最廣泛被驗證的隨機數 F 生器之一, 但是基於完全確定性, 它 F 不適合所有目的, F 且完全不適合加密目的。

該 module 提供的函式實際上是 `random.Random` class (類 F) 中一個隱藏實例的綁定方法 (bound method)。你可以實例化自己的 `Random` 實例, 以得到不共享狀態的 F 生器。

Class `Random` can also be subclassed if you want to use a different basic generator of your own devising: see the documentation on that class for more details.

`random` module 也提供了 `SystemRandom` class, 使用系統函式 `os.urandom()` 從作業系統提供的來源 F 生隨機數。

警告： 本章所提及的偽隨機數生成器不應該使用於安全目的。有關安全性或加密用途，請參考 `secrets` module。

也參考：

M. Matsumoto and T. Nishimura, "Mersenne Twister: A 623-dimensionally equidistributed uniform pseudorandom number generator", ACM Transactions on Modeling and Computer Simulation Vol. 8, No. 1, January pp.3--30 1998.

進位互補乘法 (Complementary-Multiply-with-Carry) 用法，可作偽隨機數生成器的一個可相容替代方案，具有較長的週期和相對簡單的更新操作。

9.6.1 簿記函式 (bookkeeping functions)

`random.seed(a=None, version=2)`

初始化隨機數生成器。

如果 `a` 被省略或 `None`，則使用當前系統時間。如果隨機來源由作業系統提供，則使用它們而不是系統時間（有關可用性的詳細資訊，請參考 `os.urandom()` 函式）。

如果 `a` 是 `int`（整數），則直接使用它。

如使用版本 2（預設值），`str`、`bytes` 或 `bytearray` 物件將轉為 `int`，並使用其所有位元。

若使用版本 1（恢復現於舊版本 Python 中生成隨機序列而提供），`str` 和 `bytes` 的演算法會生成範圍更窄的種子 (seed)。

在 3.2 版的變更：移至版本 2 方案，該方案使用字串種子中的所有位元。

在 3.11 版的變更：The *seed* must be one of the following types: `None`, `int`, `float`, `str`, `bytes`, or `bytearray`.

`random.getstate()`

回傳一個物件，捕獲生成器的當前內部狀態。此物件可以傳遞給 `setstate()` 以恢復狀態。

`random.setstate(state)`

`state` 應該要從之前對 `getstate()` 的呼叫中獲得，並且以 `setstate()` 將生成器的內部狀態恢復到呼叫 `getstate()` 時的狀態。

9.6.2 回傳位元組的函式

`random.randbytes(n)`

生成 `n` 個隨機位元組。

此方法不應使用於生成安全性權杖 (Token)。請改用 `secrets.token_bytes()`。

在 3.9 版新加入。

9.6.3 回傳整數的函式

`random.randrange(stop)`

`random.randrange(start, stop[, step])`

從 `range(start, stop, step)` 中回傳一個隨機選擇的元素。這等效於 `choice(range(start, stop, step))`，但實際上沒有構建範圍物件。

位置引數模式與 `range()` 的位置引數模式匹配。不應使用關鍵字引數，因為函式可能會以不預期的方式使用它們。

在 3.2 版的變更: `randrange()` 在生成分數的值方面更複雜。以前, 它使用像 `int(random()*n)` 這樣的樣式, 這可能會生成稍微不均勻的分數。

在 3.10 版之後被採用: 非整數類型到等效整數的自動轉換已被採用。目前 `randrange(10.0)` 被無損轉換成 `randrange(10)`。將來, 這將會引發 `TypeError`。

在 3.10 版之後被採用: The exception raised for non-integer values such as `randrange(10.5)` or `randrange('10')` will be changed from `ValueError` to `TypeError`.

`random.randint(a, b)`

回傳一個隨機整數 N , 使得 $a \leq N \leq b$ 。是 `randrange(a, b+1)` 的別名。

`random.getrandbits(k)`

回傳一個具有 k 個隨機位元的非負 Python 整數。此方法會隨 `MersenneTwister` 生成器一起提供, 一些其他的生成器也可能將其作為 API 的可選部分。如果可用, `getrandbits()` 使 `randrange()` 能處理任意大的範圍。

在 3.9 版的變更: 此方法現在接受 k 為零。

9.6.4 回傳序列的函式

`random.choice(seq)`

從非空序列 `seq` 回傳一個隨機元素。如果 `seq` 為空, 則引發 `IndexError`。

`random.choices(population, weights=None, *, cum_weights=None, k=1)`

回傳從 `population` 中重置取樣出的一個大小為 k 的元素 list。如果 `population` 為空, 則引發 `IndexError`。

如果指定了 `weights` 序列, 則根據相對權重進行選擇。另外, 如果給定 `cum_weights` 序列, 則根據累積權重進行選擇 (可能使用 `itertools.accumulate()` 計算)。例如, 相對權重 `[10, 5, 30, 5]` 等同於累積權重 `[10, 15, 45, 50]`。在內部, 相對權重在進行選擇之前會轉換成累積權重, 因此提供累積權重可以節省工作。

如果既未指定 `weights` 也未指定 `cum_weights`, 則以相等的機率進行選擇。如果提供了加權序列, 則該序列的長度必須與 `population` 序列的長度相同。它是一個 `TypeError` 來指定 `weights` 和 `cum_weights`。

`weights` 或 `cum_weights` 可以使用任何與 `random()` 所回傳的 `float` 值 (包括整數、float 和分數, 但不包括小數) 交互操作 (interoperates) 的數值類型。權重假定為非負數和有限的。如果所有權重均為零, 則引發 `ValueError`。

對於給定的種子, 具有相等權重的 `choices()` 函式通常生成與重復呼叫 `choice()` 不同的序列。`choices()` 使用的演算法使用浮點院算來實現內部一致性和速度。`choice()` 使用的演算法預設為整數運算和重復選擇, 以避免舍入誤差生成的微小偏差。

在 3.6 版新加入。

在 3.9 版的變更: 如果所有權重均為零, 則引發 `ValueError`。

`random.shuffle(x)`

將序列 `x` 原地 (in place) 隨機打亂位置。

要打亂一個不可變的序列則回傳一個新的被打亂的 list (串列), 請使用 `sample(x, k=len(x))`。

請注意, 即使對於較小的 `len(x)`, `x` 的置換總數也會快速成長到大於大多數隨機數生成器的週期。這意味著長序列的大多數置換永遠無法生成。例如, 長度為 2080 的序列是 `Mersenne Twister` 隨機數生成器週期可以容納的最大序列。

在 3.11 版的變更: Removed the optional parameter `random`.

`random.sample(population, k, *, counts=None)`

回傳從母體序列中選擇出的一個包含獨特元素、長度為 k 的 list。用於不重置的隨機取樣。

回傳包含母體元素的新清單, 同時保持原始母體不變。生成的清單按選擇順序排列, 因此所有子切片也會是有效的隨機樣本。這允許抽取獲勝者 (樣本) 分數大和第二名獲勝者 (子切片)。

母體成員不必是 *hashable* 或唯一的。如果母體包含重項，則每次出現都是樣本中可能出現的一個選擇。

可以一次指定一個重元素，也可以使用可選的僅關鍵字 *counts* 參數指定重元素。例如 `sample(['red', 'blue'], counts=[4, 2], k=5)` 等同於 `sample(['red', 'red', 'red', 'red', 'blue', 'blue'], k=5)`。

若要從整數範圍中選擇範例，請使用 *range()* 物件作引數。這對於從大型母體中取樣特別快速且節省空間：`sample(range(10000000), k=60)`。

如果樣本大小大於母體大小，*ValueError* 會被引發。

在 3.9 版的變更：新增 *counts* 參數。

在 3.11 版的變更：The *population* must be a sequence. Automatic conversion of sets to lists is no longer supported.

9.6.5 實數分布

以下函式生特定的實數分。函式參數以分方程中的對應變數命名，如常見的數學實踐所示；這些方程式中的大多數都可以在任意統計文本中找到。

`random.random()`

回傳範圍 $0.0 \leq x < 1.0$ 中的下一個隨機浮點數

`random.uniform(a, b)`

回傳一個隨機浮點數 N ，當 $a \leq b$ 時確保 $N \in [a, b]$ 、 $b < a$ 時確保 $N \in [b, a]$ 。

The end-point value b may or may not be included in the range depending on floating-point rounding in the expression $a + (b-a) * \text{random}()$.

`random.triangular(low, high, mode)`

回傳一個隨機浮點數 N ，使得 $low \leq N \leq high$ ， N 在這些邊界之間具有指定的 *mode*。*low* 和 *high* 邊界預設為零和一。*mode* 引數預設為邊界之間的中點，從而給出對稱分。

`random.betavariate(alpha, beta)`

Beta（貝它）分布。參數的條件 $\alpha > 0$ 和 $\beta > 0$ 。回傳值的範圍介於 0 和 1 之間。

`random.expovariate(lambd)`

指數分。*lambd* 除以所需的平均數。它應該不為零。（該參數將被稱作“*lambda*”，但這是 Python 中的保留字）如果 *lambd* 正，則回傳值的範圍從 0 到正無窮大；如果 *lambd* 負，則回傳值的範圍從負無窮大到 0。

`random.gammavariate(alpha, beta)`

Gamma（伽瑪）分。（不是 Gamma 函式！）。形狀 (shape) 和比例 (scale) 參數 *alpha* 和 *beta* 必須具有正值。（根據呼叫習慣不同，部分來源會將 *beta* 定義為比例的倒數）。

Probability distribution function（機率密度函式）是：

```
pdf(x) = (x ** (alpha - 1) * math.exp(-x / beta)) /
          (math.gamma(alpha) * beta ** alpha)
```

`random.gauss(mu=0.0, sigma=1.0)`

常態分，也稱高斯分。*mu* 是平均數，*sigma* 是標準差。這比下面定義的 *normalvariate()* 函式快一點。

多執行緒須注意：當兩個執行緒同時呼叫此函式時，它們可能會收到相同的傳回值。這可以透過三種方式避免。1) 讓每個執行緒使用隨機數生器的不同實例。2) 在所有呼叫周圍加鎖。3) 使用較慢但執行緒安全的 *normalvariate()* 函式代替。

在 3.11 版的變更：*mu* and *sigma* now have default arguments.

`random.lognormvariate(mu, sigma)`

對數常態分。如果你取此分的自然對數，你將獲得一個具有平均數 *mu* 和標準差 *sigma* 的常態分。*mu* 可以任何值，且 *sigma* 必須大於零。

`random.normalvariate(mu=0.0, sigma=1.0)`

常態分。*mu* 是平均數，*sigma* 是標準差。

在 3.11 版的變更: *mu* and *sigma* now have default arguments.

`random.vonmisesvariate(mu, kappa)`

mu 是平均角度，以 0 到 2π 之間的弧度表示，*kappa* 是濃度參數，必須大於或等於零。如果 *kappa* 等於零，則此分在 0 到 2π 的範圍將小均的隨機角度。

`random.paretovariate(alpha)`

Pareto distribution (柏拉圖分)。*alpha* 是形狀參數。

`random.weibullvariate(alpha, beta)`

Weibull distribution (韋伯分)。*alpha* 是比例參數，*beta* 是形狀參數。

9.6.6 替代生器

`class random.Random([seed])`

實現 *random* 模組使用的預設隨機數生器的 class。

在 3.11 版的變更: Formerly the *seed* could be any hashable object. Now it is limited to: *None*, *int*, *float*, *str*, *bytes*, or *bytearray*.

Subclasses of *Random* should override the following methods if they wish to make use of a different basic generator:

seed (*a=None*, *version=2*)

Override this method in subclasses to customise the *seed()* behaviour of *Random* instances.

getstate ()

Override this method in subclasses to customise the *getstate()* behaviour of *Random* instances.

setstate (*state*)

Override this method in subclasses to customise the *setstate()* behaviour of *Random* instances.

random ()

Override this method in subclasses to customise the *random()* behaviour of *Random* instances.

Optionally, a custom generator subclass can also supply the following method:

getrandbits (*k*)

Override this method in subclasses to customise the *getrandbits()* behaviour of *Random* instances.

`class random.SystemRandom([seed])`

使用 *os.urandom()* 函式從作業系統提供的來源生隨機數的 Class。非在所有系統上都可用。不依賴於軟體狀態，且序列不可復現。因此 *seed()* 方法有效果且被忽略。如果呼叫 *getstate()* 和 *setstate()* 方法會引發 *NotImplementedError*。

9.6.7 關於 Reproducibility（複現性）的注意事項

有時，能重現隨機數生成器給出的序列很有用。只要多執行緒未運行，透過重使用種子值，同一序列就應該可以被復現。

大多數隨機 module 的演算法和 seed 設定函式在 Python 版本中可能會發生變化，但可以保證兩個方面不會改變：

- 如果增加了新的 seed 設定函式，則將提供向後相容的播種器 (seeder)。
- 當相容的播種器被賦予相同的種子時，生成器的 `random()` 方法將持續生成相同的序列。

9.6.8 范例

基礎範例：

```
>>> random()                                # Random float:  0.0 <= x < 1.0
0.37444887175646646

>>> uniform(2.5, 10.0)                      # Random float:  2.5 <= x <= 10.0
3.1800146073117523

>>> expovariate(1 / 5)                      # Interval between arrivals averaging 5_
↪seconds
5.148957571865031

>>> randrange(10)                          # Integer from 0 to 9 inclusive
7

>>> randrange(0, 101, 2)                    # Even integer from 0 to 100 inclusive
26

>>> choice(['win', 'lose', 'draw'])         # Single random element from a sequence
'draw'

>>> deck = 'ace two three four'.split()
>>> shuffle(deck)                           # Shuffle a list
>>> deck
['four', 'two', 'ace', 'three']

>>> sample([10, 20, 30, 40, 50], k=4)        # Four samples without replacement
[40, 10, 50, 30]
```

模擬：

```
>>> # Six roulette wheel spins (weighted sampling with replacement)
>>> choices(['red', 'black', 'green'], [18, 18, 2], k=6)
['red', 'green', 'black', 'black', 'red', 'black']

>>> # Deal 20 cards without replacement from a deck
>>> # of 52 playing cards, and determine the proportion of cards
>>> # with a ten-value:  ten, jack, queen, or king.
>>> dealt = sample(['tens', 'low cards'], counts=[16, 36], k=20)
>>> dealt.count('tens') / 20
0.15

>>> # Estimate the probability of getting 5 or more heads from 7 spins
>>> # of a biased coin that settles on heads 60% of the time.
>>> def trial():
...     return choices('HT', cum_weights=(0.60, 1.00), k=7).count('H') >= 5
...
>>> sum(trial() for i in range(10_000)) / 10_000
```

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```

0.4169

>>> # Probability of the median of 5 samples being in middle two quartiles
>>> def trial():
...     return 2_500 <= sorted(choices(range(10_000), k=5))[2] < 7_500
...
>>> sum(trial() for i in range(10_000)) / 10_000
0.7958

```

統計 bootstrapping (自助法) 的範例, 使用有重置的重新取樣來估計樣本平均數的信賴區間:

```

# https://www.thoughtco.com/example-of-bootstrapping-3126155
from statistics import fmean as mean
from random import choices

data = [41, 50, 29, 37, 81, 30, 73, 63, 20, 35, 68, 22, 60, 31, 95]
means = sorted(mean(choices(data, k=len(data))) for i in range(100))
print(f'The sample mean of {mean(data):.1f} has a 90% confidence '
      f'interval from {means[5]:.1f} to {means[94]:.1f}')

```

重新取樣排列測試的範例, 來確定觀察到的藥物與安慰劑之間差別的統計學意義或 p 值:

```

# Example from "Statistics is Easy" by Dennis Shasha and Manda Wilson
from statistics import fmean as mean
from random import shuffle

drug = [54, 73, 53, 70, 73, 68, 52, 65, 65]
placebo = [54, 51, 58, 44, 55, 52, 42, 47, 58, 46]
observed_diff = mean(drug) - mean(placebo)

n = 10_000
count = 0
combined = drug + placebo
for i in range(n):
    shuffle(combined)
    new_diff = mean(combined[:len(drug)]) - mean(combined[len(drug):])
    count += (new_diff >= observed_diff)

print(f'{n} label reshufflings produced only {count} instances with a difference')
print(f'at least as extreme as the observed difference of {observed_diff:.1f}.')
print(f'The one-sided p-value of {count / n:.4f} leads us to reject the null')
print(f'hypothesis that there is no difference between the drug and the placebo.')

```

模擬多伺服器 F 列 (queue) 的到達時間與服務交付:

```

from heapq import heapify, heapreplace
from random import expovariate, gauss
from statistics import mean, quantiles

average_arrival_interval = 5.6
average_service_time = 15.0
stdev_service_time = 3.5
num_servers = 3

waits = []
arrival_time = 0.0
servers = [0.0] * num_servers # time when each server becomes available
heapify(servers)
for i in range(1_000_000):
    arrival_time += expovariate(1.0 / average_arrival_interval)
    next_server_available = servers[0]

```

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```

wait = max(0.0, next_server_available - arrival_time)
waits.append(wait)
service_duration = max(0.0, gauss(average_service_time, stdev_service_time))
service_completed = arrival_time + wait + service_duration
heapreplace(servers, service_completed)

print(f'Mean wait: {mean(waits):.1f}    Max wait: {max(waits):.1f}')
print('Quartiles:', [round(q, 1) for q in quantiles(waits)])

```

也參考:

[Statistics for Hackers](#) 是由 [Jake Vanderplas](#) 作的教學影片，僅使用幾個基本概念（包括模擬、取樣、洗牌、交叉驗證）進行統計分析。

[Economics Simulation](#) a simulation of a marketplace by [Peter Norvig](#) that shows effective use of many of the tools and distributions provided by this module (gauss, uniform, sample, betavariate, choice, triangular, and randrange).

[A Concrete Introduction to Probability \(using Python\)](#) a tutorial by [Peter Norvig](#) covering the basics of probability theory, how to write simulations, and how to perform data analysis using Python.

9.6.9 使用方案

These recipes show how to efficiently make random selections from the combinatoric iterators in the *itertools* module:

```

def random_product(*args, repeat=1):
    "Random selection from itertools.product(*args, **kwargs)"
    pools = [tuple(pool) for pool in args] * repeat
    return tuple(map(random.choice, pools))

def random_permutation(iterable, r=None):
    "Random selection from itertools.permutations(iterable, r)"
    pool = tuple(iterable)
    r = len(pool) if r is None else r
    return tuple(random.sample(pool, r))

def random_combination(iterable, r):
    "Random selection from itertools.combinations(iterable, r)"
    pool = tuple(iterable)
    n = len(pool)
    indices = sorted(random.sample(range(n), r))
    return tuple(pool[i] for i in indices)

def random_combination_with_replacement(iterable, r):
    "Choose r elements with replacement. Order the result to match the iterable."
    # Result will be in set(itertools.combinations_with_replacement(iterable, r)).
    pool = tuple(iterable)
    n = len(pool)
    indices = sorted(random.choices(range(n), k=r))
    return tuple(pool[i] for i in indices)

```

預設的 *random()* 回傳 $0.0 \leq x < 1.0$ 範圍內 2^{-53} 的倍數。所有數字都是均分 $\frac{1}{2^{53}}$ 的，且可以完全表示 Python float。但是，該間隔中的許多其他可表示的 float 不是可能的選擇。例如 0.05954861408025609 不是 2^{-53} 的整數倍。

以下範例用不同的方法。間隔中的所有 float 都是可能的選擇。尾數來自 $2^{52} \leq \text{尾數} < 2^{53}$ 範圍內的整數均分 $\frac{1}{2^{53}}$ 。指數來自幾何分 $\frac{1}{2}$ ，其中小於 -53 的指數的出現頻率是下一個較大指數的一半。

```

from random import Random
from math import ldexp

```

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```
class FullRandom(Random):

    def random(self):
        mantissa = 0x10_0000_0000_0000 | self.getrandbits(52)
        exponent = -53
        x = 0
        while not x:
            x = self.getrandbits(32)
            exponent += x.bit_length() - 32
        return ldexp(mantissa, exponent)
```

Class 中的所有實數分數都將使用新方法：

```
>>> fr = FullRandom()
>>> fr.random()
0.05954861408025609
>>> fr.expovariate(0.25)
8.87925541791544
```

該範例在概念上等效於一種演算法，該演算法從 $0.0 \leq x < 1.0$ 範圍內 2^{-1074} 的所有倍數中進行選擇。這些數字都是均勻分佈的，但大多數必須向下舍入到最接近的可表示的 Python float。 (2^{-1074}) 是最小的非正規格 float，等於 `math.ulp(0.0)`。

也參考：

生成隨機浮點值 Allen B. Downey 的一篇論文描述了生成比通常由 `random()` 生成的 float 更 fine-grained (細粒的) 的方法。

9.7 statistics --- 數學統計函式

在 3.4 版新加入。

原始碼：[Lib/statistics.py](#)

這個模組提供計算數值 (Real-valued) 資料的數學統計函式。

這個模組並非旨在與 NumPy、SciPy 等第三方函式庫，或者像 Minitab、SAS 和 Matlab 等專門設計給專業統計學家的高階統計軟體互相競爭。此模組的目標在於繪圖和科學計算。

除非特別說明，這些函數支援 `int`、`float`、`Decimal` 以及 `Fraction`。目前不支援其他型別（無論是或數值型別）。含有混合型別的資料的集合亦是尚未定義，且取決於該型別的實作。若你的輸入資料含有混合型別，你可以考慮使用 `map()` 來確保結果是一致的，例如：`map(float, input_data)`。

有些資料集使用 NaN（非數）來表示缺漏的資料。由於 NaN 具有特殊的比較語義，在排序資料或是統計出現次數的統計函數中，會引發意料之外或是未定義的行為。受影響的函數包含 `median()`、`median_low()`、`median_high()`、`median_grouped()`、`mode()`、`multimode()` 以及 `quantiles()`。在呼叫這些函數之前，應該先移除 NaN 值：

```
>>> from statistics import median
>>> from math import isnan
>>> from itertools import filterfalse

>>> data = [20.7, float('NaN'), 19.2, 18.3, float('NaN'), 14.4]
>>> sorted(data) # This has surprising behavior
[20.7, nan, 14.4, 18.3, 19.2, nan]
>>> median(data) # This result is unexpected
16.35
```

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```

>>> sum(map(isnan, data))      # Number of missing values
2
>>> clean = list(filterfalse(isnan, data))  # Strip NaN values
>>> clean
[20.7, 19.2, 18.3, 14.4]
>>> sorted(clean)  # Sorting now works as expected
[14.4, 18.3, 19.2, 20.7]
>>> median(clean)      # This result is now well defined
18.75

```

9.7.1 平均值與中央位置量數

這些函式計算來自一個母體或樣本的平均值或代表值。

<code>mean()</code>	資料的算術平均數（平均值）。
<code>fmean()</code>	快速浮點數算數平均數，可調整權重。
<code>geometric_mean()</code>	資料的幾何平均數。
<code>harmonic_mean()</code>	資料的調和平均數。
<code>median()</code>	資料的中位數（中間值）。
<code>median_low()</code>	資料中較小的中位數。
<code>median_high()</code>	資料中較大的中位數。
<code>median_grouped()</code>	分組資料的中位數或 50% 處。
<code>mode()</code>	離散 (discrete) 或名目 (nomial) 資料中的 數（出現次數最多次的值），只回傳一個。
<code>multimode()</code>	離散或名目資料中的 數（出現次數最多次的值）組成的 list。
<code>quantiles()</code>	將資料分成數個具有相等機率的區間，即分位數 (quantile)。

9.7.2 離度 (spread) 的測量

這些函式計算母體或樣本偏離平均值的程度。

<code>pstdev()</code>	資料的母體標準差。
<code>pvariance()</code>	資料的母體變數。
<code>stdev()</code>	資料的樣本標準差。
<code>variance()</code>	資料的樣本變數。

9.7.3 兩個輸入之間的關 統計

這些函式計算兩個輸入之間的關 統計數據。

<code>covariance()</code>	兩變數的樣本共變數。
<code>correlation()</code>	兩個變數之間的 Pearson 相關數 (correlation coefficient)。
<code>linear_regression()</code>	簡單 性 歸的斜率和截距。

9.7.4 函式細節

⚠：這些函數⚠不要求輸入的資料必須排序過。⚠了⚠讀方便，大部份的範例仍已排序過。

`statistics.mean(data)`

回傳 *data* 的樣本算數平均數，輸入可⚠一個 *sequence* 或者 *iterable*。

算數平均數⚠資料總和除以資料點的數目。他通常被稱⚠「平均值」，⚠管它只是⚠多不同的數學平均值之一。它是衡量資料集中位置的一種指標。

若 *data* ⚠空，則會引發 *StatisticsError*。

使用範例：

```
>>> mean([1, 2, 3, 4, 4])
2.8
>>> mean([-1.0, 2.5, 3.25, 5.75])
2.625

>>> from fractions import Fraction as F
>>> mean([F(3, 7), F(1, 21), F(5, 3), F(1, 3)])
Fraction(13, 21)

>>> from decimal import Decimal as D
>>> mean([D("0.5"), D("0.75"), D("0.625"), D("0.375")])
Decimal('0.5625')
```

備⚠：平均值⚠烈受到離群值 (outliers) 的影響，且不一定能當作這些資料點的典型範例。若要使用更穩健但效率較低的集中趨勢 (central tendency) 度量，請參考 *median()*。

樣本平均數提供了對真實母體平均數的不偏估計 (unbiased estimate)，所以從所有可能的樣本中取平均值時，*mean(sample)* 會收斂至整個母體的真实平均值。若 *data* ⚠整個母體而非單一樣本，則 *mean(data)* 等同於計算真實的母體平均數 μ 。

`statistics.fmean(data, weights=None)`

將 *data* 轉⚠浮點數⚠計算其算數平均數。

這個函式運算比 *mean()* 更快，⚠且它總是回傳一個 *float*。*data* 可以是一個 *sequence* 或者 *iterable*。如果輸入的資料⚠空，則引發 *StatisticsError*。

```
>>> fmean([3.5, 4.0, 5.25])
4.25
```

支援選擇性的加權。例如，一位教授以 20% 的比重計算小考分數，20% 的比重計算作業分數，30% 的比重計算期中考試分數，以及 30% 的比重計算期末考試分數：

```
>>> grades = [85, 92, 83, 91]
>>> weights = [0.20, 0.20, 0.30, 0.30]
>>> fmean(grades, weights)
87.6
```

如果有提供 *weights*，它必須與 *data* 長度相同，否則將引發 *ValueError*。

在 3.8 版新加入。

在 3.11 版的變更：新增 *weights* 的支援。

`statistics.geometric_mean(data)`

將 *data* 轉⚠成浮點數⚠計算其幾何平均數。

幾何平均數使用數值的乘積（與之對照，算數平均數使用的是數值的和）來表示 *data* 的集中趨勢或典型值。

若輸入的資料集空、包含零、包含負值，則引發 `StatisticsError`。 `data` 可 sequence 或者 iterable。

目前有特了精確結果而特多下什工夫。（然而，未來或許會有。）

```
>>> round(geometric_mean([54, 24, 36]), 1)
36.0
```

在 3.8 版新加入。

`statistics.harmonic_mean(data, weights=None)`

回傳 `data` 的調和平均數。 `data` 可實數 (real-valued) sequence 或者 iterable。如果省略 `weights` 或者 `weights` 為 `None`，則假設各權重相等。

調和平均數是資料的倒數 (reciprocal) 經過 `mean()` 運算過後的倒數。例如，三個數 a 、 b 與 c 的調和平均數等於 $3 / (1/a + 1/b + 1/c)$ 。若其中一個值零，結果將零。

調和平均數是一種平均數，是衡量資料中心位置的一種方法。它通常用於計算比率 (ratio) 或率 (rate) 的平均，例如速率 (speed)。

假設一輛汽車以時速 40 公里的速率行駛 10 公里，然後再以時速 60 公里的速率行駛 10 公里，求汽車的平均速率？

```
>>> harmonic_mean([40, 60])
48.0
```

假設一輛汽車以時速 40 公里的速率行駛 5 公里，然後在交通順暢時，加速到時速 60 公里，以此速度行駛剩下的 30 公里。求汽車的平均速率？

```
>>> harmonic_mean([40, 60], weights=[5, 30])
56.0
```

若 `data` 空、含有任何小於零的元素、或者加權總和不正數，則引發 `StatisticsError`。

目前的演算法設計，若在輸入當中遇到零，則會提前退出。這意味著後續的輸入未進行有效性檢查。（這種行在未來可能會改變。）

在 3.6 版新加入。

在 3.10 版的變更：新增 `weights` 的支援。

`statistics.median(data)`

使用常見的「中間兩數取平均」方法回傳數值資料的中位數（中間值）。若 `data` 空，則會引發 `StatisticsError`。 `data` 可一個 sequence 或者 iterable。

中位數是一種穩健的衡量資料中心位置的方法，較不易被離群值影響。當資料點數量奇數時，會回傳中間的資料點：

```
>>> median([1, 3, 5])
3
```

當資料點數量偶數時，中位數透過中間兩個值的平均數來插值計算：

```
>>> median([1, 3, 5, 7])
4.0
```

若你的資料離散資料，且你不介意中位數可能非真實的資料點，那這函式適合你。

若你的資料順序 (ordinal) 資料（支援排序操作）但非數值型（不支援加法），可以考慮改用 `median_low()` 或是 `median_high()` 代替。

`statistics.median_low(data)`

回傳數值型資料的低中位數 (low median)。若 `data` 空，則引發 `StatisticsError`。 `data` 可 sequence 或者 iterable。

低中位數一定會在原本的資料集當中。當資料點數量為奇數時，回傳中間值。當數量為偶數時，回傳兩個中間值當中較小的值。

```
>>> median_low([1, 3, 5])
3
>>> median_low([1, 3, 5, 7])
3
```

當你的資料為離散資料，且你希望中位數是實際的資料點而不是插值時，可以用低中位數。

`statistics.median_high(data)`

回傳數值型資料的高中位數 (high median)。若 `data` 為空，則引發 `StatisticsError`。`data` 可為 sequence 或者 iterable。

高中位數一定會在原本的資料集當中。當資料點數量為奇數時，回傳中間值。當數量為偶數時，回傳兩個中間值當中較大的值。

```
>>> median_high([1, 3, 5])
3
>>> median_high([1, 3, 5, 7])
5
```

當你的資料為離散資料，且你希望中位數是實際的資料點而不是插值時，可以用高中位數。

`statistics.median_grouped(data, interval=1)`

回傳分組連續資料的中位數，該數值透過插法計算第 50 百分位數而得。若 `data` 為空，則會引發 `StatisticsError`。`data` 可為一個 sequence 或者 iterable。

```
>>> median_grouped([52, 52, 53, 54])
52.5
```

在以下範例中，資料已經四舍五入，每個值代表每組資料的中點。舉例來說，1 是組 0.5--1.5 的中點，2 是組 1.5--2.5 的中點，3 是組 2.5--3.5 的中點等。根據輸入的資料，中間值落在 3.5--4.5 的組中，使用插法來估計它：

```
>>> median_grouped([1, 2, 2, 3, 4, 4, 4, 4, 4, 5])
3.7
```

選擇性引數 `interval` 表示組距 (class interval)，預設值為 1。改變組距自然會改變插值：

```
>>> median_grouped([1, 3, 3, 5, 7], interval=1)
3.25
>>> median_grouped([1, 3, 3, 5, 7], interval=2)
3.5
```

此函式不檢查資料點是否至少間隔 `interval` 以上。

CPython 實作細節：在部份情況下，`median_grouped()` 可能會限制將資料點轉為浮點數。這種行爲在未來可能會改變。

也參考：

- "Statistics for the Behavioral Sciences", Frederick J Gravetter and Larry B Wallnau (8th Edition).
- Gnome Gnumeric 試算表中的 `SSMEDIAN` 函式，包括這篇討論。

`statistics.mode(data)`

回傳離散或名目 `data` 中出現次數最多次的值，只回傳一個。該數（如果存在）是最典型的值，用來衡量資料的中心位置。

若有多個出現次數相同的該數，則回傳在 `data` 中最先出現的該數。如果希望回傳其中最小或最大的該數，可以使用 `min(multimode(data))` 或 `max(multimode(data))`。如果輸入的 `data` 為空，則會引發 `StatisticsError`。

`mode` 假定離散資料，回傳單一的值。這也是一般學校教授的标准數定義：

```
>>> mode([1, 1, 2, 3, 3, 3, 3, 4])
3
```

數特之處在於它是此套件中唯一也適用於名目（非數值型）資料的統計量：

```
>>> mode(["red", "blue", "blue", "red", "green", "red", "red"])
'red'
```

在 3.8 版的變更：現在，遇到資料中有多個數時，會回傳第一個遇到的數。在以前，當找到大於一個數時，會引發 `StatisticsError`。

`statistics.multimode(data)`

回傳一個 list，其組成 `data` 中出現次數最多次的值，按照它們在 `data` 中首次出現的順序排列。如果有多個數，將會回傳所有結果。若 `data` 空，則回傳空的 list：

```
>>> multimode('aabbccdddeeffffgg')
['b', 'd', 'f']
>>> multimode('')
[]
```

在 3.8 版新加入。

`statistics.pstdev(data, mu=None)`

回傳母體標準差（即母體變數的平方根）。有關引數以及其他細節，請參見 `pvariance()`。

```
>>> pstdev([1.5, 2.5, 2.5, 2.75, 3.25, 4.75])
0.986893273527251
```

`statistics.pvariance(data, mu=None)`

回傳 `data` 的母體變數。`data` 可非空實數 sequence 或者 iterable。變數，或者以平均數中心的二階動差，用於衡量資料的變性（離度或分散程度）。變數大表示資料分散，變數小表示資料集中在平均數附近。

若有傳入選擇性的第二個引數 `mu`，該引數通常是 `data` 的平均值。它也可以用於計算非以平均值中心的第二動差。如果有傳入此引數或者引數 `None`（預設值），則自動計算資料的算數平均數。

使用此函式來計算整個母體的變數。如果要從樣本估算變數，`variance()` 通常是較好的選擇。

若 `data` 空，則引發 `StatisticsError`。

範例：

```
>>> data = [0.0, 0.25, 0.25, 1.25, 1.5, 1.75, 2.75, 3.25]
>>> pvariance(data)
1.25
```

如果已經計算出資料的平均值，你可以將其作選擇性的第二個引數 `mu` 傳遞以避免重新計算：

```
>>> mu = mean(data)
>>> pvariance(data, mu)
1.25
```

支援小數 (decimal) 與分數 (fraction)：

```
>>> from decimal import Decimal as D
>>> pvariance([D("27.5"), D("30.25"), D("30.25"), D("34.5"), D("41.75")])
Decimal('24.815')

>>> from fractions import Fraction as F
>>> pvariance([F(1, 4), F(5, 4), F(1, 2)])
Fraction(13, 72)
```


備註：當在整個母體上呼叫此函式時，會回傳母體變異數 σ^2 。當在樣本上呼叫此函式時，會回傳有偏差的樣本變異數 s^2 ，也就是具有 N 個自由度的變異數。

若你以某種方式知道真正的母體平均數 μ ，你可以將一個已知的母體平均數作為第二個引數提供給此函式，用以計算樣本的變異數。只要資料點是母體的隨機樣本，結果將是母體變異數的不偏估計。

`statistics.stdev(data, xbar=None)`

回傳樣本標準差（即樣本變異數的平方根）。有關引數以及其他細節，請參見 `variance()`。

```
>>> stdev([1.5, 2.5, 2.5, 2.75, 3.25, 4.75])
1.0810874155219827
```

`statistics.variance(data, xbar=None)`

回傳 `data` 的樣本變異數。`data` 為兩個值以上的實數 iterable。變異數，或者以平均數為中心的二階動差，用於衡量資料的變異性（離度或分散程度）。變異數大表示資料分散，變異數小表示資料集中在平均數附近。

若有傳入選擇性的第二個引數 `xbar`，它應該是 `data` 的平均值。如果有傳入或者為 `None`（預設值），則自動計算資料的平均值。

當你的資料是來自母體的樣本時，請使用此函式。若要從整個母體計算變異數，請參見 `pvariance()`。

若 `data` 少於兩個值，則引發 `StatisticsError`。

範例：

```
>>> data = [2.75, 1.75, 1.25, 0.25, 0.5, 1.25, 3.5]
>>> variance(data)
1.3720238095238095
```

如果已經計算出資料的平均值，你可以將其作為選擇性的第二個引數 `mu` 傳遞以避免重新計算：

```
>>> m = mean(data)
>>> variance(data, m)
1.3720238095238095
```

此函式不會驗證你傳入的 `xbar` 是否為實際的平均數。傳入任意的 `xbar` 會導致無效或不可能的結果。

支援小數 (decimal) 與分數 (fraction)：

```
>>> from decimal import Decimal as D
>>> variance([D("27.5"), D("30.25"), D("30.25"), D("34.5"), D("41.75")])
Decimal('31.01875')

>>> from fractions import Fraction as F
>>> variance([F(1, 6), F(1, 2), F(5, 3)])
Fraction(67, 108)
```

備註：這是經過 Bessel 校正 (Bessel's correction) 後的樣本變異數 s^2 ，又稱為自由度 $N-1$ 的變異數。只要資料點具有代表性（例如：獨立且具有相同分布），結果應該會是對真實母體變異數的不偏估計。

若你剛好知道真正的母體平均數 μ ，你應該將其作為 `mu` 參數傳入 `pvariance()` 函式來計算樣本變異數。

`statistics.quantiles(data, *, n=4, method='exclusive')`

將 `data` 分成 n 個具有相等機率的連續區間。回傳一個包含 $n - 1$ 個用於切分各區間的分隔點的 list。

將 n 設 4 以表示四分位數 (quartile) (預設值)。將 n 設置 100 表示百分位數 (percentile)，這將給出 99 個分隔點將 *data* 分成 100 個大小相等的組。如果 n 不是至少 1，則引發 *StatisticsError*。*data* 可以是包含樣本資料的任何 iterable。為了取得有意義的結果，*data* 中的資料點數量應大於 n 。如果資料點少於兩個，則引發 *StatisticsError*。

分隔點是從兩個最近的資料點线性插值計算出來的。舉例來說，如果分隔點落在兩個樣本值 100 與 112 之間的距離三分之一處，則分隔點的值將 104。

計算分位數的 *method* 可以根據 *data* 是否包含或排除來自母體的最小與最大可能的值而改變。

預設的 *method* 是 "exclusive"，用於從可能找到比樣本更極端的值的母體中抽樣的樣本資料。對於 m 個已排序的資料點，計算出低於 i -th 的部分 $i / (m + 1)$ 。給定九個樣本資料，此方法將對資料排序且計算下列百分位數：10%、20%、30%、40%、50%、60%、70%、80%、90%。

若將 *method* 設 "inclusive"，則用於描述母體或者已知包含母體中最極端值的樣本資料。在 *data* 中的最小值被視第 0 百分位數，最大值 第 100 百分位數。對於 m 個已排序的資料點，計算出低於 i -th 的部分 $(i - 1) / (m - 1)$ 。給定十一個樣本資料，此方法將對資料排序且計算下列百分位數：0%、10%、20%、30%、40%、50%、60%、70%、80%、90%、100%。

```
# Decile cut points for empirically sampled data
>>> data = [105, 129, 87, 86, 111, 111, 89, 81, 108, 92, 110,
...         100, 75, 105, 103, 109, 76, 119, 99, 91, 103, 129,
...         106, 101, 84, 111, 74, 87, 86, 103, 103, 106, 86,
...         111, 75, 87, 102, 121, 111, 88, 89, 101, 106, 95,
...         103, 107, 101, 81, 109, 104]
>>> [round(q, 1) for q in quantiles(data, n=10)]
[81.0, 86.2, 89.0, 99.4, 102.5, 103.6, 106.0, 109.8, 111.0]
```

在 3.8 版新加入。

`statistics.covariance(x, y, /)`

回傳兩輸入 x 與 y 的樣本共變數 (sample covariance)。共變數是衡量兩輸入的聯合變性 (joint variability) 的指標。

兩輸入必須具有相同長度 (至少兩個)，否則會引發 *StatisticsError*。

範例：

```
>>> x = [1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> y = [1, 2, 3, 1, 2, 3, 1, 2, 3]
>>> covariance(x, y)
0.75
>>> z = [9, 8, 7, 6, 5, 4, 3, 2, 1]
>>> covariance(x, z)
-7.5
>>> covariance(z, x)
-7.5
```

在 3.10 版新加入。

`statistics.correlation(x, y, /)`

回傳兩輸入的 Pearson 相關係數 (Pearson's correlation coefficient)。Pearson 相關係數 r 的值介於 -1 與 +1 之間。它衡量线性關係的強度與方向，其中 +1 表示強烈正线性相關，-1 表示強烈負线性相關，而 0 表示無线性關係。

兩輸入必須具有相同長度 (至少兩個)，且不須非常數，否則會引發 *StatisticsError*。

範例：

```
>>> x = [1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> y = [9, 8, 7, 6, 5, 4, 3, 2, 1]
>>> correlation(x, x)
1.0
```

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```
>>> correlation(x, y)
-1.0
```

在 3.10 版新加入。

`statistics.linear_regression(x, y, /, *, proportional=False)`

回傳使用普通最小平方法 (ordinary least square) 估計出的簡單线性回歸 (simple linear regression) 參數中的斜率 (slope) 與截距 (intercept)。簡單线性回歸描述自變數 (independent variable) x 與應變數 (dependent variable) y 之間的關係，用以下的线性函式表示：

$$y = \text{slope} * x + \text{intercept} + \text{noise}$$

其中 `slope` 和 `intercept` 是被估計的线性回歸參數，而 `noise` 表示由线性回歸未解釋的資料變异性 (它等於應變數的預測值與實際值之差)。

兩輸入必須具有相同長度 (至少兩個)，且自變數 x 不得為常數，否則會引發 `StatisticsError`。

舉例來說，我們可以使用 `Monty Python` 系列電影的上映日期來預測至 2019 年為止，假設他們保持固定的製作速度，應該會產生的 `Monty Python` 電影的累計數量。

```
>>> year = [1971, 1975, 1979, 1982, 1983]
>>> films_total = [1, 2, 3, 4, 5]
>>> slope, intercept = linear_regression(year, films_total)
>>> round(slope * 2019 + intercept)
16
```

若將 `proportional` 設為 `True`，則假設自變數 x 與應變數 y 是直接成比例的，資料座落在通過原點的一直線上。由於 `intercept` 始終為 0.0，因此线性函式可簡化如下：

$$y = \text{slope} * x + \text{noise}$$

在 3.10 版新加入。

在 3.11 版的變更：新增 `proportional` 的支援。

9.7.5 例外

定義了一個單一的例外：

exception `statistics.StatisticsError`

`ValueError` 的子類，用於和統計相關的例外。

9.7.6 NormalDist 物件

`NormalDist` 是一種用於建立與操作隨機變數 (random variable) 的常態分布的工具。它是一個將量測資料的平均數與標準差視為單一實體的類。

常態分布源自於中央極限定理 (Central Limit Theorem)，在統計學中有著廣泛的應用。

class `statistics.NormalDist(mu=0.0, sigma=1.0)`

此方法會回傳一個新 `NormalDist` 物件，其中 `mu` 代表算數平均數而 `sigma` 代表標準差。

若 `sigma` 為負值，則引發 `StatisticsError`。

mean

常態分布中的算數平均數唯讀屬性。

median

常態分布中的中位數唯讀屬性。

mode

常態分布中的`mode`唯讀屬性。

stdev

常態分布中的標準差唯讀屬性。

variance

常態分布中的變異數唯讀屬性。

classmethod from_samples (data)

利用 `fmean()` 與 `stdev()` 函式，估計 `data` 的 `mu` 與 `sigma` 參數，建立一個常態分布的實例。

`data` 可以是任何 `iterable`，應包含可以轉換為 `float` 的值。若 `data` 有包含至少兩個以上的元素，則引發 `StatisticsError`，因至少需要一個點來估計中央值且至少需要兩個點來估計分散情形。

samples (n, *, seed=None)

給定平均值與標準差，生成 `n` 個隨機樣本。回傳一個由 `float` 組成的 `list`。

若有給定 `seed`，則會建立一個以此為基礎的亂數生成器實例。這對於建立可重現的結果很有幫助，即使在多執行緒情境下也是如此。

pdf (x)

利用機率密度函式 (probability density function, pdf) 計算隨機變數 X 接近給定值 x 的相對概度 (relative likelihood)。數學上，它是比率 $P(x \leq X < x+dx) / dx$ 在 dx 趨近於零時的極限值。

相對概度是樣本出現在狹窄範圍的機率，除以該範圍的寬度（故稱「密度」）計算而得。由於概度是相對於其它點，故其值可大於 1.0。

cdf (x)

利用累積分布函式 (cumulative distribution function, cdf) 計算隨機變數 X 小於或等於 x 的機率。數學上，它記 $P(X \leq x)$ 。

inv_cdf (p)

計算反累積分布函式 (inverse cumulative distribution function)，也稱分位數函式 (quantile function) 或者百分率點 (percent-point) 函式。數學上記 $x : P(X \leq x) = p$ 。

找出一個值 x ，使得隨機變數 X 小於或等於該值的機率等於給定的機率 p 。

overlap (other)

衡量兩常態分布之間的一致性。回傳一個介於 0.0 與 1.0 之間的值，表示兩機率密度函式的重疊區域。

quantiles (n=4)

將常態分布分割成 n 個具有相等機率的連續區間。回傳一個 `list`，包含 $(n-1)$ 個切割區間的分隔點。

將 n 設定為 4 表示四分位數（預設值）。將 n 設定為 10 表示十分位數。將 n 設定為 100 表示百分位數，這會生成 99 個分隔點，將常態分布切割成大小相等的群組。

zscore (x)

計算標準分數 (Standard Score)，用以描述在常態分布中， x 高出或低於平均數幾個標準差： $(x - \text{mean}) / \text{stdev}$ 。

在 3.9 版新加入。

`NormalDist` 的實例支援對常數的加法、乘法、乘法與除法。這些操作用於平移與縮放。例如：

```
>>> temperature_february = NormalDist(5, 2.5)           # Celsius
>>> temperature_february * (9/5) + 32                  # Fahrenheit
NormalDist(mu=41.0, sigma=4.5)
```

不支援將常數除以 `NormalDist` 的實例，因結果將不符合常態分布。

由於常態分布源自於自變數的加法效應 (additive effects)，因此可以將兩個獨立的常態分布隨機變數相加與相，且表示 `NormalDist` 的實例。例如：

```
>>> birth_weights = NormalDist.from_samples([2.5, 3.1, 2.1, 2.4, 2.7, 3.5])
>>> drug_effects = NormalDist(0.4, 0.15)
>>> combined = birth_weights + drug_effects
>>> round(combined.mean, 1)
3.1
>>> round(combined.stdev, 1)
0.5
```

在 3.8 版新加入。

NormalDist 范例與錦囊妙計

`NormalDist` 可以輕易地解經典的機率問題。

例如，給定 SAT 測驗的歷史資料，顯示成績平均 1060、標準差 195 的常態分布。我們要求出分數在 1100 與 1200 之間（四舍五入至最接近的整數）的學生的百分比：

```
>>> sat = NormalDist(1060, 195)
>>> fraction = sat.cdf(1200 + 0.5) - sat.cdf(1100 - 0.5)
>>> round(fraction * 100.0, 1)
18.4
```

找出 SAT 分數的四分位數以及十分位數：

```
>>> list(map(round, sat.quantiles()))
[928, 1060, 1192]
>>> list(map(round, sat.quantiles(n=10)))
[810, 896, 958, 1011, 1060, 1109, 1162, 1224, 1310]
```

欲估計一個不易透過解析方法求解的模型的分布，`NormalDist` 可以生成輸入樣本以進行 Monte Carlo 模擬：

```
>>> def model(x, y, z):
...     return (3*x + 7*x*y - 5*y) / (11 * z)
...
>>> n = 100_000
>>> X = NormalDist(10, 2.5).samples(n, seed=3652260728)
>>> Y = NormalDist(15, 1.75).samples(n, seed=4582495471)
>>> Z = NormalDist(50, 1.25).samples(n, seed=6582483453)
>>> quantiles(map(model, X, Y, Z))
[1.4591308524824727, 1.8035946855390597, 2.175091447274739]
```

當樣本數量很大，且試驗成功的機率接近 50%，可以使用常態分布來近似二項分布 (Binomial distributions)。

例如，一場有 750 位參加者的開源研討會中，有兩間可容納 500 人的會議室。一場是關於 Python 的講座，另一場則是關於 Ruby 的。在過去的會議中，有 65% 的參加者傾向參與 Python 講座。假設參與者的偏好有改變，那 Python 會議室未超過自身容量限制的機率是？

```
>>> n = 750                # Sample size
>>> p = 0.65               # Preference for Python
>>> q = 1.0 - p            # Preference for Ruby
>>> k = 500                # Room capacity

>>> # Approximation using the cumulative normal distribution
>>> from math import sqrt
>>> round(NormalDist(mu=n*p, sigma=sqrt(n*p*q)).cdf(k + 0.5), 4)
0.8402
```

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```
>>> # Solution using the cumulative binomial distribution
>>> from math import comb, fsum
>>> round(fsum(comb(n, r) * p**r * q**(n-r) for r in range(k+1)), 4)
0.8402

>>> # Approximation using a simulation
>>> from random import seed, choices
>>> seed(8675309)
>>> def trial():
...     return choices(('Python', 'Ruby'), (p, q), k=n).count('Python')
>>> mean(trial() <= k for i in range(10_000))
0.8398
```

常態分布常在機器學習問題中出現。

維基百科有個 [Naive Bayesian Classifier](#) 的優良範例。課題 從身高、體重與鞋子尺寸等符合常態分布的特徵量測值中判斷一個人的性別。

給定一組包含八個人的量測值的訓練資料集。假設這些量測值服從常態分布，我們可以利用 `NormalDist` 來總結資料：

```
>>> height_male = NormalDist.from_samples([6, 5.92, 5.58, 5.92])
>>> height_female = NormalDist.from_samples([5, 5.5, 5.42, 5.75])
>>> weight_male = NormalDist.from_samples([180, 190, 170, 165])
>>> weight_female = NormalDist.from_samples([100, 150, 130, 150])
>>> foot_size_male = NormalDist.from_samples([12, 11, 12, 10])
>>> foot_size_female = NormalDist.from_samples([6, 8, 7, 9])
```

接著，我們遇到一個新的人，他的特徵量測值已知，但性別未知：

```
>>> ht = 6.0          # height
>>> wt = 130          # weight
>>> fs = 8            # foot size
```

從可能 男性或女性的 50% 先驗機率 (prior probability) 開端，我們將後驗機率 (posterior probability) 計算 先驗機率乘以給定性 下，各特徵量測值的概度乘積：

```
>>> prior_male = 0.5
>>> prior_female = 0.5
>>> posterior_male = (prior_male * height_male.pdf(ht) *
...                   weight_male.pdf(wt) * foot_size_male.pdf(fs))

>>> posterior_female = (prior_female * height_female.pdf(ht) *
...                     weight_female.pdf(wt) * foot_size_female.pdf(fs))
```

最終的預測結果將取 於最大的後驗機率。這被稱 最大後驗機率 (maximum a posteriori) 或者 MAP：

```
>>> 'male' if posterior_male > posterior_female else 'female'
'female'
```

The modules described in this chapter provide functions and classes that support a functional programming style, and general operations on callables.

本章包含下列的模組：

10.1 `itertools` --- Functions creating iterators for efficient looping

This module implements a number of *iterator* building blocks inspired by constructs from APL, Haskell, and SML. Each has been recast in a form suitable for Python.

The module standardizes a core set of fast, memory efficient tools that are useful by themselves or in combination. Together, they form an “iterator algebra” making it possible to construct specialized tools succinctly and efficiently in pure Python.

For instance, SML provides a tabulation tool: `tabulate(f)` which produces a sequence `f(0), f(1), ...`. The same effect can be achieved in Python by combining `map()` and `count()` to form `map(f, count())`.

These tools and their built-in counterparts also work well with the high-speed functions in the *operator* module. For example, the multiplication operator can be mapped across two vectors to form an efficient dot-product: `sum(starmap(operator.mul, zip(vec1, vec2, strict=True)))`.

Infinite iterators:

Iterator	引數	結果	範例
<code>count()</code>	start, [step]	start, start+step, start+2*step, ...	<code>count(10) --> 10 11 12 13 14</code> ...
<code>cycle()</code>	p	p0, p1, ... plast, p0, p1, ...	<code>cycle('ABCD') --> A B C D A B</code> C D ...
<code>repeat()</code>	elem [,n]	elem, elem, elem, ... endlessly or up to n times	<code>repeat(10, 3) --> 10 10 10</code>

Iterators terminating on the shortest input sequence:

Iterator	引數	結果	範例
<code>accumulate()</code>	<code>p [,func]</code>	<code>p0, p0+p1, p0+p1+p2, ...</code>	<code>accumulate([1,2,3,4,5]) --> 1 3 6 10 15</code>
<code>chain()</code>	<code>p, q, ...</code>	<code>p0, p1, ... plast, q0, q1, ...</code>	<code>chain('ABC', 'DEF') --> A B C D E F</code>
<code>chain.from_iterable</code>	iterable	<code>p0, p1, ... plast, q0, q1, ...</code>	<code>chain.from_iterable(['ABC', 'DEF']) --> A B C D E F</code>
<code>compress()</code>	data, selectors	<code>(d[0] if s[0]), (d[1] if s[1]), ...</code>	<code>compress('ABCDEF', [1,0,1,0,1,1]) --> A C E F</code>
<code>dropwhile()</code>	<code>pred, seq</code>	<code>seq[n], seq[n+1], starting when pred fails</code>	<code>dropwhile(lambda x: x<5, [1,4,6,4,1]) --> 6 4 1</code>
<code>filterfalse()</code>	<code>pred, seq</code>	elements of seq where <code>pred(elem)</code> is false	<code>filterfalse(lambda x: x%2, range(10)) --> 0 2 4 6 8</code>
<code>groupby()</code>	iterable[, key]	sub-iterators grouped by value of <code>key(v)</code>	
<code>islice()</code>	<code>seq, [start,] stop [, step]</code>	elements from <code>seq[start:stop:step]</code>	<code>islice('ABCDEFGH', 2, None) --> C D E F G</code>
<code>pairwise()</code>	iterable	<code>(p[0], p[1]), (p[1], p[2]), ...</code>	<code>pairwise('ABCDEFGH') --> AB BC CD DE EF FG</code>
<code>starmap()</code>	<code>func, seq</code>	<code>func(*seq[0]), func(*seq[1]), ...</code>	<code>starmap(pow, [(2,5), (3,2), (10,3)]) --> 32 9 1000</code>
<code>takewhile()</code>	<code>pred, seq</code>	<code>seq[0], seq[1], until pred fails</code>	<code>takewhile(lambda x: x<5, [1,4,6,4,1]) --> 1 4</code>
<code>tee()</code>	<code>it, n</code>	<code>it1, it2, ... itn</code> splits one iterator into <code>n</code>	
<code>zip_longest()</code>	<code>p, q, ...</code>	<code>(p[0], q[0]), (p[1], q[1]), ...</code>	<code>zip_longest('ABCD', 'xy', fillvalue='-') --> Ax By C- D-</code>

Combinatoric iterators:

Iterator	引數	結果
<code>product()</code>	<code>p, q, ... [repeat=1]</code>	cartesian product, equivalent to a nested for-loop
<code>permutations()</code>	<code>p[, r]</code>	<code>r</code> -length tuples, all possible orderings, no repeated elements
<code>combinations()</code>	<code>p, r</code>	<code>r</code> -length tuples, in sorted order, no repeated elements
<code>combinations_with_replacement</code>	<code>p, r</code>	<code>r</code> -length tuples, in sorted order, with repeated elements

Examples	結果
<code>product('ABCD', repeat=2)</code>	AA AB AC AD BA BB BC BD CA CB CC CD DA DB DC DD
<code>permutations('ABCD', 2)</code>	AB AC AD BA BC BD CA CB CD DA DB DC
<code>combinations('ABCD', 2)</code>	AB AC AD BC BD CD
<code>combinations_with_replacement('ABC', 2)</code>	AA AB AC AD BB BC BD CC CD DD

10.1.1 Itertool functions

The following module functions all construct and return iterators. Some provide streams of infinite length, so they should only be accessed by functions or loops that truncate the stream.

`itertools.accumulate(iterable[, func, *, initial=None])`

Make an iterator that returns accumulated sums, or accumulated results of other binary functions (specified via the optional *func* argument).

If *func* is supplied, it should be a function of two arguments. Elements of the input *iterable* may be any type that can be accepted as arguments to *func*. (For example, with the default operation of addition, elements may be any addable type including *Decimal* or *Fraction*.)

Usually, the number of elements output matches the input iterable. However, if the keyword argument *initial* is provided, the accumulation leads off with the *initial* value so that the output has one more element than the input iterable.

大致等價於：

```
def accumulate(iterable, func=operator.add, *, initial=None):
    'Return running totals'
    # accumulate([1,2,3,4,5]) --> 1 3 6 10 15
    # accumulate([1,2,3,4,5], initial=100) --> 100 101 103 106 110 115
    # accumulate([1,2,3,4,5], operator.mul) --> 1 2 6 24 120
    it = iter(iterable)
    total = initial
    if initial is None:
        try:
            total = next(it)
        except StopIteration:
            return
    yield total
    for element in it:
        total = func(total, element)
        yield total
```

There are a number of uses for the *func* argument. It can be set to *min()* for a running minimum, *max()* for a running maximum, or *operator.mul()* for a running product. Amortization tables can be built by accumulating interest and applying payments:

```
>>> data = [3, 4, 6, 2, 1, 9, 0, 7, 5, 8]
>>> list(accumulate(data, operator.mul))      # running product
[3, 12, 72, 144, 144, 1296, 0, 0, 0, 0]
>>> list(accumulate(data, max))              # running maximum
[3, 4, 6, 6, 6, 9, 9, 9, 9, 9]

# Amortize a 5% loan of 1000 with 4 annual payments of 90
>>> cashflows = [1000, -90, -90, -90, -90]
>>> list(accumulate(cashflows, lambda bal, pmt: bal*1.05 + pmt))
[1000, 960.0, 918.0, 873.9000000000001, 827.5950000000001]
```

See *functools.reduce()* for a similar function that returns only the final accumulated value.

在 3.2 版新加入。

在 3.3 版的變更: 新增選用的 *func* 參數。

在 3.8 版的變更: 新增選用的 *initial* 參數。

`itertools.chain(*iterables)`

Make an iterator that returns elements from the first iterable until it is exhausted, then proceeds to the next iterable, until all of the iterables are exhausted. Used for treating consecutive sequences as a single sequence. Roughly equivalent to:

```
def chain(*iterables):
    # chain('ABC', 'DEF') --> A B C D E F
    for it in iterables:
        for element in it:
            yield element
```

classmethod `chain.from_iterable(iterable)`

Alternate constructor for `chain()`. Gets chained inputs from a single iterable argument that is evaluated lazily. Roughly equivalent to:

```
def from_iterable(iterables):
    # chain.from_iterable(['ABC', 'DEF']) --> A B C D E F
    for it in iterables:
        for element in it:
            yield element
```

itertools.combinations(iterable, r)

Return *r* length subsequences of elements from the input *iterable*.

The combination tuples are emitted in lexicographic ordering according to the order of the input *iterable*. So, if the input *iterable* is sorted, the output tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, there will be no repeated values in each combination.

大致等價於：

```
def combinations(iterable, r):
    # combinations('ABCD', 2) --> AB AC AD BC BD CD
    # combinations(range(4), 3) --> 012 013 023 123
    pool = tuple(iterable)
    n = len(pool)
    if r > n:
        return
    indices = list(range(r))
    yield tuple(pool[i] for i in indices)
    while True:
        for i in reversed(range(r)):
            if indices[i] != i + n - r:
                break
        else:
            return
        indices[i] += 1
        for j in range(i+1, r):
            indices[j] = indices[j-1] + 1
        yield tuple(pool[i] for i in indices)
```

The code for `combinations()` can be also expressed as a subsequence of `permutations()` after filtering entries where the elements are not in sorted order (according to their position in the input pool):

```
def combinations(iterable, r):
    pool = tuple(iterable)
    n = len(pool)
    for indices in permutations(range(n), r):
        if sorted(indices) == list(indices):
            yield tuple(pool[i] for i in indices)
```

The number of items returned is $n! / r! / (n-r)!$ when $0 \leq r \leq n$ or zero when $r > n$.

itertools.combinations_with_replacement(iterable, r)

Return *r* length subsequences of elements from the input *iterable* allowing individual elements to be repeated more than once.

The combination tuples are emitted in lexicographic ordering according to the order of the input *iterable*. So, if the input *iterable* is sorted, the output tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, the generated combinations will also be unique.

大致等價於：

```
def combinations_with_replacement(iterable, r):
    # combinations_with_replacement('ABC', 2) --> AA AB AC BB BC CC
    pool = tuple(iterable)
    n = len(pool)
    if not n and r:
        return
    indices = [0] * r
    yield tuple(pool[i] for i in indices)
    while True:
        for i in reversed(range(r)):
            if indices[i] != n - 1:
                break
        else:
            return
        indices[i:] = [indices[i] + 1] * (r - i)
        yield tuple(pool[i] for i in indices)
```

The code for `combinations_with_replacement()` can be also expressed as a subsequence of `product()` after filtering entries where the elements are not in sorted order (according to their position in the input pool):

```
def combinations_with_replacement(iterable, r):
    pool = tuple(iterable)
    n = len(pool)
    for indices in product(range(n), repeat=r):
        if sorted(indices) == list(indices):
            yield tuple(pool[i] for i in indices)
```

The number of items returned is $(n+r-1)! / r! / (n-1)!$ when $n > 0$.

在 3.1 版新加入。

`itertools.compress(data, selectors)`

Make an iterator that filters elements from *data* returning only those that have a corresponding element in *selectors* that evaluates to True. Stops when either the *data* or *selectors* iterables has been exhausted. Roughly equivalent to:

```
def compress(data, selectors):
    # compress('ABCDEF', [1,0,1,0,1,1]) --> A C E F
    return (d for d, s in zip(data, selectors) if s)
```

在 3.1 版新加入。

`itertools.count(start=0, step=1)`

Make an iterator that returns evenly spaced values starting with number *start*. Often used as an argument to `map()` to generate consecutive data points. Also, used with `zip()` to add sequence numbers. Roughly equivalent to:

```
def count(start=0, step=1):
    # count(10) --> 10 11 12 13 14 ...
    # count(2.5, 0.5) --> 2.5 3.0 3.5 ...
    n = start
    while True:
        yield n
        n += step
```

When counting with floating point numbers, better accuracy can sometimes be achieved by substituting multiplicative code such as: `(start + step * i for i in count())`.

在 3.1 版的變更: 新增 `step` 引數 允許多非整數引數。

`itertools.cycle(iterable)`

Make an iterator returning elements from the iterable and saving a copy of each. When the iterable is exhausted, return elements from the saved copy. Repeats indefinitely. Roughly equivalent to:

```
def cycle(iterable):
    # cycle('ABCD') --> A B C D A B C D A B C D ...
    saved = []
    for element in iterable:
        yield element
        saved.append(element)
    while saved:
        for element in saved:
            yield element
```

Note, this member of the toolkit may require significant auxiliary storage (depending on the length of the iterable).

`itertools.dropwhile(predicate, iterable)`

Make an iterator that drops elements from the iterable as long as the predicate is true; afterwards, returns every element. Note, the iterator does not produce *any* output until the predicate first becomes false, so it may have a lengthy start-up time. Roughly equivalent to:

```
def dropwhile(predicate, iterable):
    # dropwhile(lambda x: x<5, [1,4,6,4,1]) --> 6 4 1
    iterable = iter(iterable)
    for x in iterable:
        if not predicate(x):
            yield x
            break
    for x in iterable:
        yield x
```

`itertools.filterfalse(predicate, iterable)`

Make an iterator that filters elements from iterable returning only those for which the predicate is false. If *predicate* is None, return the items that are false. Roughly equivalent to:

```
def filterfalse(predicate, iterable):
    # filterfalse(lambda x: x%2, range(10)) --> 0 2 4 6 8
    if predicate is None:
        predicate = bool
    for x in iterable:
        if not predicate(x):
            yield x
```

`itertools.groupby(iterable, key=None)`

Make an iterator that returns consecutive keys and groups from the *iterable*. The *key* is a function computing a key value for each element. If not specified or is None, *key* defaults to an identity function and returns the element unchanged. Generally, the iterable needs to already be sorted on the same key function.

The operation of `groupby()` is similar to the `uniq` filter in Unix. It generates a break or new group every time the value of the key function changes (which is why it is usually necessary to have sorted the data using the same key function). That behavior differs from SQL's GROUP BY which aggregates common elements regardless of their input order.

The returned group is itself an iterator that shares the underlying iterable with `groupby()`. Because the source is shared, when the `groupby()` object is advanced, the previous group is no longer visible. So, if that data is needed later, it should be stored as a list:

```

groups = []
uniquekeys = []
data = sorted(data, key=keyfunc)
for k, g in groupby(data, keyfunc):
    groups.append(list(g))      # Store group iterator as a list
    uniquekeys.append(k)

```

`groupby()` 大致等價於：

```

class groupby:
    # [k for k, g in groupby('AAAABBBCCDAABBB')] --> A B C D A B
    # [list(g) for k, g in groupby('AAAABBBCCD')] --> AAAA BBB CC D

    def __init__(self, iterable, key=None):
        if key is None:
            key = lambda x: x
        self.keyfunc = key
        self.it = iter(iterable)
        self.tgtkey = self.currkey = self.currvalue = object()

    def __iter__(self):
        return self

    def __next__(self):
        self.id = object()
        while self.currkey == self.tgtkey:
            self.currvalue = next(self.it)      # Exit on StopIteration
            self.currkey = self.keyfunc(self.currvalue)
        self.tgtkey = self.currkey
        return (self.currkey, self._grouper(self.tgtkey, self.id))

    def _grouper(self, tgtkey, id):
        while self.id is id and self.currkey == tgtkey:
            yield self.currvalue
            try:
                self.currvalue = next(self.it)
            except StopIteration:
                return
            self.currkey = self.keyfunc(self.currvalue)

```

`itertools.islice(iterable, stop)`

`itertools.islice(iterable, start, stop[, step])`

Make an iterator that returns selected elements from the iterable. If *start* is non-zero, then elements from the iterable are skipped until *start* is reached. Afterward, elements are returned consecutively unless *step* is set higher than one which results in items being skipped. If *stop* is `None`, then iteration continues until the iterator is exhausted, if at all; otherwise, it stops at the specified position.

If *start* is `None`, then iteration starts at zero. If *step* is `None`, then the step defaults to one.

Unlike regular slicing, `islice()` does not support negative values for *start*, *stop*, or *step*. Can be used to extract related fields from data where the internal structure has been flattened (for example, a multi-line report may list a name field on every third line).

大致等價於：

```

def islice(iterable, *args):
    # islice('ABCDEFGH', 2) --> A B
    # islice('ABCDEFGH', 2, 4) --> C D
    # islice('ABCDEFGH', 2, None) --> C D E F G
    # islice('ABCDEFGH', 0, None, 2) --> A C E G
    s = slice(*args)
    start, stop, step = s.start or 0, s.stop or sys.maxsize, s.step or 1

```

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```

it = iter(range(start, stop, step))
try:
    nexti = next(it)
except StopIteration:
    # Consume *iterable* up to the *start* position.
    for i, element in zip(range(start), iterable):
        pass
    return
try:
    for i, element in enumerate(iterable):
        if i == nexti:
            yield element
            nexti = next(it)
except StopIteration:
    # Consume to *stop*.
    for i, element in zip(range(i + 1, stop), iterable):
        pass

```

`itertools.pairwise(iterable)`

Return successive overlapping pairs taken from the input *iterable*.

The number of 2-tuples in the output iterator will be one fewer than the number of inputs. It will be empty if the input *iterable* has fewer than two values.

大致等價於：

```

def pairwise(iterable):
    # pairwise('ABCDEFGH') --> AB BC CD DE EF FG
    a, b = tee(iterable)
    next(b, None)
    return zip(a, b)

```

在 3.10 版新加入。

`itertools.permutations(iterable, r=None)`

Return successive *r* length permutations of elements in the *iterable*.

If *r* is not specified or is `None`, then *r* defaults to the length of the *iterable* and all possible full-length permutations are generated.

The permutation tuples are emitted in lexicographic order according to the order of the input *iterable*. So, if the input *iterable* is sorted, the output tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, there will be no repeated values within a permutation.

大致等價於：

```

def permutations(iterable, r=None):
    # permutations('ABCD', 2) --> AB AC AD BA BC BD CA CB CD DA DB DC
    # permutations(range(3)) --> 012 021 102 120 201 210
    pool = tuple(iterable)
    n = len(pool)
    r = n if r is None else r
    if r > n:
        return
    indices = list(range(n))
    cycles = list(range(n, n-r, -1))
    yield tuple(pool[i] for i in indices[:r])
    while n:
        for i in reversed(range(r)):
            cycles[i] -= 1
            if cycles[i] == 0:

```

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```

        indices[i:] = indices[i+1:] + indices[i:i+1]
        cycles[i] = n - i
    else:
        j = cycles[i]
        indices[i], indices[-j] = indices[-j], indices[i]
        yield tuple(pool[i] for i in indices[:r])
        break
    else:
        return

```

The code for `permutations()` can be also expressed as a subsequence of `product()`, filtered to exclude entries with repeated elements (those from the same position in the input pool):

```

def permutations(iterable, r=None):
    pool = tuple(iterable)
    n = len(pool)
    r = n if r is None else r
    for indices in product(range(n), repeat=r):
        if len(set(indices)) == r:
            yield tuple(pool[i] for i in indices)

```

The number of items returned is $n! / (n-r)!$ when $0 \leq r \leq n$ or zero when $r > n$.

`itertools.product(*iterables, repeat=1)`

Cartesian product of input iterables.

Roughly equivalent to nested for-loops in a generator expression. For example, `product(A, B)` returns the same as `((x,y) for x in A for y in B)`.

The nested loops cycle like an odometer with the rightmost element advancing on every iteration. This pattern creates a lexicographic ordering so that if the input's iterables are sorted, the product tuples are emitted in sorted order.

To compute the product of an iterable with itself, specify the number of repetitions with the optional `repeat` keyword argument. For example, `product(A, repeat=4)` means the same as `product(A, A, A, A)`.

This function is roughly equivalent to the following code, except that the actual implementation does not build up intermediate results in memory:

```

def product(*args, repeat=1):
    # product('ABCD', 'xy') --> Ax Ay Bx By Cx Cy Dx Dy
    # product(range(2), repeat=3) --> 000 001 010 011 100 101 110 111
    pools = [tuple(pool) for pool in args] * repeat
    result = [[]]
    for pool in pools:
        result = [x+[y] for x in result for y in pool]
    for prod in result:
        yield tuple(prod)

```

Before `product()` runs, it completely consumes the input iterables, keeping pools of values in memory to generate the products. Accordingly, it is only useful with finite inputs.

`itertools.repeat(object[, times])`

Make an iterator that returns `object` over and over again. Runs indefinitely unless the `times` argument is specified.

大致等價於：

```

def repeat(object, times=None):
    # repeat(10, 3) --> 10 10 10
    if times is None:
        while True:

```

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```

        yield object
    else:
        for i in range(times):
            yield object

```

A common use for *repeat* is to supply a stream of constant values to *map* or *zip*:

```

>>> list(map(pow, range(10), repeat(2)))
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]

```

`itertools.starmap(function, iterable)`

Make an iterator that computes the function using arguments obtained from the iterable. Used instead of *map()* when argument parameters are already grouped in tuples from a single iterable (when the data has been "pre-zipped").

The difference between *map()* and *starmap()* parallels the distinction between `function(a,b)` and `function(*c)`. Roughly equivalent to:

```

def starmap(function, iterable):
    # starmap(pow, [(2,5), (3,2), (10,3)]) --> 32 9 1000
    for args in iterable:
        yield function(*args)

```

`itertools.takewhile(predicate, iterable)`

Make an iterator that returns elements from the iterable as long as the predicate is true. Roughly equivalent to:

```

def takewhile(predicate, iterable):
    # takewhile(lambda x: x<5, [1,4,6,4,1]) --> 1 4
    for x in iterable:
        if predicate(x):
            yield x
        else:
            break

```

`itertools.tee(iterable, n=2)`

Return *n* independent iterators from a single iterable.

The following Python code helps explain what *tee* does (although the actual implementation is more complex and uses only a single underlying FIFO queue):

```

def tee(iterable, n=2):
    it = iter(iterable)
    dequeues = [collections.deque() for i in range(n)]
    def gen(mydeque):
        while True:
            if not mydeque:
                # when the local deque is empty
                try:
                    newval = next(it)
                    # fetch a new value and
                except StopIteration:
                    return
                for d in dequeues:
                    # load it to all the dequeues
                    d.append(newval)
            yield mydeque.popleft()
    return tuple(gen(d) for d in dequeues)

```

Once a *tee()* has been created, the original *iterable* should not be used anywhere else; otherwise, the *iterable* could get advanced without the *tee* objects being informed.

tee iterators are not threadsafe. A *RuntimeError* may be raised when using simultaneously iterators returned by the same *tee()* call, even if the original *iterable* is threadsafe.

This `itertools` may require significant auxiliary storage (depending on how much temporary data needs to be stored). In general, if one iterator uses most or all of the data before another iterator starts, it is faster to use `list()` instead of `tee()`.

`itertools.zip_longest(*iterables, fillvalue=None)`

Make an iterator that aggregates elements from each of the iterables. If the iterables are of uneven length, missing values are filled-in with `fillvalue`. Iteration continues until the longest iterable is exhausted. Roughly equivalent to:

```
def zip_longest(*args, fillvalue=None):
    # zip_longest('ABCD', 'xy', fillvalue='-') --> Ax By C- D-
    iterators = [iter(it) for it in args]
    num_active = len(iterators)
    if not num_active:
        return
    while True:
        values = []
        for i, it in enumerate(iterators):
            try:
                value = next(it)
            except StopIteration:
                num_active -= 1
                if not num_active:
                    return
                iterators[i] = repeat(fillvalue)
                value = fillvalue
        values.append(value)
        yield tuple(values)
```

If one of the iterables is potentially infinite, then the `zip_longest()` function should be wrapped with something that limits the number of calls (for example `islice()` or `takewhile()`). If not specified, `fillvalue` defaults to `None`.

10.1.2 Itertools Recipes

This section shows recipes for creating an extended toolset using the existing `itertools` as building blocks.

The primary purpose of the `itertools` recipes is educational. The recipes show various ways of thinking about individual tools—for example, that `chain.from_iterable` is related to the concept of flattening. The recipes also give ideas about ways that the tools can be combined—for example, how `compress()` and `range()` can work together. The recipes also show patterns for using `itertools` with the `operator` and `collections` modules as well as with the built-in `itertools` such as `map()`, `filter()`, `reversed()`, and `enumerate()`.

A secondary purpose of the recipes is to serve as an incubator. The `accumulate()`, `compress()`, and `pairwise()` `itertools` started out as recipes. Currently, the `iter_index()` recipe is being tested to see whether it proves its worth.

Substantially all of these recipes and many, many others can be installed from the [more-itertools project](#) found on the Python Package Index:

```
python -m pip install more-itertools
```

Many of the recipes offer the same high performance as the underlying toolset. Superior memory performance is kept by processing elements one at a time rather than bringing the whole iterable into memory all at once. Code volume is kept small by linking the tools together in a functional style which helps eliminate temporary variables. High speed is retained by preferring “vectorized” building blocks over the use of `for`-loops and `generators` which incur interpreter overhead.

```
import collections
import math
import operator
```

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```

import random

def take(n, iterable):
    "Return first n items of the iterable as a list"
    return list(islice(iterable, n))

def prepend(value, iterable):
    "Prepend a single value in front of an iterable"
    # prepend(1, [2, 3, 4]) --> 1 2 3 4
    return chain([value], iterable)

def tabulate(function, start=0):
    "Return function(0), function(1), ..."
    return map(function, count(start))

def tail(n, iterable):
    "Return an iterator over the last n items"
    # tail(3, 'ABCDEFGH') --> E F G
    return iter(collections.deque(iterable, maxlen=n))

def consume(iterator, n=None):
    "Advance the iterator n-steps ahead. If n is None, consume entirely."
    # Use functions that consume iterators at C speed.
    if n is None:
        # feed the entire iterator into a zero-length deque
        collections.deque(iterator, maxlen=0)
    else:
        # advance to the empty slice starting at position n
        next(islice(iterator, n, n), None)

def nth(iterable, n, default=None):
    "Returns the nth item or a default value"
    return next(islice(iterable, n, n), None, default)

def all_equal(iterable):
    "Returns True if all the elements are equal to each other"
    g = groupby(iterable)
    return next(g, True) and not next(g, False)

def quantify(iterable, pred=bool):
    "Count how many times the predicate is True"
    return sum(map(pred, iterable))

def ncycles(iterable, n):
    "Returns the sequence elements n times"
    return chain.from_iterable(repeat(tuple(iterable), n))

def batched(iterable, n):
    "Batch data into tuples of length n. The last batch may be shorter."
    # batched('ABCDEFGH', 3) --> ABC DEF G
    if n < 1:
        raise ValueError('n must be at least one')
    it = iter(iterable)
    while batch := tuple(islice(it, n)):
        yield batch

def grouper(iterable, n, *, incomplete='fill', fillvalue=None):
    "Collect data into non-overlapping fixed-length chunks or blocks"
    # grouper('ABCDEFGH', 3, fillvalue='x') --> ABC DEF Gxx
    # grouper('ABCDEFGH', 3, incomplete='strict') --> ABC DEF ValueError
    # grouper('ABCDEFGH', 3, incomplete='ignore') --> ABC DEF

```

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```

args = [iter(iterable)] * n
if incomplete == 'fill':
    return zip_longest(*args, fillvalue=fillvalue)
if incomplete == 'strict':
    return zip(*args, strict=True)
if incomplete == 'ignore':
    return zip(*args)
else:
    raise ValueError('Expected fill, strict, or ignore')

def sumprod(vec1, vec2):
    "Compute a sum of products."
    return sum(starmap(operator.mul, zip(vec1, vec2, strict=True)))

def sum_of_squares(it):
    "Add up the squares of the input values."
    # sum_of_squares([10, 20, 30]) -> 1400
    return sumprod(*tee(it))

def transpose(it):
    "Swap the rows and columns of the input."
    # transpose([(1, 2, 3), (11, 22, 33)]) --> (1, 11) (2, 22) (3, 33)
    return zip(*it, strict=True)

def matmul(m1, m2):
    "Multiply two matrices."
    # matmul([(7, 5), (3, 5)], [[2, 5], [7, 9]]) --> (49, 80), (41, 60)
    n = len(m2[0])
    return batched(starmap(sumprod, product(m1, transpose(m2))), n)

def convolve(signal, kernel):
    # See: https://betterexplained.com/articles/intuitive-convolution/
    # convolve(data, [0.25, 0.25, 0.25, 0.25]) --> Moving average (blur)
    # convolve(data, [1, -1]) --> 1st finite difference (1st derivative)
    # convolve(data, [1, -2, 1]) --> 2nd finite difference (2nd derivative)
    kernel = tuple(kernel)[::-1]
    n = len(kernel)
    window = collections.deque([0], maxlen=n) * n
    for x in chain(signal, repeat(0, n-1)):
        window.append(x)
        yield sumprod(kernel, window)

def polynomial_from_roots(roots):
    """Compute a polynomial's coefficients from its roots.

    (x - 5) (x + 4) (x - 3) expands to: x3 - 4x2 - 17x + 60
    """
    # polynomial_from_roots([5, -4, 3]) --> [1, -4, -17, 60]
    expansion = [1]
    for r in roots:
        expansion = convolve(expansion, (1, -r))
    return list(expansion)

def polynomial_eval(coefficients, x):
    """Evaluate a polynomial at a specific value.

    Computes with better numeric stability than Horner's method.
    """
    # Evaluate x3 - 4x2 - 17x + 60 at x = 2.5
    # polynomial_eval([1, -4, -17, 60], x=2.5) --> 8.125
    n = len(coefficients)

```

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```

if n == 0:
    return x * 0 # coerce zero to the type of x
powers = map(pow, repeat(x), reversed(range(n)))
return sumprod(coefficients, powers)

def iter_index(iterable, value, start=0):
    "Return indices where a value occurs in a sequence or iterable."
    # iter_index('AABCADEAF', 'A') --> 0 1 4 7
    try:
        seq_index = iterable.index
    except AttributeError:
        # Slow path for general iterables
        it = islice(iterable, start, None)
        i = start - 1
        try:
            while True:
                yield (i := i + operator.indexOf(it, value) + 1)
        except ValueError:
            pass
    else:
        # Fast path for sequences
        i = start - 1
        try:
            while True:
                yield (i := seq_index(value, i+1))
        except ValueError:
            pass

def sieve(n):
    "Primes less than n"
    # sieve(30) --> 2 3 5 7 11 13 17 19 23 29
    data = bytearray((0, 1)) * (n // 2)
    data[:3] = 0, 0, 0
    limit = math.isqrt(n) + 1
    for p in compress(range(limit), data):
        data[p*p : n : p+p] = bytes(len(range(p*p, n, p+p)))
    data[2] = 1
    return iter_index(data, 1) if n > 2 else iter([])

def factor(n):
    "Prime factors of n."
    # factor(99) --> 3 3 11
    for prime in sieve(math.isqrt(n) + 1):
        while True:
            quotient, remainder = divmod(n, prime)
            if remainder:
                break
            yield prime
            n = quotient
            if n == 1:
                return
    if n > 1:
        yield n

def flatten(list_of_lists):
    "Flatten one level of nesting"
    return chain.from_iterable(list_of_lists)

def repeatfunc(func, times=None, *args):
    """Repeat calls to func with specified arguments.

```

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```

Example: repeatfunc(random.random)
"""
if times is None:
    return starmap(func, repeat(args))
return starmap(func, repeat(args, times))

def triplewise(iterable):
    "Return overlapping triplets from an iterable"
    # triplewise('ABCDEFG') --> ABC BCD CDE DEF EFG
    for (a, _), (b, c) in pairwise(pairwise(iterable)):
        yield a, b, c

def sliding_window(iterable, n):
    # sliding_window('ABCDEFG', 4) --> ABCD BCDE CDEF DEFG
    it = iter(iterable)
    window = collections.deque(islice(it, n), maxlen=n)
    if len(window) == n:
        yield tuple(window)
    for x in it:
        window.append(x)
        yield tuple(window)

def roundrobin(*iterables):
    "roundrobin('ABC', 'D', 'EF') --> A D E B F C"
    # Recipe credited to George Sakkis
    num_active = len(iterables)
    nexts = cycle(iter(it).__next__ for it in iterables)
    while num_active:
        try:
            for next in nexts:
                yield next()
        except StopIteration:
            # Remove the iterator we just exhausted from the cycle.
            num_active -= 1
            nexts = cycle(islice(nexts, num_active))

def partition(pred, iterable):
    "Use a predicate to partition entries into false entries and true entries"
    # partition(is_odd, range(10)) --> 0 2 4 6 8 and 1 3 5 7 9
    t1, t2 = tee(iterable)
    return filterfalse(pred, t1), filter(pred, t2)

def before_and_after(predicate, it):
    """ Variant of takewhile() that allows complete
        access to the remainder of the iterator.

    >>> it = iter('ABCdEfGhI')
    >>> all_upper, remainder = before_and_after(str.isupper, it)
    >>> ''.join(all_upper)
    'ABC'
    >>> ''.join(remainder)      # takewhile() would lose the 'd'
    'dEfGhI'

    Note that the first iterator must be fully
    consumed before the second iterator can
    generate valid results.
    """
    it = iter(it)
    transition = []
    def true_iterator():
        for elem in it:

```

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```

        if predicate(elem):
            yield elem
        else:
            transition.append(elem)
            return
    def remainder_iterator():
        yield from transition
        yield from it
    return true_iterator(), remainder_iterator()

def subslices(seq):
    "Return all contiguous non-empty subslices of a sequence"
    # subslices('ABCD') --> A AB ABC ABCD B BC BCD C CD D
    slices = starmap(slice, combinations(range(len(seq) + 1), 2))
    return map(operator.getitem, repeat(seq), slices)

def powerset(iterable):
    "powerset([1,2,3]) --> () (1,) (2,) (3,) (1,2) (1,3) (2,3) (1,2,3)"
    s = list(iterable)
    return chain.from_iterable(combinations(s, r) for r in range(len(s)+1))

def unique_everseen(iterable, key=None):
    "List unique elements, preserving order. Remember all elements ever seen."
    # unique_everseen('AAAABBBCCDAABBB') --> A B C D
    # unique_everseen('ABBcCAD', str.lower) --> A B c D
    seen = set()
    if key is None:
        for element in filterfalse(seen.__contains__, iterable):
            seen.add(element)
            yield element
        # For order preserving deduplication,
        # a faster but non-lazy solution is:
        # yield from dict.fromkeys(iterable)
    else:
        for element in iterable:
            k = key(element)
            if k not in seen:
                seen.add(k)
                yield element
        # For use cases that allow the last matching element to be returned,
        # a faster but non-lazy solution is:
        # t1, t2 = tee(iterable)
        # yield from dict(zip(map(key, t1), t2)).values()

def unique_justseen(iterable, key=None):
    "List unique elements, preserving order. Remember only the element just seen."
    # unique_justseen('AAAABBBCCDAABBB') --> A B C D A B
    # unique_justseen('ABBcCAD', str.lower) --> A B c A D
    return map(next, map(operator.itemgetter(1), groupby(iterable, key)))

def iter_except(func, exception, first=None):
    """ Call a function repeatedly until an exception is raised.

    Converts a call-until-exception interface to an iterator interface.
    Like builtins.iter(func, sentinel) but uses an exception instead
    of a sentinel to end the loop.

    Examples:
        iter_except(functools.partial(heapop, h), IndexError) # priority queue_
        ↪ iterator
        iter_except(d.popitem, KeyError) # non-blocking_

```

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```

↪dict iterator
    iter_except(d.popleft, IndexError)           # non-blocking
↪deque iterator
    iter_except(q.get_nowait, Queue.Empty)       # loop over a
↪producer Queue
    iter_except(s.pop, KeyError)                 # non-blocking
↪set iterator

    """
    try:
        if first is not None:
            yield first()                        # For database APIs needing an initial cast
↪to db.first()
            while True:
                yield func()
    except exception:
        pass

def first_true(iterable, default=False, pred=None):
    """Returns the first true value in the iterable.

    If no true value is found, returns *default*

    If *pred* is not None, returns the first item
    for which pred(item) is true.

    """
    # first_true([a,b,c], x) --> a or b or c or x
    # first_true([a,b], x, f) --> a if f(a) else b if f(b) else x
    return next(filter(pred, iterable), default)

def nth_combination(iterable, r, index):
    "Equivalent to list(combinations(iterable, r))[index]"
    pool = tuple(iterable)
    n = len(pool)
    c = math.comb(n, r)
    if index < 0:
        index += c
    if index < 0 or index >= c:
        raise IndexError
    result = []
    while r:
        c, n, r = c*r//n, n-1, r-1
        while index >= c:
            index -= c
            c, n = c*(n-r)//n, n-1
        result.append(pool[-1-n])
    return tuple(result)

```

10.2 functools --- Higher-order functions and operations on callable objects

原始碼: [Lib/functools.py](#)

The `functools` module is for higher-order functions: functions that act on or return other functions. In general, any callable object can be treated as a function for the purposes of this module.

The `functools` module defines the following functions:

`@functools.cache` (*user_function*)

Simple lightweight unbounded function cache. Sometimes called "memoize".

Returns the same as `lru_cache(maxsize=None)`, creating a thin wrapper around a dictionary lookup for the function arguments. Because it never needs to evict old values, this is smaller and faster than `lru_cache()` with a size limit.

舉例來 F:

```
@cache
def factorial(n):
    return n * factorial(n-1) if n else 1

>>> factorial(10)      # no previously cached result, makes 11 recursive calls
3628800
>>> factorial(5)       # just looks up cached value result
120
>>> factorial(12)      # makes two new recursive calls, the other 10 are cached
479001600
```

The cache is threadsafe so that the wrapped function can be used in multiple threads. This means that the underlying data structure will remain coherent during concurrent updates.

It is possible for the wrapped function to be called more than once if another thread makes an additional call before the initial call has been completed and cached.

在 3.9 版新加入.

`@functools.cached_property` (*func*)

Transform a method of a class into a property whose value is computed once and then cached as a normal attribute for the life of the instance. Similar to `property()`, with the addition of caching. Useful for expensive computed properties of instances that are otherwise effectively immutable.

範例:

```
class DataSet:

    def __init__(self, sequence_of_numbers):
        self._data = tuple(sequence_of_numbers)

    @cached_property
    def stdev(self):
        return statistics.stdev(self._data)
```

The mechanics of `cached_property()` are somewhat different from `property()`. A regular property blocks attribute writes unless a setter is defined. In contrast, a `cached_property` allows writes.

The `cached_property` decorator only runs on lookups and only when an attribute of the same name doesn't exist. When it does run, the `cached_property` writes to the attribute with the same name. Subsequent attribute reads and writes take precedence over the `cached_property` method and it works like a normal attribute.

The cached value can be cleared by deleting the attribute. This allows the `cached_property` method to run again.

Note, this decorator interferes with the operation of [PEP 412](#) key-sharing dictionaries. This means that instance dictionaries can take more space than usual.

Also, this decorator requires that the `__dict__` attribute on each instance be a mutable mapping. This means it will not work with some types, such as metaclasses (since the `__dict__` attributes on type instances are read-only proxies for the class namespace), and those that specify `__slots__` without including `__dict__` as one of the defined slots (as such classes don't provide a `__dict__` attribute at all).

If a mutable mapping is not available or if space-efficient key sharing is desired, an effect similar to `cached_property()` can also be achieved by stacking `property()` on top of `lru_cache()`. See [faq-cache-method-calls](#) for more details on how this differs from `cached_property()`.

在 3.8 版新加入。

`functools.cmp_to_key(func)`

Transform an old-style comparison function to a *key function*. Used with tools that accept key functions (such as `sorted()`, `min()`, `max()`, `heapq.nlargest()`, `heapq.nsmallest()`, `itertools.groupby()`). This function is primarily used as a transition tool for programs being converted from Python 2 which supported the use of comparison functions.

A comparison function is any callable that accepts two arguments, compares them, and returns a negative number for less-than, zero for equality, or a positive number for greater-than. A key function is a callable that accepts one argument and returns another value to be used as the sort key.

範例：

```
sorted(iterable, key=cmp_to_key(locale.strcoll)) # locale-aware sort order
```

For sorting examples and a brief sorting tutorial, see [sortinghowto](#).

在 3.2 版新加入。

`@functools.lru_cache(user_function)`

`@functools.lru_cache(maxsize=128, typed=False)`

Decorator to wrap a function with a memoizing callable that saves up to the *maxsize* most recent calls. It can save time when an expensive or I/O bound function is periodically called with the same arguments.

The cache is threadsafe so that the wrapped function can be used in multiple threads. This means that the underlying data structure will remain coherent during concurrent updates.

It is possible for the wrapped function to be called more than once if another thread makes an additional call before the initial call has been completed and cached.

Since a dictionary is used to cache results, the positional and keyword arguments to the function must be *hashable*.

Distinct argument patterns may be considered to be distinct calls with separate cache entries. For example, `f(a=1, b=2)` and `f(b=2, a=1)` differ in their keyword argument order and may have two separate cache entries.

If *user_function* is specified, it must be a callable. This allows the *lru_cache* decorator to be applied directly to a user function, leaving the *maxsize* at its default value of 128:

```
@lru_cache
def count_vowels(sentence):
    return sum(sentence.count(vowel) for vowel in 'AEIOUaeiou')
```

If *maxsize* is set to `None`, the LRU feature is disabled and the cache can grow without bound.

If *typed* is set to `true`, function arguments of different types will be cached separately. If *typed* is `false`, the implementation will usually regard them as equivalent calls and only cache a single result. (Some types such as *str* and *int* may be cached separately even when *typed* is `false`.)

Note, type specificity applies only to the function's immediate arguments rather than their contents. The scalar arguments, `Decimal(42)` and `Fraction(42)` are be treated as distinct calls with distinct results. In contrast, the tuple arguments `('answer', Decimal(42))` and `('answer', Fraction(42))` are treated as equivalent.

The wrapped function is instrumented with a `cache_parameters()` function that returns a new *dict* showing the values for *maxsize* and *typed*. This is for information purposes only. Mutating the values has no effect.

To help measure the effectiveness of the cache and tune the *maxsize* parameter, the wrapped function is instrumented with a `cache_info()` function that returns a *named tuple* showing *hits*, *misses*, *maxsize* and *currsz*.

The decorator also provides a `cache_clear()` function for clearing or invalidating the cache.

The original underlying function is accessible through the `__wrapped__` attribute. This is useful for introspection, for bypassing the cache, or for rewrapping the function with a different cache.

The cache keeps references to the arguments and return values until they age out of the cache or until the cache is cleared.

If a method is cached, the `self` instance argument is included in the cache. See [faq-cache-method-calls](#)

An **LRU (least recently used)** cache works best when the most recent calls are the best predictors of upcoming calls (for example, the most popular articles on a news server tend to change each day). The cache's size limit assures that the cache does not grow without bound on long-running processes such as web servers.

In general, the LRU cache should only be used when you want to reuse previously computed values. Accordingly, it doesn't make sense to cache functions with side-effects, functions that need to create distinct mutable objects on each call (such as generators and async functions), or impure functions such as `time()` or `random()`.

Example of an LRU cache for static web content:

```
@lru_cache(maxsize=32)
def get_pep(num):
    'Retrieve text of a Python Enhancement Proposal'
    resource = 'https://peps.python.org/pep-%04d/' % num
    try:
        with urllib.request.urlopen(resource) as s:
            return s.read()
    except urllib.error.HTTPError:
        return 'Not Found'

>>> for n in 8, 290, 308, 320, 8, 218, 320, 279, 289, 320, 9991:
...     pep = get_pep(n)
...     print(n, len(pep))

>>> get_pep.cache_info()
CacheInfo(hits=3, misses=8, maxsize=32, currsz=8)
```

Example of efficiently computing **Fibonacci numbers** using a cache to implement a **dynamic programming** technique:

```
@lru_cache(maxsize=None)
def fib(n):
    if n < 2:
        return n
    return fib(n-1) + fib(n-2)

>>> [fib(n) for n in range(16)]
[0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610]

>>> fib.cache_info()
CacheInfo(hits=28, misses=16, maxsize=None, currsz=16)
```

在 3.2 版新加入。

在 3.3 版的變更: 新增 *typed* 選項。

在 3.8 版的變更: 新增 *user_function* 選項。

在 3.9 版的變更: Added the function `cache_parameters()`

@functools.total_ordering

Given a class defining one or more rich comparison ordering methods, this class decorator supplies the rest. This simplifies the effort involved in specifying all of the possible rich comparison operations:

The class must define one of `__lt__()`, `__le__()`, `__gt__()`, or `__ge__()`. In addition, the class should supply an `__eq__()` method.

舉例來:

```
@total_ordering
class Student:
    def __is_valid_operand(self, other):
        return (hasattr(other, "lastname") and
                hasattr(other, "firstname"))
    def __eq__(self, other):
        if not self.__is_valid_operand(other):
            return NotImplemented
        return ((self.lastname.lower(), self.firstname.lower()) ==
                (other.lastname.lower(), other.firstname.lower()))
    def __lt__(self, other):
        if not self.__is_valid_operand(other):
            return NotImplemented
        return ((self.lastname.lower(), self.firstname.lower()) <
                (other.lastname.lower(), other.firstname.lower()))
```

備: While this decorator makes it easy to create well behaved totally ordered types, it *does* come at the cost of slower execution and more complex stack traces for the derived comparison methods. If performance benchmarking indicates this is a bottleneck for a given application, implementing all six rich comparison methods instead is likely to provide an easy speed boost.

備: This decorator makes no attempt to override methods that have been declared in the class *or its superclasses*. Meaning that if a superclass defines a comparison operator, *total_ordering* will not implement it again, even if the original method is abstract.

在 3.2 版新加入。

在 3.4 版的變更: Returning `NotImplemented` from the underlying comparison function for unrecognised types is now supported.

functools.partial(func, /, *args, **keywords)

Return a new *partial object* which when called will behave like *func* called with the positional arguments *args* and keyword arguments *keywords*. If more arguments are supplied to the call, they are appended to *args*. If additional keyword arguments are supplied, they extend and override *keywords*. Roughly equivalent to:

```
def partial(func, /, *args, **keywords):
    def newfunc(*fargs, **fkeywords):
        newkeywords = {**keywords, **fkeywords}
        return func(*args, *fargs, **newkeywords)
    newfunc.func = func
    newfunc.args = args
    newfunc.keywords = keywords
    return newfunc
```

The `partial()` is used for partial function application which "freezes" some portion of a function's arguments and/or keywords resulting in a new object with a simplified signature. For example, `partial()` can be used to create a callable that behaves like the `int()` function where the `base` argument defaults to two:

```
>>> from functools import partial
>>> basetwo = partial(int, base=2)
>>> basetwo.__doc__ = 'Convert base 2 string to an int.'
>>> basetwo('10010')
18
```

class `functools.partialmethod(func, /, *args, **keywords)`

Return a new `partialmethod` descriptor which behaves like `partial` except that it is designed to be used as a method definition rather than being directly callable.

`func` must be a *descriptor* or a callable (objects which are both, like normal functions, are handled as descriptors).

When `func` is a descriptor (such as a normal Python function, `classmethod()`, `staticmethod()`, `abstractmethod()` or another instance of `partialmethod`), calls to `__get__` are delegated to the underlying descriptor, and an appropriate *partial object* returned as the result.

When `func` is a non-descriptor callable, an appropriate bound method is created dynamically. This behaves like a normal Python function when used as a method: the `self` argument will be inserted as the first positional argument, even before the `args` and `keywords` supplied to the `partialmethod` constructor.

範例：

```
>>> class Cell:
...     def __init__(self):
...         self._alive = False
...     @property
...     def alive(self):
...         return self._alive
...     def set_state(self, state):
...         self._alive = bool(state)
...     set_alive = partialmethod(set_state, True)
...     set_dead = partialmethod(set_state, False)
...
>>> c = Cell()
>>> c.alive
False
>>> c.set_alive()
>>> c.alive
True
```

在 3.4 版新加入。

`functools.reduce(function, iterable[, initializer])`

Apply *function* of two arguments cumulatively to the items of *iterable*, from left to right, so as to reduce the iterable to a single value. For example, `reduce(lambda x, y: x+y, [1, 2, 3, 4, 5])` calculates `(((1+2)+3)+4)+5`. The left argument, *x*, is the accumulated value and the right argument, *y*, is the update value from the *iterable*. If the optional *initializer* is present, it is placed before the items of the iterable in the calculation, and serves as a default when the iterable is empty. If *initializer* is not given and *iterable* contains only one item, the first item is returned.

Roughly equivalent to:

```
def reduce(function, iterable, initializer=None):
    it = iter(iterable)
    if initializer is None:
        value = next(it)
    else:
        value = initializer
```

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```

for element in it:
    value = function(value, element)
return value

```

See `itertools.accumulate()` for an iterator that yields all intermediate values.

`@functools.singledispatch`

Transform a function into a *single-dispatch generic function*.

To define a generic function, decorate it with the `@singledispatch` decorator. When defining a function using `@singledispatch`, note that the dispatch happens on the type of the first argument:

```

>>> from functools import singledispatch
>>> @singledispatch
... def fun(arg, verbose=False):
...     if verbose:
...         print("Let me just say,", end=" ")
...     print(arg)

```

To add overloaded implementations to the function, use the `register()` attribute of the generic function, which can be used as a decorator. For functions annotated with types, the decorator will infer the type of the first argument automatically:

```

>>> @fun.register
... def _(arg: int, verbose=False):
...     if verbose:
...         print("Strength in numbers, eh?", end=" ")
...     print(arg)
...
>>> @fun.register
... def _(arg: list, verbose=False):
...     if verbose:
...         print("Enumerate this:")
...     for i, elem in enumerate(arg):
...         print(i, elem)

```

`types.UnionType` and `typing.Union` can also be used:

```

>>> @fun.register
... def _(arg: int | float, verbose=False):
...     if verbose:
...         print("Strength in numbers, eh?", end=" ")
...     print(arg)
...
>>> from typing import Union
>>> @fun.register
... def _(arg: Union[list, set], verbose=False):
...     if verbose:
...         print("Enumerate this:")
...     for i, elem in enumerate(arg):
...         print(i, elem)
...

```

For code which doesn't use type annotations, the appropriate type argument can be passed explicitly to the decorator itself:

```

>>> @fun.register(complex)
... def _(arg, verbose=False):
...     if verbose:
...         print("Better than complicated.", end=" ")
...     print(arg.real, arg.imag)
...

```

To enable registering *lambdas* and pre-existing functions, the `register()` attribute can also be used in a functional form:

```
>>> def nothing(arg, verbose=False):
...     print("Nothing.")
...
>>> fun.register(type(None), nothing)
```

The `register()` attribute returns the undecorated function. This enables decorator stacking, *pickling*, and the creation of unit tests for each variant independently:

```
>>> @fun.register(float)
... @fun.register(Decimal)
... def fun_num(arg, verbose=False):
...     if verbose:
...         print("Half of your number:", end=" ")
...         print(arg / 2)
...
>>> fun_num is fun
False
```

When called, the generic function dispatches on the type of the first argument:

```
>>> fun("Hello, world.")
Hello, world.
>>> fun("test.", verbose=True)
Let me just say, test.
>>> fun(42, verbose=True)
Strength in numbers, eh? 42
>>> fun(['spam', 'spam', 'eggs', 'spam'], verbose=True)
Enumerate this:
0 spam
1 spam
2 eggs
3 spam
>>> fun(None)
Nothing.
>>> fun(1.23)
0.615
```

Where there is no registered implementation for a specific type, its method resolution order is used to find a more generic implementation. The original function decorated with `@singledispatch` is registered for the base *object* type, which means it is used if no better implementation is found.

If an implementation is registered to an *abstract base class*, virtual subclasses of the base class will be dispatched to that implementation:

```
>>> from collections.abc import Mapping
>>> @fun.register
... def _(arg: Mapping, verbose=False):
...     if verbose:
...         print("Keys & Values")
...         for key, value in arg.items():
...             print(key, "=>", value)
...
>>> fun({"a": "b"})
a => b
```

To check which implementation the generic function will choose for a given type, use the `dispatch()` attribute:

```
>>> fun.dispatch(float)
<function fun_num at 0x1035a2840>
>>> fun.dispatch(dict)      # note: default implementation
<function fun at 0x103fe0000>
```

To access all registered implementations, use the read-only registry attribute:

```
>>> fun.registry.keys()
dict_keys([<class 'NoneType'>, <class 'int'>, <class 'object'>,
          <class 'decimal.Decimal'>, <class 'list'>,
          <class 'float'>])
>>> fun.registry[float]
<function fun_num at 0x1035a2840>
>>> fun.registry[object]
<function fun at 0x103fe0000>
```

在 3.4 版新加入。

在 3.7 版的變更: The `register()` attribute now supports using type annotations.

在 3.11 版的變更: The `register()` attribute now supports `types.UnionType` and `typing.Union` as type annotations.

class `functools.singledispatchmethod` (*func*)

Transform a method into a *single-dispatch generic function*.

To define a generic method, decorate it with the `@singledispatchmethod` decorator. When defining a function using `@singledispatchmethod`, note that the dispatch happens on the type of the first non-*self* or non-*cls* argument:

```
class Negator:
    @singledispatchmethod
    def neg(self, arg):
        raise NotImplementedError("Cannot negate a")

    @neg.register
    def _(self, arg: int):
        return -arg

    @neg.register
    def _(self, arg: bool):
        return not arg
```

`@singledispatchmethod` supports nesting with other decorators such as `@classmethod`. Note that to allow for `dispatcher.register`, `singledispatchmethod` must be the *outer most* decorator. Here is the `Negator` class with the `neg` methods bound to the class, rather than an instance of the class:

```
class Negator:
    @singledispatchmethod
    @classmethod
    def neg(cls, arg):
        raise NotImplementedError("Cannot negate a")

    @neg.register
    @classmethod
    def _(cls, arg: int):
        return -arg

    @neg.register
    @classmethod
    def _(cls, arg: bool):
        return not arg
```

The same pattern can be used for other similar decorators: `@staticmethod`, `@abstractmethod`, and others.

在 3.8 版新加入.

`functools.update_wrapper(wrapper, wrapped, assigned=WRAPPER_ASSIGNMENTS, updated=WRAPPER_UPDATES)`

Update a *wrapper* function to look like the *wrapped* function. The optional arguments are tuples to specify which attributes of the original function are assigned directly to the matching attributes on the wrapper function and which attributes of the wrapper function are updated with the corresponding attributes from the original function. The default values for these arguments are the module level constants `WRAPPER_ASSIGNMENTS` (which assigns to the wrapper function's `__module__`, `__name__`, `__qualname__`, `__annotations__` and `__doc__`, the documentation string) and `WRAPPER_UPDATES` (which updates the wrapper function's `__dict__`, i.e. the instance dictionary).

To allow access to the original function for introspection and other purposes (e.g. bypassing a caching decorator such as `lru_cache()`), this function automatically adds a `__wrapped__` attribute to the wrapper that refers to the function being wrapped.

The main intended use for this function is in *decorator* functions which wrap the decorated function and return the wrapper. If the wrapper function is not updated, the metadata of the returned function will reflect the wrapper definition rather than the original function definition, which is typically less than helpful.

`update_wrapper()` may be used with callables other than functions. Any attributes named in *assigned* or *updated* that are missing from the object being wrapped are ignored (i.e. this function will not attempt to set them on the wrapper function). `AttributeError` is still raised if the wrapper function itself is missing any attributes named in *updated*.

在 3.2 版的變更: The `__wrapped__` attribute is now automatically added. The `__annotations__` attribute is now copied by default. Missing attributes no longer trigger an `AttributeError`.

在 3.4 版的變更: The `__wrapped__` attribute now always refers to the wrapped function, even if that function defined a `__wrapped__` attribute. (see bpo-17482)

`@functools.wraps(wrapped, assigned=WRAPPER_ASSIGNMENTS, updated=WRAPPER_UPDATES)`

This is a convenience function for invoking `update_wrapper()` as a function decorator when defining a wrapper function. It is equivalent to `partial(update_wrapper, wrapped=wrapped, assigned=assigned, updated=updated)`. For example:

```
>>> from functools import wraps
>>> def my_decorator(f):
...     @wraps(f)
...     def wrapper(*args, **kwargs):
...         print('Calling decorated function')
...         return f(*args, **kwargs)
...     return wrapper
...
>>> @my_decorator
... def example():
...     """Docstring"""
...     print('Called example function')
...
>>> example()
Calling decorated function
Called example function
>>> example.__name__
'example'
>>> example.__doc__
'Docstring'
```

Without the use of this decorator factory, the name of the example function would have been `'wrapper'`, and the docstring of the original `example()` would have been lost.

10.2.1 `partial` 物件

`partial` objects are callable objects created by `partial()`. They have three read-only attributes:

`partial.func`

A callable object or function. Calls to the `partial` object will be forwarded to `func` with new arguments and keywords.

`partial.args`

The leftmost positional arguments that will be prepended to the positional arguments provided to a `partial` object call.

`partial.keywords`

The keyword arguments that will be supplied when the `partial` object is called.

`partial` objects are like function objects in that they are callable, weak referenceable, and can have attributes. There are some important differences. For instance, the `__name__` and `__doc__` attributes are not created automatically. Also, `partial` objects defined in classes behave like static methods and do not transform into bound methods during instance attribute look-up.

10.3 `operator` --- 標準運算子替代函式

原始碼: [Lib/operator.py](#)

`operator` module (模組) 提供了一套與 Python 原生運算子對應的高效率函式。例如, `operator.add(x, y)` 與表示式 `x+y` 相同。許多函式名與特殊方法名相同, 只是有雙底。了向後相容, 許多包含雙底的函式被保留下來, 但了易於表達, 建議使用有雙底的函式。

函式種類有物件的比較運算、邏輯運算、數學運算以及序列運算。

物件比較函式適用於所有物件, 函式根據它們對應的 rich comparison 運算子命名:

```
operator.lt(a, b)
operator.le(a, b)
operator.eq(a, b)
operator.ne(a, b)
operator.ge(a, b)
operator.gt(a, b)
operator.__lt__(a, b)
operator.__le__(a, b)
operator.__eq__(a, b)
operator.__ne__(a, b)
operator.__ge__(a, b)
operator.__gt__(a, b)
```

在 `a` 和 `b` 之間進行“rich comparison”。具體來, `lt(a, b)` 與 `a < b` 相同, `le(a, b)` 與 `a <= b` 相同, `eq(a, b)` 與 `a == b` 相同, `ne(a, b)` 與 `a != b` 相同, `gt(a, b)` 與 `a > b` 相同, `ge(a, b)` 與 `a >= b` 相同。注意這些函式可以回傳任何值, 無論它是否可當作 boolean (布林) 值。關於 rich comparison 的更多資訊請參考 `comparisons`。

邏輯運算通常也適用於所有物件, 且支援真值檢測、標識檢測和 boolean 運算:

```
operator.not_(obj)
operator.__not__(obj)
```

Return the outcome of `not obj`. (Note that there is no `__not__()` method for object instances; only the interpreter core defines this operation. The result is affected by the `__bool__()` and `__len__()` methods.)

`operator.truth(obj)`

如果 `obj` 為真值則回傳 `True`，否則回傳 `False`。這等價於使用 `bool` 建構器。

`operator.is_(a, b)`

回傳 `a is b`。檢測物件標識。

`operator.is_not(a, b)`

回傳 `a is not b`。檢測物件標識。

數學和位元運算的種類是最多的：

`operator.abs(obj)`

`operator.__abs__(obj)`

回傳 `obj` 的絕對值。

`operator.add(a, b)`

`operator.__add__(a, b)`

對於數字 `a` 和 `b`，回傳 `a + b`。

`operator.and_(a, b)`

`operator.__and__(a, b)`

回傳 `x` 和 `y` 位元運算與 (and) 的結果。

`operator.floordiv(a, b)`

`operator.__floordiv__(a, b)`

回傳 `a // b`。

`operator.index(a)`

`operator.__index__(a)`

回傳 `a` 轉為整數的結果。等價於 `a.__index__()`。

在 3.10 版的變更：結果總是 `int` 型。在過去的版本中，結果可能為 `int` 子類的實例。

`operator.inv(obj)`

`operator.invert(obj)`

`operator.__inv__(obj)`

`operator.__invert__(obj)`

回傳數字 `obj` 按位元取反 (inverse) 的結果。這等價於 `~obj`。

`operator.lshift(a, b)`

`operator.__lshift__(a, b)`

回傳 `a` 左移 `b` 位的結果。

`operator.mod(a, b)`

`operator.__mod__(a, b)`

回傳 `a % b`。

`operator.mul(a, b)`

`operator.__mul__(a, b)`

對於數字 `a` 和 `b`，回傳 `a * b`。

`operator.matmul(a, b)`

`operator.__matmul__(a, b)`

回傳 `a @ b`。

在 3.5 版新加入。

`operator.neg(obj)`

`operator.__neg__(obj)`

回傳 *obj* 取負值的結果 ($-obj$)。

`operator.or_(a, b)`

`operator.__or__(a, b)`

回傳 *a* 和 *b* 按位元或 (or) 的結果。

`operator.pos(obj)`

`operator.__pos__(obj)`

回傳 *obj* 取正的結果 ($+obj$)。

`operator.pow(a, b)`

`operator.__pow__(a, b)`

對於數字 *a* 和 *b*，回傳 $a ** b$ 。

`operator.rshift(a, b)`

`operator.__rshift__(a, b)`

回傳 *a* 右移 *b* 位的結果。

`operator.sub(a, b)`

`operator.__sub__(a, b)`

回傳 $a - b$ 。

`operator.truediv(a, b)`

`operator.__truediv__(a, b)`

回傳 a / b ，例如 $2/3$ 將等於 .66 而不是 0。這也被稱作「真」除法。

`operator.xor(a, b)`

`operator.__xor__(a, b)`

回傳 *a* 和 *b* 按位元異或 (exclusive or) 的結果。

適用於序列的操作（其中一些也適用於對映 (mapping)），包括：

`operator.concat(a, b)`

`operator.__concat__(a, b)`

對於序列 *a* 和 *b*，回傳 $a + b$ 。

`operator.contains(a, b)`

`operator.__contains__(a, b)`

回傳 $b \text{ in } a$ 檢測的結果。請注意運算元是反序的。

`operator.countOf(a, b)`

回傳 *b* 在 *a* 中的出現次數。

`operator.delitem(a, b)`

`operator.__delitem__(a, b)`

移除 *a* 中索引 *b* 的值。

`operatorgetitem(a, b)`

`operator.__getitem__(a, b)`

回傳 *a* 中索引 *b* 的值。

`operator.indexOf(a, b)`

回傳 *b* 在 *a* 中首次出現所在的索引。

`operator.setitem(a, b, c)`

`operator.__setitem__(a, b, c)`

將 *a* 中索引 *b* 的值設為 *c*。

`operator.length_hint(obj, default=0)`

回傳物件 *obj* 的估計長度。首先嘗試回傳其實際長度，再使用 `object.__length_hint__()` 得出估計值，最後才是回傳預設值。

在 3.4 版新加入。

The following operation works with callables:

`operator.call(obj, /, *args, **kwargs)`

`operator.__call__(obj, /, *args, **kwargs)`

Return `obj(*args, **kwargs)`.

在 3.11 版新加入。

`operator` module 還定義了一些用於常規屬性和條目查詢的工具。這些工具適合用來編寫快速欄位提取器以作 `map()`、`sorted()`、`itertools.groupby()` 或其他需要函式引數的函式之引數。

`operator.attrgetter(attr)`

`operator.attrgetter(*attrs)`

回傳一個可從運算元中獲取 *attr* 的可呼叫 (callable) 物件。如果請求了一個以上的屬性，則回傳一個包含屬性的 tuple (元組)。屬性名稱還可包含點號。例如：

- 在 `f = attrgetter('name')` 之後，呼叫 `f(b)` 將回傳 `b.name`。
- 在 `f = attrgetter('name', 'date')` 之後，呼叫 `f(b)` 將回傳 `(b.name, b.date)`。
- 在 `f = attrgetter('name.first', 'name.last')` 之後，呼叫 `f(b)` 將回傳 `(b.name.first, b.name.last)`。

等價於：

```
def attrgetter(*items):
    if any(not isinstance(item, str) for item in items):
        raise TypeError('attribute name must be a string')
    if len(items) == 1:
        attr = items[0]
        def g(obj):
            return resolve_attr(obj, attr)
    else:
        def g(obj):
            return tuple(resolve_attr(obj, attr) for attr in items)
    return g

def resolve_attr(obj, attr):
    for name in attr.split("."):
        obj = getattr(obj, name)
    return obj
```

`operator.itemgetter(item)`

`operator.itemgetter(*items)`

Return a callable object that fetches *item* from its operand using the operand's `__getitem__()` method. If multiple items are specified, returns a tuple of lookup values. For example:

- 在 `f = itemgetter(2)` 之後，呼叫 `f(r)` 將回傳 `r[2]`。
- 在 `g = itemgetter(2, 5, 3)` 之後，呼叫 `g(r)` 將回傳 `(r[2], r[5], r[3])`。

等價於：

```
def itemgetter(*items):
    if len(items) == 1:
        item = items[0]
        def g(obj):
            return obj[item]
```

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```

else:
    def g(obj):
        return tuple(obj[item] for item in items)
    return g

```

The items can be any type accepted by the operand's `__getitem__()` method. Dictionaries accept any *hashable* value. Lists, tuples, and strings accept an index or a slice:

```

>>> itemgetter(1)('ABCDEFGH')
'B'
>>> itemgetter(1, 3, 5)('ABCDEFGH')
('B', 'D', 'F')
>>> itemgetter(slice(2, None))('ABCDEFGH')
'CDEFGH'
>>> soldier = dict(rank='captain', name='dotterbart')
>>> itemgetter('rank')(soldier)
'captain'

```

使用 `itemgetter()` 從 tuple 中提取特定欄位的例子：

```

>>> inventory = [('apple', 3), ('banana', 2), ('pear', 5), ('orange', 1)]
>>> getcount = itemgetter(1)
>>> list(map(getcount, inventory))
[3, 2, 5, 1]
>>> sorted(inventory, key=getcount)
[('orange', 1), ('banana', 2), ('apple', 3), ('pear', 5)]

```

`operator.methodcaller(name, /, *args, **kwargs)`

回傳一個在運算元上呼叫 `name method` 的可呼叫物件。如果給定額外的引數和/或關鍵字引數，它們也將被傳給該 `method`。例如：

- 在 `f = methodcaller('name')` 之後，呼叫 `f(b)` 將回傳 `b.name()`。
- 在 `f = methodcaller('name', 'foo', bar=1)` 之後，呼叫 `f(b)` 將回傳 `b.name('foo', bar=1)`。

等價於：

```

def methodcaller(name, /, *args, **kwargs):
    def caller(obj):
        return getattr(obj, name)(*args, **kwargs)
    return caller

```

10.3.1 運算子與函式間的對映

以下表格表示了抽象運算如何對應於 Python 語法中的運算子和 `operator` module 中的函式。

運算	語法	函式
加法	<code>a + b</code>	<code>add(a, b)</code>
字串串接	<code>seq1 + seq2</code>	<code>concat(seq1, seq2)</code>
包含性檢測	<code>obj in seq</code>	<code>contains(seq, obj)</code>
除法	<code>a / b</code>	<code>truediv(a, b)</code>
除法	<code>a // b</code>	<code>floordiv(a, b)</code>
按位元與 (And)	<code>a & b</code>	<code>and_(a, b)</code>
按位元互斥或 (Exclusive Or)	<code>a ^ b</code>	<code>xor(a, b)</code>
按位元取反 (Inversion)	<code>~ a</code>	<code>invert(a)</code>
按位元或 (Or)	<code>a b</code>	<code>or_(a, b)</code>

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表格 1 – 繼續上一頁

運算	語法	函式
取	<code>a ** b</code>	<code>pow(a, b)</code>
標識	<code>a is b</code>	<code>is_(a, b)</code>
標識	<code>a is not b</code>	<code>is_not(a, b)</code>
索引賦值	<code>obj[k] = v</code>	<code>setitem(obj, k, v)</code>
索引除	<code>del obj[k]</code>	<code>delitem(obj, k)</code>
索引取值	<code>obj[k]</code>	<code>getitem(obj, k)</code>
左移	<code>a << b</code>	<code>lshift(a, b)</code>
模除 (Modulo)	<code>a % b</code>	<code>mod(a, b)</code>
乘法	<code>a * b</code>	<code>mul(a, b)</code>
矩陣乘法	<code>a @ b</code>	<code>matmul(a, b)</code>
反相 (算術)	<code>- a</code>	<code>neg(a)</code>
反相 (邏輯)	<code>not a</code>	<code>not_(a)</code>
正數	<code>+ a</code>	<code>pos(a)</code>
右移	<code>a >> b</code>	<code>rshift(a, b)</code>
切片賦值	<code>seq[i:j] = values</code>	<code>setitem(seq, slice(i, j), values)</code>
切片除	<code>del seq[i:j]</code>	<code>delitem(seq, slice(i, j))</code>
切片取值	<code>seq[i:j]</code>	<code>getitem(seq, slice(i, j))</code>
字串格式化	<code>s % obj</code>	<code>mod(s, obj)</code>
法	<code>a - b</code>	<code>sub(a, b)</code>
真值檢測	<code>obj</code>	<code>truth(obj)</code>
比較大小	<code>a < b</code>	<code>lt(a, b)</code>
比較大小	<code>a <= b</code>	<code>le(a, b)</code>
相等性	<code>a == b</code>	<code>eq(a, b)</code>
不等性	<code>a != b</code>	<code>ne(a, b)</code>
比較大小	<code>a >= b</code>	<code>ge(a, b)</code>
比較大小	<code>a > b</code>	<code>gt(a, b)</code>

10.3.2 原地 (in-place) 運算子

許多運算都有「原地」版本。以下列出的是提供對原地運算子（與一般語法相比）更底層存取的函式，例如 `statement x += y` 相當於 `x = operator.iadd(x, y)`。一種方式來講就是 `z = operator.iadd(x, y)` 等價於合陳述式 `z = x; z += y`。

在這些例子中，請注意當呼叫一個原地方法時，運算和賦值是分成兩個步驟來執行的。下面列出的原地函式只執行第一步，即呼叫原地方法，第二步賦值則不加處理。

對於不可變 (immutable) 的目標例如字串、數字和 tuple，更新的值會被計算，但不會被再被賦值給輸入變數：

```
>>> a = 'hello'
>>> iadd(a, ' world')
'hello world'
>>> a
'hello'
```

對於可變 (mutable) 的目標例如 list 和 dictionary，原地方法將執行更新，因此不需要後續賦值操作：

```
>>> s = ['h', 'e', 'l', 'l', 'o']
>>> iadd(s, [' ', 'w', 'o', 'r', 'l', 'd'])
['h', 'e', 'l', 'l', 'o', ' ', 'w', 'o', 'r', 'l', 'd']
>>> s
['h', 'e', 'l', 'l', 'o', ' ', 'w', 'o', 'r', 'l', 'd']
```

`operator.iadd(a, b)`

`operator.__iadd__(a, b)`

`a = iadd(a, b)` 等價於 `a += b`。

```

operator.iand(a, b)
operator.__iand__(a, b)
    a = iand(a, b) 等價於 a &= b。
operator.iconcat(a, b)
operator.__iconcat__(a, b)
    a = iconcat(a, b) 等價於 a += b, 其中 a 和 b 是序列。
operator.ifloordiv(a, b)
operator.__ifloordiv__(a, b)
    a = ifloordiv(a, b) 等價於 a //= b。
operator.ilshift(a, b)
operator.__ilshift__(a, b)
    a = ilshift(a, b) 等價於 a <<= b。
operator.imod(a, b)
operator.__imod__(a, b)
    a = imod(a, b) 等價於 a %= b。
operator.imul(a, b)
operator.__imul__(a, b)
    a = imul(a, b) 等價於 a *= b。
operator.imatmul(a, b)
operator.__imatmul__(a, b)
    a = imatmul(a, b) 等價於 a @= b。
    在 3.5 版新加入。
operator.ior(a, b)
operator.__ior__(a, b)
    a = ior(a, b) 等價於 a |= b。
operator.ipow(a, b)
operator.__ipow__(a, b)
    a = ipow(a, b) 等價於 a **= b。
operator.irshift(a, b)
operator.__irshift__(a, b)
    a = irshift(a, b) 等價於 a >>= b。
operator.isub(a, b)
operator.__isub__(a, b)
    a = isub(a, b) 等價於 a -= b。
operator.itruediv(a, b)
operator.__itruediv__(a, b)
    a = itruediv(a, b) 等價於 a /= b。
operator.ixor(a, b)
operator.__ixor__(a, b)
    a = ixor(a, b) 等價於 a ^= b。

```

檔案與目錄存取

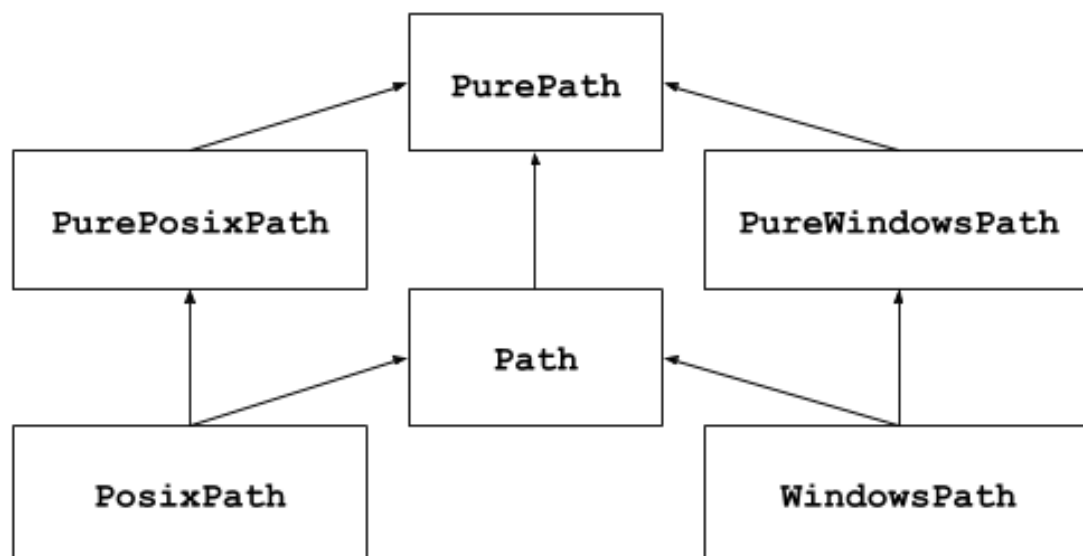
本章中描述的 module（模組）用於處理硬碟檔案和目錄。例如，有一些 module 用於讀取檔案的屬性、以可移植 (portable) 方式操作路徑以及建立暫存檔。本章中的完整 module 清單是：

11.1 pathlib --- Object-oriented filesystem paths

在 3.4 版新加入。

原始碼：[Lib/pathlib.py](#)

這個模組提供了涵蓋不同作業系統中語義對等的檔案路徑類別 (class)。路徑類別被分為純路徑及具體路徑兩種，純路徑提供純粹的計算操作而不涉及輸入輸出 (I/O)，而具體路徑則繼承自純路徑，同時提供輸入輸出操作。



If you've never used this module before or just aren't sure which class is right for your task, `Path` is most likely what you need. It instantiates a *concrete path* for the platform the code is running on.

Pure paths are useful in some special cases; for example:

1. If you want to manipulate Windows paths on a Unix machine (or vice versa). You cannot instantiate a `WindowsPath` when running on Unix, but you can instantiate `PureWindowsPath`.
2. You want to make sure that your code only manipulates paths without actually accessing the OS. In this case, instantiating one of the pure classes may be useful since those simply don't have any OS-accessing operations.

也參考:

PEP 428: The pathlib module -- object-oriented filesystem paths.

也參考:

For low-level path manipulation on strings, you can also use the `os.path` module.

11.1.1 Basic use

Importing the main class:

```
>>> from pathlib import Path
```

Listing subdirectories:

```
>>> p = Path('.')
>>> [x for x in p.iterdir() if x.is_dir()]
[PosixPath('.hg'), PosixPath('docs'), PosixPath('dist'),
 PosixPath('__pycache__'), PosixPath('build')]
```

Listing Python source files in this directory tree:

```
>>> list(p.glob('**/*.py'))
[PosixPath('test_pathlib.py'), PosixPath('setup.py'),
 PosixPath('pathlib.py'), PosixPath('docs/conf.py'),
 PosixPath('build/lib/pathlib.py')]
```

Navigating inside a directory tree:

```
>>> p = Path('/etc')
>>> q = p / 'init.d' / 'reboot'
>>> q
PosixPath('/etc/init.d/reboot')
>>> q.resolve()
PosixPath('/etc/rc.d/init.d/halt')
```

Querying path properties:

```
>>> q.exists()
True
>>> q.is_dir()
False
```

Opening a file:

```
>>> with q.open() as f: f.readline()
...
'#!/bin/bash\n'
```

11.1.2 純路徑

純路徑物件提供處理路徑的操作，實際上不會存取檔案系統。有三種方法可以存取這些類 (class)，我們也稱之為類型：

class `pathlib.PurePath(*pathsegments)`

一個通用的類，表示系統的路徑類型（實例化時會建立一個 `PurePosixPath` 或 `PureWindowsPath`）：

```
>>> PurePath('setup.py')           # Running on a Unix machine
PurePosixPath('setup.py')
```

`pathsegments` 中的每個元素可以是以下三種的其中一種：一個表示路徑片段的字串、實作了 `os.PathLike` 介面 (interface) 的回傳字串的物件，或者另一個路徑物件：

```
>>> PurePath('foo', 'some/path', 'bar')
PurePosixPath('foo/some/path/bar')
>>> PurePath(Path('foo'), Path('bar'))
PurePosixPath('foo/bar')
```

當 `pathsegments` 是空的時候，預設使用目前的目錄：

```
>>> PurePath()
PurePosixPath('.')
```

如果一個片段是絕對路徑，則所有先前的片段將被忽略（類似於 `os.path.join()`）：

```
>>> PurePath('/etc', '/usr', 'lib64')
PurePosixPath('/usr/lib64')
>>> PureWindowsPath('c:/Windows', 'd:bar')
PureWindowsPath('d:bar')
```

在 Windows 系統上，當遇到具有根目錄的相對路徑片段（例如 `r'\foo'`）時，磁碟機 (drive) 部分不會被重置：

```
>>> PureWindowsPath('c:/Windows', '/Program Files')
PureWindowsPath('c:/Program Files')
```

不必要的斜和單點會被合，但雙點 ('..') 和前置的雙斜 ('//') 不會被合，因這樣會因各種原因改變路徑的意義（例如符號連結 (symbolic links)、UNC 路徑）：

```
>>> PurePath('foo//bar')
PurePosixPath('foo/bar')
>>> PurePath('//foo/bar')
PurePosixPath('//foo/bar')
>>> PurePath('foo/./bar')
PurePosixPath('foo/bar')
>>> PurePath('foo/../bar')
PurePosixPath('foo/../bar')
```

（一個使得 `PurePosixPath('foo/../bar')` 等同於 `PurePosixPath('bar')` 的單純方法，但如果 `foo` 是一個目錄的符號連結，這是錯誤的。）

純路徑物件實作了 `os.PathLike` 介面，使得它們可以在任何接受該介面的地方使用。

在 3.6 版的變更：新增了對於 `os.PathLike` 介面的支援。

class `pathlib.PurePosixPath(*pathsegments)`

`PurePath` 的一個子類 (subclass)，該路徑類型表示非 Windows 檔案系統的路徑：

```
>>> PurePosixPath('/etc')
PurePosixPath('/etc')
```

`pathsegments` 的指定方式與 `PurePath` 類似。

class `pathlib.PureWindowsPath(*pathsegments)`

`PurePath` 的一個子類，該路徑類型表示 Windows 檔案系統的路徑，包括 UNC paths：

```
>>> PureWindowsPath('c:/Program Files/')
PureWindowsPath('c:/Program Files')
>>> PureWindowsPath('//server/share/file')
PureWindowsPath('//server/share/file')
```

`pathsegments` 的指定方式與 `PurePath` 類似。

不論你使用的是什麼系統，你都可以實例化這些類，因它們不提供任何涉及系統呼叫 (system calls) 的操作。

通用特性

路徑物件是不可變 (immutable) 且 *hashable*（可雜）的。相同類型的路徑物件可以被比較和排序。這些特性遵守該類型的大小寫規則：

```
>>> PurePosixPath('foo') == PurePosixPath('FOO')
False
>>> PureWindowsPath('foo') == PureWindowsPath('FOO')
True
>>> PureWindowsPath('FOO') in { PureWindowsPath('foo') }
True
>>> PureWindowsPath('C:') < PureWindowsPath('d:')
True
```

不同類型的路徑物件在比較時視不相等且無法被排序：

```
>>> PureWindowsPath('foo') == PurePosixPath('foo')
False
>>> PureWindowsPath('foo') < PurePosixPath('foo')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: '<' not supported between instances of 'PureWindowsPath' and
↳ 'PurePosixPath'
```

運算子

斜杠運算子 (slash operator) 用於建立子路徑，就像是 `os.path.join()` 函式一樣。如果引數是絕對路徑，則忽略前一個路徑。在 Windows 系統上，當引數是以根目錄為基礎的相對路徑（例如，`r' \foo'`），磁碟路徑不會被重置：

```
>>> p = PurePath('/etc')
>>> p
PurePosixPath('/etc')
>>> p / 'init.d' / 'apache2'
PurePosixPath('/etc/init.d/apache2')
>>> q = PurePath('bin')
>>> '/usr' / q
PurePosixPath('/usr/bin')
>>> p / '/an_absolute_path'
PurePosixPath('/an_absolute_path')
>>> PureWindowsPath('c:/Windows', '/Program Files')
PureWindowsPath('c:/Program Files')
```

路徑物件可以被用在任何可以使用 `os.PathLike` 的地方：

```
>>> import os
>>> p = PurePath('/etc')
>>> os.fspath(p)
'/etc'
```

The string representation of a path is the raw filesystem path itself (in native form, e.g. with backslashes under Windows), which you can pass to any function taking a file path as a string:

```
>>> p = PurePath('/etc')
>>> str(p)
'/etc'
>>> p = PureWindowsPath('c:/Program Files')
>>> str(p)
'c:\\Program Files'
```

Similarly, calling `bytes` on a path gives the raw filesystem path as a bytes object, as encoded by `os.fsencode()`:

```
>>> bytes(p)
b'/etc'
```

備註： Calling `bytes` is only recommended under Unix. Under Windows, the unicode form is the canonical representation of filesystem paths.

Accessing individual parts

To access the individual “parts” (components) of a path, use the following property:

`PurePath.parts`

A tuple giving access to the path’s various components:

```
>>> p = PurePath('/usr/bin/python3')
>>> p.parts
('/', 'usr', 'bin', 'python3')

>>> p = PureWindowsPath('c:/Program Files/PSF')
>>> p.parts
('c:\\', 'Program Files', 'PSF')
```

(note how the drive and local root are regrouped in a single part)

Methods and properties

Pure paths provide the following methods and properties:

`PurePath.drive`

A string representing the drive letter or name, if any:

```
>>> PureWindowsPath('c:/Program Files/').drive
'c:'
>>> PureWindowsPath('/Program Files/').drive
''
>>> PurePosixPath('/etc').drive
''
```

UNC shares are also considered drives:

```
>>> PureWindowsPath('//host/share/foo.txt').drive
'\\\\host\\share'
```

`PurePath.root`

A string representing the (local or global) root, if any:

```
>>> PureWindowsPath('c:/Program Files/').root
'\\'
>>> PureWindowsPath('c:Program Files/').root
''
>>> PurePosixPath('/etc').root
'/'
```

UNC shares always have a root:

```
>>> PureWindowsPath('//host/share').root
'\\'
```

If the path starts with more than two successive slashes, `PurePosixPath` collapses them:

```
>>> PurePosixPath('//etc').root
'/'
>>> PurePosixPath('///etc').root
'/'
>>> PurePosixPath('////etc').root
'/'
```

備 註: This behavior conforms to *The Open Group Base Specifications Issue 6*, paragraph 4.11 [Pathname Resolution](#):

"A pathname that begins with two successive slashes may be interpreted in an implementation-defined manner, although more than two leading slashes shall be treated as a single slash."

`PurePath.anchor`

The concatenation of the drive and root:

```
>>> PureWindowsPath('c:/Program Files/').anchor
'c:\\'
>>> PureWindowsPath('c:Program Files/').anchor
'c:'
>>> PurePosixPath('/etc').anchor
'/'
```

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```
'/'
>>> PureWindowsPath('//host/share').anchor
'\\\\host\\share\\'
```

PurePath.parents

An immutable sequence providing access to the logical ancestors of the path:

```
>>> p = PureWindowsPath('c:/foo/bar/setup.py')
>>> p.parents[0]
PureWindowsPath('c:/foo/bar')
>>> p.parents[1]
PureWindowsPath('c:/foo')
>>> p.parents[2]
PureWindowsPath('c:/')
```

在 3.10 版的變更: The parents sequence now supports *slices* and negative index values.

PurePath.parent

The logical parent of the path:

```
>>> p = PurePosixPath('/a/b/c/d')
>>> p.parent
PurePosixPath('/a/b/c')
```

You cannot go past an anchor, or empty path:

```
>>> p = PurePosixPath('/')
>>> p.parent
PurePosixPath('/')
>>> p = PurePosixPath('.')
>>> p.parent
PurePosixPath('.')
>>> p = PurePosixPath('')
>>> p.parent
PurePosixPath('')
```

備 F: This is a purely lexical operation, hence the following behaviour:

```
>>> p = PurePosixPath('foo/..')
>>> p.parent
PurePosixPath('foo')
```

If you want to walk an arbitrary filesystem path upwards, it is recommended to first call `Path.resolve()` so as to resolve symlinks and eliminate `".."` components.

PurePath.name

A string representing the final path component, excluding the drive and root, if any:

```
>>> PurePosixPath('my/library/setup.py').name
'setup.py'
```

UNC drive names are not considered:

```
>>> PureWindowsPath('//some/share/setup.py').name
'setup.py'
>>> PureWindowsPath('//some/share').name
''
```

PurePath.suffix

The file extension of the final component, if any:

```
>>> PurePosixPath('my/library/setup.py').suffix
'.py'
>>> PurePosixPath('my/library.tar.gz').suffix
'.gz'
>>> PurePosixPath('my/library').suffix
''
```

PurePath.suffixes

A list of the path's file extensions:

```
>>> PurePosixPath('my/library.tar.gar').suffixes
['.tar', '.gar']
>>> PurePosixPath('my/library.tar.gz').suffixes
['.tar', '.gz']
>>> PurePosixPath('my/library').suffixes
[]
```

PurePath.stem

The final path component, without its suffix:

```
>>> PurePosixPath('my/library.tar.gz').stem
'library.tar'
>>> PurePosixPath('my/library.tar').stem
'library'
>>> PurePosixPath('my/library').stem
'library'
```

PurePath.as_posix()

Return a string representation of the path with forward slashes (/):

```
>>> p = PureWindowsPath('c:\\windows')
>>> str(p)
'c:\\windows'
>>> p.as_posix()
'c:/windows'
```

PurePath.as_uri()

Represent the path as a file URI. *ValueError* is raised if the path isn't absolute.

```
>>> p = PurePosixPath('/etc/passwd')
>>> p.as_uri()
'file:///etc/passwd'
>>> p = PureWindowsPath('c:/Windows')
>>> p.as_uri()
'file:///c:/Windows'
```

PurePath.is_absolute()

Return whether the path is absolute or not. A path is considered absolute if it has both a root and (if the flavour allows) a drive:

```
>>> PurePosixPath('/a/b').is_absolute()
True
>>> PurePosixPath('a/b').is_absolute()
False

>>> PureWindowsPath('c:/a/b').is_absolute()
True
>>> PureWindowsPath('/a/b').is_absolute()
False
>>> PureWindowsPath('c:').is_absolute()
```

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```
False
>>> PureWindowsPath('//some/share').is_absolute()
True
```

`PurePath.is_relative_to(*other)`

Return whether or not this path is relative to the *other* path.

```
>>> p = PurePath('/etc/passwd')
>>> p.is_relative_to('/etc')
True
>>> p.is_relative_to('/usr')
False
```

If multiple arguments are supplied, they are joined together.

This method is string-based; it neither accesses the filesystem nor treats “.” segments specially. The following code is equivalent:

```
>>> u = PurePath('/usr')
>>> u == p or u in p.parents
False
```

在 3.9 版新加入.

`PurePath.is_reserved()`

With *PureWindowsPath*, return True if the path is considered reserved under Windows, False otherwise. With *PurePosixPath*, False is always returned.

```
>>> PureWindowsPath('nul').is_reserved()
True
>>> PurePosixPath('nul').is_reserved()
False
```

File system calls on reserved paths can fail mysteriously or have unintended effects.

`PurePath.joinpath(*other)`

Calling this method is equivalent to combining the path with each of the *other* arguments in turn:

```
>>> PurePosixPath('/etc').joinpath('passwd')
PurePosixPath('/etc/passwd')
>>> PurePosixPath('/etc').joinpath(PurePosixPath('passwd'))
PurePosixPath('/etc/passwd')
>>> PurePosixPath('/etc').joinpath('init.d', 'apache2')
PurePosixPath('/etc/init.d/apache2')
>>> PureWindowsPath('c:').joinpath('/Program Files')
PureWindowsPath('c:/Program Files')
```

`PurePath.match(pattern)`

Match this path against the provided glob-style pattern. Return True if matching is successful, False otherwise.

If *pattern* is relative, the path can be either relative or absolute, and matching is done from the right:

```
>>> PurePath('a/b.py').match('*.py')
True
>>> PurePath('/a/b/c.py').match('b/*.py')
True
>>> PurePath('/a/b/c.py').match('a/*.py')
False
```

If *pattern* is absolute, the path must be absolute, and the whole path must match:

```
>>> PurePath('/a.py').match('/*.py')
True
>>> PurePath('a/b.py').match('/*.py')
False
```

As with other methods, case-sensitivity follows platform defaults:

```
>>> PurePosixPath('b.py').match('*.PY')
False
>>> PureWindowsPath('b.py').match('*.PY')
True
```

`PurePath.relative_to(*other)`

Compute a version of this path relative to the path represented by *other*. If it's impossible, `ValueError` is raised:

```
>>> p = PurePosixPath('/etc/passwd')
>>> p.relative_to('/')
PurePosixPath('etc/passwd')
>>> p.relative_to('/etc')
PurePosixPath('passwd')
>>> p.relative_to('/usr')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "pathlib.py", line 694, in relative_to
    .format(str(self), str(formatted))
ValueError: '/etc/passwd' is not in the subpath of '/usr' OR one path is
↳relative and the other absolute.
```

If multiple arguments are supplied, they are joined together.

NOTE: This function is part of `PurePath` and works with strings. It does not check or access the underlying file structure.

`PurePath.with_name(name)`

Return a new path with the *name* changed. If the original path doesn't have a name, `ValueError` is raised:

```
>>> p = PureWindowsPath('c:/Downloads/pathlib.tar.gz')
>>> p.with_name('setup.py')
PureWindowsPath('c:/Downloads/setup.py')
>>> p = PureWindowsPath('c:/')
>>> p.with_name('setup.py')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "/home/antoine/cpython/default/Lib/pathlib.py", line 751, in with_name
    raise ValueError("%r has an empty name" % (self,))
ValueError: PureWindowsPath('c:/') has an empty name
```

`PurePath.with_stem(stem)`

Return a new path with the *stem* changed. If the original path doesn't have a name, `ValueError` is raised:

```
>>> p = PureWindowsPath('c:/Downloads/draft.txt')
>>> p.with_stem('final')
PureWindowsPath('c:/Downloads/final.txt')
>>> p = PureWindowsPath('c:/Downloads/pathlib.tar.gz')
>>> p.with_stem('lib')
PureWindowsPath('c:/Downloads/lib.gz')
>>> p = PureWindowsPath('c:/')
>>> p.with_stem('')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "/home/antoine/cpython/default/Lib/pathlib.py", line 861, in with_stem
```

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```

return self.with_name(stem + self.suffix)
File "/home/antoine/cpython/default/Lib/pathlib.py", line 851, in with_name
raise ValueError("%r has an empty name" % (self,))
ValueError: PureWindowsPath('c:/') has an empty name

```

在 3.9 版新加入。

`PurePath.with_suffix(suffix)`

Return a new path with the *suffix* changed. If the original path doesn't have a suffix, the new *suffix* is appended instead. If the *suffix* is an empty string, the original suffix is removed:

```

>>> p = PureWindowsPath('c:/Downloads/pathlib.tar.gz')
>>> p.with_suffix('.bz2')
PureWindowsPath('c:/Downloads/pathlib.tar.bz2')
>>> p = PureWindowsPath('README')
>>> p.with_suffix('.txt')
PureWindowsPath('README.txt')
>>> p = PureWindowsPath('README.txt')
>>> p.with_suffix('')
PureWindowsPath('README')

```

11.1.3 Concrete paths

Concrete paths are subclasses of the pure path classes. In addition to operations provided by the latter, they also provide methods to do system calls on path objects. There are three ways to instantiate concrete paths:

class `pathlib.Path(*pathsegments)`

A subclass of *PurePath*, this class represents concrete paths of the system's path flavour (instantiating it creates either a *PosixPath* or a *WindowsPath*):

```

>>> Path('setup.py')
PosixPath('setup.py')

```

pathsegments 的指定方式與 *PurePath* 類似。

class `pathlib.PosixPath(*pathsegments)`

A subclass of *Path* and *PurePosixPath*, this class represents concrete non-Windows filesystem paths:

```

>>> PosixPath('/etc')
PosixPath('/etc')

```

pathsegments 的指定方式與 *PurePath* 類似。

class `pathlib.WindowsPath(*pathsegments)`

A subclass of *Path* and *PureWindowsPath*, this class represents concrete Windows filesystem paths:

```

>>> WindowsPath('c:/Program Files/')
WindowsPath('c:/Program Files')

```

pathsegments 的指定方式與 *PurePath* 類似。

You can only instantiate the class flavour that corresponds to your system (allowing system calls on non-compatible path flavours could lead to bugs or failures in your application):

```

>>> import os
>>> os.name
'posix'
>>> Path('setup.py')
PosixPath('setup.py')

```

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```
>>> PosixPath('setup.py')
PosixPath('setup.py')
>>> WindowsPath('setup.py')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "pathlib.py", line 798, in __new__
    % (cls.__name__,))
NotImplementedError: cannot instantiate 'WindowsPath' on your system
```

Methods

Concrete paths provide the following methods in addition to pure paths methods. Many of these methods can raise an *OSError* if a system call fails (for example because the path doesn't exist).

在 3.8 版的變更: *exists()*, *is_dir()*, *is_file()*, *is_mount()*, *is_symlink()*, *is_block_device()*, *is_char_device()*, *is_fifo()*, *is_socket()* now return False instead of raising an exception for paths that contain characters unrepresentable at the OS level.

classmethod `Path.cwd()`

Return a new path object representing the current directory (as returned by *os.getcwd()*):

```
>>> Path.cwd()
PosixPath('/home/antoine/pathlib')
```

classmethod `Path.home()`

Return a new path object representing the user's home directory (as returned by *os.path.expanduser()* with ~ construct). If the home directory can't be resolved, *RuntimeError* is raised.

```
>>> Path.home()
PosixPath('/home/antoine')
```

在 3.5 版新加入.

`Path.stat(*, follow_symlinks=True)`

Return a *os.stat_result* object containing information about this path, like *os.stat()*. The result is looked up at each call to this method.

This method normally follows symlinks; to stat a symlink add the argument *follow_symlinks=False*, or use *lstat()*.

```
>>> p = Path('setup.py')
>>> p.stat().st_size
956
>>> p.stat().st_mtime
1327883547.852554
```

在 3.10 版的變更: 新增 *follow_symlinks* 參數。

`Path.chmod(mode, *, follow_symlinks=True)`

Change the file mode and permissions, like *os.chmod()*.

This method normally follows symlinks. Some Unix flavours support changing permissions on the symlink itself; on these platforms you may add the argument *follow_symlinks=False*, or use *lchmod()*.

```
>>> p = Path('setup.py')
>>> p.stat().st_mode
33277
>>> p.chmod(0o444)
>>> p.stat().st_mode
33060
```

在 3.10 版的變更: 新增 *follow_symlinks* 參數。

`Path.exists()`

Whether the path points to an existing file or directory:

```
>>> Path('.').exists()
True
>>> Path('setup.py').exists()
True
>>> Path('/etc').exists()
True
>>> Path('nonexistentfile').exists()
False
```

備註: If the path points to a symlink, *exists()* returns whether the symlink *points to* an existing file or directory.

`Path.expanduser()`

Return a new path with expanded ~ and ~user constructs, as returned by *os.path.expanduser()*. If a home directory can't be resolved, *RuntimeError* is raised.

```
>>> p = PosixPath('~ /films/Monty Python')
>>> p.expanduser()
PosixPath('/home/eric/films/Monty Python')
```

在 3.5 版新加入。

`Path.glob(pattern)`

Glob the given relative *pattern* in the directory represented by this path, yielding all matching files (of any kind):

```
>>> sorted(Path('.').glob('*.py'))
[PosixPath('pathlib.py'), PosixPath('setup.py'), PosixPath('test_pathlib.py')]
>>> sorted(Path('.').glob('**/*.py'))
[PosixPath('docs/conf.py')]
```

Patterns are the same as for *fnmatch*, with the addition of "*" which means "this directory and all subdirectories, recursively". In other words, it enables recursive globbing:

```
>>> sorted(Path('.').glob('**/*.py'))
[PosixPath('build/lib/pathlib.py'),
 PosixPath('docs/conf.py'),
 PosixPath('pathlib.py'),
 PosixPath('setup.py'),
 PosixPath('test_pathlib.py')]
```

備註: Using the "*" pattern in large directory trees may consume an inordinate amount of time.

引發一個附帶引數 *self*、*pattern* 的稽核事件 `pathlib.Path.glob`。

在 3.11 版的變更: Return only directories if *pattern* ends with a pathname components separator (*sep* or *altsep*).

`Path.group()`

Return the name of the group owning the file. *KeyError* is raised if the file's gid isn't found in the system database.

`Path.is_dir()`

Return True if the path points to a directory (or a symbolic link pointing to a directory), False if it points to another kind of file.

`False` is also returned if the path doesn't exist or is a broken symlink; other errors (such as permission errors) are propagated.

`Path.is_file()`

Return `True` if the path points to a regular file (or a symbolic link pointing to a regular file), `False` if it points to another kind of file.

`False` is also returned if the path doesn't exist or is a broken symlink; other errors (such as permission errors) are propagated.

`Path.is_mount()`

Return `True` if the path is a *mount point*: a point in a file system where a different file system has been mounted. On POSIX, the function checks whether *path*'s parent, `path/..`, is on a different device than *path*, or whether `path/..` and *path* point to the same i-node on the same device --- this should detect mount points for all Unix and POSIX variants. Not implemented on Windows.

在 3.7 版新加入。

`Path.is_symlink()`

Return `True` if the path points to a symbolic link, `False` otherwise.

`False` is also returned if the path doesn't exist; other errors (such as permission errors) are propagated.

`Path.is_socket()`

Return `True` if the path points to a Unix socket (or a symbolic link pointing to a Unix socket), `False` if it points to another kind of file.

`False` is also returned if the path doesn't exist or is a broken symlink; other errors (such as permission errors) are propagated.

`Path.is_fifo()`

Return `True` if the path points to a FIFO (or a symbolic link pointing to a FIFO), `False` if it points to another kind of file.

`False` is also returned if the path doesn't exist or is a broken symlink; other errors (such as permission errors) are propagated.

`Path.is_block_device()`

Return `True` if the path points to a block device (or a symbolic link pointing to a block device), `False` if it points to another kind of file.

`False` is also returned if the path doesn't exist or is a broken symlink; other errors (such as permission errors) are propagated.

`Path.is_char_device()`

Return `True` if the path points to a character device (or a symbolic link pointing to a character device), `False` if it points to another kind of file.

`False` is also returned if the path doesn't exist or is a broken symlink; other errors (such as permission errors) are propagated.

`Path.iterdir()`

When the path points to a directory, yield path objects of the directory contents:

```
>>> p = Path('docs')
>>> for child in p.iterdir(): child
...
PosixPath('docs/conf.py')
PosixPath('docs/_templates')
PosixPath('docs/make.bat')
PosixPath('docs/index.rst')
PosixPath('docs/_build')
PosixPath('docs/_static')
PosixPath('docs/Makefile')
```

The children are yielded in arbitrary order, and the special entries `'.'` and `'..'` are not included. If a file is removed from or added to the directory after creating the iterator, whether a path object for that file be included is unspecified.

`Path.lchmod(mode)`

Like `Path.chmod()` but, if the path points to a symbolic link, the symbolic link's mode is changed rather than its target's.

`Path.lstat()`

Like `Path.stat()` but, if the path points to a symbolic link, return the symbolic link's information rather than its target's.

`Path.mkdir(mode=0o777, parents=False, exist_ok=False)`

Create a new directory at this given path. If `mode` is given, it is combined with the process' `umask` value to determine the file mode and access flags. If the path already exists, `FileExistsError` is raised.

If `parents` is true, any missing parents of this path are created as needed; they are created with the default permissions without taking `mode` into account (mimicking the POSIX `mkdir -p` command).

If `parents` is false (the default), a missing parent raises `FileNotFoundError`.

If `exist_ok` is false (the default), `FileExistsError` is raised if the target directory already exists.

If `exist_ok` is true, `FileExistsError` will not be raised unless the given path already exists in the file system and is not a directory (same behavior as the POSIX `mkdir -p` command).

在 3.5 版的變更: 新增 `exist_ok` 參數。

`Path.open(mode='r', buffering=-1, encoding=None, errors=None, newline=None)`

Open the file pointed to by the path, like the built-in `open()` function does:

```
>>> p = Path('setup.py')
>>> with p.open() as f:
...     f.readline()
...
'#!/usr/bin/env python3\n'
```

`Path.owner()`

回傳擁有該檔案的用 戶 的名稱。如果在系統資料庫中找不到該檔案的 `uid`，則會引發 `KeyError`。

`Path.read_bytes()`

將指向檔案的二進制 內容以一個位元組 (bytes) 物件回傳：

```
>>> p = Path('my_binary_file')
>>> p.write_bytes(b'Binary file contents')
20
>>> p.read_bytes()
b'Binary file contents'
```

在 3.5 版新加入。

`Path.read_text(encoding=None, errors=None)`

將指向檔案的解碼 內容以字串形式回傳：

```
>>> p = Path('my_text_file')
>>> p.write_text('Text file contents')
18
>>> p.read_text()
'Text file contents'
```

該檔案被打開 且隨後關閉。選填參數的含義與 `open()` 函數中的相同。

在 3.5 版新加入。

`Path.readlink()`

回傳符號連結指向的路徑 (如 `os.readlink()` 的回傳值):

```
>>> p = Path('mylink')
>>> p.symlink_to('setup.py')
>>> p.readlink()
PosixPath('setup.py')
```

在 3.9 版新加入。

`Path.rename(target)`

將此檔案或目錄重新命名為所提供的 *target*，回傳一個新的路徑 (`Path`) 物件指向該 *target*。在 Unix 系統上，若 *target* 存在且是一個檔案，若使用者有權限，則會在不顯示訊息的情況下進行取代。在 Windows 系統上，若 *target* 存在，則會引發 `FileExistsError` 錯誤。*target* 可以是字串或另一個路徑物件：

```
>>> p = Path('foo')
>>> p.open('w').write('some text')
9
>>> target = Path('bar')
>>> p.rename(target)
PosixPath('bar')
>>> target.open().read()
'some text'
```

目標路徑可以是絕對路徑或相對路徑。相對路徑會相對於當前的工作目錄進行解釋，*not* 相對於路徑物件所在的目錄。

此功能是使用 `os.rename()` 實現的，提供相同的保證。

在 3.8 版的變更: 新增了回傳值，回傳新的路徑 (`Path`) 物件。

`Path.replace(target)`

將此檔案或目錄重新命名為給定的 *target*，回傳一個指向 *target* 的新路徑物件。如果 *target* 指向一個現有的檔案或空目錄，它將被無條件地取代。

目標路徑可以是絕對路徑或相對路徑。相對路徑會相對於當前的工作目錄進行解釋，*not* 相對於路徑物件所在的目錄。

在 3.8 版的變更: 新增了回傳值，回傳新的路徑 (`Path`) 物件。

`Path.absolute()`

使路徑成為絕對路徑，不進行標準化或解析符號連結。回傳一個新的路徑物件：

```
>>> p = Path('tests')
>>> p
PosixPath('tests')
>>> p.absolute()
PosixPath('/home/antoine/pathlib/tests')
```

`Path.resolve(strict=False)`

將路徑轉為絕對路徑，解析所有符號連結。回傳一個新的路徑物件：

```
>>> p = Path()
>>> p
PosixPath('.')
>>> p.resolve()
PosixPath('/home/antoine/pathlib')
```

同時也會消除“..”的路徑組件 (這是唯一的方法)：


```
>>> p = Path('docs/./setup.py')
>>> p.resolve()
PosixPath('/home/antoine/pathlib/setup.py')
```

如果路徑不存在且 `strict` 為 `True`，則引發 `FileNotFoundError`。如果 `strict` 為 `False`，則將盡可能解析該路徑，並將任何剩余部分追加到路徑中，而不檢查其是否存在。如果在解析過程中遇到無窮迴圈，則引發 `RuntimeError`。

在 3.6 版新加入: `strict` 引數 (在 3.6 版本之前的行是嚴格的)。

`Path.rglob(pattern)`

這相當於在給定的相對 `pattern` 前面加上 `**/"` 並呼叫 `Path.glob()`：

```
>>> sorted(Path().rglob("*.py"))
[PosixPath('build/lib/pathlib.py'),
 PosixPath('docs/conf.py'),
 PosixPath('pathlib.py'),
 PosixPath('setup.py'),
 PosixPath('test_pathlib.py')]
```

引發一個附帶引數 `self`、`pattern` 的稽核事件 `pathlib.Path.rglob`。

在 3.11 版的變更: Return only directories if `pattern` ends with a pathname components separator (`sep` or `altsep`).

`Path.rmdir()`

移除此目錄。該目錄必須為空。

`Path.samefile(other_path)`

回傳是否此路徑指向與 `other_path` 相同的檔案，`other_path` 可以是路徑 (`Path`) 物件或字串。其語義類似於 `os.path.samefile()` 和 `os.path.samestat()`。

An `OSError` can be raised if either file cannot be accessed for some reason.

```
>>> p = Path('spam')
>>> q = Path('eggs')
>>> p.samefile(q)
False
>>> p.samefile('spam')
True
```

在 3.5 版新加入。

`Path.symlink_to(target, target_is_directory=False)`

Make this path a symbolic link pointing to `target`.

On Windows, a symlink represents either a file or a directory, and does not morph to the target dynamically. If the target is present, the type of the symlink will be created to match. Otherwise, the symlink will be created as a directory if `target_is_directory` is `True` or a file symlink (the default) otherwise. On non-Windows platforms, `target_is_directory` is ignored.

```
>>> p = Path('mylink')
>>> p.symlink_to('setup.py')
>>> p.resolve()
PosixPath('/home/antoine/pathlib/setup.py')
>>> p.stat().st_size
956
>>> p.lstat().st_size
8
```

備註: The order of arguments (link, target) is the reverse of `os.symlink()`'s.

`Path.hardlink_to(target)`

Make this path a hard link to the same file as *target*.

備 F: The order of arguments (link, target) is the reverse of `os.link()`'s.

在 3.10 版新加入。

`Path.link_to(target)`

Make *target* a hard link to this path.

警告: This function does not make this path a hard link to *target*, despite the implication of the function and argument names. The argument order (target, link) is the reverse of `Path.symlink_to()` and `Path.hardlink_to()`, but matches that of `os.link()`.

在 3.8 版新加入。

在 3.10 版之後被 F 用: This method is deprecated in favor of `Path.hardlink_to()`, as the argument order of `Path.link_to()` does not match that of `Path.symlink_to()`.

`Path.touch(mode=0o666, exist_ok=True)`

Create a file at this given path. If *mode* is given, it is combined with the process' `umask` value to determine the file mode and access flags. If the file already exists, the function succeeds if *exist_ok* is true (and its modification time is updated to the current time), otherwise `FileExistsError` is raised.

`Path.unlink(missing_ok=False)`

Remove this file or symbolic link. If the path points to a directory, use `Path.rmdir()` instead.

If *missing_ok* is false (the default), `FileNotFoundError` is raised if the path does not exist.

If *missing_ok* is true, `FileNotFoundError` exceptions will be ignored (same behavior as the POSIX `rm -f` command).

在 3.8 版的變更: 新增 *missing_ok* 參數。

`Path.write_bytes(data)`

Open the file pointed to in bytes mode, write *data* to it, and close the file:

```
>>> p = Path('my_binary_file')
>>> p.write_bytes(b'Binary file contents')
20
>>> p.read_bytes()
b'Binary file contents'
```

An existing file of the same name is overwritten.

在 3.5 版新加入。

`Path.write_text(data, encoding=None, errors=None, newline=None)`

Open the file pointed to in text mode, write *data* to it, and close the file:

```
>>> p = Path('my_text_file')
>>> p.write_text('Text file contents')
18
>>> p.read_text()
'Text file contents'
```

An existing file of the same name is overwritten. The optional parameters have the same meaning as in `open()`.

在 3.5 版新加入。

在 3.10 版的變更: 新增 *newline* 參數。

11.1.4 Correspondence to tools in the `os` module

Below is a table mapping various `os` functions to their corresponding `PurePath/Path` equivalent.

備註: Not all pairs of functions/methods below are equivalent. Some of them, despite having some overlapping use-cases, have different semantics. They include `os.path.abspath()` and `Path.absolute()`, `os.path.realpath()` and `PurePath.relative_to()`.

<code>os</code> 和 <code>os.path</code>	<code>pathlib</code>
<code>os.path.abspath()</code>	<code>Path.absolute()</code> ¹
<code>os.path.realpath()</code>	<code>Path.resolve()</code>
<code>os.chmod()</code>	<code>Path.chmod()</code>
<code>os.mkdir()</code>	<code>Path.mkdir()</code>
<code>os.makedirs()</code>	<code>Path.mkdir()</code>
<code>os.rename()</code>	<code>Path.rename()</code>
<code>os.replace()</code>	<code>Path.replace()</code>
<code>os.rmdir()</code>	<code>Path.rmdir()</code>
<code>os.remove()</code> , <code>os.unlink()</code>	<code>Path.unlink()</code>
<code>os.getcwd()</code>	<code>Path.cwd()</code>
<code>os.path.exists()</code>	<code>Path.exists()</code>
<code>os.path.expanduser()</code>	<code>Path.expanduser()</code> 和 <code>Path.home()</code>
<code>os.listdir()</code>	<code>Path.iterdir()</code>
<code>os.path.isdir()</code>	<code>Path.is_dir()</code>
<code>os.path.isfile()</code>	<code>Path.is_file()</code>
<code>os.path.islink()</code>	<code>Path.is_symlink()</code>
<code>os.link()</code>	<code>Path.hardlink_to()</code>
<code>os.symlink()</code>	<code>Path.symlink_to()</code>
<code>os.readlink()</code>	<code>Path.readlink()</code>
<code>os.path.realpath()</code>	<code>PurePath.relative_to()</code> ²
<code>os.stat()</code>	<code>Path.stat()</code> , <code>Path.owner()</code> , <code>Path.group()</code>
<code>os.path.isabs()</code>	<code>PurePath.is_absolute()</code>
<code>os.path.join()</code>	<code>PurePath.joinpath()</code>
<code>os.path.basename()</code>	<code>PurePath.name</code>
<code>os.path.dirname()</code>	<code>PurePath.parent</code>
<code>os.path.samefile()</code>	<code>Path.samefile()</code>
<code>os.path.splitext()</code>	<code>PurePath.stem</code> 和 <code>PurePath.suffix</code>

解

11.2 `os.path` --- 常見的路徑名操作

原始碼: `Lib/posixpath.py` (用於 POSIX 系統) 和 `Lib/ntpath.py` (用於 Windows).

該模組實現了一些有用的路徑名操作函式。若要讀取或寫入檔案，請參閱 `open()` 函數，要存取檔案系統，請參閱 `os` 模組。路徑參數可以以字串、位元組或任何依照 `os.PathLike` 協議實作的物件傳遞。

與 Unix shell 不同，Python 不會自動進行路徑展開 (path expansions)。當應用程式需要進行類似 shell 的路徑展開時，可以明確地呼叫 `expanduser()` 和 `expandvars()` 等函式。(另請參閱 `glob` 模組。)

¹ `os.path.abspath()` normalizes the resulting path, which may change its meaning in the presence of symlinks, while `Path.absolute()` does not.

² `PurePath.relative_to()` requires self to be the subpath of the argument, but `os.path.realpath()` does not.

也參考:

`pathlib` 模組提供了高階的路徑物件。

備註: 所有這些函數都只接受位元組或字串物件作參數。如果回傳的是路徑或檔案名稱，結果將是相同型別的物件。

備註: 由於不同的作業系統具有不同的路徑命名慣例，在標準函式庫中的路徑模組有數個版本可供使用，而 `os.path` 模組都會是運行 Python 之作業系統所適用本地路徑。然而，如果你想要操作始終以某個不同於本機格式表示的路徑，你也可以引入使用對應的模組。它們都具有相同的介面：

- `posixpath` 用於 UNIX 形式的路徑
 - `ntpath` 用於 Windows 的路徑
-

在 3.8 版的變更: 對於包含有作業系統層級無法表示之字元或位元組的路徑，`exists()`、`lexists()`、`isdir()`、`isfile()`、`islink()` 和 `ismount()` 函式現在會回傳 `False`，而不是引發例外。

`os.path.abspath(path)`

回傳經正規化的對路徑名 `path`。在大多數平台上，這等效於按照以下方式呼叫 `normpath()` 函式：`normpath(join(os.getcwd(), path))`。

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.basename(path)`

回傳路徑名 `path` 的基底名稱。這是將 `path` 傳遞給函式 `split()` 後回傳結果中的第二個元素。請注意，此函式的結果與 Unix 的 `basename` 程式不同；對於 `'/foo/bar/'`，`basename` 回傳 `'bar'`，而 `basename()` 函式回傳空字串 `('')`。

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.commonpath(paths)`

回傳序列 `paths` 中每個路徑名的最長共同子路徑。如果 `paths` 同時包含對路徑和相對路徑、`paths` 位於不同的磁碟機或 `paths` 空，則引發 `ValueError`。與 `commonprefix()` 不同，此函式回傳的是有效路徑。

適用: Unix、Windows。

在 3.5 版新加入。

在 3.6 版的變更: 接受一個類路徑物件的序列。

`os.path.commonprefix(list)`

回傳 `list` 中所有路徑的最長路徑前綴（逐字元比較）。如果 `list` 空，則回傳空字串 `('')`。

備註: 由於此函式是逐字元比較，因此可能會回傳無效的路徑。若要獲得有效的路徑，請參考 `commonpath()` 函式。

```
>>> os.path.commonprefix(['/usr/lib', '/usr/local/lib'])
'/usr/l'

>>> os.path.commonpath(['/usr/lib', '/usr/local/lib'])
'/usr'
```

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.dirname(path)`

回傳路徑名 `path` 的目名稱。這是將 `path` 傳遞給函式 `split()` 後回傳之成對結果中的第一個元素。

在 3.6 版的變更: 接受一個 *path-like object*。

os.path.exists (*path*)

如果 *path* 是一個存在的路徑或一個開的檔案描述器則回傳 `True`。對於已損壞的符號連結則回傳 `False`。在某些平台上，即使 *path* 實際存在，如果未被授予執行 `os.stat()` 的權限，此函式仍可能回傳 `False`。

在 3.3 版的變更: 現在 *path* 可以是一個整數: 如果它是一個開的檔案描述器，則回傳 `True`; 否則回傳 `False`。

在 3.6 版的變更: 接受一個 *path-like object*。

os.path.lexists (*path*)

如果 *path* 是一個存在的路徑則回傳 `True`。對於已損壞的符號連結也回傳 `True`。在缺乏 `os.lstat()` 的平台上，與 `exists()` 函式等效。

在 3.6 版的變更: 接受一個 *path-like object*。

os.path.expanduser (*path*)

在 Unix 和 Windows 上，將引數中以 `~` 或 `~user` 開頭的部分替換該 *user* 的家目錄。

在 Unix 上，如果環境變數 `HOME` 有被設置，則將初始的 `~` 替換該變數的值; 否則將使用建模組 `pwd` 在密碼目錄中查找當前使用者的家目錄。對於初始的 `~user`，直接在密碼目錄中查找該使用者的家目錄。

在 Windows 上，如果 `USERPROFILE` 有被設置，則使用該變數的值; 否則將結合 `HOMEPATH` 和 `HOMEDRIVE`。對於初始的 `~user`，會檢查當前使用者的家目錄的最後一個目錄元件是否與 `USERNAME` 相符，如果相符則替換它。

如果展開失敗或路徑不以波浪符號 (`tilde`) 開頭，則回傳原始路徑，不做任何變更。

在 3.6 版的變更: 接受一個 *path-like object*。

在 3.8 版的變更: 在 Windows 上不再使用 `HOME` 變數。

os.path.expandvars (*path*)

Return the argument with environment variables expanded. Substrings of the form `$name` or `${name}` are replaced by the value of environment variable *name*. Malformed variable names and references to non-existing variables are left unchanged.

On Windows, `%name%` expansions are supported in addition to `$name` and `${name}`.

在 3.6 版的變更: 接受一個 *path-like object*。

os.path.getatime (*path*)

Return the time of last access of *path*. The return value is a floating point number giving the number of seconds since the epoch (see the `time` module). Raise `OSError` if the file does not exist or is inaccessible.

os.path.getmtime (*path*)

Return the time of last modification of *path*. The return value is a floating point number giving the number of seconds since the epoch (see the `time` module). Raise `OSError` if the file does not exist or is inaccessible.

在 3.6 版的變更: 接受一個 *path-like object*。

os.path.getctime (*path*)

Return the system's ctime which, on some systems (like Unix) is the time of the last metadata change, and, on others (like Windows), is the creation time for *path*. The return value is a number giving the number of seconds since the epoch (see the `time` module). Raise `OSError` if the file does not exist or is inaccessible.

在 3.6 版的變更: 接受一個 *path-like object*。

os.path.getsize (*path*)

Return the size, in bytes, of *path*. Raise `OSError` if the file does not exist or is inaccessible.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.isabs(path)`

Return True if *path* is an absolute pathname. On Unix, that means it begins with a slash, on Windows that it begins with a (back)slash after chopping off a potential drive letter.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.isfile(path)`

Return True if *path* is an *existing* regular file. This follows symbolic links, so both *islink()* and *isfile()* can be true for the same path.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.isdir(path)`

Return True if *path* is an *existing* directory. This follows symbolic links, so both *islink()* and *isdir()* can be true for the same path.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.islink(path)`

Return True if *path* refers to an *existing* directory entry that is a symbolic link. Always False if symbolic links are not supported by the Python runtime.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.ismount(path)`

Return True if pathname *path* is a *mount point*: a point in a file system where a different file system has been mounted. On POSIX, the function checks whether *path*'s parent, *path/..*, is on a different device than *path*, or whether *path/..* and *path* point to the same i-node on the same device --- this should detect mount points for all Unix and POSIX variants. It is not able to reliably detect bind mounts on the same filesystem. On Windows, a drive letter root and a share UNC are always mount points, and for any other path `GetVolumePathName` is called to see if it is different from the input path.

在 3.4 版新加入: Support for detecting non-root mount points on Windows.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.join(path, *paths)`

Join one or more path segments intelligently. The return value is the concatenation of *path* and all members of **paths*, with exactly one directory separator following each non-empty part, except the last. That is, the result will only end in a separator if the last part is either empty or ends in a separator. If a segment is an absolute path (which on Windows requires both a drive and a root), then all previous segments are ignored and joining continues from the absolute path segment.

On Windows, the drive is not reset when a rooted path segment (e.g., `r'\foo'`) is encountered. If a segment is on a different drive or is an absolute path, all previous segments are ignored and the drive is reset. Note that since there is a current directory for each drive, `os.path.join("c:", "foo")` represents a path relative to the current directory on drive C: (`c:foo`), not `c:\foo`.

在 3.6 版的變更: Accepts a *path-like object* for *path* and *paths*.

`os.path.normcase(path)`

Normalize the case of a pathname. On Windows, convert all characters in the pathname to lowercase, and also convert forward slashes to backward slashes. On other operating systems, return the path unchanged.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.normpath(path)`

Normalize a pathname by collapsing redundant separators and up-level references so that `A//B`, `A/B/`, `A/./B` and `A/foo/./B` all become `A/B`. This string manipulation may change the meaning of a path that contains symbolic links. On Windows, it converts forward slashes to backward slashes. To normalize case, use *normcase()*.

備 註:

On POSIX systems, in accordance with IEEE Std 1003.1 2013 Edition; 4.13 Pathname Resolution, if a pathname begins with exactly two slashes, the first component following the leading characters may be interpreted in an implementation-defined manner, although more than two leading characters shall be treated as a single character.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.realpath(path, *, strict=False)`

Return the canonical path of the specified filename, eliminating any symbolic links encountered in the path (if they are supported by the operating system).

If a path doesn't exist or a symlink loop is encountered, and *strict* is `True`, `OSError` is raised. If *strict* is `False`, the path is resolved as far as possible and any remainder is appended without checking whether it exists.

備 F: This function emulates the operating system's procedure for making a path canonical, which differs slightly between Windows and UNIX with respect to how links and subsequent path components interact.

Operating system APIs make paths canonical as needed, so it's not normally necessary to call this function.

在 3.6 版的變更: 接受一個 *path-like object*。

在 3.8 版的變更: Symbolic links and junctions are now resolved on Windows.

在 3.10 版的變更: 新增 *strict* 參數。

`os.path.relpath(path, start=os.curdir)`

Return a relative filepath to *path* either from the current directory or from an optional *start* directory. This is a path computation: the filesystem is not accessed to confirm the existence or nature of *path* or *start*. On Windows, `ValueError` is raised when *path* and *start* are on different drives.

start defaults to `os.curdir`.

適用: Unix、Windows。

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.samefile(path1, path2)`

Return `True` if both pathname arguments refer to the same file or directory. This is determined by the device number and i-node number and raises an exception if an `os.stat()` call on either pathname fails.

適用: Unix、Windows。

在 3.2 版的變更: 新增對 Windows 的支援。

在 3.4 版的變更: Windows now uses the same implementation as all other platforms.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.sameopenfile(fp1, fp2)`

Return `True` if the file descriptors *fp1* and *fp2* refer to the same file.

適用: Unix、Windows。

在 3.2 版的變更: 新增對 Windows 的支援。

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.samestat(stat1, stat2)`

Return `True` if the stat tuples *stat1* and *stat2* refer to the same file. These structures may have been returned by `os.fstat()`, `os.lstat()`, or `os.stat()`. This function implements the underlying comparison used by `samefile()` and `sameopenfile()`.

適用: Unix、Windows。

在 3.4 版的變更: 新增對 Windows 的支援。

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.split(path)`

Split the pathname *path* into a pair, (*head*, *tail*) where *tail* is the last pathname component and *head* is everything leading up to that. The *tail* part will never contain a slash; if *path* ends in a slash, *tail* will be empty. If there is no slash in *path*, *head* will be empty. If *path* is empty, both *head* and *tail* are empty. Trailing slashes are stripped from *head* unless it is the root (one or more slashes only). In all cases, `join(head, tail)` returns a path to the same location as *path* (but the strings may differ). Also see the functions `dirname()` and `basename()`.

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.splitdrive(path)`

Split the pathname *path* into a pair (*drive*, *tail*) where *drive* is either a mount point or the empty string. On systems which do not use drive specifications, *drive* will always be the empty string. In all cases, *drive* + *tail* will be the same as *path*.

On Windows, splits a pathname into drive/UNC sharepoint and relative path.

If the path contains a drive letter, *drive* will contain everything up to and including the colon:

```
>>> splitdrive("c:/dir")
("c:", "/dir")
```

If the path contains a UNC path, *drive* will contain the host name and share, up to but not including the fourth separator:

```
>>> splitdrive("//host/computer/dir")
("//host/computer", "/dir")
```

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.splitext(path)`

Split the pathname *path* into a pair (*root*, *ext*) such that `root + ext == path`, and the extension, *ext*, is empty or begins with a period and contains at most one period.

If the path contains no extension, *ext* will be '':

```
>>> splitext('bar')
('bar', '')
```

If the path contains an extension, then *ext* will be set to this extension, including the leading period. Note that previous periods will be ignored:

```
>>> splitext('foo.bar.exe')
('foo.bar', '.exe')
>>> splitext('/foo/bar.exe')
('/foo/bar', '.exe')
```

Leading periods of the last component of the path are considered to be part of the root:

```
>>> splitext('.cshrc')
('.cshrc', '')
>>> splitext('/foo/....jpg')
('/foo/....jpg', '')
```

在 3.6 版的變更: 接受一個 *path-like object*。

`os.path.supports_unicode_filenames`

True if arbitrary Unicode strings can be used as file names (within limitations imposed by the file system).

11.3 fileinput --- Iterate over lines from multiple input streams

原始碼: [Lib/fileinput.py](#)

This module implements a helper class and functions to quickly write a loop over standard input or a list of files. If you just want to read or write one file see [open\(\)](#).

The typical use is:

```
import fileinput
for line in fileinput.input(encoding="utf-8"):
    process(line)
```

This iterates over the lines of all files listed in `sys.argv[1:]`, defaulting to `sys.stdin` if the list is empty. If a filename is `'-'`, it is also replaced by `sys.stdin` and the optional arguments *mode* and *openhook* are ignored. To specify an alternative list of filenames, pass it as the first argument to [input\(\)](#). A single file name is also allowed.

All files are opened in text mode by default, but you can override this by specifying the *mode* parameter in the call to [input\(\)](#) or [FileInput](#). If an I/O error occurs during opening or reading a file, [OSError](#) is raised.

在 3.3 版的變更: [IOError](#) used to be raised; it is now an alias of [OSError](#).

If `sys.stdin` is used more than once, the second and further use will return no lines, except perhaps for interactive use, or if it has been explicitly reset (e.g. using `sys.stdin.seek(0)`).

Empty files are opened and immediately closed; the only time their presence in the list of filenames is noticeable at all is when the last file opened is empty.

Lines are returned with any newlines intact, which means that the last line in a file may not have one.

You can control how files are opened by providing an opening hook via the *openhook* parameter to [fileinput.input\(\)](#) or [FileInput\(\)](#). The hook must be a function that takes two arguments, *filename* and *mode*, and returns an accordingly opened file-like object. If *encoding* and/or *errors* are specified, they will be passed to the hook as additional keyword arguments. This module provides a [hook_compressed\(\)](#) to support compressed files.

The following function is the primary interface of this module:

```
fileinput.input(files=None, inplace=False, backup='', *, mode='r', openhook=None, encoding=None,
               errors=None)
```

Create an instance of the [FileInput](#) class. The instance will be used as global state for the functions of this module, and is also returned to use during iteration. The parameters to this function will be passed along to the constructor of the [FileInput](#) class.

The [FileInput](#) instance can be used as a context manager in the `with` statement. In this example, *input* is closed after the `with` statement is exited, even if an exception occurs:

```
with fileinput.input(files=('spam.txt', 'eggs.txt'), encoding="utf-8") as f:
    for line in f:
        process(line)
```

在 3.2 版的變更: Can be used as a context manager.

在 3.8 版的變更: The keyword parameters *mode* and *openhook* are now keyword-only.

在 3.10 版的變更: The keyword-only parameter *encoding* and *errors* are added.

The following functions use the global state created by [fileinput.input\(\)](#); if there is no active state, [RuntimeError](#) is raised.

```
fileinput.filename()
```

Return the name of the file currently being read. Before the first line has been read, returns `None`.

`fileinput.fileeno()`

Return the integer "file descriptor" for the current file. When no file is opened (before the first line and between files), returns -1.

`fileinput.lineno()`

Return the cumulative line number of the line that has just been read. Before the first line has been read, returns 0. After the last line of the last file has been read, returns the line number of that line.

`fileinput.filelineno()`

Return the line number in the current file. Before the first line has been read, returns 0. After the last line of the last file has been read, returns the line number of that line within the file.

`fileinput.isfirstline()`

Return True if the line just read is the first line of its file, otherwise return False.

`fileinput.isstdin()`

Return True if the last line was read from `sys.stdin`, otherwise return False.

`fileinput.nextfile()`

Close the current file so that the next iteration will read the first line from the next file (if any); lines not read from the file will not count towards the cumulative line count. The filename is not changed until after the first line of the next file has been read. Before the first line has been read, this function has no effect; it cannot be used to skip the first file. After the last line of the last file has been read, this function has no effect.

`fileinput.close()`

Close the sequence.

The class which implements the sequence behavior provided by the module is available for subclassing as well:

```
class fileinput.FileInput (files=None, inplace=False, backup=" ", *, mode='r', openhook=None,
                           encoding=None, errors=None)
```

Class `FileInput` is the implementation; its methods `filename()`, `fileeno()`, `lineno()`, `filelineno()`, `isfirstline()`, `isstdin()`, `nextfile()` and `close()` correspond to the functions of the same name in the module. In addition it is *iterable* and has a `readline()` method which returns the next input line. The sequence must be accessed in strictly sequential order; random access and `readline()` cannot be mixed.

With `mode` you can specify which file mode will be passed to `open()`. It must be one of 'r' and 'rb'.

The `openhook`, when given, must be a function that takes two arguments, `filename` and `mode`, and returns an accordingly opened file-like object. You cannot use `inplace` and `openhook` together.

You can specify `encoding` and `errors` that is passed to `open()` or `openhook`.

A `FileInput` instance can be used as a context manager in the `with` statement. In this example, `input` is closed after the `with` statement is exited, even if an exception occurs:

```
with FileInput(files=('spam.txt', 'eggs.txt')) as input:
    process(input)
```

在 3.2 版的變更: Can be used as a context manager.

在 3.8 版的變更: The keyword parameter `mode` and `openhook` are now keyword-only.

在 3.10 版的變更: The keyword-only parameter `encoding` and `errors` are added.

在 3.11 版的變更: The 'rU' and 'U' modes and the `__getitem__()` method have been removed.

Optional in-place filtering: if the keyword argument `inplace=True` is passed to `fileinput.input()` or to the `FileInput` constructor, the file is moved to a backup file and standard output is directed to the input file (if a file of the same name as the backup file already exists, it will be replaced silently). This makes it possible to write a filter that rewrites its input file in place. If the `backup` parameter is given (typically as `backup='<some extension>'`), it specifies the extension for the backup file, and the backup file remains around; by default, the extension is '.bak' and it is deleted when the output file is closed. In-place filtering is disabled when standard input is read.

The two following opening hooks are provided by this module:

`fileinput.hook_compressed` (*filename, mode, *, encoding=None, errors=None*)

Transparently opens files compressed with gzip and bzip2 (recognized by the extensions `'.gz'` and `'.bz2'`) using the `gzip` and `bz2` modules. If the filename extension is not `'.gz'` or `'.bz2'`, the file is opened normally (ie, using `open()` without any decompression).

The `encoding` and `errors` values are passed to `io.TextIOWrapper` for compressed files and open for normal files.

Usage example: `fi = fileinput.FileInput(openhook=fileinput.hook_compressed, encoding="utf-8")`

在 3.10 版的變更: The keyword-only parameter `encoding` and `errors` are added.

`fileinput.hook_encoded` (*encoding, errors=None*)

Returns a hook which opens each file with `open()`, using the given `encoding` and `errors` to read the file.

Usage example: `fi = fileinput.FileInput(openhook=fileinput.hook_encoded("utf-8", "surrogateescape"))`

在 3.6 版的變更: 新增可選參數 `errors`。

在 3.10 版之後被⌘用: This function is deprecated since `fileinput.input()` and `FileInput` now have `encoding` and `errors` parameters.

11.4 stat --- Interpreting stat() results

原始碼: [Lib/stat.py](#)

The `stat` module defines constants and functions for interpreting the results of `os.stat()`, `os.fstat()` and `os.lstat()` (if they exist). For complete details about the `stat()`, `fstat()` and `lstat()` calls, consult the documentation for your system.

在 3.4 版的變更: The `stat` module is backed by a C implementation.

The `stat` module defines the following functions to test for specific file types:

`stat.S_ISDIR(mode)`

Return non-zero if the mode is from a directory.

`stat.S_ISCHR(mode)`

Return non-zero if the mode is from a character special device file.

`stat.S_ISBLK(mode)`

Return non-zero if the mode is from a block special device file.

`stat.S_ISREG(mode)`

Return non-zero if the mode is from a regular file.

`stat.S_ISFIFO(mode)`

Return non-zero if the mode is from a FIFO (named pipe).

`stat.S_ISLNK(mode)`

Return non-zero if the mode is from a symbolic link.

`stat.S_ISSOCK(mode)`

Return non-zero if the mode is from a socket.

`stat.S_ISDOOR(mode)`

Return non-zero if the mode is from a door.

在 3.4 版新加入.

`stat.S_ISPORT(mode)`

Return non-zero if the mode is from an event port.

在 3.4 版新加入.

`stat.S_ISWHT(mode)`

Return non-zero if the mode is from a whiteout.

在 3.4 版新加入.

Two additional functions are defined for more general manipulation of the file's mode:

`stat.S_IMODE(mode)`

Return the portion of the file's mode that can be set by `os.chmod()` ---that is, the file's permission bits, plus the sticky bit, set-group-id, and set-user-id bits (on systems that support them).

`stat.S_IFMT(mode)`

Return the portion of the file's mode that describes the file type (used by the `S_IS*()` functions above).

Normally, you would use the `os.path.is*()` functions for testing the type of a file; the functions here are useful when you are doing multiple tests of the same file and wish to avoid the overhead of the `stat()` system call for each test. These are also useful when checking for information about a file that isn't handled by `os.path`, like the tests for block and character devices.

範例:

```
import os, sys
from stat import *

def walktree(top, callback):
    '''recursively descend the directory tree rooted at top,
       calling the callback function for each regular file'''

    for f in os.listdir(top):
        pathname = os.path.join(top, f)
        mode = os.lstat(pathname).st_mode
        if S_ISDIR(mode):
            # It's a directory, recurse into it
            walktree(pathname, callback)
        elif S_ISREG(mode):
            # It's a file, call the callback function
            callback(pathname)
        else:
            # Unknown file type, print a message
            print('Skipping %s' % pathname)

def visitfile(file):
    print('visiting', file)

if __name__ == '__main__':
    walktree(sys.argv[1], visitfile)
```

An additional utility function is provided to convert a file's mode in a human readable string:

`stat.filemode(mode)`

Convert a file's mode to a string of the form `'-rwxrwxrwx'`.

在 3.3 版新加入.

在 3.4 版的變更: The function supports `S_IFDOOR`, `S_IFPORT` and `S_IFWHT`.

All the variables below are simply symbolic indexes into the 10-tuple returned by `os.stat()`, `os.fstat()` or `os.lstat()`.

`stat.ST_MODE`

Inode protection mode.

`stat.ST_INO`

Inode number.

`stat.ST_DEV`

Device inode resides on.

`stat.ST_NLINK`

Number of links to the inode.

`stat.ST_UID`

User id of the owner.

`stat.ST_GID`

Group id of the owner.

`stat.ST_SIZE`

Size in bytes of a plain file; amount of data waiting on some special files.

`stat.ST_ATIME`

Time of last access.

`stat.ST_MTIME`

Time of last modification.

`stat.ST_CTIME`

The "ctime" as reported by the operating system. On some systems (like Unix) is the time of the last metadata change, and, on others (like Windows), is the creation time (see platform documentation for details).

The interpretation of "file size" changes according to the file type. For plain files this is the size of the file in bytes. For FIFOs and sockets under most flavors of Unix (including Linux in particular), the "size" is the number of bytes waiting to be read at the time of the call to `os.stat()`, `os.fstat()`, or `os.lstat()`; this can sometimes be useful, especially for polling one of these special files after a non-blocking open. The meaning of the size field for other character and block devices varies more, depending on the implementation of the underlying system call.

The variables below define the flags used in the `ST_MODE` field.

Use of the functions above is more portable than use of the first set of flags:

`stat.S_IFSOCK`

Socket.

`stat.S_IFLNK`

Symbolic link.

`stat.S_IFREG`

Regular file.

`stat.S_IFBLK`

Block device.

`stat.S_IFDIR`

Directory.

`stat.S_IFCHR`

Character device.

`stat.S_IFIFO`

FIFO.

`stat.S_IFDOOR`

Door.

在 3.4 版新加入.

`stat.S_IFPORT`

Event port.

在 3.4 版新加入.

`stat.S_IFWHT`

Whiteout.

在 3.4 版新加入.

備 F: `S_IFDOOR`, `S_IFPORT` or `S_IFWHT` are defined as 0 when the platform does not have support for the file types.

The following flags can also be used in the *mode* argument of `os.chmod()`:

`stat.S_ISUID`

Set UID bit.

`stat.S_ISGID`

Set-group-ID bit. This bit has several special uses. For a directory it indicates that BSD semantics is to be used for that directory: files created there inherit their group ID from the directory, not from the effective group ID of the creating process, and directories created there will also get the `S_ISGID` bit set. For a file that does not have the group execution bit (`S_IXGRP`) set, the set-group-ID bit indicates mandatory file/record locking (see also `S_ENFMT`).

`stat.S_ISVTX`

Sticky bit. When this bit is set on a directory it means that a file in that directory can be renamed or deleted only by the owner of the file, by the owner of the directory, or by a privileged process.

`stat.S_IRWXU`

Mask for file owner permissions.

`stat.S_IRUSR`

Owner has read permission.

`stat.S_IWUSR`

Owner has write permission.

`stat.S_IXUSR`

Owner has execute permission.

`stat.S_IRWXG`

Mask for group permissions.

`stat.S_IRGRP`

Group has read permission.

`stat.S_IWGRP`

Group has write permission.

`stat.S_IXGRP`

Group has execute permission.

`stat.S_IRWXO`

Mask for permissions for others (not in group).

`stat.S_IROTH`

Others have read permission.

`stat.S_IWOTH`

Others have write permission.

`stat.S_IXOTH`

Others have execute permission.

`stat.S_ENFMT`

System V file locking enforcement. This flag is shared with `S_ISGID`: file/record locking is enforced on files that do not have the group execution bit (`S_IXGRP`) set.

`stat.S_IREAD`

Unix V7 synonym for `S_IRUSR`.

`stat.S_IWRITE`

Unix V7 synonym for `S_IWUSR`.

`stat.S_IEXEC`

Unix V7 synonym for `S_IXUSR`.

The following flags can be used in the `flags` argument of `os.chflags()`:

`stat.UF_NODUMP`

Do not dump the file.

`stat.UF_IMMUTABLE`

The file may not be changed.

`stat.UF_APPEND`

The file may only be appended to.

`stat.UF_OPAQUE`

The directory is opaque when viewed through a union stack.

`stat.UF_NOUNLINK`

The file may not be renamed or deleted.

`stat.UF_COMPRESSED`

The file is stored compressed (macOS 10.6+).

`stat.UF_HIDDEN`

The file should not be displayed in a GUI (macOS 10.5+).

`stat.SF_ARCHIVED`

The file may be archived.

`stat.SF_IMMUTABLE`

The file may not be changed.

`stat.SF_APPEND`

The file may only be appended to.

`stat.SF_NOUNLINK`

The file may not be renamed or deleted.

`stat.SF_SNAPSHOT`

The file is a snapshot file.

See the *BSD or macOS systems man page `chflags(2)` for more information.

On Windows, the following file attribute constants are available for use when testing bits in the `st_file_attributes` member returned by `os.stat()`. See the [Windows API documentation](#) for more detail on the meaning of these constants.

```
stat.FILE_ATTRIBUTE_ARCHIVE
stat.FILE_ATTRIBUTE_COMPRESSED
stat.FILE_ATTRIBUTE_DEVICE
stat.FILE_ATTRIBUTE_DIRECTORY
stat.FILE_ATTRIBUTE_ENCRYPTED
stat.FILE_ATTRIBUTE_HIDDEN
stat.FILE_ATTRIBUTE_INTEGRITY_STREAM
stat.FILE_ATTRIBUTE_NORMAL
stat.FILE_ATTRIBUTE_NOT_CONTENT_INDEXED
stat.FILE_ATTRIBUTE_NO_SCRUB_DATA
stat.FILE_ATTRIBUTE_OFFLINE
stat.FILE_ATTRIBUTE_READONLY
stat.FILE_ATTRIBUTE_REPARSE_POINT
stat.FILE_ATTRIBUTE_SPARSE_FILE
stat.FILE_ATTRIBUTE_SYSTEM
stat.FILE_ATTRIBUTE_TEMPORARY
stat.FILE_ATTRIBUTE_VIRTUAL
```

在 3.5 版新加入。

On Windows, the following constants are available for comparing against the `st_reparse_tag` member returned by `os.lstat()`. These are well-known constants, but are not an exhaustive list.

```
stat.IO_REPARSE_TAG_SYMLINK
stat.IO_REPARSE_TAG_MOUNT_POINT
stat.IO_REPARSE_TAG_APPEXECLINK
```

在 3.8 版新加入。

11.5 filecmp --- File and Directory Comparisons

原始碼: [Lib/filecmp.py](#)

The `filecmp` module defines functions to compare files and directories, with various optional time/correctness trade-offs. For comparing files, see also the `difflib` module.

The `filecmp` module defines the following functions:

`filecmp.cmp(f1, f2, shallow=True)`

Compare the files named *f1* and *f2*, returning `True` if they seem equal, `False` otherwise.

If *shallow* is true and the `os.stat()` signatures (file type, size, and modification time) of both files are identical, the files are taken to be equal.

Otherwise, the files are treated as different if their sizes or contents differ.

Note that no external programs are called from this function, giving it portability and efficiency.

This function uses a cache for past comparisons and the results, with cache entries invalidated if the `os.stat()` information for the file changes. The entire cache may be cleared using `clear_cache()`.

`filecmp.cmpfiles(dir1, dir2, common, shallow=True)`

Compare the files in the two directories *dir1* and *dir2* whose names are given by *common*.

Returns three lists of file names: *match*, *mismatch*, *errors*. *match* contains the list of files that match, *mismatch* contains the names of those that don't, and *errors* lists the names of files which could not be compared. Files

are listed in *errors* if they don't exist in one of the directories, the user lacks permission to read them or if the comparison could not be done for some other reason.

The *shallow* parameter has the same meaning and default value as for `filecmp.cmp()`.

For example, `cmpfiles('a', 'b', ['c', 'd/e'])` will compare `a/c` with `b/c` and `a/d/e` with `b/d/e`. `'c'` and `'d/e'` will each be in one of the three returned lists.

`filecmp.clear_cache()`

Clear the filecmp cache. This may be useful if a file is compared so quickly after it is modified that it is within the mtime resolution of the underlying filesystem.

在 3.4 版新加入。

11.5.1 The `dircmp` class

class `filecmp.dircmp(a, b, ignore=None, hide=None)`

Construct a new directory comparison object, to compare the directories *a* and *b*. *ignore* is a list of names to ignore, and defaults to `filecmp.DEFAULT_IGNORES`. *hide* is a list of names to hide, and defaults to `[os.curdir, os.pardir]`.

The `dircmp` class compares files by doing *shallow* comparisons as described for `filecmp.cmp()`.

The `dircmp` class provides the following methods:

report()

Print (to `sys.stdout`) a comparison between *a* and *b*.

report_partial_closure()

Print a comparison between *a* and *b* and common immediate subdirectories.

report_full_closure()

Print a comparison between *a* and *b* and common subdirectories (recursively).

The `dircmp` class offers a number of interesting attributes that may be used to get various bits of information about the directory trees being compared.

Note that via `__getattr__()` hooks, all attributes are computed lazily, so there is no speed penalty if only those attributes which are lightweight to compute are used.

left

The directory *a*.

right

The directory *b*.

left_list

Files and subdirectories in *a*, filtered by *hide* and *ignore*.

right_list

Files and subdirectories in *b*, filtered by *hide* and *ignore*.

common

Files and subdirectories in both *a* and *b*.

left_only

Files and subdirectories only in *a*.

right_only

Files and subdirectories only in *b*.

common_dirs

Subdirectories in both *a* and *b*.

common_files

Files in both *a* and *b*.

common_funny

Names in both *a* and *b*, such that the type differs between the directories, or names for which `os.stat()` reports an error.

same_files

Files which are identical in both *a* and *b*, using the class's file comparison operator.

diff_files

Files which are in both *a* and *b*, whose contents differ according to the class's file comparison operator.

funny_files

Files which are in both *a* and *b*, but could not be compared.

subdirs

A dictionary mapping names in `common_dirs` to `dircmp` instances (or `MyDirCmp` instances if this instance is of type `MyDirCmp`, a subclass of `dircmp`).

在 3.10 版的變更: Previously entries were always `dircmp` instances. Now entries are the same type as `self`, if `self` is a subclass of `dircmp`.

filecmp.DEFAULT_IGNORES

在 3.4 版新加入.

List of directories ignored by `dircmp` by default.

Here is a simplified example of using the `subdirs` attribute to search recursively through two directories to show common different files:

```
>>> from filecmp import dircmp
>>> def print_diff_files(dcmp):
...     for name in dcmp.diff_files:
...         print("diff_file %s found in %s and %s" % (name, dcmp.left,
...             dcmp.right))
...     for sub_dcmp in dcmp.subdirs.values():
...         print_diff_files(sub_dcmp)
...
>>> dcmp = dircmp('dir1', 'dir2')
>>> print_diff_files(dcmp)
```

11.6 tempfile --- 生成臨時檔案和目錄 F

原始碼: [Lib/tempfile.py](#)

This module creates temporary files and directories. It works on all supported platforms. `TemporaryFile`, `NamedTemporaryFile`, `TemporaryDirectory`, and `SpooledTemporaryFile` are high-level interfaces which provide automatic cleanup and can be used as *context managers*. `mkstemp()` and `mkdtemp()` are lower-level functions which require manual cleanup.

所有可被使用者呼叫的函式和建構函式都帶有可以設定臨時檔案和臨時目錄 F 的路徑和名稱的引數。此 module 所使用的檔名 F 一個隨機字元組成的字串，這讓檔案可以更安全地在共享的臨時目錄 F 中被建立。F 了維持向後相容性，引數的順序會稍微奇怪，所以 F 了讓程式更容易被理解，建議使用關鍵字引數。

這個 module 定義了以下可供使用者呼叫的項目：

```
tempfile.TemporaryFile (mode='w+b', buffering=-1, encoding=None, newline=None, suffix=None,
                        prefix=None, dir=None, *, errors=None)
```

回傳一個可當作臨時儲存區域的 *file-like object*。建立該檔案使用了與 `mkstemp()` 相同的安全規則。它將在關閉（包括當物件被垃圾回收 (garbage collect) 時的隱式關閉）後立即銷毀。在 Unix 下，該檔案所在的目錄可能根本不被建立、或者在建立檔案後立即就被刪除，其他平臺不支援此功能；你的程式不應依賴使用此功能建立的臨時檔案名稱，因為它在檔案系統中的名稱有可能是不可見的。

The resulting object can be used as a *context manager* (see 範例). On completion of the context or destruction of the file object the temporary file will be removed from the filesystem.

`mode` 參數預設為 `'w+b'`，所以建立的檔案不用關閉就可以讀取或寫入。因為用的是二進位制模式，所以無論存的是什麼資料，它在所有平臺上的行都一致。`buffering`、`encoding`、`errors` 和 `newline` 的含義與 `open()` 中的相同。

參數 `dir`、`prefix` 和 `suffix` 的含義和預設值都與它們在 `mkstemp()` 中的相同。

在 POSIX 平臺上，回傳物件是真實的檔案物件。在其他平臺上，它是一個 *file-like object*，它的 `file` 屬性指向底層的真实檔案物件。

The `os.O_TMPFILE` flag is used if it is available and works (Linux-specific, requires Linux kernel 3.11 or later).

在不是 Posix 或 Cygwin 的平臺上，`TemporaryFile` 是 `NamedTemporaryFile` 的別名。

引發一個附帶引數 `fullpath` 的 `tempfile.mkstemp` 稽核事件。

在 3.5 版的變更: The `os.O_TMPFILE` flag is now used if available.

在 3.8 版的變更: 新增 `errors` 參數。

```
tempfile.NamedTemporaryFile (mode='w+b', buffering=-1, encoding=None, newline=None,
                              suffix=None, prefix=None, dir=None, delete=True, *, errors=None)
```

此函式執行的操作與 `TemporaryFile()` 幾乎相同，不同之處是確保該臨時檔案在檔案系統中具有可見的名稱（在 Unix 上目錄條目不會被 `unlink`）。檔名可以由回傳 *file-like object* 的 `name` 屬性取得。在臨時檔案仍開啟時，是否允許用檔名第二次開啟檔案，在各個平臺上是不同的（在 Unix 上可以；在 Windows NT 版本以上不行）。如果 `delete` 為 `true`（預設值），則檔案會在關閉後立即被刪除。該函式回傳的物件始終是 *file-like object*，它的 `file` 屬性是底層的真实檔案物件。*file-like object* 可以像普通檔案一樣在 `with` 陳述句中使用。

On POSIX (only), a process that is terminated abruptly with SIGKILL cannot automatically delete any `NamedTemporaryFiles` it created.

引發一個附帶引數 `fullpath` 的 `tempfile.mkstemp` 稽核事件。

在 3.8 版的變更: 新增 `errors` 參數。

```
class tempfile.SpooledTemporaryFile (max_size=0, mode='w+b', buffering=-1, encoding=None,
                                       newline=None, suffix=None, prefix=None, dir=None, *,
                                       errors=None)
```

This class operates exactly as `TemporaryFile()` does, except that data is spooled in memory until the file size exceeds `max_size`, or until the file's `fileno()` method is called, at which point the contents are written to disk and operation proceeds as with `TemporaryFile()`.

rollover()

The resulting file has one additional method, `rollover()`, which causes the file to roll over to an on-disk file regardless of its size.

The returned object is a *file-like object* whose `_file` attribute is either an `io.BytesIO` or `io.TextIOWrapper` object (depending on whether binary or text `mode` was specified) or a true file object, depending on whether `rollover()` has been called. This *file-like object* can be used in a `with` statement, just like a normal file.

在 3.3 版的變更: the `truncate` method now accepts a `size` argument.

在 3.8 版的變更: 新增 `errors` 參數。

在 3.11 版的變更: Fully implements the `io.BufferedIOBase` and `io.TextIOBase` abstract base classes (depending on whether binary or text *mode* was specified).

```
class tempfile.TemporaryDirectory (suffix=None, prefix=None, dir=None,
                                     ignore_cleanup_errors=False)
```

This class securely creates a temporary directory using the same rules as `mkdtemp()`. The resulting object can be used as a *context manager* (see 範例). On completion of the context or destruction of the temporary directory object, the newly created temporary directory and all its contents are removed from the filesystem.

name

The directory name can be retrieved from the `name` attribute of the returned object. When the returned object is used as a *context manager*, the `name` will be assigned to the target of the `as` clause in the `with` statement, if there is one.

cleanup()

The directory can be explicitly cleaned up by calling the `cleanup()` method. If `ignore_cleanup_errors` is true, any unhandled exceptions during explicit or implicit cleanup (such as a `PermissionError` removing open files on Windows) will be ignored, and the remaining removable items deleted on a "best-effort" basis. Otherwise, errors will be raised in whatever context cleanup occurs (the `cleanup()` call, exiting the context manager, when the object is garbage-collected or during interpreter shutdown).

引發一個附帶引數 `fullpath` 的 `tempfile.mkdtemp` 稽核事件。

在 3.2 版新加入。

在 3.10 版的變更: 新增 `ignore_cleanup_errors` 參數。

```
tempfile.mkstemp (suffix=None, prefix=None, dir=None, text=False)
```

盡可能以最安全的方式建立一個臨時檔案。假設所在平臺正確實作了 `os.open()` 的 `os.O_EXCL` 旗標, 則建立檔案時不會有 race condition (競態條件) 的情。該檔案只能由建立者讀寫, 如果所在平臺用 permission bit (許可權位元) 來表示檔案是否可執行, 則有人有執行權。檔案描述器不會被子行程繼承。

與 `TemporaryFile()` 不同, `mkstemp()` 使用者用完臨時檔案後需要自行將其除。

如果 `suffix` 不是 `None` 則檔名將以該後綴結尾, 若 `None` 則有後綴。 `mkstemp()` 不會在檔名和後綴之間加點 (dot), 如果需要加一個點號, 請將其放在 `suffix` 的開頭。

如果 `prefix` 不是 `None` 則檔名將以該字首開頭, 若 `None` 則使用預設前綴。預設前綴是 `gettempprefix()` 或 `gettempprefixb()` 函式的回傳值 (自動呼叫合適的函式)。

如果 `dir` 不 `None` 則在指定的目建立檔案, 若 `None` 則使用預設目。預設目是從一個相依於平臺的列表中選擇出來的, 但是使用者可以設定 `TMPDIR`、`TEMP` 或 `TMP` 環境變數來設定目的位置。因此, 不能保證生成的臨時檔案路徑是使用者友善的, 比如透過 `os.popen()` 將路徑傳遞給外部命令時仍需要加引號 (quoting)。

如果 `suffix`、`prefix` 和 `dir` 中的任何一個不是 `None`, 就要保證它們資料型相同。如果它們是位元組串, 則回傳名稱的型就是位元組串而非字串。如果不想遵循預設行但又想要回傳值是位元組串型, 請傳入 `suffix=b''`。

如果指定了 `text` 且真值, 檔案會以文字模式開。否則, 檔案 (預設) 以二進位制模式開。

`mkstemp()` 回傳一個 tuple, tuple 中, 第一個元素是一個作業系統層級 (OS-level) 控制代碼, 指向一個開的檔案 (如同 `os.open()` 的回傳值), 第二元素是該檔案的對路徑。

引發一個附帶引數 `fullpath` 的 `tempfile.mkstemp` 稽核事件。

在 3.5 版的變更: 現在, `suffix`、`prefix` 和 `dir` 可以以位元組串型按順序提供, 以獲得位元組串型的回傳值。在之前只允許使用字串。 `suffix` 和 `prefix` 現在可以接受 `None`, 且預設 `None` 以使用合適的預設值。

在 3.6 版的變更: `dir` 參數現在可接受一個類路徑物件 (path-like object)。

`tempfile.mkdtemp(suffix=None, prefix=None, dir=None)`

盡可能以最安全的方式建立一個臨時目錄，建立該目錄時不會有 race condition 的情況，該目錄只能由建立者讀取、寫入和搜尋。

`mkdtemp()` 的使用者用完臨時目錄後需要自行將其刪除。

引數 `prefix`、`suffix` 和 `dir` 的含義與它們在 `mkstemp()` 中相同。

`mkdtemp()` returns the absolute pathname of the new directory if `dir` is `None` or is an absolute path. If `dir` is a relative path, `mkdtemp()` returns a relative path on Python 3.11 and lower. However, on 3.12 it will return an absolute path in all situations.

引發一個附帶引數 `fullpath` 的 `tempfile.mkdtemp` 稽核事件。

在 3.5 版的變更: 現在, `suffix`、`prefix` 和 `dir` 可以以位元組串型按順序提供, 以獲得位元組串型的回傳值。在之前只允許使用字串。`suffix` 和 `prefix` 現在可以接受 `None`, 且預設 `None` 以使用合適的預設值。

在 3.6 版的變更: `dir` 參數現在可接受一個類路徑物件 (*path-like object*)。

`tempfile.gettempdir()`

回傳儲存臨時檔案的目錄名稱。這設定了此 module 所有函式 `dir` 引數的預設值。

Python 搜尋標準目錄列表來找到呼叫者可以在其中建立檔案的目錄。這個列表是:

1. `TMPDIR` 環境變數指向的目錄。
2. `TEMP` 環境變數指向的目錄。
3. `TMP` 環境變數指向的目錄。
4. 與平臺相關的位置:
 - 在 Windows 上, 目錄依次 `C:\TEMP`、`C:\TMP`、`\TEMP` 和 `\TMP`。
 - 在所有其他平臺上, 目錄依次 `/tmp`、`/var/tmp` 和 `/usr/tmp`。
5. 不得已時, 使用當前工作目錄。

搜尋的結果會被 cache (快取) 起來, 請見下面 `tempdir` 的描述。

在 3.10 版的變更: 回傳一個字串。在之前的版本中它會回傳任意 `tempdir` 的值而不考慮它的型, 只要它不是 `None`。

`tempfile.gettempdirb()`

與 `gettempdir()` 相同, 但回傳值位元組串型。

在 3.5 版新加入。

`tempfile.gettempprefix()`

回傳用於建立臨時檔案的檔名前綴, 它不包含目錄部分。

`tempfile.gettempprefixb()`

與 `gettempprefix()` 相同, 但回傳值位元組串型。

在 3.5 版新加入。

此 module 使用一個全域性變數來儲存由 `gettempdir()` 回傳的臨時檔案使用的目錄路徑。它可被直接設定以覆蓋選擇過程, 但不建議這樣做。此 module 中的所有函式都接受一個 `dir` 引數, 它可被用於指定目錄。這是個推薦的做法, 它不會透過改變全域性 API 行而對其他不預期此行程式造成影響。

`tempfile.tempdir`

當被設 `None` 以外的值時, 此變數會此 module 所定義函式的引數 `dir` 定義預設值, 包括確定其型位元組串還是字串。它不可以 *path-like object*。

如果在呼叫除 `gettempprefix()` 外的上述任何函式時 `tempdir` 是 `None` (預設值) 則它會按照 `gettempdir()` 中所描述的演算法來初始化。

備註： 請注意如果你將 `tempdir` 設定位元組串值，會有一個麻煩的副作用：`mkstemp()` 和 `mkdtemp()` 的全域性預設回傳型會在有提供明顯字串型值的 `prefix`、`suffix` 或 `dir` 時被改定位元組串。請不要編寫預期此行或依賴於此行的程式。這個奇怪的行是了維持與以往實作版本的相容性。

11.6.1 范例

以下是 `tempfile` module 的一些常見用法範例：

```
>>> import tempfile

# create a temporary file and write some data to it
>>> fp = tempfile.TemporaryFile()
>>> fp.write(b'Hello world!')
# read data from file
>>> fp.seek(0)
>>> fp.read()
b'Hello world!'
# close the file, it will be removed
>>> fp.close()

# create a temporary file using a context manager
>>> with tempfile.TemporaryFile() as fp:
...     fp.write(b'Hello world!')
...     fp.seek(0)
...     fp.read()
b'Hello world!'
>>>
# file is now closed and removed

# create a temporary directory using the context manager
>>> with tempfile.TemporaryDirectory() as tmpdirname:
...     print('created temporary directory', tmpdirname)
>>>
# directory and contents have been removed
```

11.6.2 已用的函式和變數

在過去，建立臨時檔案首先使用 `mktemp()` 函式生成一個檔名，然後使用該檔名建立檔案。不幸的是這是不安全的，因在呼叫 `mktemp()` 與隨後嘗試建立檔案之間的時間，其他程式可能會使用該名稱建立檔案。解方案是將兩個步驟結合起來，立即建立檔案。這個方案目前被 `mkstemp()` 和上述其他函式所用。

`tempfile.mktemp(suffix='', prefix='tmp', dir=None)`

在 2.3 版之後被用：使用 `mkstemp()` 代替。

回傳一個在呼叫本方法時不存在檔案的對路徑。引數 `prefix`、`suffix` 和 `dir` 與 `mkstemp()` 中所用的類似，除了在於不支援位元組串型的檔名且不支援 `suffix=None` 和 `prefix=None`。

警告： 使用此功能可能會在程式中引入安全漏洞。當你開始使用本方法回傳的檔案執行任何操作時，可能有人已經捷足先登了。`mktemp()` 的功能可以很輕鬆地用帶有 `delete=False` 參數的 `NamedTemporaryFile()` 代替：

```
>>> f = NamedTemporaryFile(delete=False)
>>> f.name
'/tmp/tmpjtjujtt'
>>> f.write(b"Hello World!\n")
```



```

13
>>> f.close()
>>> os.unlink(f.name)
>>> os.path.exists(f.name)
False

```

11.7 glob --- Unix 風格的路徑名稱模式擴展

原始碼: [Lib/glob.py](#)

`glob` 模組根據 Unix shell 使用的規則查找與指定模式匹配的所有路徑名稱，結果以任意順序回傳。有波浪號 (tilde) 擴展，但是 `*`、`?` 和用 `[]` 表示的字元範圍將被正確匹配。這是透過同時使用 `os.scandir()` 和 `fnmatch.fnmatch()` 函式來完成的，而有實際調用 `subshell`。

請注意，以點 (.) 開頭的檔案只能與同樣以點開頭的模式匹配，這與 `fnmatch.fnmatch()` 或 `pathlib.Path.glob()` 不同。(對於波浪號和 shell 變數擴展，請使用 `os.path.expanduser()` 和 `os.path.expandvars()`。)

對於文本 (literal) 匹配，將元字元 (meta-character) 括在方括號中。例如，`'[?]'` 會匹配 `'?'` 字元。

也參考:

`pathlib` 模組提供高階路徑物件。

`glob.glob(pathname, *, root_dir=None, dir_fd=None, recursive=False, include_hidden=False)`

回傳與 `pathname` 匹配、可能為空的路徑名稱 list，它必須是包含路徑規範的字串。`pathname` 可以是絕對的 (如 `/usr/src/Python-1.5/Makefile`) 或相對的 (如 `../../Tools/**/*.gif`)，且可以包含 shell 樣式的通用字元 (wildcard)。已損壞的符號連接也會 (如同在 shell) 被包含在結果中。結果是否排序取決於檔案系統 (file system)。如果在呼叫此函式期間刪除或新增滿足條件的檔案，則結果不一定會包含該檔案的路徑名稱。

如果 `root_dir` 不是 `None`，它應該是一個指定搜索根目的 *path-like object*。它在呼叫它之前更改當前目的影響與 `glob()` 相同。如果 `pathname` 是相對的，結果將包含相對於 `root_dir` 的路徑。

此函式可以支援以 `dir_fd` 參數使用相對目描述器的路徑。

如果 `recursive` 為真，模式 `***` 將匹配任何檔案、零個或多個目、子目和目的符號連結。如果模式後面有 `os.sep` 或 `os.altsep` 那檔案將不會被匹配。

如果 `include_hidden` 為真，`***` 模式將匹配被隱藏的目。

引發一個附帶引數 `pathname`、`recursive` 的稽核事件 `glob.glob`。

引發一個附帶引數 `pathname`、`recursive`、`root_dir`、`dir_fd` 的稽核事件 `glob.glob/2`。

備註: 在大型目樹中使用 `***` 模式可能會消耗過多的時間。

在 3.5 版的變更: 支援以 `***` 使用遞迴 `glob`。

在 3.10 版的變更: 新增 `root_dir` 與 `dir_fd` 參數。

在 3.11 版的變更: 新增 `include_hidden` 參數。

`glob.iglob(pathname, *, root_dir=None, dir_fd=None, recursive=False, include_hidden=False)`

回傳一個會生成與 `glob()` 相同的值的 *iterator*，而不是同時存儲全部的值。

引發一個附帶引數 `pathname`、`recursive` 的稽核事件 `glob.glob`。

引發一個附帶引數 `pathname`、`recursive`、`root_dir`、`dir_fd` 的稽核事件 `glob.glob/2`。

在 3.5 版的變更: 支援以 `***` 使用遞迴 `glob`。

在 3.10 版的變更: 新增 `root_dir` 與 `dir_fd` 參數。

在 3.11 版的變更: 新增 `include_hidden` 參數。

`glob.escape(pathname)`

跳 (escape) 所有特殊字元 ('?', '*', 和 '[')。如果你想匹配其中可能包含特殊字元的任意文本字串, 這將會很有用。驅動器 (drive)/UNC 共享點 (sharepoints) 中的特殊字元不會被跳, 例如在 Windows 上, `escape('///?/c:/Quo vadis?.txt')` 會回傳 `'///?/c:/Quo vadis[?].txt'`。

在 3.4 版新加入。

例如, 在一個包含以下檔案的目錄: 1.gif、2.txt、card.gif, 和一個僅包含 3.txt 檔案的子目錄 sub, `glob()` 將產生以下結果。請注意路徑的任何前導部分是如何保留的。

```
>>> import glob
>>> glob.glob('./[0-9].*')
['./1.gif', './2.txt']
>>> glob.glob('*.gif')
['1.gif', 'card.gif']
>>> glob.glob('?.gif')
['1.gif']
>>> glob.glob('**/*.txt', recursive=True)
['2.txt', 'sub/3.txt']
>>> glob.glob('./**/', recursive=True)
['./', './sub/']
```

如果目錄包含以 . 開頭的檔案, 則預設情況下不會去匹配到它們。例如, 一個包含 card.gif 和 .card.gif 的目錄:

```
>>> import glob
>>> glob.glob('*.gif')
['card.gif']
>>> glob.glob('.*')
['.card.gif']
```

也參考:

[`fnmatch` 模組](#)

Shell 風格檔案名 (不是路徑) 的擴展

11.8 fnmatch --- Unix filename pattern matching

原始碼: [Lib/fnmatch.py](#)

This module provides support for Unix shell-style wildcards, which are *not* the same as regular expressions (which are documented in the [re](#) module). The special characters used in shell-style wildcards are:

Pattern	Meaning
*	matches everything
?	matches any single character
[seq]	matches any character in <i>seq</i>
[!seq]	matches any character not in <i>seq</i>

For a literal match, wrap the meta-characters in brackets. For example, `'[?]'` matches the character `'?'`.

Note that the filename separator ('/' on Unix) is *not* special to this module. See module [glob](#) for pathname expansion (`glob` uses `filter()` to match pathname segments). Similarly, filenames starting with a period are not special for this module, and are matched by the `*` and `?` patterns.

Also note that `functools.lru_cache()` with the `maxsize` of 32768 is used to cache the compiled regex patterns in the following functions: `fnmatch()`, `fnmatchcase()`, `filter()`.

`fnmatch.fnmatch(name, pat)`

Test whether the filename string `name` matches the pattern string `pat`, returning True or False. Both parameters are case-normalized using `os.path.normcase()`. `fnmatchcase()` can be used to perform a case-sensitive comparison, regardless of whether that's standard for the operating system.

This example will print all file names in the current directory with the extension `.txt`:

```
import fnmatch
import os

for file in os.listdir('.'):
    if fnmatch.fnmatch(file, '*.txt'):
        print(file)
```

`fnmatch.fnmatchcase(name, pat)`

Test whether the filename string `name` matches the pattern string `pat`, returning True or False; the comparison is case-sensitive and does not apply `os.path.normcase()`.

`fnmatch.filter(names, pat)`

Construct a list from those elements of the *iterable* `names` that match pattern `pat`. It is the same as `[n for n in names if fnmatch(n, pat)]`, but implemented more efficiently.

`fnmatch.translate(pat)`

Return the shell-style pattern `pat` converted to a regular expression for using with `re.match()`.

範例：

```
>>> import fnmatch, re
>>>
>>> regex = fnmatch.translate('*.txt')
>>> regex
'(?s:.*\\.txt)\\Z'
>>> reobj = re.compile(regex)
>>> reobj.match('foobar.txt')
<re.Match object; span=(0, 10), match='foobar.txt'>
```

也參考：

glob 模組

Unix shell-style path expansion.

11.9 linecache --- Random access to text lines

原始碼：[Lib/linecache.py](#)

The `linecache` module allows one to get any line from a Python source file, while attempting to optimize internally, using a cache, the common case where many lines are read from a single file. This is used by the `traceback` module to retrieve source lines for inclusion in the formatted traceback.

The `tokenize.open()` function is used to open files. This function uses `tokenize.detect_encoding()` to get the encoding of the file; in the absence of an encoding token, the file encoding defaults to UTF-8.

The `linecache` module defines the following functions:

`linecache.getline(filename, lineno, module_globals=None)`

Get line *lineno* from file named *filename*. This function will never raise an exception --- it will return `' '` on errors (the terminating newline character will be included for lines that are found).

If a file named *filename* is not found, the function first checks for a **PEP 302** `__loader__` in *module_globals*. If there is such a loader and it defines a `get_source` method, then that determines the source lines (if `get_source()` returns `None`, then `' '` is returned). Finally, if *filename* is a relative filename, it is looked up relative to the entries in the module search path, `sys.path`.

`linecache.clearcache()`

Clear the cache. Use this function if you no longer need lines from files previously read using `getline()`.

`linecache.checkcache(filename=None)`

Check the cache for validity. Use this function if files in the cache may have changed on disk, and you require the updated version. If *filename* is omitted, it will check all the entries in the cache.

`linecache.lazycache(filename, module_globals)`

Capture enough detail about a non-file-based module to permit getting its lines later via `getline()` even if *module_globals* is `None` in the later call. This avoids doing I/O until a line is actually needed, without having to carry the module globals around indefinitely.

在 3.5 版新加入。

範例：

```
>>> import linecache
>>> linecache.getline(linecache.__file__, 8)
'import sys\n'
```

11.10 `shutil` --- High-level file operations

原始碼： [Lib/shutil.py](#)

The `shutil` module offers a number of high-level operations on files and collections of files. In particular, functions are provided which support file copying and removal. For operations on individual files, see also the `os` module.

警告： Even the higher-level file copying functions (`shutil.copy()`, `shutil.copy2()`) cannot copy all file metadata.

On POSIX platforms, this means that file owner and group are lost as well as ACLs. On Mac OS, the resource fork and other metadata are not used. This means that resources will be lost and file type and creator codes will not be correct. On Windows, file owners, ACLs and alternate data streams are not copied.

11.10.1 Directory and files operations

`shutil.copyfileobj(fsrc, fdst[, length])`

Copy the contents of the *file-like object* *fsrc* to the file-like object *fdst*. The integer *length*, if given, is the buffer size. In particular, a negative *length* value means to copy the data without looping over the source data in chunks; by default the data is read in chunks to avoid uncontrolled memory consumption. Note that if the current file position of the *fsrc* object is not 0, only the contents from the current file position to the end of the file will be copied.

`shutil.copyfile(src, dst, *, follow_symlinks=True)`

Copy the contents (no metadata) of the file named *src* to a file named *dst* and return *dst* in the most efficient way possible. *src* and *dst* are *path-like objects* or path names given as strings.

dst must be the complete target file name; look at `copy()` for a copy that accepts a target directory path. If *src* and *dst* specify the same file, `SameFileError` is raised.

The destination location must be writable; otherwise, an `OSError` exception will be raised. If *dst* already exists, it will be replaced. Special files such as character or block devices and pipes cannot be copied with this function.

If `follow_symlinks` is false and *src* is a symbolic link, a new symbolic link will be created instead of copying the file *src* points to.

引發一個附帶引數 *src*、*dst* 的稽核事件 `shutil.copyfile`。

在 3.3 版的變更: `IOError` used to be raised instead of `OSError`. Added `follow_symlinks` argument. Now returns *dst*.

在 3.4 版的變更: Raise `SameFileError` instead of `Error`. Since the former is a subclass of the latter, this change is backward compatible.

在 3.8 版的變更: Platform-specific fast-copy syscalls may be used internally in order to copy the file more efficiently. See *Platform-dependent efficient copy operations* section.

exception `shutil.SameFileError`

This exception is raised if source and destination in `copyfile()` are the same file.

在 3.4 版新加入。

`shutil.copymode(src, dst, *, follow_symlinks=True)`

Copy the permission bits from *src* to *dst*. The file contents, owner, and group are unaffected. *src* and *dst* are *path-like objects* or path names given as strings. If `follow_symlinks` is false, and both *src* and *dst* are symbolic links, `copymode()` will attempt to modify the mode of *dst* itself (rather than the file it points to). This functionality is not available on every platform; please see `copystat()` for more information. If `copymode()` cannot modify symbolic links on the local platform, and it is asked to do so, it will do nothing and return.

引發一個附帶引數 *src*、*dst* 的稽核事件 `shutil.copymode`。

在 3.3 版的變更: 新增 `follow_symlinks` 引數。

`shutil.copystat(src, dst, *, follow_symlinks=True)`

Copy the permission bits, last access time, last modification time, and flags from *src* to *dst*. On Linux, `copystat()` also copies the "extended attributes" where possible. The file contents, owner, and group are unaffected. *src* and *dst* are *path-like objects* or path names given as strings.

If `follow_symlinks` is false, and *src* and *dst* both refer to symbolic links, `copystat()` will operate on the symbolic links themselves rather than the files the symbolic links refer to—reading the information from the *src* symbolic link, and writing the information to the *dst* symbolic link.

備 F: Not all platforms provide the ability to examine and modify symbolic links. Python itself can tell you what functionality is locally available.

- If `os.chmod` in `os.supports_follow_symlinks` is True, `copystat()` can modify the permission bits of a symbolic link.
- If `os.utime` in `os.supports_follow_symlinks` is True, `copystat()` can modify the last access and modification times of a symbolic link.
- If `os.chflags` in `os.supports_follow_symlinks` is True, `copystat()` can modify the flags of a symbolic link. (`os.chflags` is not available on all platforms.)

On platforms where some or all of this functionality is unavailable, when asked to modify a symbolic link, `copystat()` will copy everything it can. `copystat()` never returns failure.

更多資訊請見 `os.supports_follow_symlinks`。

引發一個附帶引數 `src`、`dst` 的稽核事件 `shutil.copystat`。

在 3.3 版的變更: Added `follow_symlinks` argument and support for Linux extended attributes.

`shutil.copy(src, dst, *, follow_symlinks=True)`

Copies the file `src` to the file or directory `dst`. `src` and `dst` should be *path-like objects* or strings. If `dst` specifies a directory, the file will be copied into `dst` using the base filename from `src`. If `dst` specifies a file that already exists, it will be replaced. Returns the path to the newly created file.

If `follow_symlinks` is false, and `src` is a symbolic link, `dst` will be created as a symbolic link. If `follow_symlinks` is true and `src` is a symbolic link, `dst` will be a copy of the file `src` refers to.

`copy()` copies the file data and the file's permission mode (see `os.chmod()`). Other metadata, like the file's creation and modification times, is not preserved. To preserve all file metadata from the original, use `copy2()` instead.

引發一個附帶引數 `src`、`dst` 的稽核事件 `shutil.copyfile`。

引發一個附帶引數 `src`、`dst` 的稽核事件 `shutil.copymode`。

在 3.3 版的變更: Added `follow_symlinks` argument. Now returns path to the newly created file.

在 3.8 版的變更: Platform-specific fast-copy syscalls may be used internally in order to copy the file more efficiently. See *Platform-dependent efficient copy operations* section.

`shutil.copy2(src, dst, *, follow_symlinks=True)`

Identical to `copy()` except that `copy2()` also attempts to preserve file metadata.

When `follow_symlinks` is false, and `src` is a symbolic link, `copy2()` attempts to copy all metadata from the `src` symbolic link to the newly created `dst` symbolic link. However, this functionality is not available on all platforms. On platforms where some or all of this functionality is unavailable, `copy2()` will preserve all the metadata it can; `copy2()` never raises an exception because it cannot preserve file metadata.

`copy2()` uses `copystat()` to copy the file metadata. Please see `copystat()` for more information about platform support for modifying symbolic link metadata.

引發一個附帶引數 `src`、`dst` 的稽核事件 `shutil.copyfile`。

引發一個附帶引數 `src`、`dst` 的稽核事件 `shutil.copystat`。

在 3.3 版的變更: Added `follow_symlinks` argument, try to copy extended file system attributes too (currently Linux only). Now returns path to the newly created file.

在 3.8 版的變更: Platform-specific fast-copy syscalls may be used internally in order to copy the file more efficiently. See *Platform-dependent efficient copy operations* section.

`shutil.ignore_patterns(*patterns)`

This factory function creates a function that can be used as a callable for `copytree()`'s `ignore` argument, ignoring files and directories that match one of the glob-style *patterns* provided. See the example below.

`shutil.copytree(src, dst, symlinks=False, ignore=None, copy_function=copy2,
ignore_dangling_symlinks=False, dirs_exist_ok=False)`

Recursively copy an entire directory tree rooted at `src` to a directory named `dst` and return the destination directory. All intermediate directories needed to contain `dst` will also be created by default.

Permissions and times of directories are copied with `copystat()`, individual files are copied using `copy2()`.

If `symlinks` is true, symbolic links in the source tree are represented as symbolic links in the new tree and the metadata of the original links will be copied as far as the platform allows; if false or omitted, the contents and metadata of the linked files are copied to the new tree.

When *symlinks* is false, if the file pointed by the symlink doesn't exist, an exception will be added in the list of errors raised in an *Error* exception at the end of the copy process. You can set the optional *ignore_dangling_symlinks* flag to true if you want to silence this exception. Notice that this option has no effect on platforms that don't support *os.symlink()*.

If *ignore* is given, it must be a callable that will receive as its arguments the directory being visited by *copytree()*, and a list of its contents, as returned by *os.listdir()*. Since *copytree()* is called recursively, the *ignore* callable will be called once for each directory that is copied. The callable must return a sequence of directory and file names relative to the current directory (i.e. a subset of the items in its second argument); these names will then be ignored in the copy process. *ignore_patterns()* can be used to create such a callable that ignores names based on glob-style patterns.

If exception(s) occur, an *Error* is raised with a list of reasons.

If *copy_function* is given, it must be a callable that will be used to copy each file. It will be called with the source path and the destination path as arguments. By default, *copy2()* is used, but any function that supports the same signature (like *copy()*) can be used.

If *dirs_exist_ok* is false (the default) and *dst* already exists, a *FileExistsError* is raised. If *dirs_exist_ok* is true, the copying operation will continue if it encounters existing directories, and files within the *dst* tree will be overwritten by corresponding files from the *src* tree.

引發一個附帶引數 *src*、*dst* 的稽核事件 *shutil.copytree*。

在 3.2 版的變更: Added the *copy_function* argument to be able to provide a custom copy function. Added the *ignore_dangling_symlinks* argument to silence dangling symlinks errors when *symlinks* is false.

在 3.3 版的變更: Copy metadata when *symlinks* is false. Now returns *dst*.

在 3.8 版的變更: Platform-specific fast-copy syscalls may be used internally in order to copy the file more efficiently. See *Platform-dependent efficient copy operations* section.

在 3.8 版的變更: Added the *dirs_exist_ok* parameter.

*shutil.rmtree(path, ignore_errors=False, onerror=None, *, dir_fd=None)*

Delete an entire directory tree; *path* must point to a directory (but not a symbolic link to a directory). If *ignore_errors* is true, errors resulting from failed removals will be ignored; if false or omitted, such errors are handled by calling a handler specified by *onerror* or, if that is omitted, they raise an exception.

This function can support *paths relative to directory descriptors*.

備 F: On platforms that support the necessary fd-based functions a symlink attack resistant version of *rmtree()* is used by default. On other platforms, the *rmtree()* implementation is susceptible to a symlink attack: given proper timing and circumstances, attackers can manipulate symlinks on the filesystem to delete files they wouldn't be able to access otherwise. Applications can use the *rmtree.avoids_symlink_attacks* function attribute to determine which case applies.

If *onerror* is provided, it must be a callable that accepts three parameters: *function*, *path*, and *excinfo*.

The first parameter, *function*, is the function which raised the exception; it depends on the platform and implementation. The second parameter, *path*, will be the path name passed to *function*. The third parameter, *excinfo*, will be the exception information returned by *sys.exc_info()*. Exceptions raised by *onerror* will not be caught.

引發一個附帶引數 *path*、*dir_fd* 的稽核事件 *shutil.rmtree*。

在 3.3 版的變更: Added a symlink attack resistant version that is used automatically if platform supports fd-based functions.

在 3.8 版的變更: On Windows, will no longer delete the contents of a directory junction before removing the junction.

在 3.11 版的變更: *dir_fd* 參數。

rmtree.avoids_symlink_attacks

Indicates whether the current platform and implementation provides a symlink attack resistant version of `rmtree()`. Currently this is only true for platforms supporting fd-based directory access functions.

在 3.3 版新加入。

shutil.move(*src*, *dst*, *copy_function*=*copy2*)

Recursively move a file or directory (*src*) to another location and return the destination.

If *dst* is an existing directory or a symlink to a directory, then *src* is moved inside that directory. The destination path in that directory must not already exist.

If *dst* already exists but is not a directory, it may be overwritten depending on `os.rename()` semantics.

If the destination is on the current filesystem, then `os.rename()` is used. Otherwise, *src* is copied to the destination using *copy_function* and then removed. In case of symlinks, a new symlink pointing to the target of *src* will be created as the destination and *src* will be removed.

If *copy_function* is given, it must be a callable that takes two arguments, *src* and the destination, and will be used to copy *src* to the destination if `os.rename()` cannot be used. If the source is a directory, `copytree()` is called, passing it the *copy_function*. The default *copy_function* is `copy2()`. Using `copy()` as the *copy_function* allows the move to succeed when it is not possible to also copy the metadata, at the expense of not copying any of the metadata.

引發一個附帶引數 *src*、*dst* 的稽核事件 `shutil.move`。

在 3.3 版的變更: Added explicit symlink handling for foreign filesystems, thus adapting it to the behavior of GNU's **mv**. Now returns *dst*.

在 3.5 版的變更: 新增 *copy_function* 關鍵字引數。

在 3.8 版的變更: Platform-specific fast-copy syscalls may be used internally in order to copy the file more efficiently. See [Platform-dependent efficient copy operations](#) section.

在 3.9 版的變更: Accepts a *path-like object* for both *src* and *dst*.

shutil.disk_usage(*path*)

Return disk usage statistics about the given path as a *named tuple* with the attributes *total*, *used* and *free*, which are the amount of total, used and free space, in bytes. *path* may be a file or a directory.

備[Ⓕ]: On Unix filesystems, *path* must point to a path within a **mounted** filesystem partition. On those platforms, CPython doesn't attempt to retrieve disk usage information from non-mounted filesystems.

在 3.3 版新加入。

在 3.8 版的變更: On Windows, *path* can now be a file or directory.

適用: Unix、Windows。

shutil.chown(*path*, *user*=None, *group*=None)

Change owner *user* and/or *group* of the given *path*.

user can be a system user name or a uid; the same applies to *group*. At least one argument is required.

See also `os.chown()`, the underlying function.

引發一個附帶引數 *path*、*user*、*group* 的稽核事件 `shutil.chown`。

適用: Unix。

在 3.3 版新加入。

shutil.which(*cmd*, *mode*=*os.F_OK* | *os.X_OK*, *path*=None)

Return the path to an executable which would be run if the given *cmd* was called. If no *cmd* would be called, return None.

mode is a permission mask passed to `os.access()`, by default determining if the file exists and executable.

When no *path* is specified, the results of `os.environ()` are used, returning either the "PATH" value or a fallback of `os.defpath`.

On Windows, the current directory is always prepended to the *path* whether or not you use the default or provide your own, which is the behavior the command shell uses when finding executables. Additionally, when finding the *cmd* in the *path*, the `PATHEXT` environment variable is checked. For example, if you call `shutil.which("python")`, `which()` will search `PATHEXT` to know that it should look for `python.exe` within the *path* directories. For example, on Windows:

```
>>> shutil.which("python")
'C:\\Python33\\python.EXE'
```

在 3.3 版新加入.

在 3.8 版的變更: The *bytes* type is now accepted. If *cmd* type is *bytes*, the result type is also *bytes*.

exception `shutil.Error`

This exception collects exceptions that are raised during a multi-file operation. For `copytree()`, the exception argument is a list of 3-tuples (*srcname*, *dstname*, *exception*).

Platform-dependent efficient copy operations

Starting from Python 3.8, all functions involving a file copy (`copyfile()`, `copy()`, `copy2()`, `copytree()`, and `move()`) may use platform-specific "fast-copy" syscalls in order to copy the file more efficiently (see [bpo-33671](#)). "fast-copy" means that the copying operation occurs within the kernel, avoiding the use of userspace buffers in Python as in `"outfd.write(infd.read())"`.

On macOS `fcopyfile` is used to copy the file content (not metadata).

On Linux `os.sendfile()` is used.

On Windows `shutil.copyfile()` uses a bigger default buffer size (1 MiB instead of 64 KiB) and a `memoryview()`-based variant of `shutil.copyfileobj()` is used.

If the fast-copy operation fails and no data was written in the destination file then `shutil` will silently fallback on using less efficient `copyfileobj()` function internally.

在 3.8 版的變更.

copytree example

An example that uses the `ignore_patterns()` helper:

```
from shutil import copytree, ignore_patterns

copytree(source, destination, ignore=ignore_patterns('*.pyc', 'tmp*'))
```

This will copy everything except `.pyc` files and files or directories whose name starts with `tmp`.

Another example that uses the `ignore` argument to add a logging call:

```
from shutil import copytree
import logging

def _logpath(path, names):
    logging.info('Working in %s', path)
    return [] # nothing will be ignored

copytree(source, destination, ignore=_logpath)
```

rmtree 范例

This example shows how to remove a directory tree on Windows where some of the files have their read-only bit set. It uses the `onerror` callback to clear the readonly bit and reattempt the remove. Any subsequent failure will propagate.

```
import os, stat
import shutil

def remove_readonly(func, path, _):
    "Clear the readonly bit and reattempt the removal"
    os.chmod(path, stat.S_IWRITE)
    func(path)

shutil.rmtree(directory, onerror=remove_readonly)
```

11.10.2 Archiving operations

在 3.2 版新加入。

在 3.5 版的變更: 新增 *xz*tar 格式的支援。

High-level utilities to create and read compressed and archived files are also provided. They rely on the *zipfile* and *tarfile* modules.

```
shutil.make_archive(base_name, format[, root_dir[, base_dir[, verbose[, dry_run[, owner[, group[,
                                                              logger]]]]]])
```

Create an archive file (such as zip or tar) and return its name.

base_name is the name of the file to create, including the path, minus any format-specific extension.

format is the archive format: one of "zip" (if the *zlib* module is available), "tar", "gz" (if the *zlib* module is available), "bztar" (if the *bz2* module is available), or "xztar" (if the *lzma* module is available).

root_dir is a directory that will be the root directory of the archive, all paths in the archive will be relative to it; for example, we typically `chdir` into *root_dir* before creating the archive.

base_dir is the directory where we start archiving from; i.e. *base_dir* will be the common prefix of all files and directories in the archive. *base_dir* must be given relative to *root_dir*. See *Archiving example with base_dir* for how to use *base_dir* and *root_dir* together.

root_dir and *base_dir* both default to the current directory.

If *dry_run* is true, no archive is created, but the operations that would be executed are logged to *logger*.

owner and *group* are used when creating a tar archive. By default, uses the current owner and group.

logger must be an object compatible with **PEP 282**, usually an instance of *logging.Logger*.

The *verbose* argument is unused and deprecated.

引發一個附帶引數 *base_name*、*format*、*root_dir*、*base_dir* 的稽核事件 `shutil.make_archive`。

備 F: This function is not thread-safe when custom archivers registered with *register_archive_format()* are used. In this case it temporarily changes the current working directory of the process to perform archiving.

在 3.8 版的變更: The modern pax (POSIX.1-2001) format is now used instead of the legacy GNU format for archives created with `format="tar"`.

在 3.10.6 版的變更: This function is now made thread-safe during creation of standard .zip and tar archives.

`shutil.get_archive_formats()`

Return a list of supported formats for archiving. Each element of the returned sequence is a tuple (name, description).

By default `shutil` provides these formats:

- *zip*: ZIP file (if the `zlib` module is available).
- *tar*: Uncompressed tar file. Uses POSIX.1-2001 pax format for new archives.
- *gztar*: gzipped tar-file (if the `zlib` module is available).
- *bztar*: bzip2'ed tar-file (if the `bz2` module is available).
- *xztar*: xz'ed tar-file (if the `lzma` module is available).

You can register new formats or provide your own archiver for any existing formats, by using `register_archive_format()`.

`shutil.register_archive_format(name, function[, extra_args[, description]])`

Register an archiver for the format *name*.

function is the callable that will be used to unpack archives. The callable will receive the *base_name* of the file to create, followed by the *base_dir* (which defaults to `os.curdir`) to start archiving from. Further arguments are passed as keyword arguments: *owner*, *group*, *dry_run* and *logger* (as passed in `make_archive()`).

If given, *extra_args* is a sequence of (name, value) pairs that will be used as extra keywords arguments when the archiver callable is used.

description is used by `get_archive_formats()` which returns the list of archivers. Defaults to an empty string.

`shutil.unregister_archive_format(name)`

Remove the archive format *name* from the list of supported formats.

`shutil.unpack_archive(filename[, extract_dir[, format[, filter]]])`

Unpack an archive. *filename* is the full path of the archive.

extract_dir is the name of the target directory where the archive is unpacked. If not provided, the current working directory is used.

format is the archive format: one of "zip", "tar", "gztar", "bztar", or "xztar". Or any other format registered with `register_unpack_format()`. If not provided, `unpack_archive()` will use the archive file name extension and see if an unpacker was registered for that extension. In case none is found, a `ValueError` is raised.

The keyword-only *filter* argument, which was added in Python 3.11.4, is passed to the underlying unpacking function. For zip files, *filter* is not accepted. For tar files, it is recommended to set it to 'data', unless using features specific to tar and UNIX-like filesystems. (See [Extraction filters](#) for details.) The 'data' filter will become the default for tar files in Python 3.14.

引發一個附帶引數 *filename*、*extract_dir*、*format* 的稽核事件 `shutil.unpack_archive`。

警告： Never extract archives from untrusted sources without prior inspection. It is possible that files are created outside of the path specified in the *extract_dir* argument, e.g. members that have absolute filenames starting with "/" or filenames with two dots "..".

在 3.7 版的變更: Accepts a *path-like object* for *filename* and *extract_dir*.

在 3.11.4 版的變更: 新增 *filter* 引數。

`shutil.register_unpack_format(name, extensions, function[, extra_args[, description]])`

Registers an unpack format. *name* is the name of the format and *extensions* is a list of extensions corresponding to the format, like `.zip` for Zip files.

function is the callable that will be used to unpack archives. The callable will receive:

- the path of the archive, as a positional argument;
- the directory the archive must be extracted to, as a positional argument;
- possibly a *filter* keyword argument, if it was given to `unpack_archive()`;
- additional keyword arguments, specified by *extra_args* as a sequence of (name, value) tuples.

description can be provided to describe the format, and will be returned by the `get_unpack_formats()` function.

`shutil.unregister_unpack_format(name)`

Unregister an unpack format. *name* is the name of the format.

`shutil.get_unpack_formats()`

Return a list of all registered formats for unpacking. Each element of the returned sequence is a tuple (name, extensions, description).

By default `shutil` provides these formats:

- *zip*: ZIP file (unpacking compressed files works only if the corresponding module is available).
- *tar*: uncompressed tar file.
- *gztar*: gzip'ed tar-file (if the `zlib` module is available).
- *bztar*: bzip2'ed tar-file (if the `bz2` module is available).
- *xztar*: xz'ed tar-file (if the `lzma` module is available).

You can register new formats or provide your own unpacker for any existing formats, by using `register_unpack_format()`.

Archiving example

In this example, we create a gzip'ed tar-file archive containing all files found in the `.ssh` directory of the user:

```
>>> from shutil import make_archive
>>> import os
>>> archive_name = os.path.expanduser(os.path.join('~', 'myarchive'))
>>> root_dir = os.path.expanduser(os.path.join('~', '.ssh'))
>>> make_archive(archive_name, 'gztar', root_dir)
'/Users/tarek/myarchive.tar.gz'
```

The resulting archive contains:

```
$ tar -tzvf /Users/tarek/myarchive.tar.gz
drwx----- tarek/staff      0 2010-02-01 16:23:40 ./
-rw-r--r-- tarek/staff    609 2008-06-09 13:26:54 ./authorized_keys
-rwxr-xr-x tarek/staff     65 2008-06-09 13:26:54 ./config
-rwx----- tarek/staff    668 2008-06-09 13:26:54 ./id_dsa
-rwxr-xr-x tarek/staff    609 2008-06-09 13:26:54 ./id_dsa.pub
-rw----- tarek/staff   1675 2008-06-09 13:26:54 ./id_rsa
-rw-r--r-- tarek/staff    397 2008-06-09 13:26:54 ./id_rsa.pub
-rw-r--r-- tarek/staff  37192 2010-02-06 18:23:10 ./known_hosts
```

Archiving example with *base_dir*

In this example, similar to the *one above*, we show how to use `make_archive()`, but this time with the usage of *base_dir*. We now have the following directory structure:

```
$ tree tmp
tmp
├── root
│   └── structure
│       ├── content
│       │   └── please_add.txt
│       └── do_not_add.txt
```

In the final archive, `please_add.txt` should be included, but `do_not_add.txt` should not. Therefore we use the following:

```
>>> from shutil import make_archive
>>> import os
>>> archive_name = os.path.expanduser(os.path.join('~', 'myarchive'))
>>> make_archive(
...     archive_name,
...     'tar',
...     root_dir='tmp/root',
...     base_dir='structure/content',
... )
'/Users/tarek/my_archive.tar'
```

Listing the files in the resulting archive gives us:

```
$ python -m tarfile -l /Users/tarek/myarchive.tar
structure/content/
structure/content/please_add.txt
```

11.10.3 Querying the size of the output terminal

`shutil.get_terminal_size (fallback=(columns, lines))`

Get the size of the terminal window.

For each of the two dimensions, the environment variable, `COLUMNS` and `LINES` respectively, is checked. If the variable is defined and the value is a positive integer, it is used.

When `COLUMNS` or `LINES` is not defined, which is the common case, the terminal connected to `sys.__stdout__` is queried by invoking `os.get_terminal_size()`.

If the terminal size cannot be successfully queried, either because the system doesn't support querying, or because we are not connected to a terminal, the value given in `fallback` parameter is used. `fallback` defaults to `(80, 24)` which is the default size used by many terminal emulators.

The value returned is a named tuple of type `os.terminal_size`.

See also: The Single UNIX Specification, Version 2, [Other Environment Variables](#).

在 3.3 版新加入。

在 3.11 版的變更: The `fallback` values are also used if `os.get_terminal_size()` returns zeroes.

也參考:

Module `os`

作業系統介面，包括處理比 Python 檔案物件更低階檔案的函式。

Module `io`

Python 的 建立 I/O 函式庫，包含抽象類 和一些具體類 (concrete class)，如檔案 I/O。

函式 `open()`

使用 Python 打開檔案以進行讀寫檔案的標準方法。

The modules described in this chapter support storing Python data in a persistent form on disk. The `pickle` and `marshal` modules can turn many Python data types into a stream of bytes and then recreate the objects from the bytes. The various DBM-related modules support a family of hash-based file formats that store a mapping of strings to other strings.

The list of modules described in this chapter is:

12.1 `pickle` --- Python object serialization

原始碼: [Lib/pickle.py](#)

The `pickle` module implements binary protocols for serializing and de-serializing a Python object structure. "Pickling" is the process whereby a Python object hierarchy is converted into a byte stream, and "unpickling" is the inverse operation, whereby a byte stream (from a *binary file* or *bytes-like object*) is converted back into an object hierarchy. Pickling (and unpickling) is alternatively known as "serialization", "marshalling",¹ or "flattening"; however, to avoid confusion, the terms used here are "pickling" and "unpickling".

警告: The `pickle` module **is not secure**. Only unpickle data you trust.

It is possible to construct malicious pickle data which will **execute arbitrary code during unpickling**. Never unpickle data that could have come from an untrusted source, or that could have been tampered with.

Consider signing data with `hmac` if you need to ensure that it has not been tampered with.

Safer serialization formats such as `json` may be more appropriate if you are processing untrusted data. See [Comparison with json](#).

¹ Don't confuse this with the `marshal` module

12.1.1 Relationship to other Python modules

Comparison with `marshal`

Python has a more primitive serialization module called `marshal`, but in general `pickle` should always be the preferred way to serialize Python objects. `marshal` exists primarily to support Python's `.pyc` files.

The `pickle` module differs from `marshal` in several significant ways:

- The `pickle` module keeps track of the objects it has already serialized, so that later references to the same object won't be serialized again. `marshal` doesn't do this.

This has implications both for recursive objects and object sharing. Recursive objects are objects that contain references to themselves. These are not handled by `marshal`, and in fact, attempting to marshal recursive objects will crash your Python interpreter. Object sharing happens when there are multiple references to the same object in different places in the object hierarchy being serialized. `pickle` stores such objects only once, and ensures that all other references point to the master copy. Shared objects remain shared, which can be very important for mutable objects.

- `marshal` cannot be used to serialize user-defined classes and their instances. `pickle` can save and restore class instances transparently, however the class definition must be importable and live in the same module as when the object was stored.
- The `marshal` serialization format is not guaranteed to be portable across Python versions. Because its primary job in life is to support `.pyc` files, the Python implementers reserve the right to change the serialization format in non-backwards compatible ways should the need arise. The `pickle` serialization format is guaranteed to be backwards compatible across Python releases provided a compatible pickle protocol is chosen and pickling and unpickling code deals with Python 2 to Python 3 type differences if your data is crossing that unique breaking change language boundary.

Comparison with `json`

There are fundamental differences between the pickle protocols and JSON (JavaScript Object Notation):

- JSON is a text serialization format (it outputs unicode text, although most of the time it is then encoded to `utf-8`), while pickle is a binary serialization format;
- JSON is human-readable, while pickle is not;
- JSON is interoperable and widely used outside of the Python ecosystem, while pickle is Python-specific;
- JSON, by default, can only represent a subset of the Python built-in types, and no custom classes; pickle can represent an extremely large number of Python types (many of them automatically, by clever usage of Python's introspection facilities; complex cases can be tackled by implementing *specific object APIs*);
- Unlike pickle, deserializing untrusted JSON does not in itself create an arbitrary code execution vulnerability.

也参考:

The `json` module: a standard library module allowing JSON serialization and deserialization.

12.1.2 Data stream format

The data format used by `pickle` is Python-specific. This has the advantage that there are no restrictions imposed by external standards such as JSON or XDR (which can't represent pointer sharing); however it means that non-Python programs may not be able to reconstruct pickled Python objects.

By default, the `pickle` data format uses a relatively compact binary representation. If you need optimal size characteristics, you can efficiently *compress* pickled data.

The module `pickletools` contains tools for analyzing data streams generated by `pickle`. `pickletools` source code has extensive comments about opcodes used by pickle protocols.

There are currently 6 different protocols which can be used for pickling. The higher the protocol used, the more recent the version of Python needed to read the pickle produced.

- Protocol version 0 is the original "human-readable" protocol and is backwards compatible with earlier versions of Python.
- Protocol version 1 is an old binary format which is also compatible with earlier versions of Python.
- Protocol version 2 was introduced in Python 2.3. It provides much more efficient pickling of *new-style classes*. Refer to [PEP 307](#) for information about improvements brought by protocol 2.
- Protocol version 3 was added in Python 3.0. It has explicit support for *bytes* objects and cannot be unpickled by Python 2.x. This was the default protocol in Python 3.0--3.7.
- Protocol version 4 was added in Python 3.4. It adds support for very large objects, pickling more kinds of objects, and some data format optimizations. It is the default protocol starting with Python 3.8. Refer to [PEP 3154](#) for information about improvements brought by protocol 4.
- Protocol version 5 was added in Python 3.8. It adds support for out-of-band data and speedup for in-band data. Refer to [PEP 574](#) for information about improvements brought by protocol 5.

備 F: Serialization is a more primitive notion than persistence; although *pickle* reads and writes file objects, it does not handle the issue of naming persistent objects, nor the (even more complicated) issue of concurrent access to persistent objects. The *pickle* module can transform a complex object into a byte stream and it can transform the byte stream into an object with the same internal structure. Perhaps the most obvious thing to do with these byte streams is to write them onto a file, but it is also conceivable to send them across a network or store them in a database. The *shelve* module provides a simple interface to pickle and unpickle objects on DBM-style database files.

12.1.3 模組介面

To serialize an object hierarchy, you simply call the *dumps()* function. Similarly, to de-serialize a data stream, you call the *loads()* function. However, if you want more control over serialization and de-serialization, you can create a *Pickler* or an *Unpickler* object, respectively.

The *pickle* module provides the following constants:

`pickle.HIGHEST_PROTOCOL`

An integer, the highest *protocol version* available. This value can be passed as a *protocol* value to functions *dump()* and *dumps()* as well as the *Pickler* constructor.

`pickle.DEFAULT_PROTOCOL`

An integer, the default *protocol version* used for pickling. May be less than *HIGHEST_PROTOCOL*. Currently the default protocol is 4, first introduced in Python 3.4 and incompatible with previous versions.

在 3.0 版的變更: The default protocol is 3.

在 3.8 版的變更: The default protocol is 4.

The *pickle* module provides the following functions to make the pickling process more convenient:

`pickle.dump(obj, file, protocol=None, *, fix_imports=True, buffer_callback=None)`

Write the pickled representation of the object *obj* to the open *file object file*. This is equivalent to `Pickler(file, protocol).dump(obj)`.

Arguments *file*, *protocol*, *fix_imports* and *buffer_callback* have the same meaning as in the *Pickler* constructor.

在 3.8 版的變更: 新增 *buffer_callback* 引數。

`pickle.dumps(obj, protocol=None, *, fix_imports=True, buffer_callback=None)`

Return the pickled representation of the object *obj* as a *bytes* object, instead of writing it to a file.

Arguments *protocol*, *fix_imports* and *buffer_callback* have the same meaning as in the *Pickler* constructor.

在 3.8 版的變更: 新增 *buffer_callback* 引數。

`pickle.load(file, *, fix_imports=True, encoding='ASCII', errors='strict', buffers=None)`

Read the pickled representation of an object from the open *file object file* and return the reconstituted object hierarchy specified therein. This is equivalent to `Unpickler(file).load()`.

The protocol version of the pickle is detected automatically, so no protocol argument is needed. Bytes past the pickled representation of the object are ignored.

Arguments *file*, *fix_imports*, *encoding*, *errors*, *strict* and *buffers* have the same meaning as in the *Unpickler* constructor.

在 3.8 版的變更: 新增 *buffer* 引數。

`pickle.loads(data, /, *, fix_imports=True, encoding='ASCII', errors='strict', buffers=None)`

Return the reconstituted object hierarchy of the pickled representation *data* of an object. *data* must be a *bytes-like object*.

The protocol version of the pickle is detected automatically, so no protocol argument is needed. Bytes past the pickled representation of the object are ignored.

Arguments *fix_imports*, *encoding*, *errors*, *strict* and *buffers* have the same meaning as in the *Unpickler* constructor.

在 3.8 版的變更: 新增 *buffer* 引數。

The *pickle* module defines three exceptions:

exception `pickle.PickleError`

Common base class for the other pickling exceptions. It inherits from *Exception*.

exception `pickle.PicklingError`

Error raised when an unpicklable object is encountered by *Pickler*. It inherits from *PickleError*.

Refer to *What can be pickled and unpickled?* to learn what kinds of objects can be pickled.

exception `pickle.UnpicklingError`

Error raised when there is a problem unpickling an object, such as a data corruption or a security violation. It inherits from *PickleError*.

Note that other exceptions may also be raised during unpickling, including (but not necessarily limited to) *AttributeError*, *EOFError*, *ImportError*, and *IndexError*.

The *pickle* module exports three classes, *Pickler*, *Unpickler* and *PickleBuffer*:

class `pickle.Pickler(file, protocol=None, *, fix_imports=True, buffer_callback=None)`

This takes a binary file for writing a pickle data stream.

The optional *protocol* argument, an integer, tells the pickler to use the given protocol; supported protocols are 0 to *HIGHEST_PROTOCOL*. If not specified, the default is *DEFAULT_PROTOCOL*. If a negative number is specified, *HIGHEST_PROTOCOL* is selected.

The *file* argument must have a *write()* method that accepts a single bytes argument. It can thus be an on-disk file opened for binary writing, an *io.BytesIO* instance, or any other custom object that meets this interface.

If *fix_imports* is true and *protocol* is less than 3, pickle will try to map the new Python 3 names to the old module names used in Python 2, so that the pickle data stream is readable with Python 2.

If *buffer_callback* is None (the default), buffer views are serialized into *file* as part of the pickle stream.

If *buffer_callback* is not None, then it can be called any number of times with a buffer view. If the callback returns a false value (such as None), the given buffer is *out-of-band*; otherwise the buffer is serialized in-band, i.e. inside the pickle stream.

It is an error if *buffer_callback* is not None and *protocol* is None or smaller than 5.

在 3.8 版的變更: 新增 *buffer_callback* 引數。

dump (*obj*)

Write the pickled representation of *obj* to the open file object given in the constructor.

persistent_id (*obj*)

Do nothing by default. This exists so a subclass can override it.

If *persistent_id()* returns `None`, *obj* is pickled as usual. Any other value causes *Pickler* to emit the returned value as a persistent ID for *obj*. The meaning of this persistent ID should be defined by *Unpickler.persistent_load()*. Note that the value returned by *persistent_id()* cannot itself have a persistent ID.

關於細節與用法範例請見 *Persistence of External Objects*.

dispatch_table

A pickler object's dispatch table is a registry of *reduction functions* of the kind which can be declared using *copyreg.pickle()*. It is a mapping whose keys are classes and whose values are reduction functions. A reduction function takes a single argument of the associated class and should conform to the same interface as a `__reduce__()` method.

By default, a pickler object will not have a *dispatch_table* attribute, and it will instead use the global dispatch table managed by the *copyreg* module. However, to customize the pickling for a specific pickler object one can set the *dispatch_table* attribute to a dict-like object. Alternatively, if a subclass of *Pickler* has a *dispatch_table* attribute then this will be used as the default dispatch table for instances of that class.

關於用法範例請見 *Dispatch Tables*.

在 3.3 版新加入。

reducer_override (*obj*)

Special reducer that can be defined in *Pickler* subclasses. This method has priority over any reducer in the *dispatch_table*. It should conform to the same interface as a `__reduce__()` method, and can optionally return *NotImplemented* to fallback on *dispatch_table*-registered reducers to pickle *obj*.

For a detailed example, see *Custom Reduction for Types, Functions, and Other Objects*.

在 3.8 版新加入。

fast

Deprecated. Enable fast mode if set to a true value. The fast mode disables the usage of memo, therefore speeding the pickling process by not generating superfluous PUT opcodes. It should not be used with self-referential objects, doing otherwise will cause *Pickler* to recurse infinitely.

Use *pickletools.optimize()* if you need more compact pickles.

class *pickle.Unpickler* (*file*, *, *fix_imports*=*True*, *encoding*='ASCII', *errors*='strict', *buffers*=*None*)

This takes a binary file for reading a pickle data stream.

The protocol version of the pickle is detected automatically, so no protocol argument is needed.

The argument *file* must have three methods, a *read()* method that takes an integer argument, a *readinto()* method that takes a buffer argument and a *readline()* method that requires no arguments, as in the *io.BufferedReader* interface. Thus *file* can be an on-disk file opened for binary reading, an *io.BytesIO* object, or any other custom object that meets this interface.

The optional arguments *fix_imports*, *encoding* and *errors* are used to control compatibility support for pickle stream generated by Python 2. If *fix_imports* is true, pickle will try to map the old Python 2 names to the new names used in Python 3. The *encoding* and *errors* tell pickle how to decode 8-bit string instances pickled by Python 2; these default to 'ASCII' and 'strict', respectively. The *encoding* can be 'bytes' to read these 8-bit string instances as bytes objects. Using *encoding*='latin1' is required for unpickling NumPy arrays and instances of *datetime*, *date* and *time* pickled by Python 2.

If *buffers* is *None* (the default), then all data necessary for deserialization must be contained in the pickle stream. This means that the *buffer_callback* argument was *None* when a *Pickler* was instantiated (or when *dump()* or *dumps()* was called).

If *buffers* is not None, it should be an iterable of buffer-enabled objects that is consumed each time the pickle stream references an *out-of-band* buffer view. Such buffers have been given in order to the *buffer_callback* of a Pickler object.

在 3.8 版的變更: 新增 *buffer* 引數。

load()

Read the pickled representation of an object from the open file object given in the constructor, and return the reconstituted object hierarchy specified therein. Bytes past the pickled representation of the object are ignored.

persistent_load(pid)

Raise an *UnpicklingError* by default.

If defined, *persistent_load()* should return the object specified by the persistent ID *pid*. If an invalid persistent ID is encountered, an *UnpicklingError* should be raised.

關於細節與用法範例請見 *Persistence of External Objects*。

find_class(module, name)

Import *module* if necessary and return the object called *name* from it, where the *module* and *name* arguments are *str* objects. Note, unlike its name suggests, *find_class()* is also used for finding functions.

Subclasses may override this to gain control over what type of objects and how they can be loaded, potentially reducing security risks. Refer to *Restricting Globals* for details.

引發一個附帶引數 *module*、*name* 的稽核事件 `pickle.find_class`。

class pickle.PickleBuffer(buffer)

A wrapper for a buffer representing picklable data. *buffer* must be a buffer-providing object, such as a *bytes-like object* or a N-dimensional array.

PickleBuffer is itself a buffer provider, therefore it is possible to pass it to other APIs expecting a buffer-providing object, such as *memoryview*.

PickleBuffer objects can only be serialized using pickle protocol 5 or higher. They are eligible for *out-of-band serialization*.

在 3.8 版新加入。

raw()

Return a *memoryview* of the memory area underlying this buffer. The returned object is a one-dimensional, C-contiguous memoryview with format B (unsigned bytes). *BufferError* is raised if the buffer is neither C- nor Fortran-contiguous.

release()

Release the underlying buffer exposed by the PickleBuffer object.

12.1.4 What can be pickled and unpickled?

The following types can be pickled:

- built-in constants (None, True, False, Ellipsis, and *NotImplemented*);
- integers, floating-point numbers, complex numbers;
- strings, bytes, bytearrays;
- tuples, lists, sets, and dictionaries containing only picklable objects;
- functions (built-in and user-defined) accessible from the top level of a module (using `def`, not `lambda`);
- classes accessible from the top level of a module;

- instances of such classes whose the result of calling `__getstate__()` is picklable (see section *Pickling Class Instances* for details).

Attempts to pickle unpicklable objects will raise the `PicklingError` exception; when this happens, an unspecified number of bytes may have already been written to the underlying file. Trying to pickle a highly recursive data structure may exceed the maximum recursion depth, a `RecursionError` will be raised in this case. You can carefully raise this limit with `sys.setrecursionlimit()`.

Note that functions (built-in and user-defined) are pickled by fully *qualified name*, not by value.² This means that only the function name is pickled, along with the name of the containing module and classes. Neither the function's code, nor any of its function attributes are pickled. Thus the defining module must be importable in the unpickling environment, and the module must contain the named object, otherwise an exception will be raised.³

Similarly, classes are pickled by fully qualified name, so the same restrictions in the unpickling environment apply. Note that none of the class's code or data is pickled, so in the following example the class attribute `attr` is not restored in the unpickling environment:

```
class Foo:
    attr = 'A class attribute'

picklestring = pickle.dumps(Foo)
```

These restrictions are why picklable functions and classes must be defined at the top level of a module.

Similarly, when class instances are pickled, their class's code and data are not pickled along with them. Only the instance data are pickled. This is done on purpose, so you can fix bugs in a class or add methods to the class and still load objects that were created with an earlier version of the class. If you plan to have long-lived objects that will see many versions of a class, it may be worthwhile to put a version number in the objects so that suitable conversions can be made by the class's `__setstate__()` method.

12.1.5 Pickling Class Instances

In this section, we describe the general mechanisms available to you to define, customize, and control how class instances are pickled and unpickled.

In most cases, no additional code is needed to make instances picklable. By default, pickle will retrieve the class and the attributes of an instance via introspection. When a class instance is unpickled, its `__init__()` method is usually *not* invoked. The default behaviour first creates an uninitialized instance and then restores the saved attributes. The following code shows an implementation of this behaviour:

```
def save(obj):
    return (obj.__class__, obj.__dict__)

def restore(cls, attributes):
    obj = cls.__new__(cls)
    obj.__dict__.update(attributes)
    return obj
```

Classes can alter the default behaviour by providing one or several special methods:

`object.__getnewargs_ex__()`

In protocols 2 and newer, classes that implements the `__getnewargs_ex__()` method can dictate the values passed to the `__new__()` method upon unpickling. The method must return a pair (`args`, `kwargs`) where `args` is a tuple of positional arguments and `kwargs` a dictionary of named arguments for constructing the object. Those will be passed to the `__new__()` method upon unpickling.

You should implement this method if the `__new__()` method of your class requires keyword-only arguments. Otherwise, it is recommended for compatibility to implement `__getnewargs__()`.

在 3.6 版的變更: `__getnewargs_ex__()` is now used in protocols 2 and 3.

² This is why lambda functions cannot be pickled: all lambda functions share the same name: `<lambda>`.

³ The exception raised will likely be an `ImportError` or an `AttributeError` but it could be something else.

`object.__getnewargs__()`

This method serves a similar purpose as `__getnewargs_ex__()`, but supports only positional arguments. It must return a tuple of arguments `args` which will be passed to the `__new__()` method upon unpickling.

`__getnewargs__()` will not be called if `__getnewargs_ex__()` is defined.

在 3.6 版的變更: Before Python 3.6, `__getnewargs__()` was called instead of `__getnewargs_ex__()` in protocols 2 and 3.

`object.__getstate__()`

Classes can further influence how their instances are pickled by overriding the method `__getstate__()`. It is called and the returned object is pickled as the contents for the instance, instead of a default state. There are several cases:

- For a class that has no instance `__dict__` and no `__slots__`, the default state is `None`.
- For a class that has an instance `__dict__` and no `__slots__`, the default state is `self.__dict__`.
- For a class that has an instance `__dict__` and `__slots__`, the default state is a tuple consisting of two dictionaries: `self.__dict__`, and a dictionary mapping slot names to slot values. Only slots that have a value are included in the latter.
- For a class that has `__slots__` and no instance `__dict__`, the default state is a tuple whose first item is `None` and whose second item is a dictionary mapping slot names to slot values described in the previous bullet.

在 3.11 版的變更: Added the default implementation of the `__getstate__()` method in the `object` class.

`object.__setstate__(state)`

Upon unpickling, if the class defines `__setstate__()`, it is called with the unpickled state. In that case, there is no requirement for the state object to be a dictionary. Otherwise, the pickled state must be a dictionary and its items are assigned to the new instance's dictionary.

備 F: If `__reduce__()` returns a state with value `None` at pickling, the `__setstate__()` method will not be called upon unpickling.

Refer to the section *Handling Stateful Objects* for more information about how to use the methods `__getstate__()` and `__setstate__()`.

備 F: At unpickling time, some methods like `__getattr__()`, `__getattribute__()`, or `__setattr__()` may be called upon the instance. In case those methods rely on some internal invariant being true, the type should implement `__new__()` to establish such an invariant, as `__init__()` is not called when unpickling an instance.

As we shall see, pickle does not use directly the methods described above. In fact, these methods are part of the copy protocol which implements the `__reduce__()` special method. The copy protocol provides a unified interface for retrieving the data necessary for pickling and copying objects.⁴

Although powerful, implementing `__reduce__()` directly in your classes is error prone. For this reason, class designers should use the high-level interface (i.e., `__getnewargs_ex__()`, `__getstate__()` and `__setstate__()`) whenever possible. We will show, however, cases where using `__reduce__()` is the only option or leads to more efficient pickling or both.

`object.__reduce__()`

The interface is currently defined as follows. The `__reduce__()` method takes no argument and shall return either a string or preferably a tuple (the returned object is often referred to as the "reduce value").

⁴ The `copy` module uses this protocol for shallow and deep copying operations.

If a string is returned, the string should be interpreted as the name of a global variable. It should be the object's local name relative to its module; the pickle module searches the module namespace to determine the object's module. This behaviour is typically useful for singletons.

When a tuple is returned, it must be between two and six items long. Optional items can either be omitted, or `None` can be provided as their value. The semantics of each item are in order:

- A callable object that will be called to create the initial version of the object.
- A tuple of arguments for the callable object. An empty tuple must be given if the callable does not accept any argument.
- Optionally, the object's state, which will be passed to the object's `__setstate__()` method as previously described. If the object has no such method then, the value must be a dictionary and it will be added to the object's `__dict__` attribute.
- Optionally, an iterator (and not a sequence) yielding successive items. These items will be appended to the object either using `obj.append(item)` or, in batch, using `obj.extend(list_of_items)`. This is primarily used for list subclasses, but may be used by other classes as long as they have *append and extend methods* with the appropriate signature. (Whether `append()` or `extend()` is used depends on which pickle protocol version is used as well as the number of items to append, so both must be supported.)
- Optionally, an iterator (not a sequence) yielding successive key-value pairs. These items will be stored to the object using `obj[key] = value`. This is primarily used for dictionary subclasses, but may be used by other classes as long as they implement `__setitem__()`.
- Optionally, a callable with a `(obj, state)` signature. This callable allows the user to programmatically control the state-updating behavior of a specific object, instead of using `obj`'s static `__setstate__()` method. If not `None`, this callable will have priority over `obj`'s `__setstate__()`.

在 3.8 版新加入: The optional sixth tuple item, `(obj, state)`, was added.

`object.__reduce_ex__(protocol)`

Alternatively, a `__reduce_ex__()` method may be defined. The only difference is this method should take a single integer argument, the protocol version. When defined, pickle will prefer it over the `__reduce__()` method. In addition, `__reduce__()` automatically becomes a synonym for the extended version. The main use for this method is to provide backwards-compatible reduce values for older Python releases.

Persistence of External Objects

For the benefit of object persistence, the *pickle* module supports the notion of a reference to an object outside the pickled data stream. Such objects are referenced by a persistent ID, which should be either a string of alphanumeric characters (for protocol 0)⁵ or just an arbitrary object (for any newer protocol).

The resolution of such persistent IDs is not defined by the *pickle* module; it will delegate this resolution to the user-defined methods on the pickler and unpickler, `persistent_id()` and `persistent_load()` respectively.

To pickle objects that have an external persistent ID, the pickler must have a custom `persistent_id()` method that takes an object as an argument and returns either `None` or the persistent ID for that object. When `None` is returned, the pickler simply pickles the object as normal. When a persistent ID string is returned, the pickler will pickle that object, along with a marker so that the unpickler will recognize it as a persistent ID.

To unpickle external objects, the unpickler must have a custom `persistent_load()` method that takes a persistent ID object and returns the referenced object.

Here is a comprehensive example presenting how persistent ID can be used to pickle external objects by reference.

⁵ The limitation on alphanumeric characters is due to the fact that persistent IDs in protocol 0 are delimited by the newline character. Therefore if any kind of newline characters occurs in persistent IDs, the resulting pickled data will become unreadable.

```

# Simple example presenting how persistent ID can be used to pickle
# external objects by reference.

import pickle
import sqlite3
from collections import namedtuple

# Simple class representing a record in our database.
MemoRecord = namedtuple("MemoRecord", "key, task")

class DBPickler(pickle.Pickler):

    def persistent_id(self, obj):
        # Instead of pickling MemoRecord as a regular class instance, we emit a
        # persistent ID.
        if isinstance(obj, MemoRecord):
            # Here, our persistent ID is simply a tuple, containing a tag and a
            # key, which refers to a specific record in the database.
            return ("MemoRecord", obj.key)
        else:
            # If obj does not have a persistent ID, return None. This means obj
            # needs to be pickled as usual.
            return None

class DBUnpickler(pickle.Unpickler):

    def __init__(self, file, connection):
        super().__init__(file)
        self.connection = connection

    def persistent_load(self, pid):
        # This method is invoked whenever a persistent ID is encountered.
        # Here, pid is the tuple returned by DBPickler.
        cursor = self.connection.cursor()
        type_tag, key_id = pid
        if type_tag == "MemoRecord":
            # Fetch the referenced record from the database and return it.
            cursor.execute("SELECT * FROM memos WHERE key=?", (str(key_id),))
            key, task = cursor.fetchone()
            return MemoRecord(key, task)
        else:
            # Always raises an error if you cannot return the correct object.
            # Otherwise, the unpickler will think None is the object referenced
            # by the persistent ID.
            raise pickle.UnpicklingError("unsupported persistent object")

def main():
    import io
    import pprint

    # Initialize and populate our database.
    conn = sqlite3.connect(":memory:")
    cursor = conn.cursor()
    cursor.execute("CREATE TABLE memos(key INTEGER PRIMARY KEY, task TEXT)")
    tasks = (
        'give food to fish',
        'prepare group meeting',
        'fight with a zebra',
    )
    for task in tasks:

```

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```

        cursor.execute("INSERT INTO memos VALUES(NULL, ?)", (task,))

        # Fetch the records to be pickled.
        cursor.execute("SELECT * FROM memos")
        memos = [MemoRecord(key, task) for key, task in cursor]
        # Save the records using our custom DBPickler.
        file = io.BytesIO()
        DBPickler(file).dump(memos)

        print("Pickled records:")
        pprint.pprint(memos)

        # Update a record, just for good measure.
        cursor.execute("UPDATE memos SET task='learn italian' WHERE key=1")

        # Load the records from the pickle data stream.
        file.seek(0)
        memos = DBUnpickler(file, conn).load()

        print("Unpickled records:")
        pprint.pprint(memos)

if __name__ == '__main__':
    main()

```

Dispatch Tables

If one wants to customize pickling of some classes without disturbing any other code which depends on pickling, then one can create a pickler with a private dispatch table.

The global dispatch table managed by the `copyreg` module is available as `copyreg.dispatch_table`. Therefore, one may choose to use a modified copy of `copyreg.dispatch_table` as a private dispatch table.

舉例來：

```

f = io.BytesIO()
p = pickle.Pickler(f)
p.dispatch_table = copyreg.dispatch_table.copy()
p.dispatch_table[SomeClass] = reduce_SomeClass

```

creates an instance of `pickle.Pickler` with a private dispatch table which handles the `SomeClass` class specially. Alternatively, the code

```

class MyPickler(pickle.Pickler):
    dispatch_table = copyreg.dispatch_table.copy()
    dispatch_table[SomeClass] = reduce_SomeClass
f = io.BytesIO()
p = MyPickler(f)

```

does the same but all instances of `MyPickler` will by default share the private dispatch table. On the other hand, the code

```

copyreg.pickle(SomeClass, reduce_SomeClass)
f = io.BytesIO()
p = pickle.Pickler(f)

```

modifies the global dispatch table shared by all users of the `copyreg` module.

Handling Stateful Objects

Here's an example that shows how to modify pickling behavior for a class. The `TextReader` class below opens a text file, and returns the line number and line contents each time its `readline()` method is called. If a `TextReader` instance is pickled, all attributes *except* the file object member are saved. When the instance is unpickled, the file is reopened, and reading resumes from the last location. The `__setstate__()` and `__getstate__()` methods are used to implement this behavior.

```
class TextReader:
    """Print and number lines in a text file."""

    def __init__(self, filename):
        self.filename = filename
        self.file = open(filename)
        self.lineno = 0

    def readline(self):
        self.lineno += 1
        line = self.file.readline()
        if not line:
            return None
        if line.endswith('\n'):
            line = line[:-1]
        return "%i: %s" % (self.lineno, line)

    def __getstate__(self):
        # Copy the object's state from self.__dict__ which contains
        # all our instance attributes. Always use the dict.copy()
        # method to avoid modifying the original state.
        state = self.__dict__.copy()
        # Remove the unpicklable entries.
        del state['file']
        return state

    def __setstate__(self, state):
        # Restore instance attributes (i.e., filename and lineno).
        self.__dict__.update(state)
        # Restore the previously opened file's state. To do so, we need to
        # reopen it and read from it until the line count is restored.
        file = open(self.filename)
        for _ in range(self.lineno):
            file.readline()
        # Finally, save the file.
        self.file = file
```

A sample usage might be something like this:

```
>>> reader = TextReader("hello.txt")
>>> reader.readline()
'1: Hello world!'
>>> reader.readline()
'2: I am line number two.'
>>> new_reader = pickle.loads(pickle.dumps(reader))
>>> new_reader.readline()
'3: Goodbye!'
```


12.1.6 Custom Reduction for Types, Functions, and Other Objects

在 3.8 版新加入.

Sometimes, `dispatch_table` may not be flexible enough. In particular we may want to customize pickling based on another criterion than the object's type, or we may want to customize the pickling of functions and classes.

For those cases, it is possible to subclass from the `Pickler` class and implement a `reducer_override()` method. This method can return an arbitrary reduction tuple (see `__reduce__()`). It can alternatively return `NotImplemented` to fallback to the traditional behavior.

If both the `dispatch_table` and `reducer_override()` are defined, then `reducer_override()` method takes priority.

備 F: For performance reasons, `reducer_override()` may not be called for the following objects: `None`, `True`, `False`, and exact instances of `int`, `float`, `bytes`, `str`, `dict`, `set`, `frozenset`, `list` and `tuple`.

Here is a simple example where we allow pickling and reconstructing a given class:

```
import io
import pickle

class MyClass:
    my_attribute = 1

class MyPickler(pickle.Pickler):
    def reducer_override(self, obj):
        """Custom reducer for MyClass."""
        if getattr(obj, "__name__", None) == "MyClass":
            return type, (obj.__name__, obj.__bases__,
                          {'my_attribute': obj.my_attribute})
        else:
            # For any other object, fallback to usual reduction
            return NotImplemented

f = io.BytesIO()
p = MyPickler(f)
p.dump(MyClass)

del MyClass

unpickled_class = pickle.loads(f.getvalue())

assert isinstance(unpickled_class, type)
assert unpickled_class.__name__ == "MyClass"
assert unpickled_class.my_attribute == 1
```

12.1.7 Out-of-band Buffers

在 3.8 版新加入.

In some contexts, the `pickle` module is used to transfer massive amounts of data. Therefore, it can be important to minimize the number of memory copies, to preserve performance and resource consumption. However, normal operation of the `pickle` module, as it transforms a graph-like structure of objects into a sequential stream of bytes, intrinsically involves copying data to and from the pickle stream.

This constraint can be eschewed if both the *provider* (the implementation of the object types to be transferred) and the *consumer* (the implementation of the communications system) support the out-of-band transfer facilities provided by pickle protocol 5 and higher.

Provider API

The large data objects to be pickled must implement a `__reduce_ex__()` method specialized for protocol 5 and higher, which returns a `PickleBuffer` instance (instead of e.g. a `bytes` object) for any large data.

A `PickleBuffer` object *signals* that the underlying buffer is eligible for out-of-band data transfer. Those objects remain compatible with normal usage of the `pickle` module. However, consumers can also opt-in to tell `pickle` that they will handle those buffers by themselves.

Consumer API

A communications system can enable custom handling of the `PickleBuffer` objects generated when serializing an object graph.

On the sending side, it needs to pass a `buffer_callback` argument to `Pickler` (or to the `dump()` or `dumps()` function), which will be called with each `PickleBuffer` generated while pickling the object graph. Buffers accumulated by the `buffer_callback` will not see their data copied into the pickle stream, only a cheap marker will be inserted.

On the receiving side, it needs to pass a `buffers` argument to `Unpickler` (or to the `load()` or `loads()` function), which is an iterable of the buffers which were passed to `buffer_callback`. That iterable should produce buffers in the same order as they were passed to `buffer_callback`. Those buffers will provide the data expected by the reconstructors of the objects whose pickling produced the original `PickleBuffer` objects.

Between the sending side and the receiving side, the communications system is free to implement its own transfer mechanism for out-of-band buffers. Potential optimizations include the use of shared memory or datatype-dependent compression.

范例

Here is a trivial example where we implement a `bytearray` subclass able to participate in out-of-band buffer pickling:

```
class ZeroCopyByteArray(bytearray):

    def __reduce_ex__(self, protocol):
        if protocol >= 5:
            return type(self).__reconstruct, (PickleBuffer(self),), None
        else:
            # PickleBuffer is forbidden with pickle protocols <= 4.
            return type(self).__reconstruct, (bytearray(self),)

    @classmethod
    def __reconstruct(cls, obj):
        with memoryview(obj) as m:
            # Get a handle over the original buffer object
            obj = m.obj
            if type(obj) is cls:
                # Original buffer object is a ZeroCopyByteArray, return it
                # as-is.
                return obj
            else:
                return cls(obj)
```

The reconstructor (the `__reconstruct` class method) returns the buffer's providing object if it has the right type. This is an easy way to simulate zero-copy behaviour on this toy example.

On the consumer side, we can pickle those objects the usual way, which when unserialized will give us a copy of the original object:

```
b = ZeroCopyByteArray(b"abc")
data = pickle.dumps(b, protocol=5)
new_b = pickle.loads(data)
print(b == new_b)  # True
print(b is new_b)  # False: a copy was made
```

But if we pass a *buffer_callback* and then give back the accumulated buffers when unserializing, we are able to get back the original object:

```
b = ZeroCopyByteArray(b"abc")
buffers = []
data = pickle.dumps(b, protocol=5, buffer_callback=buffers.append)
new_b = pickle.loads(data, buffers=buffers)
print(b == new_b)  # True
print(b is new_b)  # True: no copy was made
```

This example is limited by the fact that *bytearray* allocates its own memory: you cannot create a *bytearray* instance that is backed by another object's memory. However, third-party datatypes such as NumPy arrays do not have this limitation, and allow use of zero-copy pickling (or making as few copies as possible) when transferring between distinct processes or systems.

也参考:

PEP 574 -- Pickle protocol 5 with out-of-band data

12.1.8 Restricting Globals

By default, unpickling will import any class or function that it finds in the pickle data. For many applications, this behaviour is unacceptable as it permits the unpickler to import and invoke arbitrary code. Just consider what this hand-crafted pickle data stream does when loaded:

```
>>> import pickle
>>> pickle.loads(b"cos\nsystem\n(S'echo hello world'\ntr.")
hello world
0
```

In this example, the unpickler imports the *os.system()* function and then apply the string argument "echo hello world". Although this example is inoffensive, it is not difficult to imagine one that could damage your system.

For this reason, you may want to control what gets unpickled by customizing *Unpickler.find_class()*. Unlike its name suggests, *Unpickler.find_class()* is called whenever a global (i.e., a class or a function) is requested. Thus it is possible to either completely forbid globals or restrict them to a safe subset.

Here is an example of an unpickler allowing only few safe classes from the *builtins* module to be loaded:

```
import builtins
import io
import pickle

safe_builtins = {
    'range',
    'complex',
    'set',
    'frozenset',
    'slice',
}

class RestrictedUnpickler(pickle.Unpickler):

    def find_class(self, module, name):
        # Only allow safe classes from builtins.
```

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```

    if module == "builtins" and name in safe_builtins:
        return getattr(builtins, name)
    # Forbid everything else.
    raise pickle.UnpicklingError("global '%s.%s' is forbidden" %
                                  (module, name))

def restricted_loads(s):
    """Helper function analogous to pickle.loads()."""
    return RestrictedUnpickler(io.BytesIO(s)).load()

```

A sample usage of our unpickler working as intended:

```

>>> restricted_loads(pickle.dumps([1, 2, range(15)]))
[1, 2, range(0, 15)]
>>> restricted_loads(b"cos\nsystem\n(S'echo hello world'\nR.")
Traceback (most recent call last):
...
pickle.UnpicklingError: global 'os.system' is forbidden
>>> restricted_loads(b'cbuiltins\neval\n'
...                  b'(S\'getattr(__import__("os"), "system")\'
...                  b'("echo hello world")\'\nR.')
Traceback (most recent call last):
...
pickle.UnpicklingError: global 'builtins.eval' is forbidden

```

As our examples shows, you have to be careful with what you allow to be unpickled. Therefore if security is a concern, you may want to consider alternatives such as the marshalling API in *xmlrpc.client* or third-party solutions.

12.1.9 Performance

Recent versions of the pickle protocol (from protocol 2 and upwards) feature efficient binary encodings for several common features and built-in types. Also, the *pickle* module has a transparent optimizer written in C.

12.1.10 范例

For the simplest code, use the *dump()* and *load()* functions.

```

import pickle

# An arbitrary collection of objects supported by pickle.
data = {
    'a': [1, 2.0, 3+4j],
    'b': ("character string", b"byte string"),
    'c': {None, True, False}
}

with open('data.pickle', 'wb') as f:
    # Pickle the 'data' dictionary using the highest protocol available.
    pickle.dump(data, f, pickle.HIGHEST_PROTOCOL)

```

The following example reads the resulting pickled data.

```

import pickle

with open('data.pickle', 'rb') as f:
    # The protocol version used is detected automatically, so we do not
    # have to specify it.
    data = pickle.load(f)

```

也參考:

`copyreg` 模組

Pickle interface constructor registration for extension types.

`pickletools` 模組

Tools for working with and analyzing pickled data.

`shelve` 模組

Indexed databases of objects; uses `pickle`.

`copy` 模組

Shallow and deep object copying.

`marshal` 模組

High-performance serialization of built-in types.

解

12.2 `copyreg` --- Register pickle support functions

原始碼: [Lib/copyreg.py](#)

The `copyreg` module offers a way to define functions used while pickling specific objects. The `pickle` and `copy` modules use those functions when pickling/copying those objects. The module provides configuration information about object constructors which are not classes. Such constructors may be factory functions or class instances.

`copyreg.constructor` (*object*)

Declares *object* to be a valid constructor. If *object* is not callable (and hence not valid as a constructor), raises `TypeError`.

`copyreg.pickle` (*type*, *function*, *constructor_ob=None*)

Declares that *function* should be used as a "reduction" function for objects of type *type*. *function* must return either a string or a tuple containing between two and six elements. See the `dispatch_table` for more details on the interface of *function*.

The *constructor_ob* parameter is a legacy feature and is now ignored, but if passed it must be a callable.

Note that the `dispatch_table` attribute of a pickler object or subclass of `pickle.Pickler` can also be used for declaring reduction functions.

12.2.1 范例

The example below would like to show how to register a pickle function and how it will be used:

```
>>> import copyreg, copy, pickle
>>> class C:
...     def __init__(self, a):
...         self.a = a
...
>>> def pickle_c(c):
...     print("pickling a C instance...")
...     return C, (c.a,)
...
>>> copyreg.pickle(C, pickle_c)
>>> c = C(1)
>>> d = copy.copy(c)
pickling a C instance...
>>> p = pickle.dumps(c)
pickling a C instance...
```

12.3 `shelve` --- Python object persistence

原始碼: [Lib/shelve.py](#)

A “shelf” is a persistent, dictionary-like object. The difference with “dbm” databases is that the values (not the keys!) in a shelf can be essentially arbitrary Python objects --- anything that the `pickle` module can handle. This includes most class instances, recursive data types, and objects containing lots of shared sub-objects. The keys are ordinary strings.

`shelve.open(filename, flag='c', protocol=None, writeback=False)`

Open a persistent dictionary. The filename specified is the base filename for the underlying database. As a side-effect, an extension may be added to the filename and more than one file may be created. By default, the underlying database file is opened for reading and writing. The optional `flag` parameter has the same interpretation as the `flag` parameter of `dbm.open()`.

By default, pickles created with `pickle.DEFAULT_PROTOCOL` are used to serialize values. The version of the pickle protocol can be specified with the `protocol` parameter.

Because of Python semantics, a shelf cannot know when a mutable persistent-dictionary entry is modified. By default modified objects are written *only* when assigned to the shelf (see 範例). If the optional `writeback` parameter is set to `True`, all entries accessed are also cached in memory, and written back on `sync()` and `close()`; this can make it handier to mutate mutable entries in the persistent dictionary, but, if many entries are accessed, it can consume vast amounts of memory for the cache, and it can make the close operation very slow since all accessed entries are written back (there is no way to determine which accessed entries are mutable, nor which ones were actually mutated).

在 3.10 版的變更: `pickle.DEFAULT_PROTOCOL` is now used as the default pickle protocol.

在 3.11 版的變更: Accepts *path-like object* for filename.

備註: Do not rely on the shelf being closed automatically; always call `close()` explicitly when you don't need it any more, or use `shelve.open()` as a context manager:

```
with shelve.open('spam') as db:
    db['eggs'] = 'eggs'
```

警告: Because the `shelve` module is backed by `pickle`, it is insecure to load a shelf from an untrusted source. Like with `pickle`, loading a shelf can execute arbitrary code.

Shelf objects support most of methods and operations supported by dictionaries (except copying, constructors and operators `|` and `|=`). This eases the transition from dictionary based scripts to those requiring persistent storage.

Two additional methods are supported:

`Shelf.sync()`

Write back all entries in the cache if the shelf was opened with `writeback` set to `True`. Also empty the cache and synchronize the persistent dictionary on disk, if feasible. This is called automatically when the shelf is closed with `close()`.

`Shelf.close()`

Synchronize and close the persistent *dict* object. Operations on a closed shelf will fail with a `ValueError`.

也參考:

[Persistent dictionary recipe](#) with widely supported storage formats and having the speed of native dictionaries.

12.3.1 Restrictions

- The choice of which database package will be used (such as `dbm.ndbm` or `dbm.gnu`) depends on which interface is available. Therefore it is not safe to open the database directly using `dbm`. The database is also (unfortunately) subject to the limitations of `dbm`, if it is used --- this means that (the pickled representation of) the objects stored in the database should be fairly small, and in rare cases key collisions may cause the database to refuse updates.
- The `shelve` module does not support *concurrent* read/write access to shelved objects. (Multiple simultaneous read accesses are safe.) When a program has a shelf open for writing, no other program should have it open for reading or writing. Unix file locking can be used to solve this, but this differs across Unix versions and requires knowledge about the database implementation used.
- On macOS `dbm.ndbm` can silently corrupt the database file on updates, which can cause hard crashes when trying to read from the database.

class `shelve.Shelf` (*dict*, *protocol=None*, *writeback=False*, *keyencoding='utf-8'*)

A subclass of `collections.abc.MutableMapping` which stores pickled values in the *dict* object.

By default, pickles created with `pickle.DEFAULT_PROTOCOL` are used to serialize values. The version of the pickle protocol can be specified with the *protocol* parameter. See the `pickle` documentation for a discussion of the pickle protocols.

If the *writeback* parameter is `True`, the object will hold a cache of all entries accessed and write them back to the *dict* at sync and close times. This allows natural operations on mutable entries, but can consume much more memory and make sync and close take a long time.

The *keyencoding* parameter is the encoding used to encode keys before they are used with the underlying dict.

A `Shelf` object can also be used as a context manager, in which case it will be automatically closed when the `with` block ends.

在 3.2 版的變更: Added the *keyencoding* parameter; previously, keys were always encoded in UTF-8.

在 3.4 版的變更: Added context manager support.

在 3.10 版的變更: `pickle.DEFAULT_PROTOCOL` is now used as the default pickle protocol.

class `shelve.BsdDbShelf` (*dict*, *protocol=None*, *writeback=False*, *keyencoding='utf-8'*)

A subclass of `Shelf` which exposes `first()`, `next()`, `previous()`, `last()` and `set_location()` methods. These are available in the third-party `bsddb` module from `pybsddb` but not in other database modules. The *dict* object passed to the constructor must support those methods. This is generally accomplished by calling one of `bsddb.hashopen()`, `bsddb.btopen()` or `bsddb.rnopen()`. The optional *protocol*, *writeback*, and *keyencoding* parameters have the same interpretation as for the `Shelf` class.

class `shelve.DbfilenameShelf` (*filename*, *flag='c'*, *protocol=None*, *writeback=False*)

A subclass of `Shelf` which accepts a *filename* instead of a dict-like object. The underlying file will be opened using `dbm.open()`. By default, the file will be created and opened for both read and write. The optional *flag* parameter has the same interpretation as for the `open()` function. The optional *protocol* and *writeback* parameters have the same interpretation as for the `Shelf` class.

12.3.2 范例

To summarize the interface (key is a string, data is an arbitrary object):

```
import shelve

d = shelve.open(filename)  # open -- file may get suffix added by low-level
                           # library

d[key] = data              # store data at key (overwrites old data if
                           # using an existing key)
data = d[key]              # retrieve a COPY of data at key (raise KeyError
                           # if no such key)
del d[key]                 # delete data stored at key (raises KeyError
                           # if no such key)

flag = key in d             # true if the key exists
klist = list(d.keys())     # a list of all existing keys (slow!)

# as d was opened WITHOUT writeback=True, beware:
d['xx'] = [0, 1, 2]        # this works as expected, but...
d['xx'].append(3)          # *this doesn't!* -- d['xx'] is STILL [0, 1, 2]!

# having opened d without writeback=True, you need to code carefully:
temp = d['xx']              # extracts the copy
temp.append(5)              # mutates the copy
d['xx'] = temp              # stores the copy right back, to persist it

# or, d=shelve.open(filename,writeback=True) would let you just code
# d['xx'].append(5) and have it work as expected, BUT it would also
# consume more memory and make the d.close() operation slower.

d.close()                  # close it
```

也參考:

dbm 模組

Generic interface to dbm-style databases.

pickle 模組

Object serialization used by *shelve*.

12.4 marshal --- 內部 Python 物件序列化

此 module (模組) 包含一個能以二進位制格式來讀寫 Python 值的函式。這種格式是 Python 專屬但獨立於機器架構的 (例如, 你可以在一臺 PC 上寫入某個 Python 值, 再將檔案傳到一臺 Sun 上在那讀取它)。這種格式的細節是有意地不在文件上明的; 它可能在不同 Python 版本中被改變 (雖然這種情況極少發生)。¹

這不是一個通用「持續性 (persistence)」module。關於通用持續性以及透過 RPC 呼叫傳遞 Python 物件, 請參見 *pickle* 和 *shelve* 等 module。*marshal* module 主要是為了支援用來讀寫「偽編譯 (pseudo-compiled)」.pyc 檔案的 Python module。因此, Python 維護者保留了在必要時以不向後相容的方式修改 *marshal* 格式的權利。如果你要序列化和反序列化 Python 物件, 請改用 *pickle* module -- 其執行效率相當、有保證版本獨立性, 且實質上 *pickle* 還支援比 *marshal* 更多樣的物件。

¹ 此 module 的名稱來源於 Modula-3 (及其他語言) 的設計者所使用的術語, 他們使用 “marshal” 來表示自包含 (self-contained) 形式資料的傳輸。嚴格來講, 將資料從內部形式轉為外部形式 (例如用於 RPC 緩衝區) 稱之為 “marshal”, 而其反向過程則稱之為 “unmarshal”。

警告：`marshal` module 對於錯誤或惡意構建的資料來是不安全的。永遠不要 `unmarshal` 來自不受信任的或來源未經驗證的資料。

不是所有 Python 物件型都有支援；一般來，此 module 只能寫入和讀取不依賴於特定 Python 調用 (invocation) 的物件。下列型是有支援的：布林 (boolean)、整數、浮點數 (floating point number)、數、字串、位元組串 (bytes)、位元組陣列 (bytearray)、元組 (tuple)、list、集合 (set)、凍結集合 (frozenset)、dictionary 和程式碼物件，需要了解的一點是元組、list、集合、凍結集合和 dictionary 只在其所包含的值也屬於這些型時才會支援。單例 (singleton) 物件 `None`、`Ellipsis` 和 `StopIteration` 也可以被 `marshal` 和 `unmarshal`。對於 `version` 低於 3 的格式，遞 list、集合和 dictionary 無法被寫入（見下文）。

有些函式可以讀/寫檔案，還有些函式可以操作類位元組串物件 (bytes-like object)。

這個 module 定義了以下函式：

`marshal.dump(value, file[, version])`

將值寫入被開的檔案。值必須受支援的型，檔案必須可寫入的 *binary file*。

如果值具有（或其所包含的物件具有）不支援的型，則會引發 `ValueError` 例外 --- 但是垃圾資料 (garbage data) 也將寫入檔案，物件也無法正確地透過 `load()` 重新讀取。

`version` 引數指明 `dump` 應該使用的資料格式（見下文）。

引發一個附帶引數 `value` 與 `version` 的稽核事件 (auditing event) `marshal.dumps`。

`marshal.load(file)`

從開的檔案讀取一個值回傳。如果讀不到有效的值（例如，由於資料不同 Python 版本的不相容 `marshal` 格式），則會引發 `EOFError`、`ValueError` 或 `TypeError`。檔案必須可讀取的 *binary file*。

引發一個有附帶引數的稽核事件 `marshal.load`。

備：如果透過 `dump()` `marshal` 了一個包含不支援型的物件，`load()` 會將不可 `marshal` 的型替 `None`。

在 3.10 版的變更：使用此呼叫每個程式碼物件引發一個 `code.__new__` 稽核事件。現在它會整個載入操作引發單個 `marshal.load` 事件。

`marshal.dumps(value[, version])`

回傳將透過 `dump(value, file)` 來被寫入一個檔案的位元組串物件，其值必須是有支援的型，如果值（或其包含的任一物件）不支援的型則會引發 `ValueError`。

`version` 引數指明 `dumps` 應當使用的資料型（見下文）。

引發一個附帶引數 `value` 與 `version` 的稽核事件 (auditing event) `marshal.dumps`。

`marshal.loads(bytes)`

將 *bytes-like object* 轉一個值。如果找不到有效的值，則會引發 `EOFError`、`ValueError` 或 `TypeError`。輸入中額外的位元組串會被忽略。

引發一個附帶引數 `bytes` 的稽核事件 `marshal.loads`。

在 3.10 版的變更：使用此呼叫每個程式碼物件引發一個 `code.__new__` 稽核事件。現在它會整個載入操作引發單個 `marshal.loads` 事件。

此外，還定義了以下常數：

`marshal.version`

表示 module 所使用的格式。第 0 版歷史格式，第 1 版共享了駐留字串 (interned string)，第 2 版對浮點數使用二進位制格式。第 3 版添加了對於物件實例化和遞的支援。目前使用的是第 4 版。

F 解

12.5 dbm --- Interfaces to Unix "databases"

原始碼: `Lib/dbm/__init__.py`

`dbm` is a generic interface to variants of the DBM database --- `dbm.gnu` or `dbm.ndbm`. If none of these modules is installed, the slow-but-simple implementation in module `dbm.dumb` will be used. There is a [third party interface](#) to the Oracle Berkeley DB.

exception `dbm.error`

A tuple containing the exceptions that can be raised by each of the supported modules, with a unique exception also named `dbm.error` as the first item --- the latter is used when `dbm.error` is raised.

`dbm.whichdb` (*filename*)

This function attempts to guess which of the several simple database modules available --- `dbm.gnu`, `dbm.ndbm` or `dbm.dumb` --- should be used to open a given file.

Return one of the following values:

- None if the file can't be opened because it's unreadable or doesn't exist
- the empty string (' ') if the file's format can't be guessed
- a string containing the required module name, such as 'dbm.ndbm' or 'dbm.gnu'

在 3.11 版的變更: *filename* accepts a [path-like object](#).

`dbm.open` (*file*, *flag*=`'r'`, *mode*=`0o666`)

Open a database and return the corresponding database object.

參數

- **file** (*path-like object*) -- The database file to open.
If the database file already exists, the `whichdb()` function is used to determine its type and the appropriate module is used; if it does not exist, the first submodule listed above that can be imported is used.
- **flag** (*str*) --
 - 'r' (default): Open existing database for reading only.
 - 'w': Open existing database for reading and writing.
 - 'c': Open database for reading and writing, creating it if it doesn't exist.
 - 'n': Always create a new, empty database, open for reading and writing.
- **mode** (*int*) -- The Unix file access mode of the file (default: octal `0o666`), used only when the database has to be created.

在 3.11 版的變更: *file* accepts a [path-like object](#).

The object returned by `open()` supports the same basic functionality as a [dict](#); keys and their corresponding values can be stored, retrieved, and deleted, and the `in` operator and the `keys()` method are available, as well as `get()` and `setdefault()` methods.

Key and values are always stored as [bytes](#). This means that when strings are used they are implicitly converted to the default encoding before being stored.

These objects also support being used in a `with` statement, which will automatically close them when done.

在 3.2 版的變更: `get()` and `setdefault()` methods are now available for all `dbm` backends.

在 3.4 版的變更: Added native support for the context management protocol to the objects returned by `open()`.

在 3.8 版的變更: Deleting a key from a read-only database raises a database module specific exception instead of `KeyError`.

The following example records some hostnames and a corresponding title, and then prints out the contents of the database:

```
import dbm

# Open database, creating it if necessary.
with dbm.open('cache', 'c') as db:

    # Record some values
    db[b'hello'] = b'there'
    db['www.python.org'] = 'Python Website'
    db['www.cnn.com'] = 'Cable News Network'

    # Note that the keys are considered bytes now.
    assert db[b'www.python.org'] == b'Python Website'
    # Notice how the value is now in bytes.
    assert db['www.cnn.com'] == b'Cable News Network'

    # Often-used methods of the dict interface work too.
    print(db.get('python.org', b'not present'))

    # Storing a non-string key or value will raise an exception (most
    # likely a TypeError).
    db['www.yahoo.com'] = 4

# db is automatically closed when leaving the with statement.
```

也參考:

shelve 模組

Persistence module which stores non-string data.

The individual submodules are described in the following sections.

12.5.1 `dbm.gnu` --- GNU database manager

原始碼: `Lib/dbm/gnu.py`

The `dbm.gnu` module provides an interface to the GDBM (GNU dbm) library, similar to the `dbm.ndbm` module, but with additional functionality like crash tolerance.

備註: The file formats created by `dbm.gnu` and `dbm.ndbm` are incompatible and can not be used interchangeably.

exception `dbm.gnu.error`

Raised on `dbm.gnu`-specific errors, such as I/O errors. `KeyError` is raised for general mapping errors like specifying an incorrect key.

`dbm.gnu.open(filename, flag='r', mode=0o666, /)`

Open a GDBM database and return a `gdbm` object.

參數

- **filename** (*path-like object*) -- The database file to open.
- **flag** (`str`) --
 - `'r'` (default): Open existing database for reading only.

- 'w': Open existing database for reading and writing.
- 'c': Open database for reading and writing, creating it if it doesn't exist.
- 'n': Always create a new, empty database, open for reading and writing.

The following additional characters may be appended to control how the database is opened:

- 'f': Open the database in fast mode. Writes to the database will not be synchronized.
- 's': Synchronized mode. Changes to the database will be written immediately to the file.
- 'u': Do not lock database.

Not all flags are valid for all versions of GDBM. See the *open_flags* member for a list of supported flag characters.

- **mode** (*int*) -- The Unix file access mode of the file (default: octal 0o666), used only when the database has to be created.

引發

error -- If an invalid *flag* argument is passed.

在 3.11 版的變更: *filename* accepts a *path-like object*.

`dbm.gnu.open_flags`

A string of characters the *flag* parameter of *open()* supports.

`gdbm` objects behave similar to *mappings*, but *items()* and *values()* methods are not supported. The following methods are also provided:

`gdbm.firstkey()`

It's possible to loop over every key in the database using this method and the *nextkey()* method. The traversal is ordered by GDBM's internal hash values, and won't be sorted by the key values. This method returns the starting key.

`gdbm.nextkey(key)`

Returns the key that follows *key* in the traversal. The following code prints every key in the database *db*, without having to create a list in memory that contains them all:

```
k = db.firstkey()
while k is not None:
    print(k)
    k = db.nextkey(k)
```

`gdbm.reorganize()`

If you have carried out a lot of deletions and would like to shrink the space used by the GDBM file, this routine will reorganize the database. `gdbm` objects will not shorten the length of a database file except by using this reorganization; otherwise, deleted file space will be kept and reused as new (key, value) pairs are added.

`gdbm.sync()`

When the database has been opened in fast mode, this method forces any unwritten data to be written to the disk.

`gdbm.close()`

Close the GDBM database.

12.5.2 dbm.ndbm --- New Database Manager

原始碼: [Lib/dbm/ndbm.py](#)

The `dbm.ndbm` module provides an interface to the NDBM (New Database Manager) library. This module can be used with the “classic” NDBM interface or the GDBM compatibility interface.

備 F: The file formats created by `dbm.gnu` and `dbm.ndbm` are incompatible and can not be used interchangeably.

警告: The NDBM library shipped as part of macOS has an undocumented limitation on the size of values, which can result in corrupted database files when storing values larger than this limit. Reading such corrupted files can result in a hard crash (segmentation fault).

exception `dbm.ndbm.error`

Raised on `dbm.ndbm`-specific errors, such as I/O errors. `KeyError` is raised for general mapping errors like specifying an incorrect key.

`dbm.ndbm.library`

Name of the NDBM implementation library used.

`dbm.ndbm.open(filename, flag='r', mode=0o666, /)`

Open an NDBM database and return an `ndbm` object.

參數

- **filename** (*path-like object*) -- The basename of the database file (without the `.dir` or `.pag` extensions).
- **flag** (`str`) --
 - `'r'` (default): Open existing database for reading only.
 - `'w'`: Open existing database for reading and writing.
 - `'c'`: Open database for reading and writing, creating it if it doesn't exist.
 - `'n'`: Always create a new, empty database, open for reading and writing.
- **mode** (`int`) -- The Unix file access mode of the file (default: octal `0o666`), used only when the database has to be created.

`ndbm` objects behave similar to *mappings*, but `items()` and `values()` methods are not supported. The following methods are also provided:

在 3.11 版的變更: Accepts *path-like object* for filename.

`ndbm.close()`

Close the NDBM database.

12.5.3 dbm.dumb --- Portable DBM implementation

原始碼: [Lib/dbm/dumb.py](#)

備註: The `dbm.dumb` module is intended as a last resort fallback for the `dbm` module when a more robust module is not available. The `dbm.dumb` module is not written for speed and is not nearly as heavily used as the other database modules.

The `dbm.dumb` module provides a persistent *dict*-like interface which is written entirely in Python. Unlike other `dbm` backends, such as `dbm.gnu`, no external library is required.

The `dbm.dumb` module defines the following:

exception `dbm.dumb.error`

Raised on `dbm.dumb`-specific errors, such as I/O errors. `KeyError` is raised for general mapping errors like specifying an incorrect key.

`dbm.dumb.open(filename, flag='c', mode=0o666)`

Open a `dbm.dumb` database. The returned database object behaves similar to a *mapping*, in addition to providing `sync()` and `close()` methods.

参数

- **filename** -- The basename of the database file (without extensions). A new database creates the following files:
 - `filename.dat`
 - `filename.dir`
- **flag(str)** --
 - `'r'`: Open existing database for reading only.
 - `'w'`: Open existing database for reading and writing.
 - `'c'` (default): Open database for reading and writing, creating it if it doesn't exist.
 - `'n'`: Always create a new, empty database, open for reading and writing.
- **mode(int)** -- The Unix file access mode of the file (default: octal `0o666`), used only when the database has to be created.

警告: It is possible to crash the Python interpreter when loading a database with a sufficiently large/complex entry due to stack depth limitations in Python's AST compiler.

在 3.5 版的變更: `open()` always creates a new database when `flag` is `'n'`.

在 3.8 版的變更: A database opened read-only if `flag` is `'r'`. A database is not created if it does not exist if `flag` is `'r'` or `'w'`.

在 3.11 版的變更: `filename` accepts a *path-like object*.

In addition to the methods provided by the `collections.abc.MutableMapping` class, the following methods are provided:

`dumbdbm.sync()`

Synchronize the on-disk directory and data files. This method is called by the `Shelve.sync()` method.

`dumbdbm.close()`

Close the database.

12.6 sqlite3 --- SQLite 資料庫的 DB-API 2.0 介面

原始碼: [Lib/sqlite3/](#) SQLite is a C library that provides a lightweight disk-based database that doesn't require a separate server process and allows accessing the database using a nonstandard variant of the SQL query language. Some applications can use SQLite for internal data storage. It's also possible to prototype an application using SQLite and then port the code to a larger database such as PostgreSQL or Oracle.

The `sqlite3` module was written by Gerhard Häring. It provides an SQL interface compliant with the DB-API 2.0 specification described by [PEP 249](#), and requires SQLite 3.7.15 or newer.

This document includes four main sections:

- [Tutorial](#) teaches how to use the `sqlite3` module.
- [Reference](#) describes the classes and functions this module defines.
- [How-to guides](#) details how to handle specific tasks.
- [解釋](#) provides in-depth background on transaction control.

也參考:

<https://www.sqlite.org>

The SQLite web page; the documentation describes the syntax and the available data types for the supported SQL dialect.

<https://www.w3schools.com/sql/>

Tutorial, reference and examples for learning SQL syntax.

PEP 249 - Database API Specification 2.0

PEP 由 Marc-André Lemburg 撰寫。

12.6.1 Tutorial

In this tutorial, you will create a database of Monty Python movies using basic `sqlite3` functionality. It assumes a fundamental understanding of database concepts, including [cursors](#) and [transactions](#).

First, we need to create a new database and open a database connection to allow `sqlite3` to work with it. Call `sqlite3.connect()` to create a connection to the database `tutorial.db` in the current working directory, implicitly creating it if it does not exist:

```
import sqlite3
con = sqlite3.connect("tutorial.db")
```

The returned `Connection` object `con` represents the connection to the on-disk database.

In order to execute SQL statements and fetch results from SQL queries, we will need to use a database cursor. Call `con.cursor()` to create the `Cursor`:

```
cur = con.cursor()
```

Now that we've got a database connection and a cursor, we can create a database table `movie` with columns for title, release year, and review score. For simplicity, we can just use column names in the table declaration -- thanks to the [flexible typing](#) feature of SQLite, specifying the data types is optional. Execute the `CREATE TABLE` statement by calling `cur.execute(...)`:

```
cur.execute("CREATE TABLE movie(title, year, score)")
```

We can verify that the new table has been created by querying the `sqlite_master` table built-in to SQLite, which should now contain an entry for the `movie` table definition (see [The Schema Table](#) for details). Execute that query by calling `cur.execute(...)`, assign the result to `res`, and call `res.fetchone()` to fetch the resulting row:

```
>>> res = cur.execute("SELECT name FROM sqlite_master")
>>> res.fetchone()
('movie',)
```

We can see that the table has been created, as the query returns a *tuple* containing the table's name. If we query `sqlite_master` for a non-existent table `spam`, `res.fetchone()` will return `None`:

```
>>> res = cur.execute("SELECT name FROM sqlite_master WHERE name='spam'")
>>> res.fetchone() is None
True
```

Now, add two rows of data supplied as SQL literals by executing an `INSERT` statement, once again by calling `cur.execute(...)`:

```
cur.execute("""
    INSERT INTO movie VALUES
        ('Monty Python and the Holy Grail', 1975, 8.2),
        ('And Now for Something Completely Different', 1971, 7.5)
""")
```

The `INSERT` statement implicitly opens a transaction, which needs to be committed before changes are saved in the database (see *Transaction control* for details). Call `con.commit()` on the connection object to commit the transaction:

```
con.commit()
```

We can verify that the data was inserted correctly by executing a `SELECT` query. Use the now-familiar `cur.execute(...)` to assign the result to `res`, and call `res.fetchall()` to return all resulting rows:

```
>>> res = cur.execute("SELECT score FROM movie")
>>> res.fetchall()
[(8.2,), (7.5,)]
```

The result is a *list* of two tuples, one per row, each containing that row's score value.

Now, insert three more rows by calling `cur.executemany(...)`:

```
data = [
    ("Monty Python Live at the Hollywood Bowl", 1982, 7.9),
    ("Monty Python's The Meaning of Life", 1983, 7.5),
    ("Monty Python's Life of Brian", 1979, 8.0),
]
cur.executemany("INSERT INTO movie VALUES(?, ?, ?)", data)
con.commit() # Remember to commit the transaction after executing INSERT.
```

Notice that `?` placeholders are used to bind data to the query. Always use placeholders instead of string formatting to bind Python values to SQL statements, to avoid *SQL injection attacks* (see *How to use placeholders to bind values in SQL queries* for more details).

We can verify that the new rows were inserted by executing a `SELECT` query, this time iterating over the results of the query:

```
>>> for row in cur.execute("SELECT year, title FROM movie ORDER BY year"):
...     print(row)
(1971, 'And Now for Something Completely Different')
(1975, 'Monty Python and the Holy Grail')
(1979, 'Monty Python's Life of Brian')
(1982, 'Monty Python Live at the Hollywood Bowl')
(1983, 'Monty Python's The Meaning of Life')
```

Each row is a two-item *tuple* of (`year`, `title`), matching the columns selected in the query.

Finally, verify that the database has been written to disk by calling `con.close()` to close the existing connection, opening a new one, creating a new cursor, then querying the database:

```
>>> con.close()
>>> new_con = sqlite3.connect("tutorial.db")
>>> new_cur = new_con.cursor()
>>> res = new_cur.execute("SELECT title, year FROM movie ORDER BY score DESC")
>>> title, year = res.fetchone()
>>> print(f'The highest scoring Monty Python movie is {title!r}, released in {year}
↪')
The highest scoring Monty Python movie is 'Monty Python and the Holy Grail', ↪
↪released in 1975
```

You've now created an SQLite database using the `sqlite3` module, inserted data and retrieved values from it in multiple ways.

也參考:

- *How-to guides* for further reading:
 - *How to use placeholders to bind values in SQL queries*
 - *How to adapt custom Python types to SQLite values*
 - *How to convert SQLite values to custom Python types*
 - *How to use the connection context manager*
 - *How to create and use row factories*
- 解釋 for in-depth background on transaction control.

12.6.2 Reference

Module functions

`sqlite3.connect` (*database*, *timeout*=5.0, *detect_types*=0, *isolation_level*='DEFERRED',
check_same_thread=True, *factory*=`sqlite3.Connection`, *cached_statements*=128,
uri=False)

Open a connection to an SQLite database.

參數

- **database** (*path-like object*) -- The path to the database file to be opened. You can pass `":memory:"` to create an SQLite database existing only in memory, and open a connection to it.
- **timeout** (*float*) -- How many seconds the connection should wait before raising an `OperationalError` when a table is locked. If another connection opens a transaction to modify a table, that table will be locked until the transaction is committed. Default five seconds.
- **detect_types** (*int*) -- Control whether and how data types not *natively supported by SQLite* are looked up to be converted to Python types, using the converters registered with `register_converter()`. Set it to any combination (using `|`, bitwise or) of `PARSE_DECLTYPES` and `PARSE_COLNAMES` to enable this. Column names takes precedence over declared types if both flags are set. Types cannot be detected for generated fields (for example `max(data)`), even when the *detect_types* parameter is set; *str* will be returned instead. By default (0), type detection is disabled.
- **isolation_level** (*str* | *None*) -- The *isolation_level* of the connection, controlling whether and how transactions are implicitly opened. Can be "DEFERRED" (default), "EXCLUSIVE" or "IMMEDIATE"; or *None* to disable opening transactions implicitly. See *Transaction control* for more.

- **check_same_thread** (*bool*) -- If True (default), *ProgrammingError* will be raised if the database connection is used by a thread other than the one that created it. If False, the connection may be accessed in multiple threads; write operations may need to be serialized by the user to avoid data corruption. See *threadsafety* for more information.
- **factory** (*Connection*) -- A custom subclass of *Connection* to create the connection with, if not the default *Connection* class.
- **cached_statements** (*int*) -- The number of statements that *sqlite3* should internally cache for this connection, to avoid parsing overhead. By default, 128 statements.
- **uri** (*bool*) -- If set to True, *database* is interpreted as a URI (Uniform Resource Identifier) with a file path and an optional query string. The scheme part *must* be "file:", and the path can be relative or absolute. The query string allows passing parameters to SQLite, enabling various *How to work with SQLite URIs*.

回傳型

Connection

引發一個附帶引數 *database* 的稽核事件 *sqlite3.connect*。

引發一個附帶引數 *connection_handle* 的稽核事件 *sqlite3.connect/handle*。

在 3.4 版的變更: Added the *uri* parameter.

在 3.7 版的變更: *database* can now also be a *path-like object*, not only a string.

在 3.10 版的變更: Added the *sqlite3.connect/handle* auditing event.

sqlite3.complete_statement (*statement*)

Return True if the string *statement* appears to contain one or more complete SQL statements. No syntactic verification or parsing of any kind is performed, other than checking that there are no unclosed string literals and the statement is terminated by a semicolon.

範例:

```
>>> sqlite3.complete_statement("SELECT foo FROM bar;")
True
>>> sqlite3.complete_statement("SELECT foo")
False
```

This function may be useful during command-line input to determine if the entered text seems to form a complete SQL statement, or if additional input is needed before calling *execute()*.

sqlite3.enable_callback_tracebacks (*flag*, /)

Enable or disable callback tracebacks. By default you will not get any tracebacks in user-defined functions, aggregates, converters, authorizer callbacks etc. If you want to debug them, you can call this function with *flag* set to True. Afterwards, you will get tracebacks from callbacks on *sys.stderr*. Use False to disable the feature again.

Register an *unraisable hook handler* for an improved debug experience:

```
>>> sqlite3.enable_callback_tracebacks(True)
>>> con = sqlite3.connect(":memory:")
>>> def evil_trace(stmt):
...     5/0
>>> con.set_trace_callback(evil_trace)
>>> def debug(unraisable):
...     print(f"{unraisable.exc_value!r} in callback {unraisable.object.__name_
↪_}")
...     print(f"Error message: {unraisable.err_msg}")
>>> import sys
>>> sys.unraisablehook = debug
>>> cur = con.execute("SELECT 1")
```

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(繼續上一頁)

```
ZeroDivisionError('division by zero') in callback evil_trace
Error message: None
```

`sqlite3.register_adapter` (*type*, *adapter*, /)

Register an *adapter callable* to adapt the Python type *type* into an SQLite type. The adapter is called with a Python object of type *type* as its sole argument, and must return a value of a *type that SQLite natively understands*.

`sqlite3.register_converter` (*typename*, *converter*, /)

Register the *converter callable* to convert SQLite objects of type *typename* into a Python object of a specific type. The converter is invoked for all SQLite values of type *typename*; it is passed a *bytes* object and should return an object of the desired Python type. Consult the parameter *detect_types* of `connect()` for information regarding how type detection works.

Note: *typename* and the name of the type in your query are matched case-insensitively.

Module constants

`sqlite3.PARSE_COLNAMES`

Pass this flag value to the *detect_types* parameter of `connect()` to look up a converter function by using the type name, parsed from the query column name, as the converter dictionary key. The type name must be wrapped in square brackets (`[]`).

```
SELECT p as "p [point]" FROM test; ! will look up converter "point"
```

This flag may be combined with `PARSE_DECLTYPES` using the `|` (bitwise or) operator.

`sqlite3.PARSE_DECLTYPES`

Pass this flag value to the *detect_types* parameter of `connect()` to look up a converter function using the declared types for each column. The types are declared when the database table is created. `sqlite3` will look up a converter function using the first word of the declared type as the converter dictionary key. For example:

```
CREATE TABLE test(
  i integer primary key, ! will look up a converter named "integer"
  p point,                ! will look up a converter named "point"
  n number(10)            ! will look up a converter named "number"
)
```

This flag may be combined with `PARSE_COLNAMES` using the `|` (bitwise or) operator.

`sqlite3.SQLITE_OK`

`sqlite3.SQLITE_DENY`

`sqlite3.SQLITE_IGNORE`

Flags that should be returned by the *authorizer_callback callable* passed to `Connection.set_authorizer()`, to indicate whether:

- Access is allowed (`SQLITE_OK`),
- The SQL statement should be aborted with an error (`SQLITE_DENY`)
- The column should be treated as a NULL value (`SQLITE_IGNORE`)

`sqlite3.apilevel`

String constant stating the supported DB-API level. Required by the DB-API. Hard-coded to `"2.0"`.

`sqlite3.paramstyle`

String constant stating the type of parameter marker formatting expected by the `sqlite3` module. Required by the DB-API. Hard-coded to `"qmark"`.

備 F: The named DB-API parameter style is also supported.

`sqlite3.sqlite_version`

Version number of the runtime SQLite library as a *string*.

`sqlite3.sqlite_version_info`

Version number of the runtime SQLite library as a *tuple* of *integers*.

`sqlite3.threadafety`

Integer constant required by the DB-API 2.0, stating the level of thread safety the `sqlite3` module supports. This attribute is set based on the default *threading mode* the underlying SQLite library is compiled with. The SQLite threading modes are:

1. **Single-thread:** In this mode, all mutexes are disabled and SQLite is unsafe to use in more than a single thread at once.
2. **Multi-thread:** In this mode, SQLite can be safely used by multiple threads provided that no single database connection is used simultaneously in two or more threads.
3. **Serialized:** In serialized mode, SQLite can be safely used by multiple threads with no restriction.

The mappings from SQLite threading modes to DB-API 2.0 threadsafety levels are as follows:

SQLite threading mode	thread-safety	SQLITE_THREADS/	DB-API 2.0 meaning
single-thread	0	0	Threads may not share the module
multi-thread	1	2	Threads may share the module, but not connections
serialized	3	1	Threads may share the module, connections and cursors

在 3.11 版的變更: Set *threadafety* dynamically instead of hard-coding it to 1.

`sqlite3.version`

Version number of this module as a *string*. This is not the version of the SQLite library.

`sqlite3.version_info`

Version number of this module as a *tuple* of *integers*. This is not the version of the SQLite library.

Connection objects

`class sqlite3.Connection`

Each open SQLite database is represented by a *Connection* object, which is created using `sqlite3.connect()`. Their main purpose is creating *Cursor* objects, and *Transaction control*.

也参考:

- *How to use connection shortcut methods*
- *How to use the connection context manager*

An SQLite database connection has the following attributes and methods:

`cursor` (*factory=Cursor*)

Create and return a *Cursor* object. The *cursor* method accepts a single optional parameter *factory*. If supplied, this must be a *callable* returning an instance of *Cursor* or its subclasses.

blobopen (*table, column, row, /, *, readonly=False, name='main'*)

Open a *Blob* handle to an existing BLOB (Binary Large Object).

參數

- **table** (*str*) -- The name of the table where the blob is located.
- **column** (*str*) -- The name of the column where the blob is located.
- **row** (*str*) -- The name of the row where the blob is located.
- **readonly** (*bool*) -- Set to `True` if the blob should be opened without write permissions. Defaults to `False`.
- **name** (*str*) -- The name of the database where the blob is located. Defaults to `"main"`.

引發

OperationalError -- When trying to open a blob in a `WITHOUT ROWID` table.

回傳型 F

Blob

備 F: The blob size cannot be changed using the *Blob* class. Use the SQL function `zeroblob` to create a blob with a fixed size.

在 3.11 版新加入.

commit ()

Commit any pending transaction to the database. If there is no open transaction, this method is a no-op.

rollback ()

Roll back to the start of any pending transaction. If there is no open transaction, this method is a no-op.

close ()

Close the database connection. Any pending transaction is not committed implicitly; make sure to *commit* () before closing to avoid losing pending changes.

execute (*sql, parameters=(), /*)

Create a new *Cursor* object and call *execute* () on it with the given *sql* and *parameters*. Return the new cursor object.

executemany (*sql, parameters, /*)

Create a new *Cursor* object and call *executemany* () on it with the given *sql* and *parameters*. Return the new cursor object.

executescript (*sql_script, /*)

Create a new *Cursor* object and call *executescript* () on it with the given *sql_script*. Return the new cursor object.

create_function (*name, nargs, func, *, deterministic=False*)

Create or remove a user-defined SQL function.

參數

- **name** (*str*) -- The name of the SQL function.
- **narg** (*int*) -- The number of arguments the SQL function can accept. If `-1`, it may take any number of arguments.
- **func** (*callable* | `None`) -- A *callable* that is called when the SQL function is invoked. The callable must return *a type natively supported by SQLite*. Set to `None` to remove an existing SQL function.

- **deterministic** (*bool*) -- If *True*, the created SQL function is marked as *deterministic*, which allows SQLite to perform additional optimizations.

引發

NotSupportedError -- If *deterministic* is used with SQLite versions older than 3.8.3.

在 3.8 版的變更: Added the *deterministic* parameter.

範例:

```
>>> import hashlib
>>> def md5sum(t):
...     return hashlib.md5(t).hexdigest()
>>> con = sqlite3.connect(":memory:")
>>> con.create_function("md5", 1, md5sum)
>>> for row in con.execute("SELECT md5(?)", (b"foo",)):
...     print(row)
('acbd18db4cc2f85cedef654fccc4a4d8',)
```

create_aggregate (*name, n_arg, aggregate_class*)

Create or remove a user-defined SQL aggregate function.

參數

- **name** (*str*) -- The name of the SQL aggregate function.
- **n_arg** (*int*) -- The number of arguments the SQL aggregate function can accept. If *-1*, it may take any number of arguments.
- **aggregate_class** (*class* | *None*) -- A class must implement the following methods:
 - *step()*: Add a row to the aggregate.
 - *finalize()*: Return the final result of the aggregate as *a type natively supported by SQLite*.

The number of arguments that the *step()* method must accept is controlled by *n_arg*.

Set to *None* to remove an existing SQL aggregate function.

範例:

```
class MySum:
    def __init__(self):
        self.count = 0

    def step(self, value):
        self.count += value

    def finalize(self):
        return self.count

con = sqlite3.connect(":memory:")
con.create_aggregate("mysum", 1, MySum)
cur = con.execute("CREATE TABLE test(i)")
cur.execute("INSERT INTO test(i) VALUES(1)")
cur.execute("INSERT INTO test(i) VALUES(2)")
cur.execute("SELECT mysum(i) FROM test")
print(cur.fetchone()[0])

con.close()
```

create_window_function (*name, num_params, aggregate_class, /*)

Create or remove a user-defined aggregate window function.

參數

- **name** (*str*) -- The name of the SQL aggregate window function to create or remove.
- **num_params** (*int*) -- The number of arguments the SQL aggregate window function can accept. If -1, it may take any number of arguments.
- **aggregate_class** (*class* | None) -- A class that must implement the following methods:
 - `step()`: Add a row to the current window.
 - `value()`: Return the current value of the aggregate.
 - `inverse()`: Remove a row from the current window.
 - `finalize()`: Return the final result of the aggregate as *a type natively supported by SQLite*.

The number of arguments that the `step()` and `value()` methods must accept is controlled by `num_params`.

Set to None to remove an existing SQL aggregate window function.

引發

NotSupportedError -- If used with a version of SQLite older than 3.25.0, which does not support aggregate window functions.

在 3.11 版新加入。

範例：

```
# Example taken from https://www.sqlite.org/windowfunctions.html#udfwinfunc
class WindowSumInt:
    def __init__(self):
        self.count = 0

    def step(self, value):
        """Add a row to the current window."""
        self.count += value

    def value(self):
        """Return the current value of the aggregate."""
        return self.count

    def inverse(self, value):
        """Remove a row from the current window."""
        self.count -= value

    def finalize(self):
        """Return the final value of the aggregate.

        Any clean-up actions should be placed here.
        """
        return self.count

con = sqlite3.connect(":memory:")
cur = con.execute("CREATE TABLE test(x, y)")
values = [
    ("a", 4),
    ("b", 5),
    ("c", 3),
    ("d", 8),
    ("e", 1),
]
cur.executemany("INSERT INTO test VALUES(?, ?)", values)
con.create_window_function("sumint", 1, WindowSumInt)
```

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```

cur.execute("""
    SELECT x, sumint(y) OVER (
        ORDER BY x ROWS BETWEEN 1 PRECEDING AND 1 FOLLOWING
    ) AS sum_y
    FROM test ORDER BY x
""")
print(cur.fetchall())

```

create_collation (*name*, *callable*, /)

Create a collation named *name* using the collating function *callable*. *callable* is passed two *string* arguments, and it should return an *integer*:

- 1 if the first is ordered higher than the second
- -1 if the first is ordered lower than the second
- 0 if they are ordered equal

The following example shows a reverse sorting collation:

```

def collate_reverse(string1, string2):
    if string1 == string2:
        return 0
    elif string1 < string2:
        return 1
    else:
        return -1

con = sqlite3.connect(":memory:")
con.create_collation("reverse", collate_reverse)

cur = con.execute("CREATE TABLE test(x)")
cur.executemany("INSERT INTO test(x) VALUES(?)", [("a",), ("b",)])
cur.execute("SELECT x FROM test ORDER BY x COLLATE reverse")
for row in cur:
    print(row)
con.close()

```

Remove a collation function by setting *callable* to `None`.

在 3.11 版的變更: The collation name can contain any Unicode character. Earlier, only ASCII characters were allowed.

interrupt ()

Call this method from a different thread to abort any queries that might be executing on the connection. Aborted queries will raise an *OperationalError*.

set_authorizer (*authorizer_callback*)

Register *callable* *authorizer_callback* to be invoked for each attempt to access a column of a table in the database. The callback should return one of *SQLITE_OK*, *SQLITE_DENY*, or *SQLITE_IGNORE* to signal how access to the column should be handled by the underlying SQLite library.

The first argument to the callback signifies what kind of operation is to be authorized. The second and third argument will be arguments or `None` depending on the first argument. The 4th argument is the name of the database ("main", "temp", etc.) if applicable. The 5th argument is the name of the innermost trigger or view that is responsible for the access attempt or `None` if this access attempt is directly from input SQL code.

Please consult the SQLite documentation about the possible values for the first argument and the meaning of the second and third argument depending on the first one. All necessary constants are available in the *sqlite3* module.

Passing `None` as *authorizer_callback* will disable the authorizer.

在 3.11 版的變更: Added support for disabling the authorizer using `None`.

set_progress_handler (*progress_handler*, *n*)

Register *callable* *progress_handler* to be invoked for every *n* instructions of the SQLite virtual machine. This is useful if you want to get called from SQLite during long-running operations, for example to update a GUI.

If you want to clear any previously installed progress handler, call the method with `None` for *progress_handler*.

Returning a non-zero value from the handler function will terminate the currently executing query and cause it to raise an *OperationalError* exception.

set_trace_callback (*trace_callback*)

Register *callable* *trace_callback* to be invoked for each SQL statement that is actually executed by the SQLite backend.

The only argument passed to the callback is the statement (as *str*) that is being executed. The return value of the callback is ignored. Note that the backend does not only run statements passed to the *Cursor.execute()* methods. Other sources include the *transaction management* of the `sqlite3` module and the execution of triggers defined in the current database.

Passing `None` as *trace_callback* will disable the trace callback.

備 F: Exceptions raised in the trace callback are not propagated. As a development and debugging aid, use *enable_callback_tracebacks()* to enable printing tracebacks from exceptions raised in the trace callback.

在 3.3 版新加入.

enable_load_extension (*enabled*, /)

Enable the SQLite engine to load SQLite extensions from shared libraries if *enabled* is `True`; else, disallow loading SQLite extensions. SQLite extensions can define new functions, aggregates or whole new virtual table implementations. One well-known extension is the fulltext-search extension distributed with SQLite.

備 F: The `sqlite3` module is not built with loadable extension support by default, because some platforms (notably macOS) have SQLite libraries which are compiled without this feature. To get loadable extension support, you must pass the `--enable-loadable-sqlite-extensions` option to **configure**.

引發一個附帶引數 `connection`、`enabled` 的稽核事件 `sqlite3.enable_load_extension`。

在 3.2 版新加入.

在 3.10 版的變更: 加入 `sqlite3.enable_load_extension` 稽核事件。

```
con.enable_load_extension(True)

# Load the fulltext search extension
con.execute("select load_extension('./fts3.so')")

# alternatively you can load the extension using an API call:
# con.load_extension("./fts3.so")

# disable extension loading again
con.enable_load_extension(False)

# example from SQLite wiki
```

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```

con.execute("CREATE VIRTUAL TABLE recipe USING fts3(name, ingredients)")
con.executescript("""
    INSERT INTO recipe (name, ingredients) VALUES('broccoli stew',
↪ 'broccoli peppers cheese tomatoes');
    INSERT INTO recipe (name, ingredients) VALUES('pumpkin stew', 'pumpkin_
↪ onions garlic celery');
    INSERT INTO recipe (name, ingredients) VALUES('broccoli pie',
↪ 'broccoli cheese onions flour');
    INSERT INTO recipe (name, ingredients) VALUES('pumpkin pie', 'pumpkin_
↪ sugar flour butter');
    """)
for row in con.execute("SELECT rowid, name, ingredients FROM recipe WHERE_
↪ name MATCH 'pie'"):
    print(row)

con.close()

```

load_extension(path, /)

Load an SQLite extension from a shared library located at *path*. Enable extension loading with *enable_load_extension()* before calling this method.

引發一個附帶引數 *connection*、*path* 的稽核事件 `sqlite3.load_extension`。

在 3.2 版新加入。

在 3.10 版的變更: 加入 `sqlite3.load_extension` 稽核事件。

iterdump()

Return an *iterator* to dump the database as SQL source code. Useful when saving an in-memory database for later restoration. Similar to the `.dump` command in the **sqlite3** shell.

範例:

```

# Convert file example.db to SQL dump file dump.sql
con = sqlite3.connect('example.db')
with open('dump.sql', 'w') as f:
    for line in con.iterdump():
        f.write('%s\n' % line)
con.close()

```

也參考:

How to handle non-UTF-8 text encodings

backup(target, *, pages=-1, progress=None, name='main', sleep=0.250)

Create a backup of an SQLite database.

Works even if the database is being accessed by other clients or concurrently by the same connection.

參數

- **target** (*Connection*) -- The database connection to save the backup to.
- **pages** (*int*) -- The number of pages to copy at a time. If equal to or less than 0, the entire database is copied in a single step. Defaults to -1.
- **progress** (*callable* | *None*) -- If set to a *callable*, it is invoked with three integer arguments for every backup iteration: the *status* of the last iteration, the *remaining* number of pages still to be copied, and the *total* number of pages. Defaults to *None*.
- **name** (*str*) -- The name of the database to back up. Either "main" (the default) for the main database, "temp" for the temporary database, or the name of a custom database as attached using the `ATTACH DATABASE` SQL statement.

- **sleep**(float) -- The number of seconds to sleep between successive attempts to back up remaining pages.

Example 1, copy an existing database into another:

```
def progress(status, remaining, total):
    print(f'Copied {total-remaining} of {total} pages...')

src = sqlite3.connect('example.db')
dst = sqlite3.connect('backup.db')
with dst:
    src.backup(dst, pages=1, progress=progress)
dst.close()
src.close()
```

Example 2, copy an existing database into a transient copy:

```
src = sqlite3.connect('example.db')
dst = sqlite3.connect(':memory:')
src.backup(dst)
```

在 3.7 版新加入.

也參考:

How to handle non-UTF-8 text encodings

getlimit(category, /)

Get a connection runtime limit.

參數

category(int) -- The SQLite limit category to be queried.

回傳型 F

int

引發

ProgrammingError -- If category is not recognised by the underlying SQLite library.

Example, query the maximum length of an SQL statement for *Connection* con (the default is 1000000000):

```
>>> con.getlimit(sqlite3.SQLITE_LIMIT_SQL_LENGTH)
1000000000
```

在 3.11 版新加入.

setlimit(category, limit, /)

Set a connection runtime limit. Attempts to increase a limit above its hard upper bound are silently truncated to the hard upper bound. Regardless of whether or not the limit was changed, the prior value of the limit is returned.

參數

- **category**(int) -- The SQLite limit category to be set.

- **limit**(int) -- The value of the new limit. If negative, the current limit is unchanged.

回傳型 F

int

引發

ProgrammingError -- If category is not recognised by the underlying SQLite library.

Example, limit the number of attached databases to 1 for *Connection* con (the default limit is 10):

```
>>> con.setlimit(sqlite3.SQLITE_LIMIT_ATTACHED, 1)
10
>>> con.getlimit(sqlite3.SQLITE_LIMIT_ATTACHED)
1
```

在 3.11 版新加入。

serialize (*, name='main')

Serialize a database into a *bytes* object. For an ordinary on-disk database file, the serialization is just a copy of the disk file. For an in-memory database or a "temp" database, the serialization is the same sequence of bytes which would be written to disk if that database were backed up to disk.

參數

name (*str*) -- The database name to be serialized. Defaults to "main".

回傳型 F

bytes

備 F: This method is only available if the underlying SQLite library has the serialize API.

在 3.11 版新加入。

deserialize (data, /, *, name='main')

Deserialize a *serialized* database into a *Connection*. This method causes the database connection to disconnect from database *name*, and reopen *name* as an in-memory database based on the serialization contained in *data*.

參數

- **data** (*bytes*) -- A serialized database.
- **name** (*str*) -- The database name to deserialize into. Defaults to "main".

引發

- *OperationalError* -- If the database connection is currently involved in a read transaction or a backup operation.
- *DatabaseError* -- If *data* does not contain a valid SQLite database.
- *OverflowError* -- If *len(data)* is larger than $2^{63} - 1$.

備 F: This method is only available if the underlying SQLite library has the deserialize API.

在 3.11 版新加入。

in_transaction

This read-only attribute corresponds to the low-level SQLite *autocommit mode*.

True if a transaction is active (there are uncommitted changes), False otherwise.

在 3.2 版新加入。

isolation_level

This attribute controls the *transaction handling* performed by *sqlite3*. If set to None, transactions are never implicitly opened. If set to one of "DEFERRED", "IMMEDIATE", or "EXCLUSIVE", corresponding to the underlying SQLite *transaction behaviour*, implicit *transaction management* is performed.

If not overridden by the *isolation_level* parameter of *connect()*, the default is "", which is an alias for "DEFERRED".

row_factory

The initial *row_factory* for *Cursor* objects created from this connection. Assigning to this attribute does not affect the *row_factory* of existing cursors belonging to this connection, only new ones. Is *None* by default, meaning each row is returned as a *tuple*.

See *How to create and use row factories* for more details.

text_factory

A *callable* that accepts a *bytes* parameter and returns a text representation of it. The callable is invoked for SQLite values with the TEXT data type. By default, this attribute is set to *str*.

See *How to handle non-UTF-8 text encodings* for more details.

total_changes

Return the total number of database rows that have been modified, inserted, or deleted since the database connection was opened.

Cursor objects

A *Cursor* object represents a *database cursor* which is used to execute SQL statements, and manage the context of a fetch operation. Cursors are created using *Connection.cursor()*, or by using any of the *connection shortcut methods*.

Cursor objects are *iterators*, meaning that if you *execute()* a SELECT query, you can simply iterate over the cursor to fetch the resulting rows:

```
for row in cur.execute("SELECT t FROM data"):
    print(row)
```

class sqlite3.Cursor

A *Cursor* instance has the following attributes and methods.

execute(sql, parameters=(), /)

Execute a single SQL statement, optionally binding Python values using *placeholders*.

參數

- **sql** (*str*) -- A single SQL statement.
- **parameters** (*dict* | *sequence*) -- Python values to bind to placeholders in *sql*. A *dict* if named placeholders are used. A *sequence* if unnamed placeholders are used. See *How to use placeholders to bind values in SQL queries*.

引發

ProgrammingError -- If *sql* contains more than one SQL statement.

If *isolation_level* is not *None*, *sql* is an INSERT, UPDATE, DELETE, or REPLACE statement, and there is no open transaction, a transaction is implicitly opened before executing *sql*.

Use *executescript()* to execute multiple SQL statements.

executemany(sql, parameters, /)

For every item in *parameters*, repeatedly execute the *parameterized* DML (Data Manipulation Language) SQL statement *sql*.

Uses the same implicit transaction handling as *execute()*.

參數

- **sql** (*str*) -- A single SQL DML statement.
- **parameters** (*iterable*) -- An iterable of parameters to bind with the placeholders in *sql*. See *How to use placeholders to bind values in SQL queries*.

引發

ProgrammingError -- If *sql* contains more than one SQL statement, or is not a DML statement.

範例:

```
rows = [
    ("row1",),
    ("row2",),
]
# cur is an sqlite3.Cursor object
cur.executemany("INSERT INTO data VALUES(?)", rows)
```

備F: Any resulting rows are discarded, including DML statements with ***RETURNING*** clauses.

executescript (*sql_script*, /)

Execute the SQL statements in *sql_script*. If there is a pending transaction, an implicit COMMIT statement is executed first. No other implicit transaction control is performed; any transaction control must be added to *sql_script*.

sql_script must be a *string*.

範例:

```
# cur is an sqlite3.Cursor object
cur.executescript("""
    BEGIN;
    CREATE TABLE person(firstname, lastname, age);
    CREATE TABLE book(title, author, published);
    CREATE TABLE publisher(name, address);
    COMMIT;
""")
```

fetchone ()

If *row_factory* is None, return the next row query result set as a *tuple*. Else, pass it to the row factory and return its result. Return None if no more data is available.

fetchmany (*size=cursor.arraysize*)

Return the next set of rows of a query result as a *list*. Return an empty list if no more rows are available.

The number of rows to fetch per call is specified by the *size* parameter. If *size* is not given, *arraysize* determines the number of rows to be fetched. If fewer than *size* rows are available, as many rows as are available are returned.

Note there are performance considerations involved with the *size* parameter. For optimal performance, it is usually best to use the *arraysize* attribute. If the *size* parameter is used, then it is best for it to retain the same value from one *fetchmany*() call to the next.

fetchall ()

Return all (remaining) rows of a query result as a *list*. Return an empty list if no rows are available. Note that the *arraysize* attribute can affect the performance of this operation.

close ()

Close the cursor now (rather than whenever `__del__` is called).

The cursor will be unusable from this point forward; a *ProgrammingError* exception will be raised if any operation is attempted with the cursor.

setinputsizes (*sizes*, /)

Required by the DB-API. Does nothing in *sqlite3*.

setoutputsize (*size*, *column=None*, /)Required by the DB-API. Does nothing in `sqlite3`.**arraysize**Read/write attribute that controls the number of rows returned by `fetchmany()`. The default value is 1 which means a single row would be fetched per call.**connection**Read-only attribute that provides the SQLite database `Connection` belonging to the cursor. A `Cursor` object created by calling `con.cursor()` will have a `connection` attribute that refers to `con`:

```
>>> con = sqlite3.connect(":memory:")
>>> cur = con.cursor()
>>> cur.connection == con
True
```

descriptionRead-only attribute that provides the column names of the last query. To remain compatible with the Python DB API, it returns a 7-tuple for each column where the last six items of each tuple are `None`.It is set for `SELECT` statements without any matching rows as well.**lastrowid**Read-only attribute that provides the row id of the last inserted row. It is only updated after successful `INSERT` or `REPLACE` statements using the `execute()` method. For other statements, after `executemany()` or `executescript()`, or if the insertion failed, the value of `lastrowid` is left unchanged. The initial value of `lastrowid` is `None`.

備 F: Inserts into `WITHOUT ROWID` tables are not recorded.

在 3.6 版的變更: 新增 `REPLACE` 陳述式的支援。**rowcount**Read-only attribute that provides the number of modified rows for `INSERT`, `UPDATE`, `DELETE`, and `REPLACE` statements; is `-1` for other statements, including CTE (Common Table Expression) queries. It is only updated by the `execute()` and `executemany()` methods, after the statement has run to completion. This means that any resulting rows must be fetched in order for `rowcount` to be updated.**row_factory**Control how a row fetched from this `Cursor` is represented. If `None`, a row is represented as a `tuple`. Can be set to the included `sqlite3.Row`; or a `callable` that accepts two arguments, a `Cursor` object and the `tuple` of row values, and returns a custom object representing an SQLite row.Defaults to what `Connection.row_factory` was set to when the `Cursor` was created. Assigning to this attribute does not affect `Connection.row_factory` of the parent connection.See *How to create and use row factories* for more details.

Row objects

`class sqlite3.Row`

A Row instance serves as a highly optimized *row_factory* for *Connection* objects. It supports iteration, equality testing, `len()`, and *mapping* access by column name and index.

Two Row objects compare equal if they have identical column names and values.

See *How to create and use row factories* for more details.

`keys()`

Return a *list* of column names as *strings*. Immediately after a query, it is the first member of each tuple in *Cursor.description*.

在 3.5 版的變更: Added support of slicing.

Blob objects

`class sqlite3.Blob`

在 3.11 版新加入.

A *Blob* instance is a *file-like object* that can read and write data in an SQLite BLOB. Call `len(blob)` to get the size (number of bytes) of the blob. Use indices and *slices* for direct access to the blob data.

Use the *Blob* as a *context manager* to ensure that the blob handle is closed after use.

```
con = sqlite3.connect(":memory:")
con.execute("CREATE TABLE test(blob_col blob)")
con.execute("INSERT INTO test(blob_col) VALUES(zeroblob(13))")

# Write to our blob, using two write operations:
with con.blobopen("test", "blob_col", 1) as blob:
    blob.write(b"hello, ")
    blob.write(b"world.")
    # Modify the first and last bytes of our blob
    blob[0] = ord("H")
    blob[-1] = ord("!")

# Read the contents of our blob
with con.blobopen("test", "blob_col", 1) as blob:
    greeting = blob.read()

print(greeting)  # outputs "b'Hello, world!'"
```

`close()`

Close the blob.

The blob will be unusable from this point onward. An *Error* (or subclass) exception will be raised if any further operation is attempted with the blob.

`read(length=-1, /)`

Read *length* bytes of data from the blob at the current offset position. If the end of the blob is reached, the data up to EOF (End of File) will be returned. When *length* is not specified, or is negative, `read()` will read until the end of the blob.

`write(data, /)`

Write *data* to the blob at the current offset. This function cannot change the blob length. Writing beyond the end of the blob will raise *ValueError*.

`tell()`

Return the current access position of the blob.

seek (*offset*, *origin*=*os.SEEK_SET*, /)

Set the current access position of the blob to *offset*. The *origin* argument defaults to *os.SEEK_SET* (absolute blob positioning). Other values for *origin* are *os.SEEK_CUR* (seek relative to the current position) and *os.SEEK_END* (seek relative to the blob's end).

PrepareProtocol objects

class `sqlite3.PrepareProtocol`

The PrepareProtocol type's single purpose is to act as a [PEP 246](#) style adaption protocol for objects that can *adapt themselves* to native SQLite types.

例外

The exception hierarchy is defined by the DB-API 2.0 ([PEP 249](#)).

exception `sqlite3.Warning`

This exception is not currently raised by the `sqlite3` module, but may be raised by applications using `sqlite3`, for example if a user-defined function truncates data while inserting. `Warning` is a subclass of `Exception`.

exception `sqlite3.Error`

The base class of the other exceptions in this module. Use this to catch all errors with one single `except` statement. `Error` is a subclass of `Exception`.

If the exception originated from within the SQLite library, the following two attributes are added to the exception:

sqlite_errcode

The numeric error code from the SQLite API

在 3.11 版新加入.

sqlite_errname

The symbolic name of the numeric error code from the SQLite API

在 3.11 版新加入.

exception `sqlite3.InterfaceError`

Exception raised for misuse of the low-level SQLite C API. In other words, if this exception is raised, it probably indicates a bug in the `sqlite3` module. `InterfaceError` is a subclass of `Error`.

exception `sqlite3.DatabaseError`

Exception raised for errors that are related to the database. This serves as the base exception for several types of database errors. It is only raised implicitly through the specialised subclasses. `DatabaseError` is a subclass of `Error`.

exception `sqlite3.DataError`

Exception raised for errors caused by problems with the processed data, like numeric values out of range, and strings which are too long. `DataError` is a subclass of `DatabaseError`.

exception `sqlite3.OperationalError`

Exception raised for errors that are related to the database's operation, and not necessarily under the control of the programmer. For example, the database path is not found, or a transaction could not be processed. `OperationalError` is a subclass of `DatabaseError`.

exception `sqlite3.IntegrityError`

Exception raised when the relational integrity of the database is affected, e.g. a foreign key check fails. It is a subclass of `DatabaseError`.

exception `sqlite3.InternalError`

Exception raised when SQLite encounters an internal error. If this is raised, it may indicate that there is a problem with the runtime SQLite library. `InternalError` is a subclass of `DatabaseError`.

exception `sqlite3.ProgrammingError`

Exception raised for `sqlite3` API programming errors, for example supplying the wrong number of bindings to a query, or trying to operate on a closed `Connection`. `ProgrammingError` is a subclass of `DatabaseError`.

exception `sqlite3.NotSupportedError`

Exception raised in case a method or database API is not supported by the underlying SQLite library. For example, setting `deterministic` to `True` in `create_function()`, if the underlying SQLite library does not support deterministic functions. `NotSupportedError` is a subclass of `DatabaseError`.

SQLite and Python types

SQLite natively supports the following types: NULL, INTEGER, REAL, TEXT, BLOB.

The following Python types can thus be sent to SQLite without any problem:

Python type	SQLite type
<code>None</code>	NULL
<code>int</code>	INTEGER
<code>float</code>	REAL
<code>str</code>	TEXT
<code>bytes</code>	BLOB

This is how SQLite types are converted to Python types by default:

SQLite type	Python type
NULL	<code>None</code>
INTEGER	<code>int</code>
REAL	<code>float</code>
TEXT	depends on <code>text_factory</code> , <code>str</code> by default
BLOB	<code>bytes</code>

The type system of the `sqlite3` module is extensible in two ways: you can store additional Python types in an SQLite database via *object adapters*, and you can let the `sqlite3` module convert SQLite types to Python types via *converters*.

Default adapters and converters

There are default adapters for the date and datetime types in the `datetime` module. They will be sent as ISO dates/ISO timestamps to SQLite.

The default converters are registered under the name "date" for `datetime.date` and under the name "timestamp" for `datetime.datetime`.

This way, you can use date/timestamps from Python without any additional fiddling in most cases. The format of the adapters is also compatible with the experimental SQLite date/time functions.

The following example demonstrates this.

```

import sqlite3
import datetime

con = sqlite3.connect(":memory:", detect_types=sqlite3.PARSE_DECLTYPES|sqlite3.
    ↳PARSE_COLNAMES)
cur = con.cursor()
cur.execute("create table test(d date, ts timestamp)")

today = datetime.date.today()
now = datetime.datetime.now()

cur.execute("insert into test(d, ts) values (?, ?)", (today, now))
cur.execute("select d, ts from test")
row = cur.fetchone()
print(today, "=>", row[0], type(row[0]))
print(now, "=>", row[1], type(row[1]))

cur.execute('select current_date as "d [date]", current_timestamp as "ts_'
    ↳'[timestamp]"')
row = cur.fetchone()
print("current_date", row[0], type(row[0]))
print("current_timestamp", row[1], type(row[1]))

con.close()

```

If a timestamp stored in SQLite has a fractional part longer than 6 numbers, its value will be truncated to microsecond precision by the timestamp converter.

備 註: The default "timestamp" converter ignores UTC offsets in the database and always returns a naive `datetime.datetime` object. To preserve UTC offsets in timestamps, either leave converters disabled, or register an offset-aware converter with `register_converter()`.

12.6.3 How-to guides

How to use placeholders to bind values in SQL queries

SQL operations usually need to use values from Python variables. However, beware of using Python's string operations to assemble queries, as they are vulnerable to [SQL injection attacks](#). For example, an attacker can simply close the single quote and inject `OR TRUE` to select all rows:

```

>>> # Never do this -- insecure!
>>> symbol = input()
>>> sql = "SELECT * FROM stocks WHERE symbol = '%s'" % symbol
>>> print(sql)
SELECT * FROM stocks WHERE symbol = '' OR TRUE; --'
>>> cur.execute(sql)

```

Instead, use the DB-API's parameter substitution. To insert a variable into a query string, use a placeholder in the string, and substitute the actual values into the query by providing them as a *tuple* of values to the second argument of the cursor's `execute()` method.

An SQL statement may use one of two kinds of placeholders: question marks (qmark style) or named placeholders (named style). For the qmark style, *parameters* must be a *sequence* whose length must match the number of placeholders, or a `ProgrammingError` is raised. For the named style, *parameters* should be an instance of a *dict* (or a subclass), which must contain keys for all named parameters; any extra items are ignored. Here's an example of both styles:

```
con = sqlite3.connect(":memory:")
cur = con.execute("CREATE TABLE lang(name, first_appeared)")

# This is the named style used with executemany():
data = (
    {"name": "C", "year": 1972},
    {"name": "Fortran", "year": 1957},
    {"name": "Python", "year": 1991},
    {"name": "Go", "year": 2009},
)
cur.executemany("INSERT INTO lang VALUES(:name, :year)", data)

# This is the qmark style used in a SELECT query:
params = (1972,)
cur.execute("SELECT * FROM lang WHERE first_appeared = ?", params)
print(cur.fetchall())
```

備F: **PEP 249** numeric placeholders are *not* supported. If used, they will be interpreted as named placeholders.

How to adapt custom Python types to SQLite values

SQLite supports only a limited set of data types natively. To store custom Python types in SQLite databases, *adapt* them to one of the *Python types SQLite natively understands*.

There are two ways to adapt Python objects to SQLite types: letting your object adapt itself, or using an *adapter callable*. The latter will take precedence above the former. For a library that exports a custom type, it may make sense to enable that type to adapt itself. As an application developer, it may make more sense to take direct control by registering custom adapter functions.

How to write adaptable objects

Suppose we have a `Point` class that represents a pair of coordinates, `x` and `y`, in a Cartesian coordinate system. The coordinate pair will be stored as a text string in the database, using a semicolon to separate the coordinates. This can be implemented by adding a `__conform__(self, protocol)` method which returns the adapted value. The object passed to *protocol* will be of type *PrepareProtocol*.

```
class Point:
    def __init__(self, x, y):
        self.x, self.y = x, y

    def __conform__(self, protocol):
        if protocol is sqlite3.PrepareProtocol:
            return f"{self.x};{self.y}"

con = sqlite3.connect(":memory:")
cur = con.cursor()

cur.execute("SELECT ?", (Point(4.0, -3.2),))
print(cur.fetchone()[0])
```

How to register adapter callables

The other possibility is to create a function that converts the Python object to an SQLite-compatible type. This function can then be registered using `register_adapter()`.

```
class Point:
    def __init__(self, x, y):
        self.x, self.y = x, y

def adapt_point(point):
    return f"{point.x};{point.y}"

sqlite3.register_adapter(Point, adapt_point)

con = sqlite3.connect(":memory:")
cur = con.cursor()

cur.execute("SELECT ?", (Point(1.0, 2.5),))
print(cur.fetchone()[0])
```

How to convert SQLite values to custom Python types

Writing an adapter lets you convert *from* custom Python types *to* SQLite values. To be able to convert *from* SQLite values to custom Python types, we use *converters*.

Let's go back to the `Point` class. We stored the `x` and `y` coordinates separated via semicolons as strings in SQLite. First, we'll define a converter function that accepts the string as a parameter and constructs a `Point` object from it.

備F: Converter functions are **always** passed a *bytes* object, no matter the underlying SQLite data type.

```
def convert_point(s):
    x, y = map(float, s.split(b";"))
    return Point(x, y)
```

We now need to tell `sqlite3` when it should convert a given SQLite value. This is done when connecting to a database, using the `detect_types` parameter of `connect()`. There are three options:

- Implicit: set `detect_types` to `PARSE_DECLTYPES`
- Explicit: set `detect_types` to `PARSE_COLNAMES`
- Both: set `detect_types` to `sqlite3.PARSE_DECLTYPES | sqlite3.PARSE_COLNAMES`. Column names take precedence over declared types.

The following example illustrates the implicit and explicit approaches:

```
class Point:
    def __init__(self, x, y):
        self.x, self.y = x, y

    def __repr__(self):
        return f"Point({self.x}, {self.y})"

def adapt_point(point):
    return f"{point.x};{point.y}"

def convert_point(s):
    x, y = list(map(float, s.split(b";")))
    return Point(x, y)
```

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```

# Register the adapter and converter
sqlite3.register_adapter(Point, adapt_point)
sqlite3.register_converter("point", convert_point)

# 1) Parse using declared types
p = Point(4.0, -3.2)
con = sqlite3.connect(":memory:", detect_types=sqlite3.PARSE_DECLTYPES)
cur = con.execute("CREATE TABLE test(p point)")

cur.execute("INSERT INTO test(p) VALUES(?)", (p,))
cur.execute("SELECT p FROM test")
print("with declared types:", cur.fetchone()[0])
cur.close()
con.close()

# 2) Parse using column names
con = sqlite3.connect(":memory:", detect_types=sqlite3.PARSE_COLNAMES)
cur = con.execute("CREATE TABLE test(p)")

cur.execute("INSERT INTO test(p) VALUES(?)", (p,))
cur.execute('SELECT p AS "p [point]" FROM test')
print("with column names:", cur.fetchone()[0])

```

Adapter and converter recipes

This section shows recipes for common adapters and converters.

```

import datetime
import sqlite3

def adapt_date_iso(val):
    """Adapt datetime.date to ISO 8601 date."""
    return val.isoformat()

def adapt_datetime_iso(val):
    """Adapt datetime.datetime to timezone-naive ISO 8601 date."""
    return val.isoformat()

def adapt_datetime_epoch(val):
    """Adapt datetime.datetime to Unix timestamp."""
    return int(val.timestamp())

sqlite3.register_adapter(datetime.date, adapt_date_iso)
sqlite3.register_adapter(datetime.datetime, adapt_datetime_iso)
sqlite3.register_adapter(datetime.datetime, adapt_datetime_epoch)

def convert_date(val):
    """Convert ISO 8601 date to datetime.date object."""
    return datetime.date.fromisoformat(val.decode())

def convert_datetime(val):
    """Convert ISO 8601 datetime to datetime.datetime object."""
    return datetime.datetime.fromisoformat(val.decode())

def convert_timestamp(val):
    """Convert Unix epoch timestamp to datetime.datetime object."""
    return datetime.datetime.fromtimestamp(int(val))

sqlite3.register_converter("date", convert_date)

```

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```
sqlite3.register_converter("datetime", convert_datetime)
sqlite3.register_converter("timestamp", convert_timestamp)
```

How to use connection shortcut methods

Using the `execute()`, `executemany()`, and `executescript()` methods of the `Connection` class, your code can be written more concisely because you don't have to create the (often superfluous) `Cursor` objects explicitly. Instead, the `Cursor` objects are created implicitly and these shortcut methods return the cursor objects. This way, you can execute a `SELECT` statement and iterate over it directly using only a single call on the `Connection` object.

```
# Create and fill the table.
con = sqlite3.connect(":memory:")
con.execute("CREATE TABLE lang(name, first_appeared)")
data = [
    ("C++", 1985),
    ("Objective-C", 1984),
]
con.executemany("INSERT INTO lang(name, first_appeared) VALUES(?, ?)", data)

# Print the table contents
for row in con.execute("SELECT name, first_appeared FROM lang"):
    print(row)

print("I just deleted", con.execute("DELETE FROM lang").rowcount, "rows")

# close() is not a shortcut method and it's not called automatically;
# the connection object should be closed manually
con.close()
```

How to use the connection context manager

A `Connection` object can be used as a context manager that automatically commits or rolls back open transactions when leaving the body of the context manager. If the body of the `with` statement finishes without exceptions, the transaction is committed. If this commit fails, or if the body of the `with` statement raises an uncaught exception, the transaction is rolled back.

If there is no open transaction upon leaving the body of the `with` statement, the context manager is a no-op.

備F: The context manager neither implicitly opens a new transaction nor closes the connection. If you need a closing context manager, consider using `contextlib.closing()`.

```
con = sqlite3.connect(":memory:")
con.execute("CREATE TABLE lang(id INTEGER PRIMARY KEY, name VARCHAR UNIQUE)")

# Successful, con.commit() is called automatically afterwards
with con:
    con.execute("INSERT INTO lang(name) VALUES(?)", ("Python",))

# con.rollback() is called after the with block finishes with an exception,
# the exception is still raised and must be caught
try:
    with con:
        con.execute("INSERT INTO lang(name) VALUES(?)", ("Python",))
except sqlite3.IntegrityError:
    print("couldn't add Python twice")
```

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```
# Connection object used as context manager only commits or rollbacks transactions,
# so the connection object should be closed manually
con.close()
```

How to work with SQLite URIs

Some useful URI tricks include:

- Open a database in read-only mode:

```
>>> con = sqlite3.connect("file:tutorial.db?mode=ro", uri=True)
>>> con.execute("CREATE TABLE readonly(data)")
Traceback (most recent call last):
OperationalError: attempt to write a readonly database
```

- Do not implicitly create a new database file if it does not already exist; will raise *OperationalError* if unable to create a new file:

```
>>> con = sqlite3.connect("file:nosuchdb.db?mode=rw", uri=True)
Traceback (most recent call last):
OperationalError: unable to open database file
```

- Create a shared named in-memory database:

```
db = "file:mem1?mode=memory&cache=shared"
con1 = sqlite3.connect(db, uri=True)
con2 = sqlite3.connect(db, uri=True)
with con1:
    con1.execute("CREATE TABLE shared(data)")
    con1.execute("INSERT INTO shared VALUES(28)")
res = con2.execute("SELECT data FROM shared")
assert res.fetchone() == (28,)
```

More information about this feature, including a list of parameters, can be found in the [SQLite URI documentation](#).

How to create and use row factories

By default, `sqlite3` represents each row as a *tuple*. If a tuple does not suit your needs, you can use the *sqlite3.Row* class or a custom *row_factory*.

While *row_factory* exists as an attribute both on the *Cursor* and the *Connection*, it is recommended to set *Connection.row_factory*, so all cursors created from the connection will use the same row factory.

Row provides indexed and case-insensitive named access to columns, with minimal memory overhead and performance impact over a tuple. To use *Row* as a row factory, assign it to the *row_factory* attribute:

```
>>> con = sqlite3.connect(":memory:")
>>> con.row_factory = sqlite3.Row
```

Queries now return *Row* objects:

```
>>> res = con.execute("SELECT 'Earth' AS name, 6378 AS radius")
>>> row = res.fetchone()
>>> row.keys()
['name', 'radius']
>>> row[0]           # Access by index.
'Earth'
>>> row["name"]      # Access by name.
'Earth'
```

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```
>>> row["RADIUS"] # Column names are case-insensitive.
6378
```

備 F: The FROM clause can be omitted in the SELECT statement, as in the above example. In such cases, SQLite returns a single row with columns defined by expressions, e.g. literals, with the given aliases `expr AS alias`.

You can create a custom `row_factory` that returns each row as a *dict*, with column names mapped to values:

```
def dict_factory(cursor, row):
    fields = [column[0] for column in cursor.description]
    return {key: value for key, value in zip(fields, row)}
```

Using it, queries now return a dict instead of a tuple:

```
>>> con = sqlite3.connect(":memory:")
>>> con.row_factory = dict_factory
>>> for row in con.execute("SELECT 1 AS a, 2 AS b"):
...     print(row)
{'a': 1, 'b': 2}
```

The following row factory returns a *named tuple*:

```
from collections import namedtuple

def namedtuple_factory(cursor, row):
    fields = [column[0] for column in cursor.description]
    cls = namedtuple("Row", fields)
    return cls._make(row)
```

`namedtuple_factory()` can be used as follows:

```
>>> con = sqlite3.connect(":memory:")
>>> con.row_factory = namedtuple_factory
>>> cur = con.execute("SELECT 1 AS a, 2 AS b")
>>> row = cur.fetchone()
>>> row
Row(a=1, b=2)
>>> row[0] # Indexed access.
1
>>> row.b # Attribute access.
2
```

With some adjustments, the above recipe can be adapted to use a *dataclass*, or any other custom class, instead of a *namedtuple*.

How to handle non-UTF-8 text encodings

By default, `sqlite3` uses *str* to adapt SQLite values with the TEXT data type. This works well for UTF-8 encoded text, but it might fail for other encodings and invalid UTF-8. You can use a custom *text_factory* to handle such cases.

Because of SQLite's *flexible typing*, it is not uncommon to encounter table columns with the TEXT data type containing non-UTF-8 encodings, or even arbitrary data. To demonstrate, let's assume we have a database with ISO-8859-2 (Latin-2) encoded text, for example a table of Czech-English dictionary entries. Assuming we now have a *Connection* instance `con` connected to this database, we can decode the Latin-2 encoded text using this *text_factory*:

```
con.text_factory = lambda data: str(data, encoding="latin2")
```

For invalid UTF-8 or arbitrary data in stored in TEXT table columns, you can use the following technique, borrowed from the [unicode-howto](#):

```
con.text_factory = lambda data: str(data, errors="surrogateescape")
```

備F: The `sqlite3` module API does not support strings containing surrogates.

也參考:

[unicode-howto](#)

12.6.4 解釋

Transaction control

The `sqlite3` module does not adhere to the transaction handling recommended by [PEP 249](#).

If the connection attribute `isolation_level` is not `None`, new transactions are implicitly opened before `execute()` and `executemany()` executes INSERT, UPDATE, DELETE, or REPLACE statements; for other statements, no implicit transaction handling is performed. Use the `commit()` and `rollback()` methods to respectively commit and roll back pending transactions. You can choose the underlying SQLite transaction behaviour—that is, whether and what type of BEGIN statements `sqlite3` implicitly executes—via the `isolation_level` attribute.

If `isolation_level` is set to `None`, no transactions are implicitly opened at all. This leaves the underlying SQLite library in [autocommit mode](#), but also allows the user to perform their own transaction handling using explicit SQL statements. The underlying SQLite library autocommit mode can be queried using the `in_transaction` attribute.

The `executescript()` method implicitly commits any pending transaction before execution of the given SQL script, regardless of the value of `isolation_level`.

在 3.6 版的變更: `sqlite3` used to implicitly commit an open transaction before DDL statements. This is no longer the case.

本章中描述的模組支援使用 `zlib`、`gzip`、`bzip2` 和 `lzma` 演算法進行資料壓縮，以及建立 ZIP 和 tar 格式的存檔。另請參閱 `shutil` 模組提供的 *Archiving operations*。

13.1 `zlib` --- 相容於 `gzip` 的壓縮

對於需要資料壓縮的應用程式，此模組提供了能使用 `zlib` 函式庫進行壓縮和解壓縮的函式。`zlib` 函式庫有自己的主頁 <https://www.zlib.net>。已知 Python 模組與早於 1.1.3 的 `zlib` 函式庫版本之間不相容；1.1.3 存在安全漏洞，因此我們建議使用 1.1.4 或更新的版本。

`zlib` 的函式有很多選項，且通常需要按特定順序使用。本文件不打算解釋所有選項排列組合的效果；相關官方資訊，請參閱 <http://www.zlib.net/manual.html> 上的 `zlib` 手冊。

若要讀寫 `.gz` 文件，請參閱 `gzip` 模組。

該模組中可用的例外和函式是：

exception `zlib.error`

當壓縮和解壓縮發生錯誤時引發的例外。

`zlib.adler32(data[, value])`

計算 `data` 的 Adler-32 核對和 (checksum)。(Adler-32 核對和幾乎與 CRC32 一樣可靠，但計算速度更快。) 結果是一個 unsigned (無符號的) 32-bit 整數。如果有提供 `value`，則將其用作核對和的起始值，否則使用預設值 1。傳入 `value` 允許了於多個輸入的串聯 (concatenation) 上計算核對和。該演算法的加密度不高，不該用於身份驗證 (authentication) 或數位簽章 (digital signature)。由於該演算法是為核對和演算法而設計的，它不適合作為通用的雜湊演算法。

在 3.0 版的變更：結果總是 unsigned。

`zlib.compress(data, /, level=-1, wbits=MAX_WBITS)`

壓縮 `data` 中的位元組，回傳一個包含壓縮資料的位元組物件。`level` 是從 0 到 9 或 -1 的整數，控制了壓縮的級數；1 (`Z_BEST_SPEED`) 最快但壓縮程度較小，9 (`Z_BEST_COMPRESSION`) 最慢但壓縮最多。0 (`Z_NO_COMPRESSION`) 代表不壓縮。預設值 -1 (`Z_DEFAULT_COMPRESSION`)。`Z_DEFAULT_COMPRESSION` 表示預設的速度和壓縮間折衷方案（目前相當於級數 6）。

`wbits` 引數控制了壓縮資料時所使用的歷史緩衝區 (history buffer) 大小（或「視窗大小」），以及輸出中是否包含標題和尾末 (trailer)。它可以指定多個值的範圍，預設 15 (`MAX_WBITS`)：

- +9 到 +15: 視窗大小的以二為底的對數，因此範圍在 512 到 32768 之間。較大的值會產生最佳的壓縮，但會用更多的記憶體。生成輸出將包含特定於 `zlib` 的標頭和尾末。
- -9 到 -15: 使用 `wbits` 的對值作視窗大小的對數，同時生成有標頭或尾末核對和的原始輸出串流。
- +25 到 +31 = 16 + (9 到 15): 使用數值的最低 4 位元作視窗大小的對數，同時在輸出中包含基本的 `gzip` 標頭和尾末核對和。

如果發生任何錯誤，則引發 `error` 例外。

在 3.6 版的變更: `level` 現在可以用作關鍵字參數。

在 3.11 版的變更: `wbits` 參數現在可用於設定視窗位元和壓縮型。

```
zlib.compressobj (level=-1, method=DEFLATED, wbits=MAX_WBITS, memLevel=DEF_MEM_LEVEL,
                  strategy=Z_DEFAULT_STRATEGY[, zdict ])
```

回傳一個壓縮物件，用於壓縮不能一次全部放入記憶體中的資料串流。

`level` 是壓縮級 -- 從 0 到 9 或 -1 的整數。1 (`Z_BEST_SPEED`) 最快但壓縮程度較小，而 9 (`Z_BEST_COMPRESSION`) 最慢但壓縮最多。0 (`Z_NO_COMPRESSION`) 代表不壓縮。預設值 -1 (`Z_DEFAULT_COMPRESSION`)。 `Z_DEFAULT_COMPRESSION` 表示預設的速度和壓縮間折衷方案（目前相當於級 6）。

`method` 代表壓縮演算法。目前唯一支援的值是 `DEFLATED`。

`wbits` 參數控制歷史緩衝區的大小（或「視窗大小」），以及將使用的標頭和尾末格式。它與前面述的 `compress()` 具有相同的含義。

`memLevel` 引數控制用於內部壓縮狀態的記憶體大小。有效值範圍 1 到 9。較高的值會使用更多的記憶體，但速度更快產生更小的輸出。

`strategy` 被用於調整壓縮演算法。可用的值 `Z_DEFAULT_STRATEGY`、`Z_FILTERED`、`Z_HUFFMAN_ONLY`、`Z_RLE` (`zlib` 1.2.0.1) 和 `Z_FIXED` (`zlib` 1.2.2.2)。

`zdict` 是事先定義好的壓縮字典。這是一個位元組序列（例如一個 `bytes` 物件），其中包含預期在要壓縮的資料中頻繁出現的子序列。那些預期會最常見的子序列應該出現在字典的尾末。

在 3.3 版的變更: 新增 `zdict` 參數與支援關鍵字引數。

```
zlib.crc32 (data[, value ])
```

計算 `data` 的 CRC (Cyclic Redundancy Check, 循環冗余核對) 核對和，結果會是一個 unsigned 32-bit 整數。如果 `value` 存在，則將其用作核對和的起始值，否則使用預設值 0。傳入 `value` 允許在多個輸入的串聯上計算核對和。該演算法的加密度不高，不該用於身份驗證或數位簽章。由於該演算法是核對和演算法而設計的，它不適合通用的雜演算法。

在 3.0 版的變更: 結果總是 unsigned。

```
zlib.decompress (data, /, wbits=MAX_WBITS, bufsize=DEF_BUF_SIZE)
```

解壓縮 `data` 中的位元組，回傳包含未壓縮資料的位元組物件。`wbits` 參數依賴於 `data` 的格式，下面將進一步討論。如果有給定 `bufsize`，它會被用作輸出緩衝區的初始大小。如果發生任何錯誤，則引發 `error` 例外。

`wbits` 參數控制歷史緩衝區的大小（或「視窗大小」），以及期望的標頭和尾末格式。它類似於 `compressobj()` 的參數，但接受更多範圍的值：

- +8 到 +15: 視窗大小的以二為底的對數。輸入必須包括一個 `zlib` 標頭和尾末。
- 0: 根據 `zlib` 標頭檔自動定視窗大小。僅有在 `zlib` 1.2.3.5 或更新的版本支援。
- -8 to -15: 使用 `wbits` 的對值作視窗大小的對數，輸入必須是有標頭或尾末的原始串流。
- +24 到 +31 = 16 + (8 到 15): 取值的最低 4 位元作視窗大小的對數，輸入必須包含 `gzip` 標頭和尾末。
- +40 到 +47 = 32 + (8 到 15): 使用值的最低 4 位元作視窗大小的對數，自動接受 `zlib` 或 `gzip` 格式。

當解壓縮一個串流時，視窗大小不得小於最初用於壓縮串流的大小；使用太小的值可能會導致 `error` 例外。預設的 `wbits` 值對應於最大的視窗大小，且需要包含 `zlib` 標頭和尾末。

`bufsize` 是用於保存解壓縮資料的緩衝區的初始大小。如果需要更多空間，緩衝區大小將根據需求來增加，因此你不需要讓該值完全剛好；調整它只會節省幾次對 `malloc()` 的呼叫。

在 3.6 版的變更: `wbits` 和 `bufsize` 可以用作關鍵字引數。

`zlib.decompressobj(wbits=MAX_WBITS[, zdict])`

回傳一個解壓縮物件，用於解壓縮不能一次全部放入記憶體中的資料串流。

`wbits` 引數控制歷史緩衝區的大小（或「視窗大小」），以及期望的標頭和尾末格式。它與前面述的 `decompress()` 具有相同的含義。

`zdict` 參數指定是先定義好的壓縮字典。如果有提供，這必須與生成要解壓縮資料的壓縮器所使用的字典相同。

備註： 如果 `zdict` 是一個可變物件 (mutable object) (例如一個 `bytearray`)，你不能在呼叫 `decompressobj()` 和第一次呼叫解壓縮器的 `decompress()` 方法之間修改它的內容。

在 3.3 版的變更: 新增 `zdict` 參數。

壓縮物件支援以下方法：

`Compress.compress(data)`

壓縮 `data`，回傳一個位元組物件，其中至少包含 `data` 中部分資料的壓縮資料。此資料應串聯到任何先前呼叫 `compress()` 方法所產生的輸出。一些輸入可能會保存在內部緩衝區中以供後續處理。

`Compress.flush([mode])`

處理所有待處理的輸入，回傳包含剩餘壓縮輸出的位元組物件。`mode` 可以從以下常數中選擇：`Z_NO_FLUSH`、`Z_PARTIAL_FLUSH`、`Z_SYNC_FLUSH`、`Z_FULL_FLUSH`、`Z_BLOCK` (`zlib 1.2.3.4`) 或 `Z_FINISH`，預設 `Z_FINISH`。除了 `Z_FINISH` 之外，所有常數都允許壓縮更多的資料位元組字串，而 `Z_FINISH` 會完成壓縮串流同時防止壓縮更多資料。在 `mode` 設定 `Z_FINISH` 的情況下呼叫 `flush()` 後，無法再次呼叫 `compress()` 方法；唯一可行的作法是刪除物件。

`Compress.copy()`

回傳壓縮物件的副本，這可用於有效壓縮一組共用初始前綴的資料。

在 3.8 版的變更: 於壓縮物件新增對 `copy.copy()` 和 `copy.deepcopy()` 的支援。

解壓縮物件支援以下方法和屬性：

`Decompress.unused_data`

一個位元組物件，它包含壓縮資料結束之後的任何位元組。也就是，在包含壓縮資料的最後一個位元組可用之前，它會一直保持 `b""`。如果整個位元組字串 (bytestring) 有包含壓縮資料，這會是 `b""`，也就是一個空位元組物件。

`Decompress.unconsumed_tail`

一個位元組物件，包含前一次 `decompress()` 的呼叫因超出了未壓縮資料緩衝區的限制而消耗掉的任何資料。`zlib` 機制尚未看到此資料，因此您必須將其（和可能有和它串聯的其他資料）反饋給後續的 `decompress()` 方法呼叫以獲得正確的輸出。

`Decompress.eof`

一個布林值，代表是否已到達壓縮資料串流的尾末。

這使其能區分有正確建構的壓縮串流和不完整或被截斷的串流。

在 3.3 版新加入。

`Decompress.decompress(data, max_length=0)`

解壓縮 `data` 回傳一個位元組物件，其包含與 `string` 中至少與部分資料相對應的未壓縮資料。此資料應串聯到任何先前呼叫 `decompress()` 方法所產生的輸出。一些輸入資料可能會保存在內部緩衝區中以供後續處理。

如果可選參數 `max_length` 不是零，則回傳值長度將不超過 `max_length`。這代表著不是所有的已壓縮輸入都可以被處理；未使用的資料將被存儲在屬性 `unconsumed_tail` 中。如果要繼續解壓縮，則必須將此位元組字串傳遞給後續對 `decompress()` 的呼叫。如果 `max_length` 是零，則整個輸入會被解壓縮，且 `unconsumed_tail` 是空。

在 3.6 版的變更: `max_length` 可以用作關鍵字引數。

`Decompress.flush([length])`

處理所有待處理的輸入，回傳包含剩餘未壓縮輸出的位元組物件。呼叫 `flush()` 後，無法再次呼叫 `decompress()` 方法；唯一可行的方法是刪除該物件。

可選參數 `length` 設定了輸出緩衝區的初始大小。

`Decompress.copy()`

回傳解壓物件的副本，這可用於在資料串流中途保存解壓縮器的狀態，以便在未來某個時間點加速對串流的隨機搜索 (random seek)。

在 3.8 版的變更: 於解壓縮物件新增對 `copy.copy()` 和 `copy.deepcopy()` 支援。

有關正在使用的 `zlib` 函式庫版本資訊可通過以下常數獲得：

`zlib.ZLIB_VERSION`

用於建置模組的 `zlib` 函式庫版本字串。這可能與實際在執行環境 (runtime) 使用的 `zlib` 函式庫不同，後者以 `ZLIB_RUNTIME_VERSION` 提供。

`zlib.ZLIB_RUNTIME_VERSION`

直譯器實際載入的 `zlib` 函式庫版本字串。

在 3.3 版新加入。

也參考：

gzip 模組

讀寫 **gzip** 格式的檔案。

<http://www.zlib.net>

`zlib` 函式庫首頁。

<http://www.zlib.net/manual.html>

`zlib` 手冊解釋了函式庫中許多函式的語義和用法。

13.2 gzip --- Support for gzip files

原始碼： [Lib/gzip.py](#)

This module provides a simple interface to compress and decompress files just like the GNU programs **gzip** and **gunzip** would.

The data compression is provided by the `zlib` module.

The `gzip` module provides the `GzipFile` class, as well as the `open()`, `compress()` and `decompress()` convenience functions. The `GzipFile` class reads and writes **gzip**-format files, automatically compressing or decompressing the data so that it looks like an ordinary *file object*.

Note that additional file formats which can be decompressed by the **gzip** and **gunzip** programs, such as those produced by **compress** and **pack**, are not supported by this module.

The module defines the following items:

`gzip.open(filename, mode='rb', compresslevel=9, encoding=None, errors=None, newline=None)`

Open a gzip-compressed file in binary or text mode, returning a *file object*.

The *filename* argument can be an actual filename (a *str* or *bytes* object), or an existing file object to read from or write to.

The *mode* argument can be any of 'r', 'rb', 'a', 'ab', 'w', 'wb', 'x' or 'xb' for binary mode, or 'rt', 'at', 'wt', or 'xt' for text mode. The default is 'rb'.

The *compresslevel* argument is an integer from 0 to 9, as for the *GzipFile* constructor.

For binary mode, this function is equivalent to the *GzipFile* constructor: `GzipFile(filename, mode, compresslevel)`. In this case, the *encoding*, *errors* and *newline* arguments must not be provided.

For text mode, a *GzipFile* object is created, and wrapped in an *io.TextIOWrapper* instance with the specified encoding, error handling behavior, and line ending(s).

在 3.3 版的變更: Added support for *filename* being a file object, support for text mode, and the *encoding*, *errors* and *newline* arguments.

在 3.4 版的變更: Added support for the 'x', 'xb' and 'xt' modes.

在 3.6 版的變更: Accepts a *path-like object*.

exception `gzip.BadGzipFile`

An exception raised for invalid gzip files. It inherits from *OSError*. *EOFError* and *zlib.error* can also be raised for invalid gzip files.

在 3.8 版新加入.

class `gzip.GzipFile(filename=None, mode=None, compresslevel=9, fileobj=None, mtime=None)`

Constructor for the *GzipFile* class, which simulates most of the methods of a *file object*, with the exception of the *truncate()* method. At least one of *fileobj* and *filename* must be given a non-trivial value.

The new class instance is based on *fileobj*, which can be a regular file, an *io.BytesIO* object, or any other object which simulates a file. It defaults to *None*, in which case *filename* is opened to provide a file object.

When *fileobj* is not *None*, the *filename* argument is only used to be included in the **gzip** file header, which may include the original filename of the uncompressed file. It defaults to the filename of *fileobj*, if discernible; otherwise, it defaults to the empty string, and in this case the original filename is not included in the header.

The *mode* argument can be any of 'r', 'rb', 'a', 'ab', 'w', 'wb', 'x', or 'xb', depending on whether the file will be read or written. The default is the mode of *fileobj* if discernible; otherwise, the default is 'rb'. In future Python releases the mode of *fileobj* will not be used. It is better to always specify *mode* for writing.

Note that the file is always opened in binary mode. To open a compressed file in text mode, use *open()* (or wrap your *GzipFile* with an *io.TextIOWrapper*).

The *compresslevel* argument is an integer from 0 to 9 controlling the level of compression; 1 is fastest and produces the least compression, and 9 is slowest and produces the most compression. 0 is no compression. The default is 9.

The *mtime* argument is an optional numeric timestamp to be written to the last modification time field in the stream when compressing. It should only be provided in compression mode. If omitted or *None*, the current time is used. See the *mtime* attribute for more details.

Calling a *GzipFile* object's *close()* method does not close *fileobj*, since you might wish to append more material after the compressed data. This also allows you to pass an *io.BytesIO* object opened for writing as *fileobj*, and retrieve the resulting memory buffer using the *io.BytesIO* object's *getvalue()* method.

GzipFile supports the *io.BufferedIOBase* interface, including iteration and the *with* statement. Only the *truncate()* method isn't implemented.

GzipFile also provides the following method and attribute:

peek(*n*)

Read *n* uncompressed bytes without advancing the file position. At most one single read on the compressed stream is done to satisfy the call. The number of bytes returned may be more or less than requested.

備註: While calling `peek()` does not change the file position of the `GzipFile`, it may change the position of the underlying file object (e.g. if the `GzipFile` was constructed with the `fileobj` parameter).

在 3.2 版新加入.

mtime

When decompressing, the value of the last modification time field in the most recently read header may be read from this attribute, as an integer. The initial value before reading any headers is `None`.

All **gzip** compressed streams are required to contain this timestamp field. Some programs, such as **gunzip**, make use of the timestamp. The format is the same as the return value of `time.time()` and the `st_mtime` attribute of the object returned by `os.stat()`.

name

The path to the gzip file on disk, as a `str` or `bytes`. Equivalent to the output of `os.fspath()` on the original input path, with no other normalization, resolution or expansion.

在 3.1 版的變更: Support for the `with` statement was added, along with the `mtime` constructor argument and `mtime` attribute.

在 3.2 版的變更: Support for zero-padded and unseekable files was added.

在 3.3 版的變更: The `io.BufferedReader.read1()` method is now implemented.

在 3.4 版的變更: Added support for the `'x'` and `'xb'` modes.

在 3.5 版的變更: Added support for writing arbitrary *bytes-like objects*. The `read()` method now accepts an argument of `None`.

在 3.6 版的變更: Accepts a *path-like object*.

在 3.9 版之後被禁用: Opening `GzipFile` for writing without specifying the `mode` argument is deprecated.

gzip.compress(*data*, *compresslevel*=9, *, *mtime*=None)

Compress the *data*, returning a `bytes` object containing the compressed data. *compresslevel* and *mtime* have the same meaning as in the `GzipFile` constructor above. When *mtime* is set to 0, this function is equivalent to `zlib.compress()` with *wbits* set to 31. The `zlib` function is faster.

在 3.2 版新加入.

在 3.8 版的變更: Added the *mtime* parameter for reproducible output.

在 3.11 版的變更: Speed is improved by compressing all data at once instead of in a streamed fashion. Calls with *mtime* set to 0 are delegated to `zlib.compress()` for better speed.

gzip.decompress(*data*)

Decompress the *data*, returning a `bytes` object containing the uncompressed data. This function is capable of decompressing multi-member gzip data (multiple gzip blocks concatenated together). When the data is certain to contain only one member the `zlib.decompress()` function with *wbits* set to 31 is faster.

在 3.2 版新加入.

在 3.11 版的變更: Speed is improved by decompressing members at once in memory instead of in a streamed fashion.

13.2.1 用法范例

Example of how to read a compressed file:

```
import gzip
with gzip.open('/home/joe/file.txt.gz', 'rb') as f:
    file_content = f.read()
```

Example of how to create a compressed GZIP file:

```
import gzip
content = b"Lots of content here"
with gzip.open('/home/joe/file.txt.gz', 'wb') as f:
    f.write(content)
```

Example of how to GZIP compress an existing file:

```
import gzip
import shutil
with open('/home/joe/file.txt', 'rb') as f_in:
    with gzip.open('/home/joe/file.txt.gz', 'wb') as f_out:
        shutil.copyfileobj(f_in, f_out)
```

Example of how to GZIP compress a binary string:

```
import gzip
s_in = b"Lots of content here"
s_out = gzip.compress(s_in)
```

也參考:

zlib 模組

The basic data compression module needed to support the **gzip** file format.

13.2.2 Command Line Interface

The *gzip* module provides a simple command line interface to compress or decompress files.

Once executed the *gzip* module keeps the input file(s).

在 3.8 版的變更: Add a new command line interface with a usage. By default, when you will execute the CLI, the default compression level is 6.

Command line options

file

If *file* is not specified, read from *sys.stdin*.

--fast

Indicates the fastest compression method (less compression).

--best

Indicates the slowest compression method (best compression).

-d, --decompress

Decompress the given file.

-h, --help

Show the help message.

13.3 bz2 --- Support for bzip2 compression

原始碼: [Lib/bz2.py](#)

This module provides a comprehensive interface for compressing and decompressing data using the bzip2 compression algorithm.

The `bz2` module contains:

- The `open()` function and `BZ2File` class for reading and writing compressed files.
- The `BZ2Compressor` and `BZ2Decompressor` classes for incremental (de)compression.
- The `compress()` and `decompress()` functions for one-shot (de)compression.

13.3.1 (De)compression of files

`bz2.open(filename, mode='rb', compresslevel=9, encoding=None, errors=None, newline=None)`

Open a bzip2-compressed file in binary or text mode, returning a *file object*.

As with the constructor for `BZ2File`, the `filename` argument can be an actual filename (a *str* or *bytes* object), or an existing file object to read from or write to.

The `mode` argument can be any of `'r'`, `'rb'`, `'w'`, `'wb'`, `'x'`, `'xb'`, `'a'` or `'ab'` for binary mode, or `'rt'`, `'wt'`, `'xt'`, or `'at'` for text mode. The default is `'rb'`.

The `compresslevel` argument is an integer from 1 to 9, as for the `BZ2File` constructor.

For binary mode, this function is equivalent to the `BZ2File` constructor: `BZ2File(filename, mode, compresslevel=compresslevel)`. In this case, the `encoding`, `errors` and `newline` arguments must not be provided.

For text mode, a `BZ2File` object is created, and wrapped in an `io.TextIOWrapper` instance with the specified encoding, error handling behavior, and line ending(s).

在 3.3 版新加入.

在 3.4 版的變更: The `'x'` (exclusive creation) mode was added.

在 3.6 版的變更: Accepts a *path-like object*.

class `bz2.BZ2File(filename, mode='r', *, compresslevel=9)`

Open a bzip2-compressed file in binary mode.

If `filename` is a *str* or *bytes* object, open the named file directly. Otherwise, `filename` should be a *file object*, which will be used to read or write the compressed data.

The `mode` argument can be either `'r'` for reading (default), `'w'` for overwriting, `'x'` for exclusive creation, or `'a'` for appending. These can equivalently be given as `'rb'`, `'wb'`, `'xb'` and `'ab'` respectively.

If `filename` is a file object (rather than an actual file name), a mode of `'w'` does not truncate the file, and is instead equivalent to `'a'`.

If `mode` is `'w'` or `'a'`, `compresslevel` can be an integer between 1 and 9 specifying the level of compression: 1 produces the least compression, and 9 (default) produces the most compression.

If `mode` is `'r'`, the input file may be the concatenation of multiple compressed streams.

`BZ2File` provides all of the members specified by the `io.BufferedIOBase`, except for `detach()` and `truncate()`. Iteration and the `with` statement are supported.

`BZ2File` also provides the following methods:

peek (*[n]*)

Return buffered data without advancing the file position. At least one byte of data will be returned (unless at EOF). The exact number of bytes returned is unspecified.

備 F: While calling *peek()* does not change the file position of the *BZ2File*, it may change the position of the underlying file object (e.g. if the *BZ2File* was constructed by passing a file object for *filename*).

在 3.3 版新加入.

fileno ()

Return the file descriptor for the underlying file.

在 3.3 版新加入.

readable ()

Return whether the file was opened for reading.

在 3.3 版新加入.

seekable ()

Return whether the file supports seeking.

在 3.3 版新加入.

writable ()

Return whether the file was opened for writing.

在 3.3 版新加入.

read1 (*size=-1*)

Read up to *size* uncompressed bytes, while trying to avoid making multiple reads from the underlying stream. Reads up to a buffer's worth of data if *size* is negative.

Returns `b''` if the file is at EOF.

在 3.3 版新加入.

readinto (*b*)

Read bytes into *b*.

Returns the number of bytes read (0 for EOF).

在 3.3 版新加入.

在 3.1 版的變更: Support for the `with` statement was added.

在 3.3 版的變更: Support was added for *filename* being a *file object* instead of an actual filename.

The 'a' (append) mode was added, along with support for reading multi-stream files.

在 3.4 版的變更: The 'x' (exclusive creation) mode was added.

在 3.5 版的變更: The *read()* method now accepts an argument of `None`.

在 3.6 版的變更: Accepts a *path-like object*.

在 3.9 版的變更: The *buffering* parameter has been removed. It was ignored and deprecated since Python 3.0. Pass an open file object to control how the file is opened.

The *compresslevel* parameter became keyword-only.

在 3.10 版的變更: This class is thread unsafe in the face of multiple simultaneous readers or writers, just like its equivalent classes in *gzip* and *lzma* have always been.

13.3.2 Incremental (de)compression

class `bz2.BZ2Compressor` (*compresslevel=9*)

Create a new compressor object. This object may be used to compress data incrementally. For one-shot compression, use the `compress()` function instead.

compresslevel, if given, must be an integer between 1 and 9. The default is 9.

compress (*data*)

Provide data to the compressor object. Returns a chunk of compressed data if possible, or an empty byte string otherwise.

When you have finished providing data to the compressor, call the `flush()` method to finish the compression process.

flush ()

Finish the compression process. Returns the compressed data left in internal buffers.

The compressor object may not be used after this method has been called.

class `bz2.BZ2Decompressor`

Create a new decompressor object. This object may be used to decompress data incrementally. For one-shot compression, use the `decompress()` function instead.

備 F: This class does not transparently handle inputs containing multiple compressed streams, unlike `decompress()` and `BZ2File`. If you need to decompress a multi-stream input with `BZ2Decompressor`, you must use a new decompressor for each stream.

decompress (*data*, *max_length=-1*)

Decompress *data* (a *bytes-like object*), returning uncompressed data as bytes. Some of *data* may be buffered internally, for use in later calls to `decompress()`. The returned data should be concatenated with the output of any previous calls to `decompress()`.

If *max_length* is nonnegative, returns at most *max_length* bytes of decompressed data. If this limit is reached and further output can be produced, the `needs_input` attribute will be set to `False`. In this case, the next call to `decompress()` may provide *data* as `b''` to obtain more of the output.

If all of the input data was decompressed and returned (either because this was less than *max_length* bytes, or because *max_length* was negative), the `needs_input` attribute will be set to `True`.

Attempting to decompress data after the end of stream is reached raises an `EOFError`. Any data found after the end of the stream is ignored and saved in the `unused_data` attribute.

在 3.5 版的變更: 新增 *max_length* 參數。

eof

`True` if the end-of-stream marker has been reached.

在 3.3 版新加入。

unused_data

Data found after the end of the compressed stream.

If this attribute is accessed before the end of the stream has been reached, its value will be `b''`.

needs_input

`False` if the `decompress()` method can provide more decompressed data before requiring new uncompressed input.

在 3.5 版新加入。

13.3.3 One-shot (de)compression

`bz2.compress(data, compresslevel=9)`

Compress *data*, a *bytes-like object*.

compresslevel, if given, must be an integer between 1 and 9. The default is 9.

For incremental compression, use a *BZ2Compressor* instead.

`bz2.decompress(data)`

Decompress *data*, a *bytes-like object*.

If *data* is the concatenation of multiple compressed streams, decompress all of the streams.

For incremental decompression, use a *BZ2Decompressor* instead.

在 3.3 版的變更: Support for multi-stream inputs was added.

13.3.4 用法范例

Below are some examples of typical usage of the *bz2* module.

Using *compress()* and *decompress()* to demonstrate round-trip compression:

```
>>> import bz2
>>> data = b"""\
... Donec rhoncus quis sapien sit amet molestie. Fusce scelerisque vel augue
... nec ullamcorper. Nam rutrum pretium placerat. Aliquam vel tristique lorem,
... sit amet cursus ante. In interdum laoreet mi, sit amet ultrices purus
... pulvinar a. Nam gravida euismod magna, non varius justo tincidunt feugiat.
... Aliquam pharetra lacus non risus vehicula rutrum. Maecenas aliquam leo
... felis. Pellentesque semper nunc sit amet nibh ullamcorper, ac elementum
... dolor luctus. Curabitur lacinia mi ornare consectetur vestibulum."""
>>> c = bz2.compress(data)
>>> len(data) / len(c) # Data compression ratio
1.513595166163142
>>> d = bz2.decompress(c)
>>> data == d # Check equality to original object after round-trip
True
```

Using *BZ2Compressor* for incremental compression:

```
>>> import bz2
>>> def gen_data(chunks=10, chunksize=1000):
...     """Yield incremental blocks of chunksize bytes."""
...     for _ in range(chunks):
...         yield b"z" * chunksize
...
>>> comp = bz2.BZ2Compressor()
>>> out = b""
>>> for chunk in gen_data():
...     # Provide data to the compressor object
...     out = out + comp.compress(chunk)
...
>>> # Finish the compression process. Call this once you have
>>> # finished providing data to the compressor.
>>> out = out + comp.flush()
```

The example above uses a very "nonrandom" stream of data (a stream of `b"z"` chunks). Random data tends to compress poorly, while ordered, repetitive data usually yields a high compression ratio.

Writing and reading a bzip2-compressed file in binary mode:

```

>>> import bz2
>>> data = b"""\
... Donec rhoncus quis sapien sit amet molestie. Fusce scelerisque vel augue
... nec ullamcorper. Nam rutrum pretium placerat. Aliquam vel tristique lorem,
... sit amet cursus ante. In interdum laoreet mi, sit amet ultrices purus
... pulvinar a. Nam gravida euismod magna, non varius justo tincidunt feugiat.
... Aliquam pharetra lacus non risus vehicula rutrum. Maecenas aliquam leo
... felis. Pellentesque semper nunc sit amet nibh ullamcorper, ac elementum
... dolor luctus. Curabitur lacinia mi ornare consectetur vestibulum."""
>>> with bz2.open("myfile.bz2", "wb") as f:
...     # Write compressed data to file
...     unused = f.write(data)
>>> with bz2.open("myfile.bz2", "rb") as f:
...     # Decompress data from file
...     content = f.read()
>>> content == data # Check equality to original object after round-trip
True

```

13.4 lzma --- Compression using the LZMA algorithm

在 3.3 版新加入。

原始碼: [Lib/lzma.py](#)

This module provides classes and convenience functions for compressing and decompressing data using the LZMA compression algorithm. Also included is a file interface supporting the `.xz` and legacy `.lzma` file formats used by the `xx` utility, as well as raw compressed streams.

The interface provided by this module is very similar to that of the `bz2` module. Note that `LZMAFile` and `bz2.BZ2File` are *not* thread-safe, so if you need to use a single `LZMAFile` instance from multiple threads, it is necessary to protect it with a lock.

exception `lzma.LZMAError`

This exception is raised when an error occurs during compression or decompression, or while initializing the compressor/decompressor state.

13.4.1 Reading and writing compressed files

`lzma.open(filename, mode='rb', *, format=None, check=-1, preset=None, filters=None, encoding=None, errors=None, newline=None)`

Open an LZMA-compressed file in binary or text mode, returning a *file object*.

The *filename* argument can be either an actual file name (given as a *str*, *bytes* or *path-like* object), in which case the named file is opened, or it can be an existing file object to read from or write to.

The *mode* argument can be any of `"r"`, `"rb"`, `"w"`, `"wb"`, `"x"`, `"xb"`, `"a"` or `"ab"` for binary mode, or `"rt"`, `"wt"`, `"xt"`, or `"at"` for text mode. The default is `"rb"`.

When opening a file for reading, the *format* and *filters* arguments have the same meanings as for `LZMADecompressor`. In this case, the *check* and *preset* arguments should not be used.

When opening a file for writing, the *format*, *check*, *preset* and *filters* arguments have the same meanings as for `LZMACompressor`.

For binary mode, this function is equivalent to the `LZMAFile` constructor: `LZMAFile(filename, mode, ...)`. In this case, the *encoding*, *errors* and *newline* arguments must not be provided.

For text mode, a `LZMAFile` object is created, and wrapped in an `io.TextIOWrapper` instance with the specified encoding, error handling behavior, and line ending(s).

在 3.4 版的變更: Added support for the "x", "xb" and "xt" modes.

在 3.6 版的變更: Accepts a *path-like object*.

class `lzma.LZMAFile` (*filename=None, mode='r', *, format=None, check=-1, preset=None, filters=None*)

Open an LZMA-compressed file in binary mode.

An *LZMAFile* can wrap an already-open *file object*, or operate directly on a named file. The *filename* argument specifies either the file object to wrap, or the name of the file to open (as a *str*, *bytes* or *path-like object*). When wrapping an existing file object, the wrapped file will not be closed when the *LZMAFile* is closed.

The *mode* argument can be either "r" for reading (default), "w" for overwriting, "x" for exclusive creation, or "a" for appending. These can equivalently be given as "rb", "wb", "xb" and "ab" respectively.

If *filename* is a file object (rather than an actual file name), a mode of "w" does not truncate the file, and is instead equivalent to "a".

When opening a file for reading, the input file may be the concatenation of multiple separate compressed streams. These are transparently decoded as a single logical stream.

When opening a file for reading, the *format* and *filters* arguments have the same meanings as for *LZMADecompressor*. In this case, the *check* and *preset* arguments should not be used.

When opening a file for writing, the *format*, *check*, *preset* and *filters* arguments have the same meanings as for *LZMACompressor*.

LZMAFile supports all the members specified by *io.BufferedIOBase*, except for *detach()* and *truncate()*. Iteration and the *with* statement are supported.

The following method is also provided:

peek (*size=-1*)

Return buffered data without advancing the file position. At least one byte of data will be returned, unless EOF has been reached. The exact number of bytes returned is unspecified (the *size* argument is ignored).

備註: While calling *peek()* does not change the file position of the *LZMAFile*, it may change the position of the underlying file object (e.g. if the *LZMAFile* was constructed by passing a file object for *filename*).

在 3.4 版的變更: Added support for the "x" and "xb" modes.

在 3.5 版的變更: The *read()* method now accepts an argument of *None*.

在 3.6 版的變更: Accepts a *path-like object*.

13.4.2 Compressing and decompressing data in memory

class `lzma.LZMACompressor` (*format=FORMAT_XZ, check=-1, preset=None, filters=None*)

Create a compressor object, which can be used to compress data incrementally.

For a more convenient way of compressing a single chunk of data, see *compress()*.

The *format* argument specifies what container format should be used. Possible values are:

- **FORMAT_XZ: The .xz container format.**
This is the default format.
- **FORMAT_ALONE: The legacy .lzma container format.**
This format is more limited than .xz -- it does not support integrity checks or multiple filters.
- **FORMAT_RAW: A raw data stream, not using any container format.**
This format specifier does not support integrity checks, and requires that you always specify a custom

filter chain (for both compression and decompression). Additionally, data compressed in this manner cannot be decompressed using `FORMAT_AUTO` (see [LZMACompressor](#)).

The *check* argument specifies the type of integrity check to include in the compressed data. This check is used when decompressing, to ensure that the data has not been corrupted. Possible values are:

- `CHECK_NONE`: No integrity check. This is the default (and the only acceptable value) for `FORMAT_ALONE` and `FORMAT_RAW`.
- `CHECK_CRC32`: 32-bit Cyclic Redundancy Check.
- `CHECK_CRC64`: 64-bit Cyclic Redundancy Check. This is the default for `FORMAT_XZ`.
- `CHECK_SHA256`: 256-bit Secure Hash Algorithm.

If the specified check is not supported, an [LZMAError](#) is raised.

The compression settings can be specified either as a preset compression level (with the *preset* argument), or in detail as a custom filter chain (with the *filters* argument).

The *preset* argument (if provided) should be an integer between 0 and 9 (inclusive), optionally OR-ed with the constant `PRESET_EXTREME`. If neither *preset* nor *filters* are given, the default behavior is to use `PRESET_DEFAULT` (preset level 6). Higher presets produce smaller output, but make the compression process slower.

備註: In addition to being more CPU-intensive, compression with higher presets also requires much more memory (and produces output that needs more memory to decompress). With preset 9 for example, the overhead for an [LZMACompressor](#) object can be as high as 800 MiB. For this reason, it is generally best to stick with the default preset.

The *filters* argument (if provided) should be a filter chain specifier. See [Specifying custom filter chains](#) for details.

compress (*data*)

Compress *data* (a *bytes* object), returning a *bytes* object containing compressed data for at least part of the input. Some of *data* may be buffered internally, for use in later calls to [compress\(\)](#) and [flush\(\)](#). The returned data should be concatenated with the output of any previous calls to [compress\(\)](#).

flush ()

Finish the compression process, returning a *bytes* object containing any data stored in the compressor's internal buffers.

The compressor cannot be used after this method has been called.

class `lzma.LZMADecompressor` (*format=FORMAT_AUTO, memlimit=None, filters=None*)

Create a decompressor object, which can be used to decompress data incrementally.

For a more convenient way of decompressing an entire compressed stream at once, see [decompress\(\)](#).

The *format* argument specifies the container format that should be used. The default is `FORMAT_AUTO`, which can decompress both `.xz` and `.lzma` files. Other possible values are `FORMAT_XZ`, `FORMAT_ALONE`, and `FORMAT_RAW`.

The *memlimit* argument specifies a limit (in bytes) on the amount of memory that the decompressor can use. When this argument is used, decompression will fail with an [LZMAError](#) if it is not possible to decompress the input within the given memory limit.

The *filters* argument specifies the filter chain that was used to create the stream being decompressed. This argument is required if *format* is `FORMAT_RAW`, but should not be used for other formats. See [Specifying custom filter chains](#) for more information about filter chains.

備註: This class does not transparently handle inputs containing multiple compressed streams, unlike [decompress\(\)](#) and [LZMAFile](#). To decompress a multi-stream input with [LZMADecompressor](#), you

must create a new decompressor for each stream.

decompress (*data*, *max_length*=-1)

Decompress *data* (a *bytes-like object*), returning uncompressed data as bytes. Some of *data* may be buffered internally, for use in later calls to *decompress()*. The returned data should be concatenated with the output of any previous calls to *decompress()*.

If *max_length* is nonnegative, returns at most *max_length* bytes of decompressed data. If this limit is reached and further output can be produced, the *needs_input* attribute will be set to `False`. In this case, the next call to *decompress()* may provide *data* as `b''` to obtain more of the output.

If all of the input data was decompressed and returned (either because this was less than *max_length* bytes, or because *max_length* was negative), the *needs_input* attribute will be set to `True`.

Attempting to decompress data after the end of stream is reached raises an *EOFError*. Any data found after the end of the stream is ignored and saved in the *unused_data* attribute.

在 3.5 版的變更: 新增 *max_length* 參數。

check

The ID of the integrity check used by the input stream. This may be `CHECK_UNKNOWN` until enough of the input has been decoded to determine what integrity check it uses.

eof

`True` if the end-of-stream marker has been reached.

unused_data

Data found after the end of the compressed stream.

Before the end of the stream is reached, this will be `b''`.

needs_input

`False` if the *decompress()* method can provide more decompressed data before requiring new uncompressed input.

在 3.5 版新加入。

`lzma.compress(data, format=FORMAT_XZ, check=-1, preset=None, filters=None)`

Compress *data* (a *bytes* object), returning the compressed data as a *bytes* object.

See *LZMACompressor* above for a description of the *format*, *check*, *preset* and *filters* arguments.

`lzma.decompress(data, format=FORMAT_AUTO, memlimit=None, filters=None)`

Decompress *data* (a *bytes* object), returning the uncompressed data as a *bytes* object.

If *data* is the concatenation of multiple distinct compressed streams, decompress all of these streams, and return the concatenation of the results.

See *LZMADecompressor* above for a description of the *format*, *memlimit* and *filters* arguments.

13.4.3 Miscellaneous

`lzma.is_check_supported(check)`

Return `True` if the given integrity check is supported on this system.

`CHECK_NONE` and `CHECK_CRC32` are always supported. `CHECK_CRC64` and `CHECK_SHA256` may be unavailable if you are using a version of **liblzma** that was compiled with a limited feature set.

13.4.4 Specifying custom filter chains

A filter chain specifier is a sequence of dictionaries, where each dictionary contains the ID and options for a single filter. Each dictionary must contain the key `"id"`, and may contain additional keys to specify filter-dependent options. Valid filter IDs are as follows:

- Compression filters:
 - `FILTER_LZMA1` (for use with `FORMAT_ALONE`)
 - `FILTER_LZMA2` (for use with `FORMAT_XZ` and `FORMAT_RAW`)
- Delta filter:
 - `FILTER_DELTA`
- Branch-Call-Jump (BCJ) filters:
 - `FILTER_X86`
 - `FILTER_IA64`
 - `FILTER_ARM`
 - `FILTER_ARMTHUMB`
 - `FILTER_POWERPC`
 - `FILTER_SPARC`

A filter chain can consist of up to 4 filters, and cannot be empty. The last filter in the chain must be a compression filter, and any other filters must be delta or BCJ filters.

Compression filters support the following options (specified as additional entries in the dictionary representing the filter):

- `preset`: A compression preset to use as a source of default values for options that are not specified explicitly.
- `dict_size`: Dictionary size in bytes. This should be between 4 KiB and 1.5 GiB (inclusive).
- `lc`: Number of literal context bits.
- `lp`: Number of literal position bits. The sum `lc + lp` must be at most 4.
- `pb`: Number of position bits; must be at most 4.
- `mode`: `MODE_FAST` or `MODE_NORMAL`.
- `nice_len`: What should be considered a "nice length" for a match. This should be 273 or less.
- `mf`: What match finder to use -- `MF_HC3`, `MF_HC4`, `MF_BT2`, `MF_BT3`, or `MF_BT4`.
- `depth`: Maximum search depth used by match finder. 0 (default) means to select automatically based on other filter options.

The delta filter stores the differences between bytes, producing more repetitive input for the compressor in certain circumstances. It supports one option, `dist`. This indicates the distance between bytes to be subtracted. The default is 1, i.e. take the differences between adjacent bytes.

The BCJ filters are intended to be applied to machine code. They convert relative branches, calls and jumps in the code to use absolute addressing, with the aim of increasing the redundancy that can be exploited by the compressor. These filters support one option, `start_offset`. This specifies the address that should be mapped to the beginning of the input data. The default is 0.

13.4.5 范例

Reading in a compressed file:

```
import lzma
with lzma.open("file.xz") as f:
    file_content = f.read()
```

Creating a compressed file:

```
import lzma
data = b"Insert Data Here"
with lzma.open("file.xz", "w") as f:
    f.write(data)
```

Compressing data in memory:

```
import lzma
data_in = b"Insert Data Here"
data_out = lzma.compress(data_in)
```

Incremental compression:

```
import lzma
lzc = lzma.LZMACompressor()
out1 = lzc.compress(b"Some data\n")
out2 = lzc.compress(b"Another piece of data\n")
out3 = lzc.compress(b"Even more data\n")
out4 = lzc.flush()
# Concatenate all the partial results:
result = b"".join([out1, out2, out3, out4])
```

Writing compressed data to an already-open file:

```
import lzma
with open("file.xz", "wb") as f:
    f.write(b"This data will not be compressed\n")
    with lzma.open(f, "w") as lzf:
        lzf.write(b"This *will* be compressed\n")
    f.write(b"Not compressed\n")
```

Creating a compressed file using a custom filter chain:

```
import lzma
my_filters = [
    {"id": lzma.FILTER_DELTA, "dist": 5},
    {"id": lzma.FILTER_LZMA2, "preset": 7 | lzma.PRESET_EXTREME},
]
with lzma.open("file.xz", "w", filters=my_filters) as f:
    f.write(b"blah blah blah")
```

13.5 zipfile --- Work with ZIP archives

原始碼: [Lib/zipfile.py](#)

The ZIP file format is a common archive and compression standard. This module provides tools to create, read, write, append, and list a ZIP file. Any advanced use of this module will require an understanding of the format, as defined in [PKZIP Application Note](#).

This module does not currently handle multi-disk ZIP files. It can handle ZIP files that use the ZIP64 extensions (that is ZIP files that are more than 4 GiB in size). It supports decryption of encrypted files in ZIP archives, but it currently cannot create an encrypted file. Decryption is extremely slow as it is implemented in native Python rather than C.

The module defines the following items:

exception `zipfile.BadZipFile`

The error raised for bad ZIP files.

在 3.2 版新加入.

exception `zipfile.BadZipfile`

Alias of `BadZipFile`, for compatibility with older Python versions.

在 3.2 版之後被用.

exception `zipfile.LargeZipFile`

The error raised when a ZIP file would require ZIP64 functionality but that has not been enabled.

class `zipfile.ZipFile`

The class for reading and writing ZIP files. See section [ZipFile 物件](#) for constructor details.

class `zipfile.Path`

Class that implements a subset of the interface provided by `pathlib.Path`, including the full `importlib.resources.abc.Traversable` interface.

在 3.8 版新加入.

class `zipfile.PyZipFile`

Class for creating ZIP archives containing Python libraries.

class `zipfile.ZipInfo` (*filename*='NoName', *date_time*=(1980, 1, 1, 0, 0, 0))

Class used to represent information about a member of an archive. Instances of this class are returned by the `getinfo()` and `infolist()` methods of `ZipFile` objects. Most users of the `zipfile` module will not need to create these, but only use those created by this module. *filename* should be the full name of the archive member, and *date_time* should be a tuple containing six fields which describe the time of the last modification to the file; the fields are described in section [ZipInfo 物件](#).

`zipfile.is_zipfile(filename)`

Returns True if *filename* is a valid ZIP file based on its magic number, otherwise returns False. *filename* may be a file or file-like object too.

在 3.1 版的變更: Support for file and file-like objects.

`zipfile.ZIP_STORED`

The numeric constant for an uncompressed archive member.

`zipfile.ZIP_DEFLATED`

The numeric constant for the usual ZIP compression method. This requires the `zlib` module.

`zipfile.ZIP_BZIP2`

The numeric constant for the BZIP2 compression method. This requires the `bz2` module.

在 3.3 版新加入.

`zipfile.ZIP_LZMA`

The numeric constant for the LZMA compression method. This requires the `lzma` module.

在 3.3 版新加入。

備註： The ZIP file format specification has included support for bzip2 compression since 2001, and for LZMA compression since 2006. However, some tools (including older Python releases) do not support these compression methods, and may either refuse to process the ZIP file altogether, or fail to extract individual files.

也參考：

PKZIP Application Note

Documentation on the ZIP file format by Phil Katz, the creator of the format and algorithms used.

Info-ZIP 首頁

Information about the Info-ZIP project's ZIP archive programs and development libraries.

13.5.1 ZipFile 物件

class `zipfile.ZipFile` (*file*, *mode*='r', *compression*=ZIP_STORED, *allowZip64*=True, *compresslevel*=None, *, *strict_timestamps*=True, *metadata_encoding*=None)

Open a ZIP file, where *file* can be a path to a file (a string), a file-like object or a *path-like object*.

The *mode* parameter should be 'r' to read an existing file, 'w' to truncate and write a new file, 'a' to append to an existing file, or 'x' to exclusively create and write a new file. If *mode* is 'x' and *file* refers to an existing file, a `FileExistsError` will be raised. If *mode* is 'a' and *file* refers to an existing ZIP file, then additional files are added to it. If *file* does not refer to a ZIP file, then a new ZIP archive is appended to the file. This is meant for adding a ZIP archive to another file (such as `python.exe`). If *mode* is 'a' and the file does not exist at all, it is created. If *mode* is 'r' or 'a', the file should be seekable.

compression is the ZIP compression method to use when writing the archive, and should be `ZIP_STORED`, `ZIP_DEFLATED`, `ZIP_BZIP2` or `ZIP_LZMA`; unrecognized values will cause `NotImplementedError` to be raised. If `ZIP_DEFLATED`, `ZIP_BZIP2` or `ZIP_LZMA` is specified but the corresponding module (`zlib`, `bz2` or `lzma`) is not available, `RuntimeError` is raised. The default is `ZIP_STORED`.

If *allowZip64* is `True` (the default) `zipfile` will create ZIP files that use the ZIP64 extensions when the zipfile is larger than 4 GiB. If it is `false` `zipfile` will raise an exception when the ZIP file would require ZIP64 extensions.

The *compresslevel* parameter controls the compression level to use when writing files to the archive. When using `ZIP_STORED` or `ZIP_LZMA` it has no effect. When using `ZIP_DEFLATED` integers 0 through 9 are accepted (see `zlib` for more information). When using `ZIP_BZIP2` integers 1 through 9 are accepted (see `bz2` for more information).

The *strict_timestamps* argument, when set to `False`, allows to zip files older than 1980-01-01 at the cost of setting the timestamp to 1980-01-01. Similar behavior occurs with files newer than 2107-12-31, the timestamp is also set to the limit.

When *mode* is 'r', *metadata_encoding* may be set to the name of a codec, which will be used to decode metadata such as the names of members and ZIP comments.

If the file is created with *mode* 'w', 'x' or 'a' and then *closed* without adding any files to the archive, the appropriate ZIP structures for an empty archive will be written to the file.

`ZipFile` is also a context manager and therefore supports the `with` statement. In the example, *myzip* is closed after the `with` statement's suite is finished---even if an exception occurs:

```
with ZipFile('spam.zip', 'w') as myzip:
    myzip.write('eggs.txt')
```

備 F: `metadata_encoding` is an instance-wide setting for the `ZipFile`. It is not currently possible to set this on a per-member basis.

This attribute is a workaround for legacy implementations which produce archives with names in the current locale encoding or code page (mostly on Windows). According to the .ZIP standard, the encoding of metadata may be specified to be either IBM code page (default) or UTF-8 by a flag in the archive header. That flag takes precedence over `metadata_encoding`, which is a Python-specific extension.

在 3.2 版的變更: Added the ability to use `ZipFile` as a context manager.

在 3.3 版的變更: Added support for `bzip2` and `lzma` compression.

在 3.4 版的變更: ZIP64 extensions are enabled by default.

在 3.5 版的變更: Added support for writing to unseekable streams. Added support for the 'x' mode.

在 3.6 版的變更: Previously, a plain `RuntimeError` was raised for unrecognized compression values.

在 3.6.2 版的變更: The `file` parameter accepts a *path-like object*.

在 3.7 版的變更: Add the `compresslevel` parameter.

在 3.8 版的變更: The `strict_timestamps` keyword-only parameter.

在 3.11 版的變更: Added support for specifying member name encoding for reading metadata in the zipfile's directory and file headers.

`ZipFile.close()`

Close the archive file. You must call `close()` before exiting your program or essential records will not be written.

`ZipFile.getinfo(name)`

Return a `ZipInfo` object with information about the archive member `name`. Calling `getinfo()` for a name not currently contained in the archive will raise a `KeyError`.

`ZipFile.infolist()`

Return a list containing a `ZipInfo` object for each member of the archive. The objects are in the same order as their entries in the actual ZIP file on disk if an existing archive was opened.

`ZipFile.namelist()`

Return a list of archive members by name.

`ZipFile.open(name, mode='r', pwd=None, *, force_zip64=False)`

Access a member of the archive as a binary file-like object. `name` can be either the name of a file within the archive or a `ZipInfo` object. The `mode` parameter, if included, must be 'r' (the default) or 'w'. `pwd` is the password used to decrypt encrypted ZIP files as a *bytes* object.

`open()` is also a context manager and therefore supports the `with` statement:

```
with ZipFile('spam.zip') as myzip:
    with myzip.open('eggs.txt') as myfile:
        print(myfile.read())
```

With `mode 'r'` the file-like object (`ZipExtFile`) is read-only and provides the following methods: `read()`, `readline()`, `readlines()`, `seek()`, `tell()`, `__iter__()`, `__next__()`. These objects can operate independently of the `ZipFile`.

With `mode='w'`, a writable file handle is returned, which supports the `write()` method. While a writable file handle is open, attempting to read or write other files in the ZIP file will raise a `ValueError`.

When writing a file, if the file size is not known in advance but may exceed 2 GiB, pass `force_zip64=True` to ensure that the header format is capable of supporting large files. If the file size is known in advance, construct a `ZipInfo` object with `file_size` set, and use that as the `name` parameter.

備註: The `open()`, `read()` and `extract()` methods can take a filename or a `ZipInfo` object. You will appreciate this when trying to read a ZIP file that contains members with duplicate names.

在 3.6 版的變更: Removed support of `mode='U'`. Use `io.TextIOWrapper` for reading compressed text files in *universal newlines* mode.

在 3.6 版的變更: `ZipFile.open()` can now be used to write files into the archive with the `mode='w'` option.

在 3.6 版的變更: Calling `open()` on a closed `ZipFile` will raise a `ValueError`. Previously, a `RuntimeError` was raised.

`ZipFile.extract(member, path=None, pwd=None)`

Extract a member from the archive to the current working directory; *member* must be its full name or a `ZipInfo` object. Its file information is extracted as accurately as possible. *path* specifies a different directory to extract to. *member* can be a filename or a `ZipInfo` object. *pwd* is the password used for encrypted files as a `bytes` object.

Returns the normalized path created (a directory or new file).

備註: If a member filename is an absolute path, a drive/UNC sharepoint and leading (back)slashes will be stripped, e.g.: `///foo/bar` becomes `foo/bar` on Unix, and `C:\foo\bar` becomes `foo\bar` on Windows. And all `".."` components in a member filename will be removed, e.g.: `../../../../foo../../../../ba..r` becomes `foo../ba..r`. On Windows illegal characters (`:`, `<`, `>`, `|`, `"`, `?`, and `*`) replaced by underscore (`_`).

在 3.6 版的變更: Calling `extract()` on a closed `ZipFile` will raise a `ValueError`. Previously, a `RuntimeError` was raised.

在 3.6.2 版的變更: The *path* parameter accepts a *path-like object*.

`ZipFile.extractall(path=None, members=None, pwd=None)`

Extract all members from the archive to the current working directory. *path* specifies a different directory to extract to. *members* is optional and must be a subset of the list returned by `namelist()`. *pwd* is the password used for encrypted files as a `bytes` object.

警告: Never extract archives from untrusted sources without prior inspection. It is possible that files are created outside of *path*, e.g. members that have absolute filenames starting with `" / "` or filenames with two dots `".."`. This module attempts to prevent that. See `extract()` note.

在 3.6 版的變更: Calling `extractall()` on a closed `ZipFile` will raise a `ValueError`. Previously, a `RuntimeError` was raised.

在 3.6.2 版的變更: The *path* parameter accepts a *path-like object*.

`ZipFile.printdir()`

Print a table of contents for the archive to `sys.stdout`.

`ZipFile.setpassword(pwd)`

Set *pwd* (a `bytes` object) as default password to extract encrypted files.

`ZipFile.read(name, pwd=None)`

Return the bytes of the file *name* in the archive. *name* is the name of the file in the archive, or a `ZipInfo` object. The archive must be open for read or append. *pwd* is the password used for encrypted files as a `bytes` object and, if specified, overrides the default password set with `setpassword()`. Calling `read()` on a `ZipFile` that uses a compression method other than `ZIP_STORED`, `ZIP_DEFLATED`, `ZIP_BZIP2` or `ZIP_LZMA` will raise a `NotImplementedError`. An error will also be raised if the corresponding compression module is not available.

在 3.6 版的變更: Calling `read()` on a closed `ZipFile` will raise a `ValueError`. Previously, a `RuntimeError` was raised.

`ZipFile.testzip()`

Read all the files in the archive and check their CRC's and file headers. Return the name of the first bad file, or else return `None`.

在 3.6 版的變更: Calling `testzip()` on a closed `ZipFile` will raise a `ValueError`. Previously, a `RuntimeError` was raised.

`ZipFile.write(filename, arcname=None, compress_type=None, compresslevel=None)`

Write the file named *filename* to the archive, giving it the archive name *arcname* (by default, this will be the same as *filename*, but without a drive letter and with leading path separators removed). If given, *compress_type* overrides the value given for the *compression* parameter to the constructor for the new entry. Similarly, *compresslevel* will override the constructor if given. The archive must be open with mode `'w'`, `'x'` or `'a'`.

備 註: The ZIP file standard historically did not specify a metadata encoding, but strongly recommended CP437 (the original IBM PC encoding) for interoperability. Recent versions allow use of UTF-8 (only). In this module, UTF-8 will automatically be used to write the member names if they contain any non-ASCII characters. It is not possible to write member names in any encoding other than ASCII or UTF-8.

備 註: Archive names should be relative to the archive root, that is, they should not start with a path separator.

備 註: If *arcname* (or *filename*, if *arcname* is not given) contains a null byte, the name of the file in the archive will be truncated at the null byte.

備 註: A leading slash in the filename may lead to the archive being impossible to open in some zip programs on Windows systems.

在 3.6 版的變更: Calling `write()` on a `ZipFile` created with mode `'r'` or a closed `ZipFile` will raise a `ValueError`. Previously, a `RuntimeError` was raised.

`ZipFile.writestr(zinfo_or_arcname, data, compress_type=None, compresslevel=None)`

Write a file into the archive. The contents is *data*, which may be either a `str` or a `bytes` instance; if it is a `str`, it is encoded as UTF-8 first. *zinfo_or_arcname* is either the file name it will be given in the archive, or a `ZipInfo` instance. If it's an instance, at least the filename, date, and time must be given. If it's a name, the date and time is set to the current date and time. The archive must be opened with mode `'w'`, `'x'` or `'a'`.

If given, *compress_type* overrides the value given for the *compression* parameter to the constructor for the new entry, or in the *zinfo_or_arcname* (if that is a `ZipInfo` instance). Similarly, *compresslevel* will override the constructor if given.

備 註: When passing a `ZipInfo` instance as the *zinfo_or_arcname* parameter, the compression method used will be that specified in the *compress_type* member of the given `ZipInfo` instance. By default, the `ZipInfo` constructor sets this member to `ZIP_STORED`.

在 3.2 版的變更: *compress_type* 引數。

在 3.6 版的變更: Calling `writestr()` on a `ZipFile` created with mode `'r'` or a closed `ZipFile` will raise a `ValueError`. Previously, a `RuntimeError` was raised.

`ZipFile.mkdir(zinfo_or_directory, mode=511)`

Create a directory inside the archive. If *zinfo_or_directory* is a string, a directory is created inside the archive

with the mode that is specified in the *mode* argument. If, however, *zinfo_or_directory* is a *ZipInfo* instance then the *mode* argument is ignored.

The archive must be opened with mode 'w', 'x' or 'a'.

在 3.11 版新加入.

The following data attributes are also available:

`ZipFile.filename`

Name of the ZIP file.

`ZipFile.debug`

The level of debug output to use. This may be set from 0 (the default, no output) to 3 (the most output). Debugging information is written to `sys.stdout`.

`ZipFile.comment`

The comment associated with the ZIP file as a *bytes* object. If assigning a comment to a *ZipFile* instance created with mode 'w', 'x' or 'a', it should be no longer than 65535 bytes. Comments longer than this will be truncated.

13.5.2 Path Objects

class `zipfile.Path` (*root*, *at*=")

Construct a Path object from a *root* zipfile (which may be a *ZipFile* instance or *file* suitable for passing to the *ZipFile* constructor).

at specifies the location of this Path within the zipfile, e.g. 'dir/file.txt', 'dir/', or ". Defaults to the empty string, indicating the root.

Path objects expose the following features of *pathlib.Path* objects:

Path objects are traversable using the / operator or `joinpath`.

`Path.name`

The final path component.

`Path.open` (*mode*='r', *, *pwd*, **)

Invoke *ZipFile.open()* on the current path. Allows opening for read or write, text or binary through supported modes: 'r', 'w', 'rb', 'wb'. Positional and keyword arguments are passed through to *io.TextIOWrapper* when opened as text and ignored otherwise. *pwd* is the *pwd* parameter to *ZipFile.open()*.

在 3.9 版的變更: Added support for text and binary modes for open. Default mode is now text.

在 3.11.2 版的變更: The *encoding* parameter can be supplied as a positional argument without causing a *TypeError*. As it could in 3.9. Code needing to be compatible with unpatched 3.10 and 3.11 versions must pass all *io.TextIOWrapper* arguments, *encoding* included, as keywords.

`Path.iterdir()`

Enumerate the children of the current directory.

`Path.is_dir()`

Return *True* if the current context references a directory.

`Path.is_file()`

Return *True* if the current context references a file.

`Path.exists()`

Return *True* if the current context references a file or directory in the zip file.

Path.suffix

The file extension of the final component.

在 3.11 版新加入: Added `Path.suffix` property.

Path.stem

The final path component, without its suffix.

在 3.11 版新加入: Added `Path.stem` property.

Path.suffixes

A list of the path's file extensions.

在 3.11 版新加入: Added `Path.suffixes` property.

Path.read_text (*, **)

Read the current file as unicode text. Positional and keyword arguments are passed through to `io.TextIOWrapper` (except `buffer`, which is implied by the context).

在 3.11.2 版的變更: The `encoding` parameter can be supplied as a positional argument without causing a `TypeError`. As it could in 3.9. Code needing to be compatible with unpatched 3.10 and 3.11 versions must pass all `io.TextIOWrapper` arguments, `encoding` included, as keywords.

Path.read_bytes ()

Read the current file as bytes.

Path.joinpath (*other)

Return a new Path object with each of the *other* arguments joined. The following are equivalent:

```
>>> Path(...).joinpath('child').joinpath('grandchild')
>>> Path(...).joinpath('child', 'grandchild')
>>> Path(...) / 'child' / 'grandchild'
```

在 3.10 版的變更: Prior to 3.10, `joinpath` was undocumented and accepted exactly one parameter.

The `zip` project provides backports of the latest path object functionality to older Pythons. Use `zip.Path` in place of `zipfile.Path` for early access to changes.

13.5.3 PyZipFile 物件

The `PyZipFile` constructor takes the same parameters as the `ZipFile` constructor, and one additional parameter, `optimize`.

class `zipfile.PyZipFile` (*file*, *mode*='r', *compression*=`ZIP_STORED`, *allowZip64*=`True`, *optimize*=-1)

在 3.2 版的變更: Added the `optimize` parameter.

在 3.4 版的變更: ZIP64 extensions are enabled by default.

Instances have one method in addition to those of `ZipFile` objects:

writepy (*pathname*, *basename*="", *filterfunc*=`None`)

Search for files `*.py` and add the corresponding file to the archive.

If the `optimize` parameter to `PyZipFile` was not given or `-1`, the corresponding file is a `*.pyc` file, compiling if necessary.

If the `optimize` parameter to `PyZipFile` was `0`, `1` or `2`, only files with that optimization level (see `compile()`) are added to the archive, compiling if necessary.

If *pathname* is a file, the filename must end with `.py`, and just the (corresponding `*.pyc`) file is added at the top level (no path information). If *pathname* is a file that does not end with `.py`, a `RuntimeError` will be raised. If it is a directory, and the directory is not a package directory, then all the files `*.pyc` are added at the top level. If the directory is a package directory, then all `*.pyc` are added under the

package name as a file path, and if any subdirectories are package directories, all of these are added recursively in sorted order.

basename is intended for internal use only.

filterfunc, if given, must be a function taking a single string argument. It will be passed each path (including each individual full file path) before it is added to the archive. If *filterfunc* returns a false value, the path will not be added, and if it is a directory its contents will be ignored. For example, if our test files are all either in `test` directories or start with the string `test_`, we can use a *filterfunc* to exclude them:

```
>>> zf = PyZipFile('myprog.zip')
>>> def notests(s):
...     fn = os.path.basename(s)
...     return (not (fn == 'test' or fn.startswith('test_')))
>>> zf.writepy('myprog', filterfunc=notests)
```

The *writepy()* method makes archives with file names like this:

```
string.pyc                # Top level name
test/__init__.pyc         # Package directory
test/testall.pyc          # Module test.testall
test/bogus/__init__.pyc   # Subpackage directory
test/bogus/myfile.pyc     # Submodule test.bogus.myfile
```

在 3.4 版的變更: Added the *filterfunc* parameter.

在 3.6.2 版的變更: The *pathname* parameter accepts a *path-like object*.

在 3.7 版的變更: Recursion sorts directory entries.

13.5.4 ZipInfo 物件

Instances of the *ZipInfo* class are returned by the *getinfo()* and *infolist()* methods of *ZipFile* objects. Each object stores information about a single member of the ZIP archive.

There is one classmethod to make a *ZipInfo* instance for a filesystem file:

classmethod *ZipInfo.from_file*(*filename*, *arcname=None*, *, *strict_timestamps=True*)

Construct a *ZipInfo* instance for a file on the filesystem, in preparation for adding it to a zip file.

filename should be the path to a file or directory on the filesystem.

If *arcname* is specified, it is used as the name within the archive. If *arcname* is not specified, the name will be the same as *filename*, but with any drive letter and leading path separators removed.

The *strict_timestamps* argument, when set to `False`, allows to zip files older than 1980-01-01 at the cost of setting the timestamp to 1980-01-01. Similar behavior occurs with files newer than 2107-12-31, the timestamp is also set to the limit.

在 3.6 版新加入.

在 3.6.2 版的變更: The *filename* parameter accepts a *path-like object*.

在 3.8 版的變更: Added the *strict_timestamps* keyword-only parameter.

Instances have the following methods and attributes:

ZipInfo.is_dir()

Return `True` if this archive member is a directory.

This uses the entry's name: directories should always end with `/`.

在 3.6 版新加入.

ZipInfo.filename

Name of the file in the archive.

ZipInfo.date_time

The time and date of the last modification to the archive member. This is a tuple of six values:

Index	Value
0	Year (\geq 1980)
1	Month (one-based)
2	Day of month (one-based)
3	Hours (zero-based)
4	Minutes (zero-based)
5	Seconds (zero-based)

備 F: The ZIP file format does not support timestamps before 1980.

ZipInfo.compress_type

Type of compression for the archive member.

ZipInfo.comment

Comment for the individual archive member as a *bytes* object.

ZipInfo.extra

Expansion field data. The [PKZIP Application Note](#) contains some comments on the internal structure of the data contained in this *bytes* object.

ZipInfo.create_system

System which created ZIP archive.

ZipInfo.create_version

PKZIP version which created ZIP archive.

ZipInfo.extract_version

PKZIP version needed to extract archive.

ZipInfo.reserved

Must be zero.

ZipInfo.flag_bits

ZIP flag bits.

ZipInfo.volume

Volume number of file header.

ZipInfo.internal_attr

Internal attributes.

ZipInfo.external_attr

External file attributes.

ZipInfo.header_offset

Byte offset to the file header.

ZipInfo.CRC

CRC-32 of the uncompressed file.

ZipInfo.compress_size

Size of the compressed data.

`ZipInfo.file_size`

Size of the uncompressed file.

13.5.5 Command-Line Interface

The `zipfile` module provides a simple command-line interface to interact with ZIP archives.

If you want to create a new ZIP archive, specify its name after the `-c` option and then list the filename(s) that should be included:

```
$ python -m zipfile -c monty.zip spam.txt eggs.txt
```

Passing a directory is also acceptable:

```
$ python -m zipfile -c monty.zip life-of-brian_1979/
```

If you want to extract a ZIP archive into the specified directory, use the `-e` option:

```
$ python -m zipfile -e monty.zip target-dir/
```

For a list of the files in a ZIP archive, use the `-l` option:

```
$ python -m zipfile -l monty.zip
```

Command-line options

-l <zipfile>

--list <zipfile>

List files in a zipfile.

-c <zipfile> <source1> ... <sourceN>

--create <zipfile> <source1> ... <sourceN>

Create zipfile from source files.

-e <zipfile> <output_dir>

--extract <zipfile> <output_dir>

Extract zipfile into target directory.

-t <zipfile>

--test <zipfile>

Test whether the zipfile is valid or not.

--metadata-encoding <encoding>

Specify encoding of member names for `-l`, `-e` and `-t`.

在 3.11 版新加入.

13.5.6 Decompression pitfalls

The extraction in `zipfile` module might fail due to some pitfalls listed below.

From file itself

Decompression may fail due to incorrect password / CRC checksum / ZIP format or unsupported compression method / decryption.

File System limitations

Exceeding limitations on different file systems can cause decompression failed. Such as allowable characters in the directory entries, length of the file name, length of the pathname, size of a single file, and number of files, etc.

Resources limitations

The lack of memory or disk volume would lead to decompression failed. For example, decompression bombs (aka [ZIP bomb](#)) apply to zipfile library that can cause disk volume exhaustion.

Interruption

Interruption during the decompression, such as pressing control-C or killing the decompression process may result in incomplete decompression of the archive.

Default behaviors of extraction

Not knowing the default extraction behaviors can cause unexpected decompression results. For example, when extracting the same archive twice, it overwrites files without asking.

13.6 `tarfile` --- Read and write tar archive files

原始碼: [Lib/tarfile.py](#)

The `tarfile` module makes it possible to read and write tar archives, including those using `gzip`, `bz2` and `lzma` compression. Use the `zipfile` module to read or write `.zip` files, or the higher-level functions in [shutil](#).

Some facts and figures:

- reads and writes `gzip`, `bz2` and `lzma` compressed archives if the respective modules are available.
- read/write support for the POSIX.1-1988 (ustar) format.
- read/write support for the GNU tar format including `longname` and `longlink` extensions, read-only support for all variants of the `sparse` extension including restoration of sparse files.
- read/write support for the POSIX.1-2001 (pax) format.
- handles directories, regular files, hardlinks, symbolic links, fifos, character devices and block devices and is able to acquire and restore file information like timestamp, access permissions and owner.

在 3.3 版的變更: Added support for `lzma` compression.

`tarfile.open` (`name=None`, `mode='r'`, `fileobj=None`, `bufsize=10240`, `**kwargs`)

Return a `TarFile` object for the pathname `name`. For detailed information on `TarFile` objects and the keyword arguments that are allowed, see [TarFile 物件](#).

`mode` has to be a string of the form `'filemode[:compression]'`, it defaults to `'r'`. Here is a full list of mode combinations:

mode	action
'r' 或 'r: *'	Open for reading with transparent compression (recommended).
'r: '	Open for reading exclusively without compression.
'r: gz'	Open for reading with gzip compression.
'r: bz2'	Open for reading with bzip2 compression.
'r: xz'	Open for reading with lzma compression.
'x' 或 'x: '	Create a tarfile exclusively without compression. Raise a <i>FileExistsError</i> exception if it already exists.
'x: gz'	Create a tarfile with gzip compression. Raise a <i>FileExistsError</i> exception if it already exists.
'x: bz2'	Create a tarfile with bzip2 compression. Raise a <i>FileExistsError</i> exception if it already exists.
'x: xz'	Create a tarfile with lzma compression. Raise a <i>FileExistsError</i> exception if it already exists.
'a' 或 'a: '	Open for appending with no compression. The file is created if it does not exist.
'w' 或 'w: '	Open for uncompressed writing.
'w: gz'	Open for gzip compressed writing.
'w: bz2'	Open for bzip2 compressed writing.
'w: xz'	Open for lzma compressed writing.

Note that 'a:gz', 'a:bz2' or 'a:xz' is not possible. If *mode* is not suitable to open a certain (compressed) file for reading, *ReadError* is raised. Use *mode* 'r' to avoid this. If a compression method is not supported, *CompressionError* is raised.

If *fileobj* is specified, it is used as an alternative to a *file object* opened in binary mode for *name*. It is supposed to be at position 0.

For modes 'w:gz', 'r:gz', 'w:bz2', 'r:bz2', 'x:gz', 'x:bz2', *tarfile.open()* accepts the keyword argument *compresslevel* (default 9) to specify the compression level of the file.

For modes 'w:xz' and 'x:xz', *tarfile.open()* accepts the keyword argument *preset* to specify the compression level of the file.

For special purposes, there is a second format for *mode*: 'filemode|[compression]'. *tarfile.open()* will return a *TarFile* object that processes its data as a stream of blocks. No random seeking will be done on the file. If given, *fileobj* may be any object that has a *read()* or *write()* method (depending on the *mode*) that works with bytes. *bufsize* specifies the blocksize and defaults to 20 * 512 bytes. Use this variant in combination with e.g. `sys.stdin.buffer`, a socket *file object* or a tape device. However, such a *TarFile* object is limited in that it does not allow random access, see 範例. The currently possible modes:

Mode	Action
'r *'	Open a <i>stream</i> of tar blocks for reading with transparent compression.
'r '	Open a <i>stream</i> of uncompressed tar blocks for reading.
'r gz'	Open a gzip compressed <i>stream</i> for reading.
'r bz2'	Open a bzip2 compressed <i>stream</i> for reading.
'r xz'	Open an lzma compressed <i>stream</i> for reading.
'w '	Open an uncompressed <i>stream</i> for writing.
'w gz'	Open a gzip compressed <i>stream</i> for writing.
'w bz2'	Open a bzip2 compressed <i>stream</i> for writing.
'w xz'	Open an lzma compressed <i>stream</i> for writing.

在 3.5 版的變更: The 'x' (exclusive creation) mode was added.

在 3.6 版的變更: The *name* parameter accepts a *path-like object*.

class `tarfile.TarFile`

Class for reading and writing tar archives. Do not use this class directly: use `tarfile.open()` instead. See *TarFile* 物件.

`tarfile.is_tarfile` (*name*)

Return *True* if *name* is a tar archive file, that the *tarfile* module can read. *name* may be a *str*, file, or file-like object.

在 3.9 版的變更: Support for file and file-like objects.

The *tarfile* module defines the following exceptions:

exception `tarfile.TarError`

Base class for all *tarfile* exceptions.

exception `tarfile.ReadError`

Is raised when a tar archive is opened, that either cannot be handled by the *tarfile* module or is somehow invalid.

exception `tarfile.CompressionError`

Is raised when a compression method is not supported or when the data cannot be decoded properly.

exception `tarfile.StreamError`

Is raised for the limitations that are typical for stream-like *TarFile* objects.

exception `tarfile.ExtractError`

Is raised for *non-fatal* errors when using *TarFile.extract()*, but only if *TarFile.errorlevel==2*.

exception `tarfile.HeaderError`

Is raised by *TarInfo.frombuf()* if the buffer it gets is invalid.

exception `tarfile.FilterError`

Base class for members *refused* by filters.

tarinfo

Information about the member that the filter refused to extract, as *TarInfo*.

exception `tarfile.AbsolutePathError`

Raised to refuse extracting a member with an absolute path.

exception `tarfile.OutsideDestinationError`

Raised to refuse extracting a member outside the destination directory.

exception `tarfile.SpecialFileError`

Raised to refuse extracting a special file (e.g. a device or pipe).

exception `tarfile.AbsoluteLinkError`

Raised to refuse extracting a symbolic link with an absolute path.

exception `tarfile.LinkOutsideDestinationError`

Raised to refuse extracting a symbolic link pointing outside the destination directory.

The following constants are available at the module level:

`tarfile.ENCODING`

The default character encoding: 'utf-8' on Windows, the value returned by `sys.getfilesystemencoding()` otherwise.

`tarfile.REGTYPE``tarfile.AREGTYPE`

A regular file *type*.

`tarfile.LNKTYPE`

A link (inside tarfile) *type*.

`tarfile.SYMTYPE`

A symbolic link *type*.

`tarfile.CHRTYPE`

A character special device *type*.

`tarfile.BLKTYPE`

A block special device *type*.

`tarfile.DIRTYPE`

A directory *type*.

`tarfile.FIFOTYPE`

A FIFO special device *type*.

`tarfile.CONTTYPE`

A contiguous file *type*.

`tarfile.GNUTYPE_LONGNAME`

A GNU tar longname *type*.

`tarfile.GNUTYPE_LONGLINK`

A GNU tar longlink *type*.

`tarfile.GNUTYPE_SPARSE`

A GNU tar sparse file *type*.

Each of the following constants defines a tar archive format that the *tarfile* module is able to create. See section *Supported tar formats* for details.

`tarfile.USTAR_FORMAT`

POSIX.1-1988 (ustar) format.

`tarfile.GNU_FORMAT`

GNU tar format.

`tarfile.PAX_FORMAT`

POSIX.1-2001 (pax) format.

`tarfile.DEFAULT_FORMAT`

The default format for creating archives. This is currently *PAX_FORMAT*.

在 3.8 版的變更: The default format for new archives was changed to *PAX_FORMAT* from *GNU_FORMAT*.

也參考:

zipfile 模組

Documentation of the *zipfile* standard module.

Archiving operations

Documentation of the higher-level archiving facilities provided by the standard *shutil* module.

GNU tar manual, Basic Tar Format

Documentation for tar archive files, including GNU tar extensions.

13.6.1 TarFile 物件

The *TarFile* object provides an interface to a tar archive. A tar archive is a sequence of blocks. An archive member (a stored file) is made up of a header block followed by data blocks. It is possible to store a file in a tar archive several times. Each archive member is represented by a *TarInfo* object, see *TarInfo* 物件 for details.

A *TarFile* object can be used as a context manager in a `with` statement. It will automatically be closed when the block is completed. Please note that in the event of an exception an archive opened for writing will not be finalized; only the internally used file object will be closed. See the 範例 section for a use case.

在 3.2 版新加入: Added support for the context management protocol.

```
class tarfile.TarFile (name=None, mode='r', fileobj=None, format=DEFAULT_FORMAT,
                      tarinfo=TarInfo, dereference=False, ignore_zeros=False, encoding=ENCODING,
                      errors='surrogateescape', pax_headers=None, debug=0, errorlevel=1)
```

All following arguments are optional and can be accessed as instance attributes as well.

name is the pathname of the archive. *name* may be a *path-like object*. It can be omitted if *fileobj* is given. In this case, the file object's `name` attribute is used if it exists.

mode is either `'r'` to read from an existing archive, `'a'` to append data to an existing file, `'w'` to create a new file overwriting an existing one, or `'x'` to create a new file only if it does not already exist.

If *fileobj* is given, it is used for reading or writing data. If it can be determined, *mode* is overridden by *fileobj*'s `mode`. *fileobj* will be used from position 0.

備 F: *fileobj* is not closed, when *TarFile* is closed.

format controls the archive format for writing. It must be one of the constants *USTAR_FORMAT*, *GNU_FORMAT* or *PAX_FORMAT* that are defined at module level. When reading, format will be automatically detected, even if different formats are present in a single archive.

The *tarinfo* argument can be used to replace the default *TarInfo* class with a different one.

If *dereference* is *False*, add symbolic and hard links to the archive. If it is *True*, add the content of the target files to the archive. This has no effect on systems that do not support symbolic links.

If *ignore_zeros* is *False*, treat an empty block as the end of the archive. If it is *True*, skip empty (and invalid) blocks and try to get as many members as possible. This is only useful for reading concatenated or damaged archives.

debug can be set from 0 (no debug messages) up to 3 (all debug messages). The messages are written to `sys.stderr`.

errorlevel controls how extraction errors are handled, see *the corresponding attribute*.

The *encoding* and *errors* arguments define the character encoding to be used for reading or writing the archive and how conversion errors are going to be handled. The default settings will work for most users. See section *Unicode issues* for in-depth information.

The *pax_headers* argument is an optional dictionary of strings which will be added as a pax global header if *format* is *PAX_FORMAT*.

在 3.2 版的變更: Use `'surrogateescape'` as the default for the *errors* argument.

在 3.5 版的變更: The `'x'` (exclusive creation) mode was added.

在 3.6 版的變更: The *name* parameter accepts a *path-like object*.

```
classmethod TarFile.open (...)
```

Alternative constructor. The *tarfile.open()* function is actually a shortcut to this classmethod.

`TarFile.getmember(name)`

Return a `TarInfo` object for member *name*. If *name* can not be found in the archive, `KeyError` is raised.

備註: If a member occurs more than once in the archive, its last occurrence is assumed to be the most up-to-date version.

`TarFile.getmembers()`

Return the members of the archive as a list of `TarInfo` objects. The list has the same order as the members in the archive.

`TarFile.getnames()`

Return the members as a list of their names. It has the same order as the list returned by `getmembers()`.

`TarFile.list(verbose=True, *, members=None)`

Print a table of contents to `sys.stdout`. If *verbose* is `False`, only the names of the members are printed. If it is `True`, output similar to that of `ls -l` is produced. If optional *members* is given, it must be a subset of the list returned by `getmembers()`.

在 3.5 版的變更: 新增 *members* 參數。

`TarFile.next()`

Return the next member of the archive as a `TarInfo` object, when `TarFile` is opened for reading. Return `None` if there is no more available.

`TarFile.extractall(path='.', members=None, *, numeric_owner=False, filter=None)`

Extract all members from the archive to the current working directory or directory *path*. If optional *members* is given, it must be a subset of the list returned by `getmembers()`. Directory information like owner, modification time and permissions are set after all members have been extracted. This is done to work around two problems: A directory's modification time is reset each time a file is created in it. And, if a directory's permissions do not allow writing, extracting files to it will fail.

If *numeric_owner* is `True`, the uid and gid numbers from the tarfile are used to set the owner/group for the extracted files. Otherwise, the named values from the tarfile are used.

The *filter* argument, which was added in Python 3.11.4, specifies how members are modified or rejected before extraction. See [Extraction filters](#) for details. It is recommended to set this explicitly depending on which *tar* features you need to support.

警告: Never extract archives from untrusted sources without prior inspection. It is possible that files are created outside of *path*, e.g. members that have absolute filenames starting with `" / "` or filenames with two dots `" . . "`.

Set *filter*='data' to prevent the most dangerous security issues, and read the [Extraction filters](#) section for details.

在 3.5 版的變更: 新增 *numeric_owner* 參數。

在 3.6 版的變更: The *path* parameter accepts a *path-like object*.

在 3.11.4 版的變更: 新增 *filter* 參數。

`TarFile.extract(member, path="", set_attrs=True, *, numeric_owner=False, filter=None)`

Extract a member from the archive to the current working directory, using its full name. Its file information is extracted as accurately as possible. *member* may be a filename or a `TarInfo` object. You can specify a different directory using *path*. *path* may be a *path-like object*. File attributes (owner, mtime, mode) are set unless *set_attrs* is false.

The *numeric_owner* and *filter* arguments are the same as for `extractall()`.

備 F: The `extract()` method does not take care of several extraction issues. In most cases you should consider using the `extractall()` method.

警告: 參 F `extractall()` 的警告。

Set `filter='data'` to prevent the most dangerous security issues, and read the [Extraction filters](#) section for details.

在 3.2 版的變更: 增加 `set_attrs` 參數。

在 3.5 版的變更: 新增 `numeric_owner` 參數。

在 3.6 版的變更: The `path` parameter accepts a *path-like object*.

在 3.11.4 版的變更: 新增 `filter` 參數。

`TarFile.extractfile(member)`

Extract a member from the archive as a file object. *member* may be a filename or a `TarInfo` object. If *member* is a regular file or a link, an `io.BufferedReader` object is returned. For all other existing members, `None` is returned. If *member* does not appear in the archive, `KeyError` is raised.

在 3.3 版的變更: Return an `io.BufferedReader` object.

`TarFile.errorlevel: int`

If *errorlevel* is 0, errors are ignored when using `TarFile.extract()` and `TarFile.extractall()`. Nevertheless, they appear as error messages in the debug output when *debug* is greater than 0. If 1 (the default), all *fatal* errors are raised as `OSError` or `FilterError` exceptions. If 2, all *non-fatal* errors are raised as `TarError` exceptions as well.

Some exceptions, e.g. ones caused by wrong argument types or data corruption, are always raised.

Custom *extraction filters* should raise `FilterError` for *fatal* errors and `ExtractError` for *non-fatal* ones.

Note that when an exception is raised, the archive may be partially extracted. It is the user's responsibility to clean up.

`TarFile.extraction_filter`

在 3.11.4 版新加入。

The *extraction filter* used as a default for the *filter* argument of `extract()` and `extractall()`.

The attribute may be `None` or a callable. String names are not allowed for this attribute, unlike the *filter* argument to `extract()`.

If `extraction_filter` is `None` (the default), calling an extraction method without a *filter* argument will use the *fully_trusted* filter for compatibility with previous Python versions.

In Python 3.12+, leaving `extraction_filter=None` will emit a `DeprecationWarning`.

In Python 3.14+, leaving `extraction_filter=None` will cause extraction methods to use the *data* filter by default.

The attribute may be set on instances or overridden in subclasses. It also is possible to set it on the `TarFile` class itself to set a global default, although, since it affects all uses of *tarfile*, it is best practice to only do so in top-level applications or *site configuration*. To set a global default this way, a filter function needs to be wrapped in `staticmethod()` to prevent injection of a `self` argument.

`TarFile.add(name, arcname=None, recursive=True, *, filter=None)`

Add the file *name* to the archive. *name* may be any type of file (directory, fifo, symbolic link, etc.). If given, *arcname* specifies an alternative name for the file in the archive. Directories are added recursively by default. This can be avoided by setting *recursive* to `False`. Recursion adds entries in sorted order. If *filter* is given, it

should be a function that takes a *TarInfo* object argument and returns the changed *TarInfo* object. If it instead returns *None* the *TarInfo* object will be excluded from the archive. See 範例 for an example.

在 3.2 版的變更: 新增 *filter* 參數。

在 3.7 版的變更: Recursion adds entries in sorted order.

`TarFile.addfile(tarinfo, fileobj=None)`

Add the *TarInfo* object *tarinfo* to the archive. If *fileobj* is given, it should be a *binary file*, and *tarinfo.size* bytes are read from it and added to the archive. You can create *TarInfo* objects directly, or by using *gettinfo()*.

`TarFile.gettarinfo(name=None, arcname=None, fileobj=None)`

Create a *TarInfo* object from the result of *os.stat()* or equivalent on an existing file. The file is either named by *name*, or specified as a *file object fileobj* with a file descriptor. *name* may be a *path-like object*. If given, *arcname* specifies an alternative name for the file in the archive, otherwise, the name is taken from *fileobj*'s *name* attribute, or the *name* argument. The name should be a text string.

You can modify some of the *TarInfo*'s attributes before you add it using *addfile()*. If the file object is not an ordinary file object positioned at the beginning of the file, attributes such as *size* may need modifying. This is the case for objects such as *GzipFile*. The *name* may also be modified, in which case *arcname* could be a dummy string.

在 3.6 版的變更: The *name* parameter accepts a *path-like object*.

`TarFile.close()`

Close the *TarFile*. In write mode, two finishing zero blocks are appended to the archive.

`TarFile.pax_headers: dict`

A dictionary containing key-value pairs of pax global headers.

13.6.2 TarInfo 物件

A *TarInfo* object represents one member in a *TarFile*. Aside from storing all required attributes of a file (like file type, size, time, permissions, owner etc.), it provides some useful methods to determine its type. It does *not* contain the file's data itself.

TarInfo objects are returned by *TarFile*'s methods *getmember()*, *getmembers()* and *gettinfo()*.

Modifying the objects returned by *getmember()* or *getmembers()* will affect all subsequent operations on the archive. For cases where this is unwanted, you can use *copy.copy()* or call the *replace()* method to create a modified copy in one step.

Several attributes can be set to *None* to indicate that a piece of metadata is unused or unknown. Different *TarInfo* methods handle *None* differently:

- The *extract()* or *extractall()* methods will ignore the corresponding metadata, leaving it set to a default.
- *addfile()* will fail.
- *list()* will print a placeholder string.

在 3.11.4 版的變更: Added *replace()* and handling of *None*.

`class tarfile.TarInfo(name="")`

Create a *TarInfo* object.

`classmethod TarInfo.frombuf(buf, encoding, errors)`

Create and return a *TarInfo* object from string buffer *buf*.

Raises *HeaderError* if the buffer is invalid.

`classmethod TarInfo.fromtarfile(tarfile)`

Read the next member from the *TarFile* object *tarfile* and return it as a *TarInfo* object.

`TarInfo.tobuf` (*format=DEFAULT_FORMAT, encoding=ENCODING, errors='surrogateescape'*)

Create a string buffer from a *TarInfo* object. For information on the arguments see the constructor of the *TarFile* class.

在 3.2 版的變更: Use 'surrogateescape' as the default for the *errors* argument.

A *TarInfo* object has the following public data attributes:

`TarInfo.name`: *str*

Name of the archive member.

`TarInfo.size`: *int*

Size in bytes.

`TarInfo.mtime`: *int* | *float*

Time of last modification in seconds since the *epoch*, as in *os.stat_result.st_mtime*.

在 3.11.4 版的變更: Can be set to *None* for *extract()* and *extractall()*, causing extraction to skip applying this attribute.

`TarInfo.mode`: *int*

Permission bits, as for *os.chmod()*.

在 3.11.4 版的變更: Can be set to *None* for *extract()* and *extractall()*, causing extraction to skip applying this attribute.

`TarInfo.type`

File type. *type* is usually one of these constants: *REGTYPE*, *AREGTYPE*, *LNKTYPE*, *SYMTYPE*, *DIRTYPE*, *FIFOTYPE*, *CONTYPE*, *CHRTYPE*, *BLKTYPE*, *GNUTYPE_SPARSE*. To determine the type of a *TarInfo* object more conveniently, use the *is*()* methods below.

`TarInfo.linkname`: *str*

Name of the target file name, which is only present in *TarInfo* objects of type *LNKTYPE* and *SYMTYPE*.

For symbolic links (*SYMTYPE*), the *linkname* is relative to the directory that contains the link. For hard links (*LNKTYPE*), the *linkname* is relative to the root of the archive.

`TarInfo.uid`: *int*

User ID of the user who originally stored this member.

在 3.11.4 版的變更: Can be set to *None* for *extract()* and *extractall()*, causing extraction to skip applying this attribute.

`TarInfo.gid`: *int*

Group ID of the user who originally stored this member.

在 3.11.4 版的變更: Can be set to *None* for *extract()* and *extractall()*, causing extraction to skip applying this attribute.

`TarInfo.uname`: *str*

User name.

在 3.11.4 版的變更: Can be set to *None* for *extract()* and *extractall()*, causing extraction to skip applying this attribute.

`TarInfo.gname`: *str*

Group name.

在 3.11.4 版的變更: Can be set to *None* for *extract()* and *extractall()*, causing extraction to skip applying this attribute.

`TarInfo.chksum`: *int*

Header checksum.

`TarInfo.devmajor`: *int*

Device major number.

`TarInfo.devminor`: *int*

Device minor number.

`TarInfo.offset`: *int*

The tar header starts here.

`TarInfo.offset_data`: *int*

The file's data starts here.

`TarInfo.sparse`

Sparse member information.

`TarInfo.pax_headers`: *dict*

A dictionary containing key-value pairs of an associated pax extended header.

`TarInfo.replace` (*name=...*, *mtime=...*, *mode=...*, *linkname=...*, *uid=...*, *gid=...*, *uname=...*, *gname=...*, *deep=True*)

在 3.11.4 版新加入。

Return a *new* copy of the `TarInfo` object with the given attributes changed. For example, to return a `TarInfo` with the group name set to 'staff', use:

```
new_tarinfo = old_tarinfo.replace(gname='staff')
```

By default, a deep copy is made. If *deep* is false, the copy is shallow, i.e. `pax_headers` and any custom attributes are shared with the original `TarInfo` object.

A `TarInfo` object also provides some convenient query methods:

`TarInfo.isfile()`

Return *True* if the `TarInfo` object is a regular file.

`TarInfo.isreg()`

Same as `isfile()`.

`TarInfo.isdir()`

Return *True* if it is a directory.

`TarInfo.issym()`

Return *True* if it is a symbolic link.

`TarInfo.islnk()`

Return *True* if it is a hard link.

`TarInfo.ischr()`

Return *True* if it is a character device.

`TarInfo.isblk()`

Return *True* if it is a block device.

`TarInfo.isfifo()`

Return *True* if it is a FIFO.

`TarInfo.isdev()`

Return *True* if it is one of character device, block device or FIFO.

13.6.3 Extraction filters

在 3.11.4 版新加入。

The *tar* format is designed to capture all details of a UNIX-like filesystem, which makes it very powerful. Unfortunately, the features make it easy to create tar files that have unintended -- and possibly malicious -- effects when extracted. For example, extracting a tar file can overwrite arbitrary files in various ways (e.g. by using absolute paths, . . path components, or symlinks that affect later members).

In most cases, the full functionality is not needed. Therefore, *tarfile* supports extraction filters: a mechanism to limit functionality, and thus mitigate some of the security issues.

也參考:

PEP 706

Contains further motivation and rationale behind the design.

The *filter* argument to `TarFile.extract()` or `extractall()` can be:

- the string `'fully_trusted'`: Honor all metadata as specified in the archive. Should be used if the user trusts the archive completely, or implements their own complex verification.
- the string `'tar'`: Honor most *tar*-specific features (i.e. features of UNIX-like filesystems), but block features that are very likely to be surprising or malicious. See `tar_filter()` for details.
- the string `'data'`: Ignore or block most features specific to UNIX-like filesystems. Intended for extracting cross-platform data archives. See `data_filter()` for details.
- `None` (default): Use `TarFile.extraction_filter`.

If that is also `None` (the default), the `'fully_trusted'` filter will be used (for compatibility with earlier versions of Python).

In Python 3.12, the default will emit a `DeprecationWarning`.

In Python 3.14, the `'data'` filter will become the default instead. It's possible to switch earlier; see `TarFile.extraction_filter`.

- A callable which will be called for each extracted member with a `TarInfo` describing the member and the destination path to where the archive is extracted (i.e. the same path is used for all members):

```
filter(member: TarInfo, path: str, /) -> TarInfo | None
```

The callable is called just before each member is extracted, so it can take the current state of the disk into account. It can:

- return a `TarInfo` object which will be used instead of the metadata in the archive, or
- return `None`, in which case the member will be skipped, or
- raise an exception to abort the operation or skip the member, depending on `errorlevel`. Note that when extraction is aborted, `extractall()` may leave the archive partially extracted. It does not attempt to clean up.

Default named filters

The pre-defined, named filters are available as functions, so they can be reused in custom filters:

`tarfile.fully_trusted_filter(member, path)`

Return *member* unchanged.

This implements the `'fully_trusted'` filter.

`tarfile.tar_filter(member, path)`

Implements the `'tar'` filter.

- Strip leading slashes (`/` and `os.sep`) from filenames.

- *Refuse* to extract files with absolute paths (in case the name is absolute even after stripping slashes, e.g. `C:/foo` on Windows). This raises *AbsolutePathError*.
- *Refuse* to extract files whose absolute path (after following symlinks) would end up outside the destination. This raises *OutsideDestinationError*.
- Clear high mode bits (setuid, setgid, sticky) and group/other write bits (`S_IWGRP` | `S_IWOTH`).

Return the modified `TarInfo` member.

`tarfile.data_filter(member, path)`

Implements the 'data' filter. In addition to what `tar_filter` does:

- *Refuse* to extract links (hard or soft) that link to absolute paths, or ones that link outside the destination. This raises *AbsoluteLinkError* or *LinkOutsideDestinationError*.
Note that such files are refused even on platforms that do not support symbolic links.
- *Refuse* to extract device files (including pipes). This raises *SpecialFileError*.
- For regular files, including hard links:
 - Set the owner read and write permissions (`S_IRUSR` | `S_IWUSR`).
 - Remove the group & other executable permission (`S_IXGRP` | `S_IXOTH`) if the owner doesn't have it (`S_IXUSR`).
- For other files (directories), set `mode` to `None`, so that extraction methods skip applying permission bits.
- Set user and group info (`uid`, `gid`, `uname`, `gname`) to `None`, so that extraction methods skip setting it.

Return the modified `TarInfo` member.

Filter errors

When a filter refuses to extract a file, it will raise an appropriate exception, a subclass of *FilterError*. This will abort the extraction if `TarFile.errorlevel` is 1 or more. With `errorlevel=0` the error will be logged and the member will be skipped, but extraction will continue.

Hints for further verification

Even with `filter='data'`, *tarfile* is not suited for extracting untrusted files without prior inspection. Among other issues, the pre-defined filters do not prevent denial-of-service attacks. Users should do additional checks.

Here is an incomplete list of things to consider:

- Extract to a *new temporary directory* to prevent e.g. exploiting pre-existing links, and to make it easier to clean up after a failed extraction.
- When working with untrusted data, use external (e.g. OS-level) limits on disk, memory and CPU usage.
- Check filenames against an allow-list of characters (to filter out control characters, confusables, foreign path separators, etc.).
- Check that filenames have expected extensions (discouraging files that execute when you “click on them”, or extension-less files like Windows special device names).
- Limit the number of extracted files, total size of extracted data, filename length (including symlink length), and size of individual files.
- Check for files that would be shadowed on case-insensitive filesystems.

Also note that:

- Tar files may contain multiple versions of the same file. Later ones are expected to overwrite any earlier ones. This feature is crucial to allow updating tape archives, but can be abused maliciously.

- *tarfile* does not protect against issues with “live” data, e.g. an attacker tinkering with the destination (or source) directory while extraction (or archiving) is in progress.

Supporting older Python versions

Extraction filters were added to Python 3.12, and are backported to older versions as security updates. To check whether the feature is available, use e.g. `hasattr(tarfile, 'data_filter')` rather than checking the Python version.

The following examples show how to support Python versions with and without the feature. Note that setting `extraction_filter` will affect any subsequent operations.

- Fully trusted archive:

```
my_tarfile.extraction_filter = (lambda member, path: member)
my_tarfile.extractall()
```

- Use the 'data' filter if available, but revert to Python 3.11 behavior ('fully_trusted') if this feature is not available:

```
my_tarfile.extraction_filter = getattr(tarfile, 'data_filter',
                                      (lambda member, path: member))
my_tarfile.extractall()
```

- Use the 'data' filter; *fail* if it is not available:

```
my_tarfile.extractall(filter=tarfile.data_filter)
```

or:

```
my_tarfile.extraction_filter = tarfile.data_filter
my_tarfile.extractall()
```

- Use the 'data' filter; *warn* if it is not available:

```
if hasattr(tarfile, 'data_filter'):
    my_tarfile.extractall(filter='data')
else:
    # remove this when no longer needed
    warn_the_user('Extracting may be unsafe; consider updating Python')
    my_tarfile.extractall()
```

Stateful extraction filter example

While *tarfile*'s extraction methods take a simple *filter* callable, custom filters may be more complex objects with an internal state. It may be useful to write these as context managers, to be used like this:

```
with StatefulFilter() as filter_func:
    tar.extractall(path, filter=filter_func)
```

Such a filter can be written as, for example:

```
class StatefulFilter:
    def __init__(self):
        self.file_count = 0

    def __enter__(self):
        return self

    def __call__(self, member, path):
```

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```

self.file_count += 1
return member

def __exit__(self, *exc_info):
    print(f'{self.file_count} files extracted')

```

13.6.4 Command-Line Interface

在 3.4 版新加入.

The `tarfile` module provides a simple command-line interface to interact with tar archives.

If you want to create a new tar archive, specify its name after the `-c` option and then list the filename(s) that should be included:

```
$ python -m tarfile -c monty.tar spam.txt eggs.txt
```

Passing a directory is also acceptable:

```
$ python -m tarfile -c monty.tar life-of-brian_1979/
```

If you want to extract a tar archive into the current directory, use the `-e` option:

```
$ python -m tarfile -e monty.tar
```

You can also extract a tar archive into a different directory by passing the directory's name:

```
$ python -m tarfile -e monty.tar other-dir/
```

For a list of the files in a tar archive, use the `-l` option:

```
$ python -m tarfile -l monty.tar
```

Command-line options

-l <tarfile>

--list <tarfile>

List files in a tarfile.

-c <tarfile> <source1> ... <sourceN>

--create <tarfile> <source1> ... <sourceN>

Create tarfile from source files.

-e <tarfile> [<output_dir>]

--extract <tarfile> [<output_dir>]

Extract tarfile into the current directory if *output_dir* is not specified.

-t <tarfile>

--test <tarfile>

Test whether the tarfile is valid or not.

-v, --verbose

Verbose output.

--filter <filtername>

Specifies the *filter* for `--extract`. See [Extraction filters](#) for details. Only string names are accepted (that is, `fully_trusted`, `tar`, and `data`).

在 3.11.4 版新加入.

13.6.5 范例

How to extract an entire tar archive to the current working directory:

```
import tarfile
tar = tarfile.open("sample.tar.gz")
tar.extractall()
tar.close()
```

How to extract a subset of a tar archive with `TarFile.extractall()` using a generator function instead of a list:

```
import os
import tarfile

def py_files(members):
    for tarinfo in members:
        if os.path.splitext(tarinfo.name)[1] == ".py":
            yield tarinfo

tar = tarfile.open("sample.tar.gz")
tar.extractall(members=py_files(tar))
tar.close()
```

How to create an uncompressed tar archive from a list of filenames:

```
import tarfile
tar = tarfile.open("sample.tar", "w")
for name in ["foo", "bar", "quux"]:
    tar.add(name)
tar.close()
```

The same example using the with statement:

```
import tarfile
with tarfile.open("sample.tar", "w") as tar:
    for name in ["foo", "bar", "quux"]:
        tar.add(name)
```

How to read a gzip compressed tar archive and display some member information:

```
import tarfile
tar = tarfile.open("sample.tar.gz", "r:gz")
for tarinfo in tar:
    print(tarinfo.name, "is", tarinfo.size, "bytes in size and is ", end="")
    if tarinfo.isreg():
        print("a regular file.")
    elif tarinfo.isdir():
        print("a directory.")
    else:
        print("something else.")
tar.close()
```

How to create an archive and reset the user information using the `filter` parameter in `TarFile.add()`:

```
import tarfile
def reset(tarinfo):
    tarinfo.uid = tarinfo.gid = 0
    tarinfo.uname = tarinfo.gname = "root"
    return tarinfo
tar = tarfile.open("sample.tar.gz", "w:gz")
tar.add("foo", filter=reset)
tar.close()
```

13.6.6 Supported tar formats

There are three tar formats that can be created with the `tarfile` module:

- The POSIX.1-1988 ustar format (`USTAR_FORMAT`). It supports filenames up to a length of at best 256 characters and linknames up to 100 characters. The maximum file size is 8 GiB. This is an old and limited but widely supported format.
- The GNU tar format (`GNU_FORMAT`). It supports long filenames and linknames, files bigger than 8 GiB and sparse files. It is the de facto standard on GNU/Linux systems. `tarfile` fully supports the GNU tar extensions for long names, sparse file support is read-only.
- The POSIX.1-2001 pax format (`PAX_FORMAT`). It is the most flexible format with virtually no limits. It supports long filenames and linknames, large files and stores pathnames in a portable way. Modern tar implementations, including GNU tar, bsdtar/libarchive and star, fully support extended *pax* features; some old or unmaintained libraries may not, but should treat *pax* archives as if they were in the universally supported *ustar* format. It is the current default format for new archives.

It extends the existing *ustar* format with extra headers for information that cannot be stored otherwise. There are two flavours of pax headers: Extended headers only affect the subsequent file header, global headers are valid for the complete archive and affect all following files. All the data in a pax header is encoded in *UTF-8* for portability reasons.

There are some more variants of the tar format which can be read, but not created:

- The ancient V7 format. This is the first tar format from Unix Seventh Edition, storing only regular files and directories. Names must not be longer than 100 characters, there is no user/group name information. Some archives have miscalculated header checksums in case of fields with non-ASCII characters.
- The SunOS tar extended format. This format is a variant of the POSIX.1-2001 pax format, but is not compatible.

13.6.7 Unicode issues

The tar format was originally conceived to make backups on tape drives with the main focus on preserving file system information. Nowadays tar archives are commonly used for file distribution and exchanging archives over networks. One problem of the original format (which is the basis of all other formats) is that there is no concept of supporting different character encodings. For example, an ordinary tar archive created on a *UTF-8* system cannot be read correctly on a *Latin-1* system if it contains non-ASCII characters. Textual metadata (like filenames, linknames, user/group names) will appear damaged. Unfortunately, there is no way to autodetect the encoding of an archive. The pax format was designed to solve this problem. It stores non-ASCII metadata using the universal character encoding *UTF-8*.

The details of character conversion in `tarfile` are controlled by the `encoding` and `errors` keyword arguments of the `TarFile` class.

`encoding` defines the character encoding to use for the metadata in the archive. The default value is `sys.getfilesystemencoding()` or `'ascii'` as a fallback. Depending on whether the archive is read or written, the metadata must be either decoded or encoded. If `encoding` is not set appropriately, this conversion may fail.

The `errors` argument defines how characters are treated that cannot be converted. Possible values are listed in section *Error Handlers*. The default scheme is `'surrogateescape'` which Python also uses for its file system calls, see *File Names, Command Line Arguments, and Environment Variables*.

For `PAX_FORMAT` archives (the default), `encoding` is generally not needed because all the metadata is stored using *UTF-8*. `encoding` is only used in the rare cases when binary pax headers are decoded or when strings with surrogate characters are stored.

The modules described in this chapter parse various miscellaneous file formats that aren't markup languages and are not related to e-mail.

14.1 `csv` --- CSV File Reading and Writing

原始碼: [Lib/csv.py](#)

The so-called CSV (Comma Separated Values) format is the most common import and export format for spreadsheets and databases. CSV format was used for many years prior to attempts to describe the format in a standardized way in [RFC 4180](#). The lack of a well-defined standard means that subtle differences often exist in the data produced and consumed by different applications. These differences can make it annoying to process CSV files from multiple sources. Still, while the delimiters and quoting characters vary, the overall format is similar enough that it is possible to write a single module which can efficiently manipulate such data, hiding the details of reading and writing the data from the programmer.

The `csv` module implements classes to read and write tabular data in CSV format. It allows programmers to say, "write this data in the format preferred by Excel," or "read data from this file which was generated by Excel," without knowing the precise details of the CSV format used by Excel. Programmers can also describe the CSV formats understood by other applications or define their own special-purpose CSV formats.

The `csv` module's `reader` and `writer` objects read and write sequences. Programmers can also read and write data in dictionary form using the `DictReader` and `DictWriter` classes.

也參考:

[PEP 305](#) - CSV 檔案 API

The Python Enhancement Proposal which proposed this addition to Python.

14.1.1 模組內容

`csv` 模組定義了以下函式：

`csv.reader(csvfile, dialect='excel', **fmtparams)`

Return a *reader object* that will process lines from the given *csvfile*. A *csvfile* must be an iterable of strings, each in the reader's defined csv format. A *csvfile* is most commonly a file-like object or list. If *csvfile* is a file object, it should be opened with `newline=''`¹. An optional *dialect* parameter can be given which is used to define a set of parameters specific to a particular CSV dialect. It may be an instance of a subclass of the *Dialect* class or one of the strings returned by the `list_dialects()` function. The other optional *fmtparams* keyword arguments can be given to override individual formatting parameters in the current dialect. For full details about the dialect and formatting parameters, see section *Dialects and Formatting Parameters*.

Each row read from the csv file is returned as a list of strings. No automatic data type conversion is performed unless the `QUOTE_NONNUMERIC` format option is specified (in which case unquoted fields are transformed into floats).

一個簡短的用法範例：

```
>>> import csv
>>> with open('eggs.csv', newline='') as csvfile:
...     spamreader = csv.reader(csvfile, delimiter=' ', quotechar='|')
...     for row in spamreader:
...         print(', '.join(row))
Spam, Spam, Spam, Spam, Spam, Baked Beans
Spam, Lovely Spam, Wonderful Spam
```

`csv.writer(csvfile, dialect='excel', **fmtparams)`

Return a writer object responsible for converting the user's data into delimited strings on the given file-like object. *csvfile* can be any object with a `write()` method. If *csvfile* is a file object, it should be opened with `newline=''`¹. An optional *dialect* parameter can be given which is used to define a set of parameters specific to a particular CSV dialect. It may be an instance of a subclass of the *Dialect* class or one of the strings returned by the `list_dialects()` function. The other optional *fmtparams* keyword arguments can be given to override individual formatting parameters in the current dialect. For full details about dialects and formatting parameters, see the *Dialects and Formatting Parameters* section. To make it as easy as possible to interface with modules which implement the DB API, the value `None` is written as the empty string. While this isn't a reversible transformation, it makes it easier to dump SQL NULL data values to CSV files without preprocessing the data returned from a `cursor.fetch*` call. All other non-string data are stringified with `str()` before being written.

一個簡短的用法範例：

```
import csv
with open('eggs.csv', 'w', newline='') as csvfile:
    spamwriter = csv.writer(csvfile, delimiter=' ',
                           quotechar='|', quoting=csv.QUOTE_MINIMAL)
    spamwriter.writerow(['Spam'] * 5 + ['Baked Beans'])
    spamwriter.writerow(['Spam', 'Lovely Spam', 'Wonderful Spam'])
```

`csv.register_dialect(name[, dialect[, **fmtparams]])`

Associate *dialect* with *name*. *name* must be a string. The dialect can be specified either by passing a sub-class of *Dialect*, or by *fmtparams* keyword arguments, or both, with keyword arguments overriding parameters of the dialect. For full details about dialects and formatting parameters, see section *Dialects and Formatting Parameters*.

`csv.unregister_dialect(name)`

Delete the dialect associated with *name* from the dialect registry. An *Error* is raised if *name* is not a registered dialect name.

¹ If `newline=''` is not specified, newlines embedded inside quoted fields will not be interpreted correctly, and on platforms that use `\r\n` line endings on write an extra `\r` will be added. It should always be safe to specify `newline=''`, since the csv module does its own (*universal*) newline handling.

`csv.get_dialect(name)`

Return the dialect associated with *name*. An *Error* is raised if *name* is not a registered dialect name. This function returns an immutable *Dialect*.

`csv.list_dialects()`

Return the names of all registered dialects.

`csv.field_size_limit([new_limit])`

Returns the current maximum field size allowed by the parser. If *new_limit* is given, this becomes the new limit.

The *csv* module defines the following classes:

class `csv.DictReader(f, fieldnames=None, restkey=None, restval=None, dialect='excel', *args, **kwargs)`

Create an object that operates like a regular reader but maps the information in each row to a *dict* whose keys are given by the optional *fieldnames* parameter.

The *fieldnames* parameter is a *sequence*. If *fieldnames* is omitted, the values in the first row of file *f* will be used as the fieldnames. Regardless of how the fieldnames are determined, the dictionary preserves their original ordering.

If a row has more fields than fieldnames, the remaining data is put in a list and stored with the fieldname specified by *restkey* (which defaults to *None*). If a non-blank row has fewer fields than fieldnames, the missing values are filled-in with the value of *restval* (which defaults to *None*).

All other optional or keyword arguments are passed to the underlying *reader* instance.

在 3.6 版的變更: Returned rows are now of type *OrderedDict*.

在 3.8 版的變更: Returned rows are now of type *dict*.

一個簡短的用法範例:

```
>>> import csv
>>> with open('names.csv', newline='') as csvfile:
...     reader = csv.DictReader(csvfile)
...     for row in reader:
...         print(row['first_name'], row['last_name'])
...
Eric Idle
John Cleese

>>> print(row)
{'first_name': 'John', 'last_name': 'Cleese'}
```

class `csv.DictWriter(f, fieldnames, restval="", extrasaction='raise', dialect='excel', *args, **kwargs)`

Create an object which operates like a regular writer but maps dictionaries onto output rows. The *fieldnames* parameter is a *sequence* of keys that identify the order in which values in the dictionary passed to the *writerow()* method are written to file *f*. The optional *restval* parameter specifies the value to be written if the dictionary is missing a key in *fieldnames*. If the dictionary passed to the *writerow()* method contains a key not found in *fieldnames*, the optional *extrasaction* parameter indicates what action to take. If it is set to 'raise', the default value, a *ValueError* is raised. If it is set to 'ignore', extra values in the dictionary are ignored. Any other optional or keyword arguments are passed to the underlying *writer* instance.

Note that unlike the *DictReader* class, the *fieldnames* parameter of the *DictWriter* class is not optional.

一個簡短的用法範例:

```
import csv

with open('names.csv', 'w', newline='') as csvfile:
    fieldnames = ['first_name', 'last_name']
    writer = csv.DictWriter(csvfile, fieldnames=fieldnames)
```

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```
writer.writeheader()
writer.writerow({'first_name': 'Baked', 'last_name': 'Beans'})
writer.writerow({'first_name': 'Lovely', 'last_name': 'Spam'})
writer.writerow({'first_name': 'Wonderful', 'last_name': 'Spam'})
```

class csv.Dialect

The *Dialect* class is a container class whose attributes contain information for how to handle doublequotes, whitespace, delimiters, etc. Due to the lack of a strict CSV specification, different applications produce subtly different CSV data. *Dialect* instances define how *reader* and *writer* instances behave.

All available *Dialect* names are returned by *list_dialects()*, and they can be registered with specific *reader* and *writer* classes through their initializer (*__init__*) functions like this:

```
import csv

with open('students.csv', 'w', newline='') as csvfile:
    writer = csv.writer(csvfile, dialect='unix')
```

class csv.excel

The *excel* class defines the usual properties of an Excel-generated CSV file. It is registered with the dialect name 'excel'.

class csv.excel_tab

The *excel_tab* class defines the usual properties of an Excel-generated TAB-delimited file. It is registered with the dialect name 'excel-tab'.

class csv.unix_dialect

The *unix_dialect* class defines the usual properties of a CSV file generated on UNIX systems, i.e. using '\n' as line terminator and quoting all fields. It is registered with the dialect name 'unix'.

在 3.2 版新加入。

class csv.Sniffer

The *Sniffer* class is used to deduce the format of a CSV file.

The *Sniffer* class provides two methods:

sniff (*sample*, *delimiters=None*)

Analyze the given *sample* and return a *Dialect* subclass reflecting the parameters found. If the optional *delimiters* parameter is given, it is interpreted as a string containing possible valid delimiter characters.

has_header (*sample*)

Analyze the sample text (presumed to be in CSV format) and return *True* if the first row appears to be a series of column headers. Inspecting each column, one of two key criteria will be considered to estimate if the sample contains a header:

- the second through n-th rows contain numeric values
- the second through n-th rows contain strings where at least one value's length differs from that of the putative header of that column.

Twenty rows after the first row are sampled; if more than half of columns + rows meet the criteria, *True* is returned.

備F: This method is a rough heuristic and may produce both false positives and negatives.

An example for *Sniffer* use:

```
with open('example.csv', newline='') as csvfile:
    dialect = csv.Sniffer().sniff(csvfile.read(1024))
    csvfile.seek(0)
    reader = csv.reader(csvfile, dialect)
    # ... process CSV file contents here ...
```

The `csv` module defines the following constants:

CSV.QUOTE_ALL

Instructs *writer* objects to quote all fields.

CSV.QUOTE_MINIMAL

Instructs *writer* objects to only quote those fields which contain special characters such as *delimiter*, *quotechar* or any of the characters in *lineterminator*.

CSV.QUOTE_NONNUMERIC

Instructs *writer* objects to quote all non-numeric fields.

Instructs the reader to convert all non-quoted fields to type *float*.

CSV.QUOTE_NONE

Instructs *writer* objects to never quote fields. When the current *delimiter* occurs in output data it is preceded by the current *escapechar* character. If *escapechar* is not set, the writer will raise *Error* if any characters that require escaping are encountered.

Instructs *reader* to perform no special processing of quote characters.

The `csv` module defines the following exception:

exception CSV.Error

Raised by any of the functions when an error is detected.

14.1.2 Dialects and Formatting Parameters

To make it easier to specify the format of input and output records, specific formatting parameters are grouped together into dialects. A dialect is a subclass of the *Dialect* class containing various attributes describing the format of the CSV file. When creating *reader* or *writer* objects, the programmer can specify a string or a subclass of the *Dialect* class as the dialect parameter. In addition to, or instead of, the *dialect* parameter, the programmer can also specify individual formatting parameters, which have the same names as the attributes defined below for the *Dialect* class.

Dialects support the following attributes:

Dialect.delimiter

A one-character string used to separate fields. It defaults to `' '`.

Dialect.doublequote

Controls how instances of *quotechar* appearing inside a field should themselves be quoted. When *True*, the character is doubled. When *False*, the *escapechar* is used as a prefix to the *quotechar*. It defaults to *True*.

On output, if *doublequote* is *False* and no *escapechar* is set, *Error* is raised if a *quotechar* is found in a field.

Dialect.escapechar

A one-character string used by the writer to escape the *delimiter* if *quoting* is set to *QUOTE_NONE* and the *quotechar* if *doublequote* is *False*. On reading, the *escapechar* removes any special meaning from the following character. It defaults to *None*, which disables escaping.

在 3.11 版的變更: An empty *escapechar* is not allowed.

Dialect.lineterminator

The string used to terminate lines produced by the *writer*. It defaults to `'\r\n'`.

備 F: The *reader* is hard-coded to recognise either `'\r'` or `'\n'` as end-of-line, and ignores *lineterminator*. This behavior may change in the future.

Dialect.quotechar

A one-character string used to quote fields containing special characters, such as the *delimiter* or *quotechar*, or which contain new-line characters. It defaults to `'\"'`.

在 3.11 版的變更: An empty *quotechar* is not allowed.

Dialect.quoting

Controls when quotes should be generated by the writer and recognised by the reader. It can take on any of the *QUOTE_* constants* and defaults to *QUOTE_MINIMAL*.

Dialect.skipinitialspace

When *True*, spaces immediately following the *delimiter* are ignored. The default is *False*.

Dialect.strict

When *True*, raise exception *Error* on bad CSV input. The default is *False*.

14.1.3 Reader Objects

Reader objects (*DictReader* instances and objects returned by the *reader()* function) have the following public methods:

csvreader.__next__()

Return the next row of the reader's iterable object as a list (if the object was returned from *reader()*) or a dict (if it is a *DictReader* instance), parsed according to the current *Dialect*. Usually you should call this as `next(reader)`.

Reader objects have the following public attributes:

csvreader.dialect

A read-only description of the dialect in use by the parser.

csvreader.line_num

The number of lines read from the source iterator. This is not the same as the number of records returned, as records can span multiple lines.

DictReader objects have the following public attribute:

DictReader.fieldnames

If not passed as a parameter when creating the object, this attribute is initialized upon first access or when the first record is read from the file.

14.1.4 Writer Objects

writer objects (*DictWriter* instances and objects returned by the *writer()* function) have the following public methods. A *row* must be an iterable of strings or numbers for *writer* objects and a dictionary mapping fieldnames to strings or numbers (by passing them through *str()* first) for *DictWriter* objects. Note that complex numbers are written out surrounded by parens. This may cause some problems for other programs which read CSV files (assuming they support complex numbers at all).

`csvwriter.writerow(row)`

Write the *row* parameter to the writer's file object, formatted according to the current *Dialect*. Return the return value of the call to the *write* method of the underlying file object.

在 3.5 版的變更: Added support of arbitrary iterables.

`csvwriter.writerows(rows)`

Write all elements in *rows* (an iterable of *row* objects as described above) to the writer's file object, formatted according to the current dialect.

Writer objects have the following public attribute:

`csvwriter.dialect`

A read-only description of the dialect in use by the writer.

DictWriter objects have the following public method:

`DictWriter.writeheader()`

Write a row with the field names (as specified in the constructor) to the writer's file object, formatted according to the current dialect. Return the return value of the `csvwriter.writerow()` call used internally.

在 3.2 版新加入.

在 3.8 版的變更: `writeheader()` now also returns the value returned by the `csvwriter.writerow()` method it uses internally.

14.1.5 范例

The simplest example of reading a CSV file:

```
import csv
with open('some.csv', newline='') as f:
    reader = csv.reader(f)
    for row in reader:
        print(row)
```

Reading a file with an alternate format:

```
import csv
with open('passwd', newline='') as f:
    reader = csv.reader(f, delimiter=':', quoting=csv.QUOTE_NONE)
    for row in reader:
        print(row)
```

The corresponding simplest possible writing example is:

```
import csv
with open('some.csv', 'w', newline='') as f:
    writer = csv.writer(f)
    writer.writerows(someiterable)
```

Since `open()` is used to open a CSV file for reading, the file will by default be decoded into unicode using the system default encoding (see `locale.getencoding()`). To decode a file using a different encoding, use the encoding argument of `open`:

```
import csv
with open('some.csv', newline='', encoding='utf-8') as f:
    reader = csv.reader(f)
    for row in reader:
        print(row)
```

The same applies to writing in something other than the system default encoding: specify the encoding argument when opening the output file.

Registering a new dialect:

```
import csv
csv.register_dialect('unixpwd', delimiter=':', quoting=csv.QUOTE_NONE)
with open('passwd', newline='') as f:
    reader = csv.reader(f, 'unixpwd')
```

A slightly more advanced use of the reader --- catching and reporting errors:

```
import csv, sys
filename = 'some.csv'
with open(filename, newline='') as f:
    reader = csv.reader(f)
    try:
        for row in reader:
            print(row)
    except csv.Error as e:
        sys.exit('file {}, line {}: {}'.format(filename, reader.line_num, e))
```

And while the module doesn't directly support parsing strings, it can easily be done:

```
import csv
for row in csv.reader(['one,two,three']):
    print(row)
```

解_F

14.2 configparser --- Configuration file parser

原始碼: [Lib/configparser.py](#)

This module provides the *ConfigParser* class which implements a basic configuration language which provides a structure similar to what's found in Microsoft Windows INI files. You can use this to write Python programs which can be customized by end users easily.

備_F: This library does *not* interpret or write the value-type prefixes used in the Windows Registry extended version of INI syntax.

也參考:

tomllib 模組

TOML is a well-specified format for application configuration files. It is specifically designed to be an improved version of INI.

shlex 模組

Support for creating Unix shell-like mini-languages which can also be used for application configuration files.

json 模組

The `json` module implements a subset of JavaScript syntax which is sometimes used for configuration, but does not support comments.

14.2.1 Quick Start

Let's take a very basic configuration file that looks like this:

```
[DEFAULT]
ServerAliveInterval = 45
Compression = yes
CompressionLevel = 9
ForwardX11 = yes

[forge.example]
User = hg

[topsecret.server.example]
Port = 50022
ForwardX11 = no
```

The structure of INI files is described *in the following section*. Essentially, the file consists of sections, each of which contains keys with values. `configparser` classes can read and write such files. Let's start by creating the above configuration file programmatically.

```
>>> import configparser
>>> config = configparser.ConfigParser()
>>> config['DEFAULT'] = {'ServerAliveInterval': '45',
...                     'Compression': 'yes',
...                     'CompressionLevel': '9'}
>>> config['forge.example'] = {}
>>> config['forge.example']['User'] = 'hg'
>>> config['topsecret.server.example'] = {}
>>> topsecret = config['topsecret.server.example']
>>> topsecret['Port'] = '50022'      # mutates the parser
>>> topsecret['ForwardX11'] = 'no'   # same here
>>> config['DEFAULT']['ForwardX11'] = 'yes'
>>> with open('example.ini', 'w') as configfile:
...     config.write(configfile)
... 
```

As you can see, we can treat a config parser much like a dictionary. There are differences, *outlined later*, but the behavior is very close to what you would expect from a dictionary.

Now that we have created and saved a configuration file, let's read it back and explore the data it holds.

```
>>> config = configparser.ConfigParser()
>>> config.sections()
[]
>>> config.read('example.ini')
['example.ini']
>>> config.sections()
['forge.example', 'topsecret.server.example']
>>> 'forge.example' in config
True
>>> 'python.org' in config
False
>>> config['forge.example']['User']
'hg'
>>> config['DEFAULT']['Compression']
'yes'
>>> topsecret = config['topsecret.server.example']
>>> topsecret['ForwardX11']
'no'
>>> topsecret['Port']
'50022'
```

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```
>>> for key in config['forge.example']:
...     print(key)
user
compressionlevel
serveraliveinterval
compression
forwardx11
>>> config['forge.example']['ForwardX11']
'yes'
```

As we can see above, the API is pretty straightforward. The only bit of magic involves the `DEFAULT` section which provides default values for all other sections¹. Note also that keys in sections are case-insensitive and stored in lowercase^{Page 568, 1}.

It is possible to read several configurations into a single `ConfigParser`, where the most recently added configuration has the highest priority. Any conflicting keys are taken from the more recent configuration while the previously existing keys are retained.

```
>>> another_config = configparser.ConfigParser()
>>> another_config.read('example.ini')
['example.ini']
>>> another_config['topsecret.server.example']['Port']
'50022'
>>> another_config.read_string("[topsecret.server.example]\nPort=48484")
>>> another_config['topsecret.server.example']['Port']
'48484'
>>> another_config.read_dict({"topsecret.server.example": {"Port": 21212}})
>>> another_config['topsecret.server.example']['Port']
'21212'
>>> another_config['topsecret.server.example']['ForwardX11']
'no'
```

This behaviour is equivalent to a `ConfigParser.read()` call with several files passed to the `filenames` parameter.

14.2.2 Supported Datatypes

Config parsers do not guess datatypes of values in configuration files, always storing them internally as strings. This means that if you need other datatypes, you should convert on your own:

```
>>> int(topsecret['Port'])
50022
>>> float(topsecret['CompressionLevel'])
9.0
```

Since this task is so common, config parsers provide a range of handy getter methods to handle integers, floats and booleans. The last one is the most interesting because simply passing the value to `bool()` would do no good since `bool('False')` is still `True`. This is why config parsers also provide `getboolean()`. This method is case-insensitive and recognizes Boolean values from 'yes'/'no', 'on'/'off', 'true'/'false' and '1'/'0'¹. For example:

```
>>> topsecret.getboolean('ForwardX11')
False
>>> config['forge.example'].getboolean('ForwardX11')
True
>>> config.getboolean('forge.example', 'Compression')
True
```

¹ Config parsers allow for heavy customization. If you are interested in changing the behaviour outlined by the footnote reference, consult the *Customizing Parser Behaviour* section.

Apart from `getboolean()`, config parsers also provide equivalent `getint()` and `getfloat()` methods. You can register your own converters and customize the provided ones.¹

14.2.3 Fallback Values

As with a dictionary, you can use a section's `get()` method to provide fallback values:

```
>>> topsecret.get('Port')
'50022'
>>> topsecret.get('CompressionLevel')
'9'
>>> topsecret.get('Cipher')
>>> topsecret.get('Cipher', '3des-cbc')
'3des-cbc'
```

Please note that default values have precedence over fallback values. For instance, in our example the 'CompressionLevel' key was specified only in the 'DEFAULT' section. If we try to get it from the section 'topsecret.server.example', we will always get the default, even if we specify a fallback:

```
>>> topsecret.get('CompressionLevel', '3')
'9'
```

One more thing to be aware of is that the parser-level `get()` method provides a custom, more complex interface, maintained for backwards compatibility. When using this method, a fallback value can be provided via the fallback keyword-only argument:

```
>>> config.get('forge.example', 'monster',
...           fallback='No such things as monsters')
'No such things as monsters'
```

The same fallback argument can be used with the `getint()`, `getfloat()` and `getboolean()` methods, for example:

```
>>> 'BatchMode' in topsecret
False
>>> topsecret.getboolean('BatchMode', fallback=True)
True
>>> config['DEFAULT']['BatchMode'] = 'no'
>>> topsecret.getboolean('BatchMode', fallback=True)
False
```

14.2.4 Supported INI File Structure

A configuration file consists of sections, each led by a `[section]` header, followed by key/value entries separated by a specific string (= or : by default^{Page 568, 1}). By default, section names are case sensitive but keys are not^{Page 568, 1}. Leading and trailing whitespace is removed from keys and values. Values can be omitted if the parser is configured to allow it^{Page 568, 1}, in which case the key/value delimiter may also be left out. Values can also span multiple lines, as long as they are indented deeper than the first line of the value. Depending on the parser's mode, blank lines may be treated as parts of multiline values or ignored.

By default, a valid section name can be any string that does not contain `\n`. To change this, see `ConfigParser.SECTCRE`.

Configuration files may include comments, prefixed by specific characters (# and ; by default^{Page 568, 1}). Comments may appear on their own on an otherwise empty line, possibly indented.^{Page 568, 1}

For example:

```

[Simple Values]
key=value
spaces in keys=allowed
spaces in values=allowed as well
spaces around the delimiter = obviously
you can also use : to delimit keys from values

[All Values Are Strings]
values like this: 1000000
or this: 3.14159265359
are they treated as numbers? : no
integers, floats and booleans are held as: strings
can use the API to get converted values directly: true

[Multiline Values]
chorus: I'm a lumberjack, and I'm okay
       I sleep all night and I work all day

[No Values]
key_without_value
empty string value here =

[You can use comments]
# like this
; or this

# By default only in an empty line.
# Inline comments can be harmful because they prevent users
# from using the delimiting characters as parts of values.
# That being said, this can be customized.

[Sections Can Be Indented]
    can_values_be_as_well = True
    does_that_mean_anything_special = False
    purpose = formatting for readability
    multiline_values = are
        handled just fine as
        long as they are indented
        deeper than the first line
        of a value
    # Did I mention we can indent comments, too?

```

14.2.5 Interpolation of values

On top of the core functionality, *ConfigParser* supports interpolation. This means values can be preprocessed before returning them from `get()` calls.

class `configparser.BasicInterpolation`

The default implementation used by *ConfigParser*. It enables values to contain format strings which refer to other values in the same section, or values in the special default section^{Page 568, 1}. Additional default values can be provided on initialization.

For example:

```

[Paths]
home_dir: /Users
my_dir: %(home_dir)s/lumberjack
my_pictures: %(my_dir)s/Pictures

[Escape]

```

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```
# use a %% to escape the % sign (% is the only character that needs to be
→escaped):
gain: 80%%
```

In the example above, `ConfigParser` with `interpolation` set to `BasicInterpolation()` would resolve `%(home_dir)s` to the value of `home_dir (/Users` in this case). `%(my_dir)s` in effect would resolve to `/Users/lumberjack`. All interpolations are done on demand so keys used in the chain of references do not have to be specified in any specific order in the configuration file.

With `interpolation` set to `None`, the parser would simply return `%(my_dir)s/Pictures` as the value of `my_pictures` and `%(home_dir)s/lumberjack` as the value of `my_dir`.

class `configparser.ExtendedInterpolation`

An alternative handler for interpolation which implements a more advanced syntax, used for instance in `zc.buildout`. Extended interpolation is using `${section:option}` to denote a value from a foreign section. Interpolation can span multiple levels. For convenience, if the `section:` part is omitted, interpolation defaults to the current section (and possibly the default values from the special section).

For example, the configuration specified above with basic interpolation, would look like this with extended interpolation:

```
[Paths]
home_dir: /Users
my_dir: ${home_dir}/lumberjack
my_pictures: ${my_dir}/Pictures

[Escape]
# use a $$ to escape the $ sign ($ is the only character that needs to be
→escaped):
cost: $$80
```

Values from other sections can be fetched as well:

```
[Common]
home_dir: /Users
library_dir: /Library
system_dir: /System
macports_dir: /opt/local

[Frameworks]
Python: 3.2
path: ${Common:system_dir}/Library/Frameworks/

[Arthur]
nickname: Two Sheds
last_name: Jackson
my_dir: ${Common:home_dir}/twosheds
my_pictures: ${my_dir}/Pictures
python_dir: ${Frameworks:path}/Python/Versions/${Frameworks:Python}
```

14.2.6 Mapping Protocol Access

在 3.2 版新加入。

Mapping protocol access is a generic name for functionality that enables using custom objects as if they were dictionaries. In case of `configparser`, the mapping interface implementation is using the `parser['section']['option']` notation.

`parser['section']` in particular returns a proxy for the section's data in the parser. This means that the values are not copied but they are taken from the original parser on demand. What's even more important is that when values are changed on a section proxy, they are actually mutated in the original parser.

`configparser` objects behave as close to actual dictionaries as possible. The mapping interface is complete and adheres to the *MutableMapping* ABC. However, there are a few differences that should be taken into account:

- By default, all keys in sections are accessible in a case-insensitive manner^{Page 568, 1}. E.g. for `option` in `parser["section"]` yields only `optionxform`'ed option key names. This means lowercased keys by default. At the same time, for a section that holds the key `'a'`, both expressions return `True`:

```
"a" in parser["section"]
"A" in parser["section"]
```

- All sections include `DEFAULTSECT` values as well which means that `.clear()` on a section may not leave the section visibly empty. This is because default values cannot be deleted from the section (because technically they are not there). If they are overridden in the section, deleting causes the default value to be visible again. Trying to delete a default value causes a `KeyError`.
- `DEFAULTSECT` cannot be removed from the parser:
 - trying to delete it raises `ValueError`,
 - `parser.clear()` leaves it intact,
 - `parser.popitem()` never returns it.
- `parser.get(section, option, **kwargs)` - the second argument is **not** a fallback value. Note however that the section-level `get()` methods are compatible both with the mapping protocol and the classic `configparser` API.
- `parser.items()` is compatible with the mapping protocol (returns a list of *section_name*, *section_proxy* pairs including the `DEFAULTSECT`). However, this method can also be invoked with arguments: `parser.items(section, raw, vars)`. The latter call returns a list of *option*, *value* pairs for a specified section, with all interpolations expanded (unless `raw=True` is provided).

The mapping protocol is implemented on top of the existing legacy API so that subclasses overriding the original interface still should have mappings working as expected.

14.2.7 Customizing Parser Behaviour

There are nearly as many INI format variants as there are applications using it. `configparser` goes a long way to provide support for the largest sensible set of INI styles available. The default functionality is mainly dictated by historical background and it's very likely that you will want to customize some of the features.

The most common way to change the way a specific config parser works is to use the `__init__()` options:

- *defaults*, default value: `None`

This option accepts a dictionary of key-value pairs which will be initially put in the `DEFAULT` section. This makes for an elegant way to support concise configuration files that don't specify values which are the same as the documented default.

Hint: if you want to specify default values for a specific section, use `read_dict()` before you read the actual file.

- *dict_type*, default value: *dict*

This option has a major impact on how the mapping protocol will behave and how the written configuration files look. With the standard dictionary, every section is stored in the order they were added to the parser. Same goes for options within sections.

An alternative dictionary type can be used for example to sort sections and options on write-back.

Please note: there are ways to add a set of key-value pairs in a single operation. When you use a regular dictionary in those operations, the order of the keys will be ordered. For example:

```
>>> parser = configparser.ConfigParser()
>>> parser.read_dict({'section1': {'key1': 'value1',
...                               'key2': 'value2',
...                               'key3': 'value3'},
...                  'section2': {'keyA': 'valueA',
...                               'keyB': 'valueB',
...                               'keyC': 'valueC'},
...                  'section3': {'foo': 'x',
...                               'bar': 'y',
...                               'baz': 'z'}})
>>> parser.sections()
['section1', 'section2', 'section3']
>>> [option for option in parser['section3']]
['foo', 'bar', 'baz']
```

- *allow_no_value*, default value: *False*

Some configuration files are known to include settings without values, but which otherwise conform to the syntax supported by *configparser*. The *allow_no_value* parameter to the constructor can be used to indicate that such values should be accepted:

```
>>> import configparser

>>> sample_config = """
... [mysqld]
... user = mysql
... pid-file = /var/run/mysqld/mysqld.pid
... skip-external-locking
... old_passwords = 1
... skip-bdb
... # we don't need ACID today
... skip-innodb
... """
>>> config = configparser.ConfigParser(allow_no_value=True)
>>> config.read_string(sample_config)

>>> # Settings with values are treated as before:
>>> config["mysqld"]["user"]
'mysql'

>>> # Settings without values provide None:
>>> config["mysqld"]["skip-bdb"]

>>> # Settings which aren't specified still raise an error:
>>> config["mysqld"]["does-not-exist"]
Traceback (most recent call last):
...
KeyError: 'does-not-exist'
```

- *delimiters*, default value: *('=', ':')*

Delimiters are substrings that delimit keys from values within a section. The first occurrence of a delimiting substring on a line is considered a delimiter. This means values (but not keys) can contain the delimiters.

See also the *space_around_delimiters* argument to `ConfigParser.write()`.

- *comment_prefixes*, default value: ('#', ';')
- *inline_comment_prefixes*, default value: None

Comment prefixes are strings that indicate the start of a valid comment within a config file. *comment_prefixes* are used only on otherwise empty lines (optionally indented) whereas *inline_comment_prefixes* can be used after every valid value (e.g. section names, options and empty lines as well). By default inline comments are disabled and '#' and ';' are used as prefixes for whole line comments.

在 3.2 版的變更: In previous versions of `configparser` behaviour matched `comment_prefixes=('#', ';')` and `inline_comment_prefixes=(';',)`.

Please note that config parsers don't support escaping of comment prefixes so using *inline_comment_prefixes* may prevent users from specifying option values with characters used as comment prefixes. When in doubt, avoid setting *inline_comment_prefixes*. In any circumstances, the only way of storing comment prefix characters at the beginning of a line in multiline values is to interpolate the prefix, for example:

```
>>> from configparser import ConfigParser, ExtendedInterpolation
>>> parser = ConfigParser(interpolation=ExtendedInterpolation())
>>> # the default BasicInterpolation could be used as well
>>> parser.read_string("""
... [DEFAULT]
... hash = #
...
... [hashes]
... shebang =
...     ${hash}!/usr/bin/env python
...     ${hash} -*- coding: utf-8 -*-
...
... extensions =
...     enabled_extension
...     another_extension
...     #disabled_by_comment
...     yet_another_extension
...
... interpolation not necessary = if # is not at line start
... even in multiline values = line #1
...     line #2
...     line #3
... """)
>>> print(parser['hashes']['shebang'])

#!/usr/bin/env python
# -*- coding: utf-8 -*-
>>> print(parser['hashes']['extensions'])

enabled_extension
another_extension
yet_another_extension
>>> print(parser['hashes']['interpolation not necessary'])
if # is not at line start
>>> print(parser['hashes']['even in multiline values'])
line #1
line #2
line #3
```

- *strict*, default value: True

When set to True, the parser will not allow for any section or option duplicates while reading from a single source (using `read_file()`, `read_string()` or `read_dict()`). It is recommended to use strict parsers in new applications.

在 3.2 版的變更: In previous versions of `configparser` behaviour matched `strict=False`.

- *empty_lines_in_values*, default value: `True`

In config parsers, values can span multiple lines as long as they are indented more than the key that holds them. By default parsers also let empty lines to be parts of values. At the same time, keys can be arbitrarily indented themselves to improve readability. In consequence, when configuration files get big and complex, it is easy for the user to lose track of the file structure. Take for instance:

```
[Section]
key = multiline
    value with a gotcha

    this = is still a part of the multiline value of 'key'
```

This can be especially problematic for the user to see if she's using a proportional font to edit the file. That is why when your application does not need values with empty lines, you should consider disallowing them. This will make empty lines split keys every time. In the example above, it would produce two keys, `key` and `this`.

- *default_section*, default value: `configparser.DEFAULTSECT` (that is: `"DEFAULT"`)

The convention of allowing a special section of default values for other sections or interpolation purposes is a powerful concept of this library, letting users create complex declarative configurations. This section is normally called `"DEFAULT"` but this can be customized to point to any other valid section name. Some typical values include: `"general"` or `"common"`. The name provided is used for recognizing default sections when reading from any source and is used when writing configuration back to a file. Its current value can be retrieved using the `parser_instance.default_section` attribute and may be modified at runtime (i.e. to convert files from one format to another).

- *interpolation*, default value: `configparser.BasicInterpolation`

Interpolation behaviour may be customized by providing a custom handler through the *interpolation* argument. `None` can be used to turn off interpolation completely, `ExtendedInterpolation()` provides a more advanced variant inspired by `zc.buildout`. More on the subject in the [dedicated documentation section](#). `RawConfigParser` has a default value of `None`.

- *converters*, default value: not set

Config parsers provide option value getters that perform type conversion. By default `getint()`, `getfloat()`, and `getboolean()` are implemented. Should other getters be desirable, users may define them in a subclass or pass a dictionary where each key is a name of the converter and each value is a callable implementing said conversion. For instance, passing `{'decimal': decimal.Decimal}` would add `getdecimal()` on both the parser object and all section proxies. In other words, it will be possible to write both `parser_instance.getdecimal('section', 'key', fallback=0)` and `parser_instance['section'].getdecimal('key', 0)`.

If the converter needs to access the state of the parser, it can be implemented as a method on a config parser subclass. If the name of this method starts with `get`, it will be available on all section proxies, in the dict-compatible form (see the `getdecimal()` example above).

More advanced customization may be achieved by overriding default values of these parser attributes. The defaults are defined on the classes, so they may be overridden by subclasses or by attribute assignment.

`ConfigParser.BOOLEAN_STATES`

By default when using `getboolean()`, config parsers consider the following values `True`: `'1'`, `'yes'`, `'true'`, `'on'` and the following values `False`: `'0'`, `'no'`, `'false'`, `'off'`. You can override this by specifying a custom dictionary of strings and their Boolean outcomes. For example:

```
>>> custom = configparser.ConfigParser()
>>> custom['section1'] = {'funky': 'nope'}
>>> custom['section1'].getboolean('funky')
Traceback (most recent call last):
...
ValueError: Not a boolean: nope
>>> custom.BOOLEAN_STATES = {'sure': True, 'nope': False}
```

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```
>>> custom['section1'].getboolean('funky')
False
```

Other typical Boolean pairs include `accept/reject` or `enabled/disabled`.

`ConfigParser.optionxform(option)`

This method transforms option names on every read, get, or set operation. The default converts the name to lowercase. This also means that when a configuration file gets written, all keys will be lowercase. Override this method if that's unsuitable. For example:

```
>>> config = """
... [Section1]
... Key = Value
...
... [Section2]
... AnotherKey = Value
... """
>>> typical = configparser.ConfigParser()
>>> typical.read_string(config)
>>> list(typical['Section1'].keys())
['key']
>>> list(typical['Section2'].keys())
['anotherkey']
>>> custom = configparser.RawConfigParser()
>>> custom.optionxform = lambda option: option
>>> custom.read_string(config)
>>> list(custom['Section1'].keys())
['Key']
>>> list(custom['Section2'].keys())
['AnotherKey']
```

備 F: The `optionxform` function transforms option names to a canonical form. This should be an idempotent function: if the name is already in canonical form, it should be returned unchanged.

`ConfigParser.SECTCRE`

A compiled regular expression used to parse section headers. The default matches `[section]` to the name "section". Whitespace is considered part of the section name, thus `[larch]` will be read as a section of name " larch ". Override this attribute if that's unsuitable. For example:

```
>>> import re
>>> config = """
... [Section 1]
... option = value
...
... [ Section 2 ]
... another = val
... """
>>> typical = configparser.ConfigParser()
>>> typical.read_string(config)
>>> typical.sections()
['Section 1', ' Section 2 ']
>>> custom = configparser.ConfigParser()
>>> custom.SECTCRE = re.compile(r"\[ *(?P<header>[^\]]+?) *\]")
>>> custom.read_string(config)
>>> custom.sections()
['Section 1', 'Section 2']
```

備 F: While `ConfigParser` objects also use an `OPTCRE` attribute for recognizing option lines, it's not recom-

mended to override it because that would interfere with constructor options *allow_no_value* and *delimiters*.

14.2.8 Legacy API Examples

Mainly because of backwards compatibility concerns, *configparser* provides also a legacy API with explicit *get/set* methods. While there are valid use cases for the methods outlined below, mapping protocol access is preferred for new projects. The legacy API is at times more advanced, low-level and downright counterintuitive.

An example of writing to a configuration file:

```
import configparser

config = configparser.RawConfigParser()

# Please note that using RawConfigParser's set functions, you can assign
# non-string values to keys internally, but will receive an error when
# attempting to write to a file or when you get it in non-raw mode. Setting
# values using the mapping protocol or ConfigParser's set() does not allow
# such assignments to take place.
config.add_section('Section1')
config.set('Section1', 'an_int', '15')
config.set('Section1', 'a_bool', 'true')
config.set('Section1', 'a_float', '3.1415')
config.set('Section1', 'baz', 'fun')
config.set('Section1', 'bar', 'Python')
config.set('Section1', 'foo', '%(bar)s is %(baz)s!')

# Writing our configuration file to 'example.cfg'
with open('example.cfg', 'w') as configfile:
    config.write(configfile)
```

An example of reading the configuration file again:

```
import configparser

config = configparser.RawConfigParser()
config.read('example.cfg')

# getfloat() raises an exception if the value is not a float
# getint() and getboolean() also do this for their respective types
a_float = config.getfloat('Section1', 'a_float')
an_int = config.getint('Section1', 'an_int')
print(a_float + an_int)

# Notice that the next output does not interpolate '%(bar)s' or '%(baz)s'.
# This is because we are using a RawConfigParser().
if config.getboolean('Section1', 'a_bool'):
    print(config.get('Section1', 'foo'))
```

To get interpolation, use *ConfigParser*:

```
import configparser

cfg = configparser.ConfigParser()
cfg.read('example.cfg')

# Set the optional *raw* argument of get() to True if you wish to disable
# interpolation in a single get operation.
print(cfg.get('Section1', 'foo', raw=False)) # -> "Python is fun!"
print(cfg.get('Section1', 'foo', raw=True))  # -> "%(bar)s is %(baz)s!"
```

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```
# The optional *vars* argument is a dict with members that will take
# precedence in interpolation.
print(cfg.get('Section1', 'foo', vars={'bar': 'Documentation',
                                       'baz': 'evil'}))

# The optional *fallback* argument can be used to provide a fallback value
print(cfg.get('Section1', 'foo'))
# -> "Python is fun!"

print(cfg.get('Section1', 'foo', fallback='Monty is not.'))
# -> "Python is fun!"

print(cfg.get('Section1', 'monster', fallback='No such things as monsters.'))
# -> "No such things as monsters."

# A bare print(cfg.get('Section1', 'monster')) would raise NoOptionError
# but we can also use:

print(cfg.get('Section1', 'monster', fallback=None))
# -> None
```

Default values are available in both types of ConfigParsers. They are used in interpolation if an option used is not defined elsewhere.

```
import configparser

# New instance with 'bar' and 'baz' defaulting to 'Life' and 'hard' each
config = configparser.ConfigParser({'bar': 'Life', 'baz': 'hard'})
config.read('example.cfg')

print(config.get('Section1', 'foo'))      # -> "Python is fun!"
config.remove_option('Section1', 'bar')
config.remove_option('Section1', 'baz')
print(config.get('Section1', 'foo'))      # -> "Life is hard!"
```

14.2.9 ConfigParser 物件

```
class configparser.ConfigParser (defaults=None, dict_type=dict, allow_no_value=False,
                                delimiters=('=', ':'), comment_prefixes=(';', '#'),
                                inline_comment_prefixes=None, strict=True,
                                empty_lines_in_values=True,
                                default_section=configparser.DEFAULTSECT,
                                interpolation=BasicInterpolation(), converters={})
```

The main configuration parser. When *defaults* is given, it is initialized into the dictionary of intrinsic defaults. When *dict_type* is given, it will be used to create the dictionary objects for the list of sections, for the options within a section, and for the default values.

When *delimiters* is given, it is used as the set of substrings that divide keys from values. When *comment_prefixes* is given, it will be used as the set of substrings that prefix comments in otherwise empty lines. Comments can be indented. When *inline_comment_prefixes* is given, it will be used as the set of substrings that prefix comments in non-empty lines.

When *strict* is *True* (the default), the parser won't allow for any section or option duplicates while reading from a single source (file, string or dictionary), raising *DuplicateSectionError* or *DuplicateOptionError*. When *empty_lines_in_values* is *False* (default: *True*), each empty line marks the end of an option. Otherwise, internal empty lines of a multiline option are kept as part of the value. When *allow_no_value* is *True* (default: *False*), options without values are accepted; the value held for these is *None* and they are serialized without the trailing delimiter.

When *default_section* is given, it specifies the name for the special section holding default values for other sections and interpolation purposes (normally named "DEFAULT"). This value can be retrieved and changed at runtime using the *default_section* instance attribute. This won't re-evaluate an already parsed config file, but will be used when writing parsed settings to a new config file.

Interpolation behaviour may be customized by providing a custom handler through the *interpolation* argument. *None* can be used to turn off interpolation completely, *ExtendedInterpolation()* provides a more advanced variant inspired by *zc.buildout*. More on the subject in the [dedicated documentation section](#).

All option names used in interpolation will be passed through the *optionxform()* method just like any other option name reference. For example, using the default implementation of *optionxform()* (which converts option names to lower case), the values *foo %(bar)s* and *foo %(BAR)s* are equivalent.

When *converters* is given, it should be a dictionary where each key represents the name of a type converter and each value is a callable implementing the conversion from string to the desired datatype. Every converter gets its own corresponding *get*()* method on the parser object and section proxies.

在 3.1 版的變更: The default *dict_type* is *collections.OrderedDict*.

在 3.2 版的變更: *allow_no_value*, *delimiters*, *comment_prefixes*, *strict*, *empty_lines_in_values*, *default_section* and *interpolation* were added.

在 3.5 版的變更: 新增 *converters* 引數。

在 3.7 版的變更: The *defaults* argument is read with *read_dict()*, providing consistent behavior across the parser: non-string keys and values are implicitly converted to strings.

在 3.8 版的變更: The default *dict_type* is *dict*, since it now preserves insertion order.

defaults()

Return a dictionary containing the instance-wide defaults.

sections()

Return a list of the sections available; the *default section* is not included in the list.

add_section(section)

Add a section named *section* to the instance. If a section by the given name already exists, *DuplicateSectionError* is raised. If the *default section* name is passed, *ValueError* is raised. The name of the section must be a string; if not, *TypeError* is raised.

在 3.2 版的變更: Non-string section names raise *TypeError*.

has_section(section)

Indicates whether the named *section* is present in the configuration. The *default section* is not acknowledged.

options(section)

Return a list of options available in the specified *section*.

has_option(section, option)

If the given *section* exists, and contains the given *option*, return *True*; otherwise return *False*. If the specified *section* is *None* or an empty string, DEFAULT is assumed.

read(filename, encoding=None)

Attempt to read and parse an iterable of filenames, returning a list of filenames which were successfully parsed.

If *filenames* is a string, a *bytes* object or a *path-like object*, it is treated as a single filename. If a file named in *filenames* cannot be opened, that file will be ignored. This is designed so that you can specify an iterable of potential configuration file locations (for example, the current directory, the user's home directory, and some system-wide directory), and all existing configuration files in the iterable will be read.

If none of the named files exist, the *ConfigParser* instance will contain an empty dataset. An application which requires initial values to be loaded from a file should load the required file or files using *read_file()* before calling *read()* for any optional files:

```
import configparser, os

config = configparser.ConfigParser()
config.read_file(open('defaults.cfg'))
config.read(['site.cfg', os.path.expanduser('~/.myapp.cfg')],
            encoding='cp1250')
```

在 3.2 版的變更: Added the *encoding* parameter. Previously, all files were read using the default encoding for *open()*.

在 3.6.1 版的變更: The *filenames* parameter accepts a *path-like object*.

在 3.7 版的變更: The *filenames* parameter accepts a *bytes* object.

read_file (*f*, *source=None*)

Read and parse configuration data from *f* which must be an iterable yielding Unicode strings (for example files opened in text mode).

Optional argument *source* specifies the name of the file being read. If not given and *f* has a *name* attribute, that is used for *source*; the default is '*<??>*'.

在 3.2 版新加入: Replaces *readfp()*.

read_string (*string*, *source='<string>'*)

Parse configuration data from a string.

Optional argument *source* specifies a context-specific name of the string passed. If not given, '*<string>*' is used. This should commonly be a filesystem path or a URL.

在 3.2 版新加入.

read_dict (*dictionary*, *source='<dict>'*)

Load configuration from any object that provides a *dict-like items()* method. Keys are section names, values are dictionaries with keys and values that should be present in the section. If the used dictionary type preserves order, sections and their keys will be added in order. Values are automatically converted to strings.

Optional argument *source* specifies a context-specific name of the dictionary passed. If not given, *<dict>* is used.

This method can be used to copy state between parsers.

在 3.2 版新加入.

get (*section*, *option*, *, *raw=False*, *vars=None*[, *fallback*])

Get an *option* value for the named *section*. If *vars* is provided, it must be a dictionary. The *option* is looked up in *vars* (if provided), *section*, and in *DEFAULTSECT* in that order. If the key is not found and *fallback* is provided, it is used as a fallback value. *None* can be provided as a *fallback* value.

All the '*%*' interpolations are expanded in the return values, unless the *raw* argument is true. Values for interpolation keys are looked up in the same manner as the *option*.

在 3.2 版的變更: Arguments *raw*, *vars* and *fallback* are keyword only to protect users from trying to use the third argument as the *fallback* fallback (especially when using the mapping protocol).

getint (*section*, *option*, *, *raw=False*, *vars=None*[, *fallback*])

A convenience method which coerces the *option* in the specified *section* to an integer. See *get()* for explanation of *raw*, *vars* and *fallback*.

getfloat (*section*, *option*, *, *raw=False*, *vars=None*[, *fallback*])

A convenience method which coerces the *option* in the specified *section* to a floating point number. See *get()* for explanation of *raw*, *vars* and *fallback*.

getboolean (*section*, *option*, *, *raw*=*False*, *vars*=*None*[, *fallback*])

A convenience method which coerces the *option* in the specified *section* to a Boolean value. Note that the accepted values for the option are '1', 'yes', 'true', and 'on', which cause this method to return *True*, and '0', 'no', 'false', and 'off', which cause it to return *False*. These string values are checked in a case-insensitive manner. Any other value will cause it to raise *ValueError*. See *get()* for explanation of *raw*, *vars* and *fallback*.

items (*raw*=*False*, *vars*=*None*)

items (*section*, *raw*=*False*, *vars*=*None*)

When *section* is not given, return a list of *section_name*, *section_proxy* pairs, including *DEFAULTSECT*.

Otherwise, return a list of *name*, *value* pairs for the options in the given *section*. Optional arguments have the same meaning as for the *get()* method.

在 3.8 版的變更: Items present in *vars* no longer appear in the result. The previous behaviour mixed actual parser options with variables provided for interpolation.

set (*section*, *option*, *value*)

If the given section exists, set the given option to the specified value; otherwise raise *NoSectionError*. *option* and *value* must be strings; if not, *TypeError* is raised.

write (*fileobject*, *space_around_delimiters*=*True*)

Write a representation of the configuration to the specified *file object*, which must be opened in text mode (accepting strings). This representation can be parsed by a future *read()* call. If *space_around_delimiters* is true, delimiters between keys and values are surrounded by spaces.

備 註: Comments in the original configuration file are not preserved when writing the configuration back. What is considered a comment, depends on the given values for *comment_prefix* and *inline_comment_prefix*.

remove_option (*section*, *option*)

Remove the specified *option* from the specified *section*. If the section does not exist, raise *NoSectionError*. If the option existed to be removed, return *True*; otherwise return *False*.

remove_section (*section*)

Remove the specified *section* from the configuration. If the section in fact existed, return *True*. Otherwise return *False*.

optionxform (*option*)

Transforms the option name *option* as found in an input file or as passed in by client code to the form that should be used in the internal structures. The default implementation returns a lower-case version of *option*; subclasses may override this or client code can set an attribute of this name on instances to affect this behavior.

You don't need to subclass the parser to use this method, you can also set it on an instance, to a function that takes a string argument and returns a string. Setting it to *str*, for example, would make option names case sensitive:

```
cfgparser = ConfigParser()
cfgparser.optionxform = str
```

Note that when reading configuration files, whitespace around the option names is stripped before *optionxform()* is called.

readfp (*fp*, *filename*=*None*)

在 3.2 版之後被 註 用: Use *read_file()* instead.

在 3.2 版的變更: *readfp()* now iterates on *fp* instead of calling *fp.readline()*.

For existing code calling *readfp()* with arguments which don't support iteration, the following generator may be used as a wrapper around the file-like object:

```
def readline_generator(fp):
    line = fp.readline()
    while line:
        yield line
        line = fp.readline()
```

Instead of `parser.readfp(fp)` use `parser.read_file(readline_generator(fp))`.

`configparser.MAX_INTERPOLATION_DEPTH`

The maximum depth for recursive interpolation for `get()` when the `raw` parameter is false. This is relevant only when the default *interpolation* is used.

14.2.10 RawConfigParser 物件

```
class configparser.RawConfigParser (defaults=None, dict_type=dict, allow_no_value=False, *,
                                     delimiters=('=', ':'), comment_prefixes=(';', '#'),
                                     inline_comment_prefixes=None, strict=True,
                                     empty_lines_in_values=True,
                                     default_section=configparser.DEFAULTSECT[, interpolation
                                     ])
```

Legacy variant of the *ConfigParser*. It has interpolation disabled by default and allows for non-string section names, option names, and values via its unsafe `add_section` and `set` methods, as well as the legacy `defaults=` keyword argument handling.

在 3.8 版的變更: The default `dict_type` is *dict*, since it now preserves insertion order.

備F: Consider using *ConfigParser* instead which checks types of the values to be stored internally. If you don't want interpolation, you can use `ConfigParser(interpolation=None)`.

add_section (*section*)

Add a section named *section* to the instance. If a section by the given name already exists, *DuplicateSectionError* is raised. If the *default section* name is passed, *ValueError* is raised.

Type of *section* is not checked which lets users create non-string named sections. This behaviour is unsupported and may cause internal errors.

set (*section, option, value*)

If the given section exists, set the given option to the specified value; otherwise raise *NoSectionError*. While it is possible to use *RawConfigParser* (or *ConfigParser* with *raw* parameters set to true) for *internal* storage of non-string values, full functionality (including interpolation and output to files) can only be achieved using string values.

This method lets users assign non-string values to keys internally. This behaviour is unsupported and will cause errors when attempting to write to a file or get it in non-raw mode. **Use the mapping protocol API** which does not allow such assignments to take place.

14.2.11 例外

exception `configparser.Error`

Base class for all other *configparser* exceptions.

exception `configparser.NoSectionError`

Exception raised when a specified section is not found.

exception configparser.DuplicateSectionError

Exception raised if `add_section()` is called with the name of a section that is already present or in strict parsers when a section is found more than once in a single input file, string or dictionary.

在 3.2 版的變更: Added the optional *source* and *lineno* attributes and parameters to `__init__()`.

exception configparser.DuplicateOptionError

Exception raised by strict parsers if a single option appears twice during reading from a single file, string or dictionary. This catches misspellings and case sensitivity-related errors, e.g. a dictionary may have two keys representing the same case-insensitive configuration key.

exception configparser.NoOptionError

Exception raised when a specified option is not found in the specified section.

exception configparser.InterpolationError

Base class for exceptions raised when problems occur performing string interpolation.

exception configparser.InterpolationDepthError

Exception raised when string interpolation cannot be completed because the number of iterations exceeds `MAX_INTERPOLATION_DEPTH`. Subclass of `InterpolationError`.

exception configparser.InterpolationMissingOptionError

Exception raised when an option referenced from a value does not exist. Subclass of `InterpolationError`.

exception configparser.InterpolationSyntaxError

Exception raised when the source text into which substitutions are made does not conform to the required syntax. Subclass of `InterpolationError`.

exception configparser.MissingSectionHeaderError

Exception raised when attempting to parse a file which has no section headers.

exception configparser.ParsingError

Exception raised when errors occur attempting to parse a file.

在 3.2 版的變更: The *filename* attribute and `__init__()` argument were renamed to *source* for consistency.

解

14.3 tomllib --- 剖析 TOML 檔案

在 3.11 版新加入。

原始碼: [Lib/tomllib](#)

此模組提供了剖析 TOML (Tom's Obvious Minimal Language, <https://toml.io>) 的一個介面，此模組不支援寫入 TOML。

也參考:

Tomli-W 套件是一個 TOML 編寫器，可以與此模組結合使用，以提供標準函式庫中 *marshal* 和 *pickle* 模組之使用者所熟悉的寫入 API。

也參考:

TOML 工具套件是一個保留風格且具有讀寫能力的 TOML 函式庫。若要編輯已存在的 TOML 文件，建議用它來替此模組。

此模組定義了以下函式：

`tomllib.load(fp, /, *, parse_float=float)`

讀取一個 TOML 檔案。第一個引數應一個可讀取的二進制檔案物件。回傳一個 *dict*。用這個轉表將 TOML 型轉成 Python 的。

parse_float 會被呼叫於要解碼的每個 TOML 浮點數字串。預設情況下，這相當於 `float(num_str)`。若有使用另一種資料型或剖析器的 TOML 浮點數（例如 `decimal.Decimal`），這就派得上用場。可呼叫物件不得回傳 *dict* 或 *list*，否則會引發 *ValueError*。

不合格的 TOML 文件會使得 *TOMLDecodeError* 被引發。

`tomllib.loads(s, /, *, parse_float=float)`

自一個 *str* 物件載入成 TOML。回傳一個 *dict*。用這個轉表轉 TOML 型成 Python 的。*parse_float* 引數和 `load()` 中的相同。

不合格的 TOML 文件會使得 *TOMLDecodeError* 被引發。

以下可用的例外：

exception `tomllib.TOMLDecodeError`
ValueError 的子類。

14.3.1 范例

剖析一個 TOML 檔案：

```
import tomllib

with open("pyproject.toml", "rb") as f:
    data = tomllib.load(f)
```

剖析一個 TOML 字串：

```
import tomllib

toml_str = """
python-version = "3.11.0"
python-implementation = "CPython"
"""

data = tomllib.loads(toml_str)
```

14.3.2 轉表

TOML	Python
TOML document	<i>dict</i>
string	<i>str</i>
integer	<i>int</i>
float	<i>float</i> （可透過 <i>parse_float</i> 調整）
boolean	<i>bool</i>
偏移日期時間 (offset date-time)	<i>datetime.datetime</i> （設定 <i>tzinfo</i> 屬性 <i>datetime.timezone</i> 的實例）
本地日期時間 (local date-time)	<i>datetime.datetime</i> （設定 <i>tzinfo</i> 為 <i>None</i> ）
本地日期 (local date)	<i>datetime.date</i>
本地時間 (local time)	<i>datetime.time</i>
array	<i>list</i>
table	<i>dict</i>
inline table	<i>dict</i>
array of tables	<i>list of dicts</i>

14.4 netrc --- netrc 檔案處理

原始碼: [Lib/netrc.py](#)

`netrc` 類能剖析 (parse) 封裝 (encapsulate) `netrc` 檔案格式，以供 Unix `ftp` 程式和其他 FTP 用端使用。

class `netrc.netrc` (`[file]`)

`netrc` 實例或其子類實例能封裝來自 `netrc` 檔案的資料。可用初始化引數（如有給定）指定要剖析的檔案，如果未給定引數，則將讀取（由 `os.path.expanduser()` 指定的）使用者主目錄中的 `.netrc` 檔案，否則將引發 `FileNotFoundError` 例外。剖析錯誤會引發 `NetrcParseError`，其帶有包括檔案名稱、列號和終止 token 的診斷資訊。如果在 POSIX 系統上未指定引數，且若檔案所有權或權限不安全（擁有者與運行該行程的使用者不同，或者可供任何其他使用者讀取或寫入），存有密碼的 `.netrc` 檔案將會引發 `NetrcParseError`。這實作了與 `ftp` 和其他使用 `.netrc` 程式等效的安全行。

在 3.4 版的變更: 新增了 POSIX 權限檢查。

在 3.7 版的變更: 當未傳遞 `file` 引數時，`os.path.expanduser()` 可用於查找 `.netrc` 檔案的位置。

在 3.10 版的變更: `netrc` 在使用特定語言環境編碼前會先嘗試 UTF-8 編碼。`netrc` 檔案中的條目就不再需要包含所有 token，缺少的 token 值被預設為空字串。現在所有 token 及其值都可以包含任意字元，例如空格和非 ASCII 字元。如果登入名稱匿名，就不會觸發安全檢查。

exception `netrc.NetrcParseError`

Exception raised by the `netrc` class when syntactical errors are encountered in source text. Instances of this exception provide three interesting attributes:

msg

Textual explanation of the error.

filename

The name of the source file.

lineno

The line number on which the error was found.

14.4.1 netrc 物件

`netrc` 實例具有以下方法：

netrc.authenticators (`host`)

回傳 `host` 身份驗證器的三元素 tuple (login, account, password)。如果 `netrc` 檔案不包含給定主機的條目，則回傳與 'default' 條目關聯的 tuple。如果無匹配主機且預設條目也不可則回傳 None。

netrc.__repr__ ()

將類資料傾印 (dump) 為 `netrc` 檔案格式的字串。（這會將解移除，可能會對條目重新排序。）

`netrc` 的實例具有公開實例變數：

netrc.hosts

將主機名稱對映到 (login, account, password) tuple 的字典。'default' 條目（如存在）表示該名稱對應到的主機 (pseudo-host)。

netrc.macros

巨集 (macro) 名稱與字串 list (串列) 的對映字典。

14.5 plistlib --- Generate and parse Apple .plist files

原始碼: [Lib/plistlib.py](#)

This module provides an interface for reading and writing the “property list” files used by Apple, primarily on macOS and iOS. This module supports both binary and XML plist files.

The property list (`.plist`) file format is a simple serialization supporting basic object types, like dictionaries, lists, numbers and strings. Usually the top level object is a dictionary.

To write out and to parse a plist file, use the `dump()` and `load()` functions.

To work with plist data in bytes objects, use `dumps()` and `loads()`.

Values can be strings, integers, floats, booleans, tuples, lists, dictionaries (but only with string keys), `bytes`, `bytearray` or `datetime.datetime` objects.

在 3.4 版的變更: New API, old API deprecated. Support for binary format plists added.

在 3.8 版的變更: Support added for reading and writing `UID` tokens in binary plists as used by `NSKeyedArchiver` and `NSKeyedUnarchiver`.

在 3.9 版的變更: Old API removed.

也參考:

PList manual page

Apple’s documentation of the file format.

This module defines the following functions:

`plistlib.load(fp, *, fmt=None, dict_type=dict)`

Read a plist file. `fp` should be a readable and binary file object. Return the unpacked root object (which usually is a dictionary).

The `fmt` is the format of the file and the following values are valid:

- `None`: Autodetect the file format
- `FMT_XML`: XML file format
- `FMT_BINARY`: Binary plist format

The `dict_type` is the type used for dictionaries that are read from the plist file.

XML data for the `FMT_XML` format is parsed using the Expat parser from `xml.parsers.expat` -- see its documentation for possible exceptions on ill-formed XML. Unknown elements will simply be ignored by the plist parser.

The parser for the binary format raises `InvalidFileException` when the file cannot be parsed.

在 3.4 版新加入.

`plistlib.loads(data, *, fmt=None, dict_type=dict)`

Load a plist from a bytes object. See `load()` for an explanation of the keyword arguments.

在 3.4 版新加入.

`plistlib.dump(value, fp, *, fmt=FMT_XML, sort_keys=True, skipkeys=False)`

Write `value` to a plist file. `fp` should be a writable, binary file object.

The `fmt` argument specifies the format of the plist file and can be one of the following values:

- `FMT_XML`: XML formatted plist file
- `FMT_BINARY`: Binary formatted plist file

When `sort_keys` is true (the default) the keys for dictionaries will be written to the plist in sorted order, otherwise they will be written in the iteration order of the dictionary.

When `skipkeys` is false (the default) the function raises `TypeError` when a key of a dictionary is not a string, otherwise such keys are skipped.

A `TypeError` will be raised if the object is of an unsupported type or a container that contains objects of unsupported types.

An `OverflowError` will be raised for integer values that cannot be represented in (binary) plist files.

在 3.4 版新加入。

`plistlib.dumps (value, *, fmt=FMT_XML, sort_keys=True, skipkeys=False)`

Return `value` as a plist-formatted bytes object. See the documentation for `dump()` for an explanation of the keyword arguments of this function.

在 3.4 版新加入。

The following classes are available:

class `plistlib.UID (data)`

Wraps an `int`. This is used when reading or writing NSKeyedArchiver encoded data, which contains UID (see PList manual).

It has one attribute, `data`, which can be used to retrieve the int value of the UID. `data` must be in the range `0 <= data < 2**64`.

在 3.8 版新加入。

The following constants are available:

`plistlib.FMT_XML`

The XML format for plist files.

在 3.4 版新加入。

`plistlib.FMT_BINARY`

The binary format for plist files

在 3.4 版新加入。

14.5.1 范例

Generating a plist:

```
import datetime
import plistlib

pl = dict(
    aString = "Doodah",
    aList = ["A", "B", 12, 32.1, [1, 2, 3]],
    aFloat = 0.1,
    anInt = 728,
    aDict = dict(
        anotherString = "<hello & hi there!>",
        aThirdString = "M\ue4ssig, Ma\xdf",
        aTrueValue = True,
        aFalseValue = False,
    ),
    someData = b"<binary gunk>",
    someMoreData = b"<lots of binary gunk>" * 10,
    aDate = datetime.datetime.now()
)
print(plistlib.dumps(pl).decode())
```

Parsing a plist:

```
import plistlib

plist = b"<plist version='1.0'>
<dict>
  <key>foo</key>
  <string>bar</string>
</dict>
</plist>"
pl = plistlib.loads(plist)
print(pl["foo"])
```

本章所描述的模組 (module) 實作了多種加密演算法。它們可以在安裝時選擇是否一同安裝。在 Unix 系統上, `crypt` 模組也有機會能被使用。以下概述:

15.1 hashlib --- Secure hashes and message digests

原始碼: [Lib/hashlib.py](#)

This module implements a common interface to many different secure hash and message digest algorithms. Included are the FIPS secure hash algorithms SHA1, SHA224, SHA256, SHA384, SHA512, (defined in the [FIPS 180-4 standard](#)), the SHA-3 series (defined in the [FIPS 202 standard](#)) as well as RSA's MD5 algorithm (defined in internet [RFC 1321](#)). The terms "secure hash" and "message digest" are interchangeable. Older algorithms were called message digests. The modern term is secure hash.

備註: If you want the `adler32` or `crc32` hash functions, they are available in the `zlib` module.

15.1.1 雜湊演算法

There is one constructor method named for each type of *hash*. All return a hash object with the same simple interface. For example: use `sha256()` to create a SHA-256 hash object. You can now feed this object with *bytes-like objects* (normally *bytes*) using the `update` method. At any point you can ask it for the *digest* of the concatenation of the data fed to it so far using the `digest()` or `hexdigest()` methods.

To allow multithreading, the Python *GIL* is released while computing a hash supplied more than 2047 bytes of data at once in its constructor or `.update` method.

Constructors for hash algorithms that are always present in this module are `sha1()`, `sha224()`, `sha256()`, `sha384()`, `sha512()`, `sha3_224()`, `sha3_256()`, `sha3_384()`, `sha3_512()`, `shake_128()`, `shake_256()`, `blake2b()`, and `blake2s()`. `md5()` is normally available as well, though it may be missing or blocked if you are using a rare "FIPS compliant" build of Python. These correspond to *algorithms_guaranteed*.

Additional algorithms may also be available if your Python distribution's `hashlib` was linked against a build of OpenSSL that provides others. Others *are not guaranteed available* on all installations and will only be accessible by name via `new()`. See [algorithms_available](#).

警告： Some algorithms have known hash collision weaknesses (including MD5 and SHA1). Refer to [Attacks on cryptographic hash algorithms](#) and the [hashlib-seealso](#) section at the end of this document.

在 3.6 版新加入: SHA3 (Keccak) and SHAKE constructors `sha3_224()`, `sha3_256()`, `sha3_384()`, `sha3_512()`, `shake_128()`, `shake_256()` were added. `blake2b()` and `blake2s()` were added. 在 3.9 版的變更: All hashlib constructors take a keyword-only argument `usedforsecurity` with default value `True`. A false value allows the use of insecure and blocked hashing algorithms in restricted environments. False indicates that the hashing algorithm is not used in a security context, e.g. as a non-cryptographic one-way compression function.

在 3.9 版的變更: Hashlib now uses SHA3 and SHAKE from OpenSSL if it provides it.

15.1.2 用法

To obtain the digest of the byte string `b"Nobody inspects the spammish repetition"`:

```
>>> import hashlib
>>> m = hashlib.sha256()
>>> m.update(b"Nobody inspects")
>>> m.update(b" the spammish repetition")
>>> m.digest()
b'\x03\x1e\xddAe\x15\x93\xc5\xfe\\x00o\xa5u+7\xfd\xdf\xf7\xbcN\x84:\xa6\xaf\x0c\x
↪x95\x0fK\x94\x06'
>>> m.hexdigest()
'031edd7d41651593c5fe5c006fa5752b37fddff7bc4e843aa6af0c950f4b9406'
```

More condensed:

```
>>> hashlib.sha256(b"Nobody inspects the spammish repetition").hexdigest()
'031edd7d41651593c5fe5c006fa5752b37fddff7bc4e843aa6af0c950f4b9406'
```

15.1.3 建構函式

`hashlib.new(name, [data,], *, usedforsecurity=True)`

Is a generic constructor that takes the string `name` of the desired algorithm as its first parameter. It also exists to allow access to the above listed hashes as well as any other algorithms that your OpenSSL library may offer.

Using `new()` with an algorithm name:

```
>>> h = hashlib.new('sha256')
>>> h.update(b"Nobody inspects the spammish repetition")
>>> h.hexdigest()
'031edd7d41651593c5fe5c006fa5752b37fddff7bc4e843aa6af0c950f4b9406'
```

`hashlib.md5([data,], *, usedforsecurity=True)`

`hashlib.sha1([data,], *, usedforsecurity=True)`

`hashlib.sha224([data,], *, usedforsecurity=True)`

`hashlib.sha256([data,], *, usedforsecurity=True)`

```

hashlib.sha384([data, ], *, usedforsecurity=True)
hashlib.sha512([data, ], *, usedforsecurity=True)
hashlib.sha3_224([data, ], *, usedforsecurity=True)
hashlib.sha3_256([data, ], *, usedforsecurity=True)
hashlib.sha3_384([data, ], *, usedforsecurity=True)
hashlib.sha3_512([data, ], *, usedforsecurity=True)

```

Named constructors such as these are faster than passing an algorithm name to `new()`.

15.1.4 Attributes

Hashlib provides the following constant module attributes:

hashlib.algorithms_guaranteed

A set containing the names of the hash algorithms guaranteed to be supported by this module on all platforms. Note that 'md5' is in this list despite some upstream vendors offering an odd "FIPS compliant" Python build that excludes it.

在 3.2 版新加入。

hashlib.algorithms_available

A set containing the names of the hash algorithms that are available in the running Python interpreter. These names will be recognized when passed to `new()`. `algorithms_guaranteed` will always be a subset. The same algorithm may appear multiple times in this set under different names (thanks to OpenSSL).

在 3.2 版新加入。

15.1.5 Hash Objects

The following values are provided as constant attributes of the hash objects returned by the constructors:

hash.digest_size

The size of the resulting hash in bytes.

hash.block_size

The internal block size of the hash algorithm in bytes.

A hash object has the following attributes:

hash.name

The canonical name of this hash, always lowercase and always suitable as a parameter to `new()` to create another hash of this type.

在 3.4 版的變更: The name attribute has been present in CPython since its inception, but until Python 3.4 was not formally specified, so may not exist on some platforms.

A hash object has the following methods:

hash.update(data)

Update the hash object with the *bytes-like object*. Repeated calls are equivalent to a single call with the concatenation of all the arguments: `m.update(a)`; `m.update(b)` is equivalent to `m.update(a+b)`.

在 3.1 版的變更: The Python GIL is released to allow other threads to run while hash updates on data larger than 2047 bytes is taking place when using hash algorithms supplied by OpenSSL.

`hash.digest()`

Return the digest of the data passed to the `update()` method so far. This is a bytes object of size `digest_size` which may contain bytes in the whole range from 0 to 255.

`hash.hexdigest()`

Like `digest()` except the digest is returned as a string object of double length, containing only hexadecimal digits. This may be used to exchange the value safely in email or other non-binary environments.

`hash.copy()`

Return a copy ("clone") of the hash object. This can be used to efficiently compute the digests of data sharing a common initial substring.

15.1.6 SHAKE variable length digests

`hashlib.shake_128([data,], usedforsecurity=True)`

`hashlib.shake_256([data,], usedforsecurity=True)`

The `shake_128()` and `shake_256()` algorithms provide variable length digests with `length_in_bits//2` up to 128 or 256 bits of security. As such, their digest methods require a length. Maximum length is not limited by the SHAKE algorithm.

`shake.digest(length)`

Return the digest of the data passed to the `update()` method so far. This is a bytes object of size `length` which may contain bytes in the whole range from 0 to 255.

`shake.hexdigest(length)`

Like `digest()` except the digest is returned as a string object of double length, containing only hexadecimal digits. This may be used to exchange the value in email or other non-binary environments.

範例：

```
>>> h = hashlib.shake_256(b'Nobody inspects the spammish repetition')
>>> h.hexdigest(20)
'44709d6fcb83d92a76dcb0b668c98e1b1d3dafe7'
```

15.1.7 File hashing

The `hashlib` module provides a helper function for efficient hashing of a file or file-like object.

`hashlib.file_digest(fileobj, digest, /)`

Return a digest object that has been updated with contents of file object.

`fileobj` must be a file-like object opened for reading in binary mode. It accepts file objects from builtin `open()`, `BytesIO` instances, `SocketIO` objects from `socket.socket.makefile()`, and similar. The function may bypass Python's I/O and use the file descriptor from `fileno()` directly. `fileobj` must be assumed to be in an unknown state after this function returns or raises. It is up to the caller to close `fileobj`.

`digest` must either be a hash algorithm name as a *str*, a hash constructor, or a callable that returns a hash object.

範例：

```
>>> import io, hashlib, hmac
>>> with open(hashlib.__file__, "rb") as f:
...     digest = hashlib.file_digest(f, "sha256")
...
>>> digest.hexdigest()
'...'
```



```
>>> buf = io.BytesIO(b"somedata")
>>> mac1 = hmac.HMAC(b"key", digestmod=hashlib.sha512)
>>> digest = hashlib.file_digest(buf, lambda: mac1)
```

```
>>> digest is mac1
True
>>> mac2 = hmac.HMAC(b"key", b"somedata", digestmod=hashlib.sha512)
>>> mac1.digest() == mac2.digest()
True
```

在 3.11 版新加入。

15.1.8 Key derivation

Key derivation and key stretching algorithms are designed for secure password hashing. Naive algorithms such as `sha1(password)` are not resistant against brute-force attacks. A good password hashing function must be tunable, slow, and include a *salt*.

`hashlib.pbkdf2_hmac` (*hash_name*, *password*, *salt*, *iterations*, *dklen=None*)

The function provides PKCS#5 password-based key derivation function 2. It uses HMAC as pseudorandom function.

The string *hash_name* is the desired name of the hash digest algorithm for HMAC, e.g. 'sha1' or 'sha256'. *password* and *salt* are interpreted as buffers of bytes. Applications and libraries should limit *password* to a sensible length (e.g. 1024). *salt* should be about 16 or more bytes from a proper source, e.g. `os.urandom()`.

The number of *iterations* should be chosen based on the hash algorithm and computing power. As of 2022, hundreds of thousands of iterations of SHA-256 are suggested. For rationale as to why and how to choose what is best for your application, read *Appendix A.2.2* of *NIST-SP-800-132*. The answers on the [stackexchange pbkdf2 iterations question](#) explain in detail.

dklen is the length of the derived key. If *dklen* is `None` then the digest size of the hash algorithm *hash_name* is used, e.g. 64 for SHA-512.

```
>>> from hashlib import pbkdf2_hmac
>>> our_app_iters = 500_000 # Application specific, read above.
>>> dk = pbkdf2_hmac('sha256', b'password', b'bad salt'*2, our_app_iters)
>>> dk.hex()
'15530bba69924174860db778f2c6f8104d3aaf9d26241840c8c4a641c8d000a9'
```

在 3.4 版新加入。

備註: A fast implementation of `pbkdf2_hmac` is available with OpenSSL. The Python implementation uses an inline version of `hmac`. It is about three times slower and doesn't release the GIL.

在 3.10 版之後被禁用: Slow Python implementation of `pbkdf2_hmac` is deprecated. In the future the function will only be available when Python is compiled with OpenSSL.

`hashlib.scrypt` (*password*, ***, *salt*, *n*, *r*, *p*, *maxmem=0*, *dklen=64*)

The function provides scrypt password-based key derivation function as defined in **RFC 7914**.

password and *salt* must be *bytes-like objects*. Applications and libraries should limit *password* to a sensible length (e.g. 1024). *salt* should be about 16 or more bytes from a proper source, e.g. `os.urandom()`.

n is the CPU/Memory cost factor, *r* the block size, *p* parallelization factor and *maxmem* limits memory (OpenSSL 1.1.0 defaults to 32 MiB). *dklen* is the length of the derived key.

在 3.6 版新加入。

15.1.9 BLAKE2

BLAKE2 is a cryptographic hash function defined in [RFC 7693](#) that comes in two flavors:

- **BLAKE2b**, optimized for 64-bit platforms and produces digests of any size between 1 and 64 bytes,
- **BLAKE2s**, optimized for 8- to 32-bit platforms and produces digests of any size between 1 and 32 bytes.

BLAKE2 supports **keyed mode** (a faster and simpler replacement for [HMAC](#)), **salted hashing**, **personalization**, and **tree hashing**.

Hash objects from this module follow the API of standard library's [hashlib](#) objects.

Creating hash objects

New hash objects are created by calling constructor functions:

```
hashlib.blake2b(data=b", *, digest_size=64, key=b", salt=b", person=b", fanout=1, depth=1, leaf_size=0,
node_offset=0, node_depth=0, inner_size=0, last_node=False, usedforsecurity=True)
```

```
hashlib.blake2s(data=b", *, digest_size=32, key=b", salt=b", person=b", fanout=1, depth=1, leaf_size=0,
node_offset=0, node_depth=0, inner_size=0, last_node=False, usedforsecurity=True)
```

These functions return the corresponding hash objects for calculating BLAKE2b or BLAKE2s. They optionally take these general parameters:

- *data*: initial chunk of data to hash, which must be *bytes-like object*. It can be passed only as positional argument.
- *digest_size*: size of output digest in bytes.
- *key*: key for keyed hashing (up to 64 bytes for BLAKE2b, up to 32 bytes for BLAKE2s).
- *salt*: salt for randomized hashing (up to 16 bytes for BLAKE2b, up to 8 bytes for BLAKE2s).
- *person*: personalization string (up to 16 bytes for BLAKE2b, up to 8 bytes for BLAKE2s).

The following table shows limits for general parameters (in bytes):

Hash	digest_size	len(key)	len(salt)	len(person)
BLAKE2b	64	64	16	16
BLAKE2s	32	32	8	8

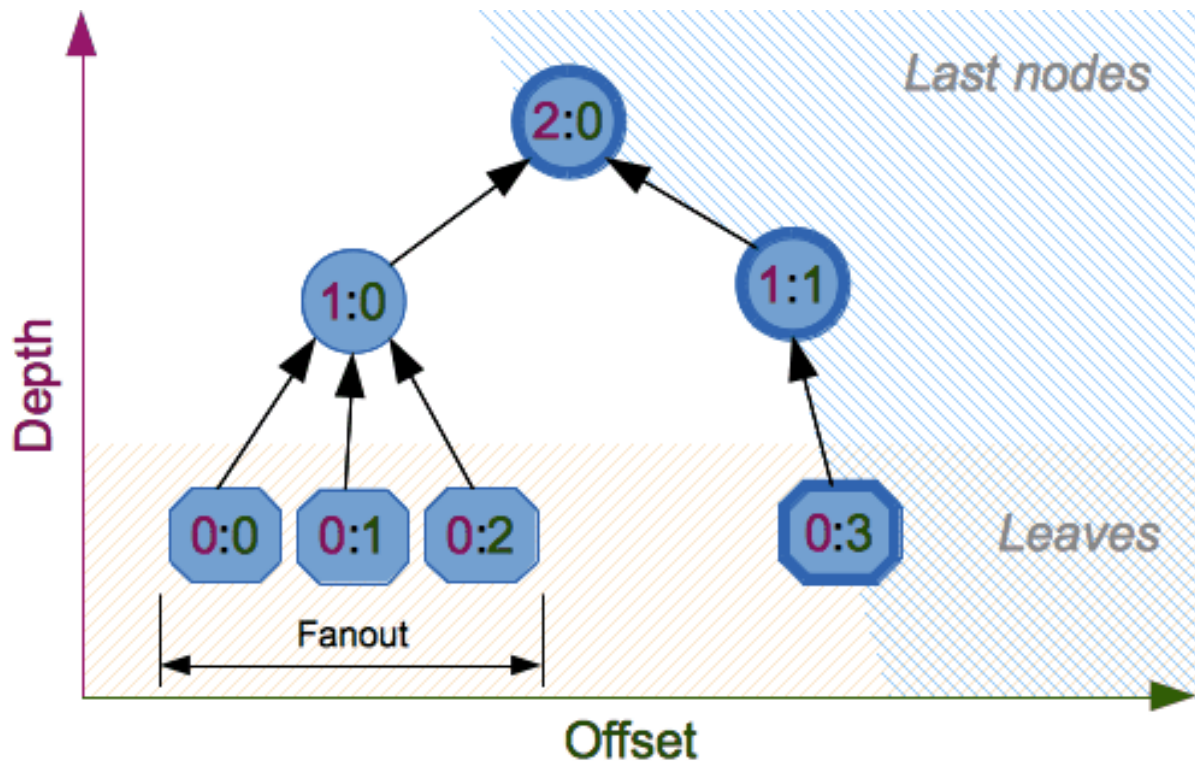
備 F: BLAKE2 specification defines constant lengths for salt and personalization parameters, however, for convenience, this implementation accepts byte strings of any size up to the specified length. If the length of the parameter is less than specified, it is padded with zeros, thus, for example, `b'salt'` and `b'salt\x00'` is the same value. (This is not the case for *key*.)

These sizes are available as module [constants](#) described below.

Constructor functions also accept the following tree hashing parameters:

- *fanout*: fanout (0 to 255, 0 if unlimited, 1 in sequential mode).
- *depth*: maximal depth of tree (1 to 255, 255 if unlimited, 1 in sequential mode).
- *leaf_size*: maximal byte length of leaf (0 to $2^{*}32-1$, 0 if unlimited or in sequential mode).
- *node_offset*: node offset (0 to $2^{*}64-1$ for BLAKE2b, 0 to $2^{*}48-1$ for BLAKE2s, 0 for the first, leftmost, leaf, or in sequential mode).
- *node_depth*: node depth (0 to 255, 0 for leaves, or in sequential mode).
- *inner_size*: inner digest size (0 to 64 for BLAKE2b, 0 to 32 for BLAKE2s, 0 in sequential mode).

- *last_node*: boolean indicating whether the processed node is the last one (`False` for sequential mode).



See section 2.10 in [BLAKE2 specification](#) for comprehensive review of tree hashing.

常數

`blake2b.SALT_SIZE`

`blake2s.SALT_SIZE`

Salt length (maximum length accepted by constructors).

`blake2b.PERSON_SIZE`

`blake2s.PERSON_SIZE`

Personalization string length (maximum length accepted by constructors).

`blake2b.MAX_KEY_SIZE`

`blake2s.MAX_KEY_SIZE`

Maximum key size.

`blake2b.MAX_DIGEST_SIZE`

`blake2s.MAX_DIGEST_SIZE`

Maximum digest size that the hash function can output.

范例

Simple hashing

To calculate hash of some data, you should first construct a hash object by calling the appropriate constructor function (`blake2b()` or `blake2s()`), then update it with the data by calling `update()` on the object, and, finally, get the digest out of the object by calling `digest()` (or `hexdigest()` for hex-encoded string).

```
>>> from hashlib import blake2b
>>> h = blake2b()
>>> h.update(b'Hello world')
>>> h.hexdigest()

↪ '6ff843ba685842aa82031d3f53c48b66326df7639a63d128974c5c14f31a0f33343a8c65551134ed1ae0f2b0dd2bb4'
↪ '
```

As a shortcut, you can pass the first chunk of data to update directly to the constructor as the positional argument:

```
>>> from hashlib import blake2b
>>> blake2b(b'Hello world').hexdigest()

↪ '6ff843ba685842aa82031d3f53c48b66326df7639a63d128974c5c14f31a0f33343a8c65551134ed1ae0f2b0dd2bb4'
↪ '
```

You can call `hash.update()` as many times as you need to iteratively update the hash:

```
>>> from hashlib import blake2b
>>> items = [b'Hello', b' ', b'world']
>>> h = blake2b()
>>> for item in items:
...     h.update(item)
>>> h.hexdigest()

↪ '6ff843ba685842aa82031d3f53c48b66326df7639a63d128974c5c14f31a0f33343a8c65551134ed1ae0f2b0dd2bb4'
↪ '
```

Using different digest sizes

BLAKE2 has configurable size of digests up to 64 bytes for BLAKE2b and up to 32 bytes for BLAKE2s. For example, to replace SHA-1 with BLAKE2b without changing the size of output, we can tell BLAKE2b to produce 20-byte digests:

```
>>> from hashlib import blake2b
>>> h = blake2b(digest_size=20)
>>> h.update(b'Replacing SHA1 with the more secure function')
>>> h.hexdigest()
'd24f26cf8de66472d58d4e1b1774b4c9158b1f4c'
>>> h.digest_size
20
>>> len(h.digest())
20
```

Hash objects with different digest sizes have completely different outputs (shorter hashes are *not* prefixes of longer hashes); BLAKE2b and BLAKE2s produce different outputs even if the output length is the same:

```
>>> from hashlib import blake2b, blake2s
>>> blake2b(digest_size=10).hexdigest()
'6fa1d8fcfd719046d762'
>>> blake2b(digest_size=11).hexdigest()
```

(繼續下一頁)

(繼續上一頁)

```
'eb6ec15daf9546254f0809'
>>> blake2s(digest_size=10).hexdigest()
'1bf21a98c78a1c376ae9'
>>> blake2s(digest_size=11).hexdigest()
'567004bf96e4a25773ebf4'
```

Keyed hashing

Keyed hashing can be used for authentication as a faster and simpler replacement for [Hash-based message authentication code](#) (HMAC). BLAKE2 can be securely used in prefix-MAC mode thanks to the indistinguishability property inherited from BLAKE.

This example shows how to get a (hex-encoded) 128-bit authentication code for message `b'message data'` with key `b'pseudorandom key'`:

```
>>> from hashlib import blake2b
>>> h = blake2b(key=b'pseudorandom key', digest_size=16)
>>> h.update(b'message data')
>>> h.hexdigest()
'3d363ff7401e02026f4a4687d4863ced'
```

As a practical example, a web application can symmetrically sign cookies sent to users and later verify them to make sure they weren't tampered with:

```
>>> from hashlib import blake2b
>>> from hmac import compare_digest
>>>
>>> SECRET_KEY = b'pseudorandomly generated server secret key'
>>> AUTH_SIZE = 16
>>>
>>> def sign(cookie):
...     h = blake2b(digest_size=AUTH_SIZE, key=SECRET_KEY)
...     h.update(cookie)
...     return h.hexdigest().encode('utf-8')
>>>
>>> def verify(cookie, sig):
...     good_sig = sign(cookie)
...     return compare_digest(good_sig, sig)
>>>
>>> cookie = b'user-alice'
>>> sig = sign(cookie)
>>> print("{0},{1}".format(cookie.decode('utf-8'), sig))
user-alice,b'43b3c982cf697e0c5ab22172d1ca7421'
>>> verify(cookie, sig)
True
>>> verify(b'user-bob', sig)
False
>>> verify(cookie, b'0102030405060708090a0b0c0d0e0f00')
False
```

Even though there's a native keyed hashing mode, BLAKE2 can, of course, be used in HMAC construction with `hmac` module:

```
>>> import hmac, hashlib
>>> m = hmac.new(b'secret key', digestmod=hashlib.blake2s)
>>> m.update(b'message')
>>> m.hexdigest()
'e3c8102868d28b5ff85fc35dda07329970d1a01e273c37481326fe0c861c8142'
```

Randomized hashing

By setting *salt* parameter users can introduce randomization to the hash function. Randomized hashing is useful for protecting against collision attacks on the hash function used in digital signatures.

Randomized hashing is designed for situations where one party, the message preparer, generates all or part of a message to be signed by a second party, the message signer. If the message preparer is able to find cryptographic hash function collisions (i.e., two messages producing the same hash value), then they might prepare meaningful versions of the message that would produce the same hash value and digital signature, but with different results (e.g., transferring \$1,000,000 to an account, rather than \$10). Cryptographic hash functions have been designed with collision resistance as a major goal, but the current concentration on attacking cryptographic hash functions may result in a given cryptographic hash function providing less collision resistance than expected. Randomized hashing offers the signer additional protection by reducing the likelihood that a preparer can generate two or more messages that ultimately yield the same hash value during the digital signature generation process --- even if it is practical to find collisions for the hash function. However, the use of randomized hashing may reduce the amount of security provided by a digital signature when all portions of the message are prepared by the signer.

(NIST SP-800-106 "Randomized Hashing for Digital Signatures")

In BLAKE2 the salt is processed as a one-time input to the hash function during initialization, rather than as an input to each compression function.

警告: *Salted hashing* (or just hashing) with BLAKE2 or any other general-purpose cryptographic hash function, such as SHA-256, is not suitable for hashing passwords. See [BLAKE2 FAQ](#) for more information.

```
>>> import os
>>> from hashlib import blake2b
>>> msg = b'some message'
>>> # Calculate the first hash with a random salt.
>>> salt1 = os.urandom(blake2b.SALT_SIZE)
>>> h1 = blake2b(salt=salt1)
>>> h1.update(msg)
>>> # Calculate the second hash with a different random salt.
>>> salt2 = os.urandom(blake2b.SALT_SIZE)
>>> h2 = blake2b(salt=salt2)
>>> h2.update(msg)
>>> # The digests are different.
>>> h1.digest() != h2.digest()
True
```

Personalization

Sometimes it is useful to force hash function to produce different digests for the same input for different purposes. Quoting the authors of the Skein hash function:

We recommend that all application designers seriously consider doing this; we have seen many protocols where a hash that is computed in one part of the protocol can be used in an entirely different part because two hash computations were done on similar or related data, and the attacker can force the application to make the hash inputs the same. Personalizing each hash function used in the protocol summarily stops this type of attack.

(The Skein Hash Function Family, p. 21)

BLAKE2 can be personalized by passing bytes to the *person* argument:

```
>>> from hashlib import blake2b
>>> FILES_HASH_PERSON = b'MyApp Files Hash'
>>> BLOCK_HASH_PERSON = b'MyApp Block Hash'
>>> h = blake2b(digest_size=32, person=FILES_HASH_PERSON)
>>> h.update(b'the same content')
>>> h.hexdigest()
'20d9cd024d4fb086aae819a1432dd2466de12947831b75c5a30cf2676095d3b4'
>>> h = blake2b(digest_size=32, person=BLOCK_HASH_PERSON)
>>> h.update(b'the same content')
>>> h.hexdigest()
'cf68fb5761b9c44e7878bfb2c4c9aea52264a80b75005e65619778de59f383a3'
```

Personalization together with the keyed mode can also be used to derive different keys from a single one.

```
>>> from hashlib import blake2s
>>> from base64 import b64decode, b64encode
>>> orig_key = b64decode(b'Rm5EPJai72qcK3RGBpW3vPNfZy5OZothY+kHY6h21KM=')
>>> enc_key = blake2s(key=orig_key, person=b'kEncrypt').digest()
>>> mac_key = blake2s(key=orig_key, person=b'kMAC').digest()
>>> print(b64encode(enc_key).decode('utf-8'))
rbPb15S/Z9t+agffno5wuhB77VbRi6F9Iv2qIxU7WHw=
>>> print(b64encode(mac_key).decode('utf-8'))
G9GtHFE1YluXY1zWPlYk1e/nWfu0WSEb0KRcjhDeP/o=
```

Tree mode

Here's an example of hashing a minimal tree with two leaf nodes:

```
  10
 /  \
00  01
```

This example uses 64-byte internal digests, and returns the 32-byte final digest:

```
>>> from hashlib import blake2b
>>>
>>> FANOUT = 2
>>> DEPTH = 2
>>> LEAF_SIZE = 4096
>>> INNER_SIZE = 64
>>>
>>> buf = bytearray(6000)
>>>
>>> # Left leaf
... h00 = blake2b(buf[0:LEAF_SIZE], fanout=FANOUT, depth=DEPTH,
...               leaf_size=LEAF_SIZE, inner_size=INNER_SIZE,
...               node_offset=0, node_depth=0, last_node=False)
>>> # Right leaf
... h01 = blake2b(buf[LEAF_SIZE:], fanout=FANOUT, depth=DEPTH,
...               leaf_size=LEAF_SIZE, inner_size=INNER_SIZE,
...               node_offset=1, node_depth=0, last_node=True)
>>> # Root node
... h10 = blake2b(digest_size=32, fanout=FANOUT, depth=DEPTH,
...               leaf_size=LEAF_SIZE, inner_size=INNER_SIZE,
...               node_offset=0, node_depth=1, last_node=True)
>>> h10.update(h00.digest())
>>> h10.update(h01.digest())
>>> h10.hexdigest()
'3ad2a9b37c6070e374c7a8c508fe20ca86b6ed54e286e93a0318e95e881db5aa'
```


Credits

BLAKE2 was designed by *Jean-Philippe Aumasson*, *Samuel Neves*, *Zooko Wilcox-O'Hearn*, and *Christian Winnerlein* based on SHA-3 finalist BLAKE created by *Jean-Philippe Aumasson*, *Luca Henzen*, *Willi Meier*, and *Raphael C.-W. Phan*.

It uses core algorithm from ChaCha cipher designed by *Daniel J. Bernstein*.

The stdlib implementation is based on `pyblake2` module. It was written by *Dmitry Chestnykh* based on C implementation written by *Samuel Neves*. The documentation was copied from `pyblake2` and written by *Dmitry Chestnykh*.

The C code was partly rewritten for Python by *Christian Heimes*.

The following public domain dedication applies for both C hash function implementation, extension code, and this documentation:

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The following people have helped with development or contributed their changes to the project and the public domain according to the Creative Commons Public Domain Dedication 1.0 Universal:

- *Alexandr Sokolovskiy*

也參考:

`hmac` 模組

A module to generate message authentication codes using hashes.

`base64` 模組

Another way to encode binary hashes for non-binary environments.

<https://nvlpubs.nist.gov/nistpubs/fips/nist.fips.180-4.pdf>

The FIPS 180-4 publication on Secure Hash Algorithms.

<https://csrc.nist.gov/publications/detail/fips/202/final>

The FIPS 202 publication on the SHA-3 Standard.

<https://www.blake2.net/>

BLAKE2 官方網站。

https://en.wikipedia.org/wiki/Cryptographic_hash_function

Wikipedia article with information on which algorithms have known issues and what that means regarding their use.

<https://www.ietf.org/rfc/rfc8018.txt>

PKCS #5: Password-Based Cryptography Specification Version 2.1

<https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-132.pdf>

NIST Recommendation for Password-Based Key Derivation.

15.2 hmac --- 基於金鑰雜 F 的訊息驗證

原始碼: `Lib/hmac.py`

此模組 (module) 實現了 RFC 2014 所描述的 HMAC 演算法。

`hmac.new(key, msg=None, digestmod)`

回傳一個新的 `hmac` 物件。`key` 是一個指定密鑰的 `bytes` (位元組) 或 `bytearray` 物件。如果提供了 `msg`, 將會呼叫 `update(msg)` 方法。`digestmod` 是 HMAC 物件所用的摘要名稱、摘要建構函式 (constructor) 或模組。它可以是適用於 `hashlib.new()` 的任何名稱。儘管該引數的位置在後, 但它 是必須的。

在 3.4 版的變更: 參數 `key` 可以 是 `bytes` 或 `bytearray` 物件。參數 `msg` 可以 是 `hashlib` 所支援的任意型。參數 `digestmod` 可以 是雜演算法的名稱。

在 3.8 版的變更: The `digestmod` argument is now required. Pass it as a keyword argument to avoid awkwardness when you do not have an initial `msg`.

`hmac.digest(key, msg, digest)`

基於給定密鑰 `key` 和 `digest` 回傳 `msg` 的摘要。此函式等價於 `HMAC(key, msg, digest).digest()`, 但使用了優化的 C 或行 實作 (inline implementation), 對放入記憶體的消息能處理得更快。參數 `key`、`msg` 和 `digest` 在 `new()` 中具有相同含義。

作 CPython 的實現細節, C 的優化實作只有當 `digest` 是字串 且是一個 OpenSSL 所支援的摘要演算法的名稱時才會被使用。

在 3.7 版新加入。

HMAC 物件具有下列方法 (method):

`HMAC.update(msg)`

用 `msg` 來更新 `hmac` 物件。重 呼叫相當於單次呼叫 傳入所有引數的拼接結果: `m.update(a); m.update(b)` 等價於 `m.update(a + b)`。

在 3.4 版的變更: 參數 `msg` 可以是 `hashlib` 所支援的任何型。

`HMAC.digest()`

回傳當前已傳給 `update()` 方法的 `bytes` 摘要。這個 `bytes` 物件的長度會與傳給建構函式的摘要 `digest_size` 的長度相同。它可以包含 NUL bytes 以及 non-ASCII bytes。

警告: 在一個例行的驗證事務運行期間, 將 `digest()` 的輸出與外部提供的摘要進行比較時, 建議使用 `compare_digest()` 函式而不是 `==` 運算子以 少被定時攻擊時的漏洞。

`HMAC.hexdigest()`

像是 `digest()` 但摘要的回傳形式 兩倍長度的字串, 且此字串只包含十六進位數位。這可以被用於在電子郵件或其他非二進位制環境中安全地交 數據。

警告: 在一個例行的驗證事務運行期間, 將 `hexdigest()` 的輸出與外部提供的摘要進行比較時, 建議使用 `compare_digest()` 函式而不是 `==` 運算子以 少被定時攻擊時的漏洞。

`HMAC.copy()`

回傳 `hmac` 物件的拷貝 ("clone")。這可以被用來有效率地計算那些共享相同初始子字串的字串的摘要。

一個 `hash` 物件具有以下屬性:

`HMAC.digest_size`

以 `bytes` 表示最終 HMAC 摘要的大小。

`HMAC.block_size`

以 `bytes` 表示雜 演算法的 部區塊大小。

在 3.4 版新加入。

HMAC.name

HMAC 的正准名稱總是小寫形式，例如 `hmac-md5`。

在 3.4 版新加入。

在 3.10 版的變更: Removed the undocumented attributes `HMAC.digest_cons`, `HMAC.inner`, and `HMAC.outer`.

這個模組還提供了下列輔助函式：

`hmac.compare_digest(a, b)`

回傳 `a == b`。此函式使用一種經專門設計的方式通過避免基於內容的短路行來防止定時分析，使得它適合處理密碼學。`a` 和 `b` 必須相同的型：可以是 *str* (僅限 ASCII, 如 `HMAC.hexdigest()` 的回傳值)，或者是 *bytes-like object*。

備註： 如果 `a` 和 `b` 具有不同的長度，或者如果發生了錯誤，定時攻擊在理論上可以獲取有關 `a` 和 `b` 的型和長度的訊息—但不能獲取他們的值。

在 3.3 版新加入。

在 3.10 版的變更: 此函式在可能的情況下會在內部使用 OpenSSL 的 `CRYPTO_memcmp()`。

也參考：

hashlib 模組

Python 模組提供安全的雜函式。

15.3 secrets --- 生用於管理機密的安全亂數

在 3.6 版新加入。

原始碼: [Lib/secrets.py](#)

`secrets` 模組可用於生高加密度的亂數，適合用來管理諸如密碼、帳號認證、安全性權杖 (security tokens) 這類資料，以及管理其他相關的機密資料。

尤其應優先使用 `secrets` 作預設來替代 `random` 模組中的預設亂數生器 (pseudo-random number generator)，該模組被設計用於建模和模擬，而非用於安全性和加密。

也參考：

PEP 506

15.3.1 亂數

`secrets` 模組使你得以存取作業系統所提供安全性最高的亂數生器。

class secrets.SystemRandom

一個用來生亂數的類，用的是作業系統提供的最高品質來源。請參 `random.SystemRandom` 以獲取更多細節。

`secrets.choice(sequence)`

從一非空序列中，回傳一個隨機選取的元素。

`secrets.randbelow(n)`

回傳一個 $[0, n)$ 範圍之的隨機整數。

`secrets.randbits(k)`

回傳一個具 k 個隨機位元的整數。

15.3.2 生權杖 (token)

`secrets` 模組提供了一些生安全性權杖的函式，適合用於諸如重設密碼、難以猜測的 URL，或類似的應用。

`secrets.token_bytes([nbytes=None])`

回傳一個隨機位元組字串，其中含有 *nbytes* 位元組的數字。如果 *nbytes* 為 `None` 或未提供，則會使用一合理預設值。

```
>>> token_bytes(16)
b'\xebr\x17D*t\xae\xd4\xe3S\xb6\xe2\xebP1\x8b'
```

`secrets.token_hex([nbytes=None])`

回傳一以十六進位表示的隨機字串。字串具有 *nbytes* 個隨機位元組，每個位元組會轉成兩個十六進位的數字。如果 *nbytes* 為 `None` 或未提供，則會使用一個合理的預設值。

```
>>> token_hex(16)
'f9bf78b9a18ce6d46a0cd2b0b86df9da'
```

`secrets.token_urlsafe([nbytes=None])`

回傳一個 URL 安全的隨機文本字串，包含 *nbytes* 個隨機位元組。文本將使用 Base64 編碼，因此平均每個位元組會對應到約 1.3 個字元。如果 *nbytes* 為 `None` 或未提供，則會使用一個合理的預設值。

```
>>> token_urlsafe(16)
'Drmhze6EPcv0fN_81Bj-nA'
```

權杖應當使用多少個位元組？

為了在面對暴力攻擊時能保證安全，權杖必須具有足夠的隨機性。不幸的是，對隨機性是否足夠的標準，會隨著電腦越來越強大而在更短時間內進行更多猜測而不斷提高。在 2015 年時，人們認為 32 位元組（256 位元）的隨機性對於 `secrets` 模組所預期的一般使用場景來說是足夠的。

對於想自行管理權杖長度的使用者，你可以對各種 `token_*` 函式明白地指定 *int* 引數（argument）來指定權杖要使用的隨機性程度。該引數以位元組數來表示要使用的隨機性程度。

否則，如未提供引數，或者如果引數為 `None`，則 `token_*` 函式則會使用一個合理的預設值。

備註：該預設值可能在任何時候被改變，包括在維護版本更新的時候。

15.3.3 其他函式

`secrets.compare_digest(a, b)`

如果字串或類位元組串物件 *a* 與 *b* 相等則回傳 `True`，否則回傳 `False`，以“固定時間比較 (constant-time compare)”的處理方式可降低時序攻擊的風險。請參閱 `hmac.compare_digest()` 以了解更多細節。

15.3.4 應用技巧和典範實務 (best practices)

本節展示了一些使用 `secrets` 來管理基本安全等級的應用技巧和典範實務。

生八個字元長的字母數字密碼：

```
import string
import secrets
alphabet = string.ascii_letters + string.digits
password = ''.join(secrets.choice(alphabet) for i in range(8))
```

備：應用程式不能以可復原的格式存儲密碼，無論是用純文本還是經過加密。它們應當先加鹽（salt），再使用高加密度的單向（不可逆）雜函式來生雜值。

生十個字元長的字母數字密碼，其中包含至少一個小寫字母，至少一個大寫字母以及至少三個數字：

```
import string
import secrets
alphabet = string.ascii_letters + string.digits
while True:
    password = ''.join(secrets.choice(alphabet) for i in range(10))
    if (any(c.islower() for c in password)
        and any(c.isupper() for c in password)
        and sum(c.isdigit() for c in password) >= 3):
        break
```

生 XKCD 風格的 passphrase：

```
import secrets
# On standard Linux systems, use a convenient dictionary file.
# Other platforms may need to provide their own word-list.
with open('/usr/share/dict/words') as f:
    words = [word.strip() for word in f]
    password = ' '.join(secrets.choice(words) for i in range(4))
```

生難以猜測的暫時性 URL，含回復密碼時所用的一個安全性權杖：

```
import secrets
url = 'https://example.com/reset=' + secrets.token_urlsafe()
```

通用作業系統服務

此章節所描述的模組 (module) 提供了作業系統特性的使用介面，例如檔案與時鐘，（幾乎）在所有作業系統上皆能使用。這些介面通常是參考 Unix 或 C 的介面來實作，不過在其他大多數系統上也能使用。以下[Ⓔ]概述：

16.1 os --- 各種作業系統介面

原始碼：[Lib/os.py](#)

This module provides a portable way of using operating system dependent functionality. If you just want to read or write a file see `open()`, if you want to manipulate paths, see the `os.path` module, and if you want to read all the lines in all the files on the command line see the `fileinput` module. For creating temporary files and directories see the `tempfile` module, and for high-level file and directory handling see the `shutil` module.

Notes on the availability of these functions:

- The design of all built-in operating system dependent modules of Python is such that as long as the same functionality is available, it uses the same interface; for example, the function `os.stat(path)` returns stat information about `path` in the same format (which happens to have originated with the POSIX interface).
- Extensions peculiar to a particular operating system are also available through the `os` module, but using them is of course a threat to portability.
- All functions accepting path or file names accept both bytes and string objects, and result in an object of the same type, if a path or file name is returned.
- On VxWorks, `os.popen`, `os.fork`, `os.execv` and `os.spawn*p*` are not supported.
- On WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`, large parts of the `os` module are not available or behave differently. API related to processes (e.g. `fork()`, `execve()`), signals (e.g. `kill()`, `wait()`), and resources (e.g. `nice()`) are not available. Others like `getuid()` and `getpid()` are emulated or stubs.

備[Ⓔ]： All functions in this module raise `OSError` (or subclasses thereof) in the case of invalid or inaccessible file names and paths, or other arguments that have the correct type, but are not accepted by the operating system.

exception `os.error`

An alias for the built-in `OSError` exception.

`os.name`

The name of the operating system dependent module imported. The following names have currently been registered: 'posix', 'nt', 'java'.

也參考:

`sys.platform` has a finer granularity. `os.uname()` gives system-dependent version information.

The `platform` module provides detailed checks for the system's identity.

16.1.1 File Names, Command Line Arguments, and Environment Variables

In Python, file names, command line arguments, and environment variables are represented using the string type. On some systems, decoding these strings to and from bytes is necessary before passing them to the operating system. Python uses the *filesystem encoding and error handler* to perform this conversion (see `sys.getfilesystemencoding()`).

The *filesystem encoding and error handler* are configured at Python startup by the `PyConfig_Read()` function: see `filesystem_encoding` and `filesystem_errors` members of `PyConfig`.

在 3.1 版的變更: On some systems, conversion using the file system encoding may fail. In this case, Python uses the *surrogateescape encoding error handler*, which means that undecodable bytes are replaced by a Unicode character U+DCxx on decoding, and these are again translated to the original byte on encoding.

The *file system encoding* must guarantee to successfully decode all bytes below 128. If the file system encoding fails to provide this guarantee, API functions can raise `UnicodeError`.

另請參閱 *locale encoding*。

16.1.2 Python UTF-8 Mode

在 3.7 版新加入: 更多資訊請見 **PEP 540**。

The Python UTF-8 Mode ignores the *locale encoding* and forces the usage of the UTF-8 encoding:

- Use UTF-8 as the *filesystem encoding*.
- `sys.getfilesystemencoding()` 回傳 'utf-8'。
- `locale.getpreferredencoding()` returns 'utf-8' (the `do_setlocale` argument has no effect).
- `sys.stdin`, `sys.stdout`, and `sys.stderr` all use UTF-8 as their text encoding, with the *surrogateescape error handler* being enabled for `sys.stdin` and `sys.stdout` (`sys.stderr` continues to use *backslashreplace* as it does in the default locale-aware mode)
- On Unix, `os.device_encoding()` returns 'utf-8' rather than the device encoding.

Note that the standard stream settings in UTF-8 mode can be overridden by `PYTHONIOENCODING` (just as they can be in the default locale-aware mode).

As a consequence of the changes in those lower level APIs, other higher level APIs also exhibit different default behaviours:

- Command line arguments, environment variables and filenames are decoded to text using the UTF-8 encoding.
- `os.fsdecode()` and `os.fsencode()` use the UTF-8 encoding.
- `open()`, `io.open()`, and `codecs.open()` use the UTF-8 encoding by default. However, they still use the strict error handler by default so that attempting to open a binary file in text mode is likely to raise an exception rather than producing nonsense data.

The *Python UTF-8 Mode* is enabled if the `LC_CTYPE` locale is `C` or `POSIX` at Python startup (see the `PyConfig_Read()` function).

It can be enabled or disabled using the `-X utf8` command line option and the `PYTHONUTF8` environment variable.

If the `PYTHONUTF8` environment variable is not set at all, then the interpreter defaults to using the current locale settings, *unless* the current locale is identified as a legacy ASCII-based locale (as described for `PYTHONCOERCECLOCALE`), and locale coercion is either disabled or fails. In such legacy locales, the interpreter will default to enabling UTF-8 mode unless explicitly instructed not to do so.

The Python UTF-8 Mode can only be enabled at the Python startup. Its value can be read from `sys.flags.utf8_mode`.

See also the UTF-8 mode on Windows and the *filesystem encoding and error handler*.

也參考:

PEP 686

Python 3.15 will make *Python UTF-8 Mode* default.

16.1.3 Process Parameters

These functions and data items provide information and operate on the current process and user.

`os.ctermid()`

Return the filename corresponding to the controlling terminal of the process.

適用: Unix、非 Emscripten、非 WASI。

`os.environ`

A *mapping* object where keys and values are strings that represent the process environment. For example, `environ['HOME']` is the pathname of your home directory (on some platforms), and is equivalent to `getenv("HOME")` in C.

This mapping is captured the first time the `os` module is imported, typically during Python startup as part of processing `site.py`. Changes to the environment made after this time are not reflected in `os.environ`, except for changes made by modifying `os.environ` directly.

This mapping may be used to modify the environment as well as query the environment. `putenv()` will be called automatically when the mapping is modified.

On Unix, keys and values use `sys.getfilesystemencoding()` and 'surrogateescape' error handler. Use `environb` if you would like to use a different encoding.

On Windows, the keys are converted to uppercase. This also applies when getting, setting, or deleting an item. For example, `environ['monty'] = 'python'` maps the key 'MONTY' to the value 'python'.

備 註: Calling `putenv()` directly does not change `os.environ`, so it's better to modify `os.environ`.

備 註: On some platforms, including FreeBSD and macOS, setting `environ` may cause memory leaks. Refer to the system documentation for `putenv()`.

You can delete items in this mapping to unset environment variables. `unsetenv()` will be called automatically when an item is deleted from `os.environ`, and when one of the `pop()` or `clear()` methods is called.

在 3.9 版的變更: Updated to support **PEP 584**'s `merge()` and `update()` operators.

os.environb

Bytes version of *environ*: a *mapping* object where both keys and values are *bytes* objects representing the process environment. *environ* and *environb* are synchronized (modifying *environb* updates *environ*, and vice versa).

environb is only available if *supports_bytes_environ* is True.

在 3.2 版新加入。

在 3.9 版的變更: Updated to support **PEP 584**'s merge (`|`) and update (`|=`) operators.

os.chdir(path)**os.fchdir(fd)****os.getcwd()**

These functions are described in *Files and Directories*.

os.fsencode(filename)

Encode *path-like filename* to the *filesystem encoding and error handler*; return *bytes* unchanged.

fsdecode() is the reverse function.

在 3.2 版新加入。

在 3.6 版的變更: Support added to accept objects implementing the *os.PathLike* interface.

os.fsdecode(filename)

Decode the *path-like filename* from the *filesystem encoding and error handler*; return *str* unchanged.

fsencode() is the reverse function.

在 3.2 版新加入。

在 3.6 版的變更: Support added to accept objects implementing the *os.PathLike* interface.

os.fspath(path)

Return the file system representation of the path.

If *str* or *bytes* is passed in, it is returned unchanged. Otherwise `__fspath__()` is called and its value is returned as long as it is a *str* or *bytes* object. In all other cases, *TypeError* is raised.

在 3.6 版新加入。

class os.PathLike

An *abstract base class* for objects representing a file system path, e.g. *pathlib.PurePath*.

在 3.6 版新加入。

abstractmethod __fspath__()

Return the file system path representation of the object.

The method should only return a *str* or *bytes* object, with the preference being for *str*.

os.getenv(key, default=None)

Return the value of the environment variable *key* as a string if it exists, or *default* if it doesn't. *key* is a string. Note that since *getenv()* uses *os.environ*, the mapping of *getenv()* is similarly also captured on import, and the function may not reflect future environment changes.

On Unix, keys and values are decoded with *sys.getfilesystemencoding()* and 'surrogateescape' error handler. Use *os.getenvb()* if you would like to use a different encoding.

適用: Unix、Windows。

os.getenvb (*key*, *default=None*)

Return the value of the environment variable *key* as bytes if it exists, or *default* if it doesn't. *key* must be bytes. Note that since `getenvb()` uses `os.environb`, the mapping of `getenvb()` is similarly also captured on import, and the function may not reflect future environment changes.

`getenvb()` is only available if `supports_bytes_environ` is True.

適用：Unix。

在 3.2 版新加入。

os.get_exec_path (*env=None*)

Returns the list of directories that will be searched for a named executable, similar to a shell, when launching a process. *env*, when specified, should be an environment variable dictionary to lookup the PATH in. By default, when *env* is None, `environ` is used.

在 3.2 版新加入。

os.getegid ()

Return the effective group id of the current process. This corresponds to the "set id" bit on the file being executed in the current process.

適用：Unix、非 Emscripten、非 WASI。

os.geteuid ()

Return the current process's effective user id.

適用：Unix、非 Emscripten、非 WASI。

os.getgid ()

Return the real group id of the current process.

適用：Unix。

The function is a stub on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

os.getgrouplist (*user*, *group*, /)

Return list of group ids that *user* belongs to. If *group* is not in the list, it is included; typically, *group* is specified as the group ID field from the password record for *user*, because that group ID will otherwise be potentially omitted.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.getgroups ()

Return list of supplemental group ids associated with the current process.

適用：Unix、非 Emscripten、非 WASI。

備註： On macOS, `getgroups()` behavior differs somewhat from other Unix platforms. If the Python interpreter was built with a deployment target of 10.5 or earlier, `getgroups()` returns the list of effective group ids associated with the current user process; this list is limited to a system-defined number of entries, typically 16, and may be modified by calls to `setgroups()` if suitably privileged. If built with a deployment target greater than 10.5, `getgroups()` returns the current group access list for the user associated with the effective user id of the process; the group access list may change over the lifetime of the process, it is not affected by calls to `setgroups()`, and its length is not limited to 16. The deployment target value, `MACOSX_DEPLOYMENT_TARGET`, can be obtained with `sysconfig.get_config_var()`.

os.getlogin ()

Return the name of the user logged in on the controlling terminal of the process. For most purposes, it is more useful to use `getpass.getuser()` since the latter checks the environment variables LOGNAME or USERNAME to find out who the user is, and falls back to `pwd.getpwuid(os.getuid())[0]` to get the login name of the current real user id.

適用：Unix、Windows、非 Emscripten、非 WASI。

os.getpgid(*pid*)

Return the process group id of the process with process id *pid*. If *pid* is 0, the process group id of the current process is returned.

適用：Unix、非 Emscripten、非 WASI。

os.getpgrp()

Return the id of the current process group.

適用：Unix、非 Emscripten、非 WASI。

os.getpid()

Return the current process id.

The function is a stub on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

os.getppid()

Return the parent's process id. When the parent process has exited, on Unix the id returned is the one of the init process (1), on Windows it is still the same id, which may be already reused by another process.

適用：Unix、Windows、非 Emscripten、非 WASI。

在 3.2 版的變更：新增對 Windows 的支援。

os.getpriority(*which*, *who*)

Get program scheduling priority. The value *which* is one of [PRIO_PROCESS](#), [PRIO_PGRP](#), or [PRIO_USER](#), and *who* is interpreted relative to *which* (a process identifier for [PRIO_PROCESS](#), process group identifier for [PRIO_PGRP](#), and a user ID for [PRIO_USER](#)). A zero value for *who* denotes (respectively) the calling process, the process group of the calling process, or the real user ID of the calling process.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.PRIO_PROCESS

os.PRIO_PGRP

os.PRIO_USER

Parameters for the [getpriority\(\)](#) and [setpriority\(\)](#) functions.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.getresuid()

Return a tuple (ruid, euid, suid) denoting the current process's real, effective, and saved user ids.

適用：Unix、非 Emscripten、非 WASI。

在 3.2 版新加入。

os.getresgid()

Return a tuple (rgid, egid, sgid) denoting the current process's real, effective, and saved group ids.

適用：Unix、非 Emscripten、非 WASI。

在 3.2 版新加入。

os.getuid()

Return the current process's real user id.

適用：Unix。

The function is a stub on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

`os.initgroups(username, gid, /)`

Call the system `initgroups()` to initialize the group access list with all of the groups of which the specified username is a member, plus the specified group id.

適用：Unix、非 Emscripten、非 WASI。

在 3.2 版新加入。

`os.putenv(key, value, /)`

Set the environment variable named *key* to the string *value*. Such changes to the environment affect subprocesses started with `os.system()`, `popen()` or `fork()` and `execv()`.

Assignments to items in `os.environ` are automatically translated into corresponding calls to `putenv()`; however, calls to `putenv()` don't update `os.environ`, so it is actually preferable to assign to items of `os.environ`. This also applies to `getenv()` and `getenvb()`, which respectively use `os.environ` and `os.environb` in their implementations.

備： On some platforms, including FreeBSD and macOS, setting `environ` may cause memory leaks. Refer to the system documentation for `putenv()`.

引發一個附帶引數 *key*、*value* 的稽核事件 `os.putenv`。

在 3.9 版的變更: The function is now always available.

`os.setegid(egid, /)`

Set the current process's effective group id.

適用：Unix、非 Emscripten、非 WASI。

`os.seteuid(euid, /)`

Set the current process's effective user id.

適用：Unix、非 Emscripten、非 WASI。

`os.setgid(gid, /)`

Set the current process' group id.

適用：Unix、非 Emscripten、非 WASI。

`os.setgroups(groups, /)`

Set the list of supplemental group ids associated with the current process to *groups*. *groups* must be a sequence, and each element must be an integer identifying a group. This operation is typically available only to the superuser.

適用：Unix、非 Emscripten、非 WASI。

備： On macOS, the length of *groups* may not exceed the system-defined maximum number of effective group ids, typically 16. See the documentation for `getgroups()` for cases where it may not return the same group list set by calling `setgroups()`.

`os.setpgrp()`

Call the system call `setpgrp()` or `setpgrp(0, 0)` depending on which version is implemented (if any). See the Unix manual for the semantics.

適用：Unix、非 Emscripten、非 WASI。

`os.setpgid(pid, grp, /)`

Call the system call `setpgid()` to set the process group id of the process with id *pid* to the process group with id *grp*. See the Unix manual for the semantics.

適用：Unix、非 Emscripten、非 WASI。

os.setpriority (*which, who, priority*)

Set program scheduling priority. The value *which* is one of `PRIO_PROCESS`, `PRIO_PGRP`, or `PRIO_USER`, and *who* is interpreted relative to *which* (a process identifier for `PRIO_PROCESS`, process group identifier for `PRIO_PGRP`, and a user ID for `PRIO_USER`). A zero value for *who* denotes (respectively) the calling process, the process group of the calling process, or the real user ID of the calling process. *priority* is a value in the range -20 to 19. The default priority is 0; lower priorities cause more favorable scheduling.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.setregid (*rgid, egid, /*)

Set the current process's real and effective group ids.

適用：Unix、非 Emscripten、非 WASI。

os.setresgid (*rgid, egid, sgid, /*)

Set the current process's real, effective, and saved group ids.

適用：Unix、非 Emscripten、非 WASI。

在 3.2 版新加入。

os.setresuid (*ruid, euid, suid, /*)

Set the current process's real, effective, and saved user ids.

適用：Unix、非 Emscripten、非 WASI。

在 3.2 版新加入。

os.setreuid (*ruid, euid, /*)

Set the current process's real and effective user ids.

適用：Unix、非 Emscripten、非 WASI。

os.getsid (*pid, /*)

Call the system call `getsid()`. See the Unix manual for the semantics.

適用：Unix、非 Emscripten、非 WASI。

os.setsid ()

Call the system call `setsid()`. See the Unix manual for the semantics.

適用：Unix、非 Emscripten、非 WASI。

os.setuid (*uid, /*)

Set the current process's user id.

適用：Unix、非 Emscripten、非 WASI。

os.strerror (*code, /*)

Return the error message corresponding to the error code in *code*. On platforms where `strerror()` returns NULL when given an unknown error number, `ValueError` is raised.

os.supports_bytes_environ

True if the native OS type of the environment is bytes (eg. False on Windows).

在 3.2 版新加入。

os.umask (*mask, /*)

Set the current numeric umask and return the previous umask.

The function is a stub on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

`os.uname()`

Returns information identifying the current operating system. The return value is an object with five attributes:

- `sysname` - 作業系統名稱
- `nodename` - name of machine on network (implementation-defined)
- `release` - operating system release
- `version` - 作業系統版本
- `machine` - hardware identifier

For backwards compatibility, this object is also iterable, behaving like a five-tuple containing `sysname`, `nodename`, `release`, `version`, and `machine` in that order.

Some systems truncate `nodename` to 8 characters or to the leading component; a better way to get the hostname is `socket.gethostname()` or even `socket.gethostbyaddr(socket.gethostname())`.

適用：Unix。

在 3.3 版的變更：Return type changed from a tuple to a tuple-like object with named attributes.

`os.unsetenv(key, /)`

Unset (delete) the environment variable named `key`. Such changes to the environment affect subprocesses started with `os.system()`, `popen()` or `fork()` and `execv()`.

Deletion of items in `os.environ` is automatically translated into a corresponding call to `unsetenv()`; however, calls to `unsetenv()` don't update `os.environ`, so it is actually preferable to delete items of `os.environ`.

引發一個附帶引數 `key` 的稽核事件 `os.unsetenv`。

在 3.9 版的變更：The function is now always available and is also available on Windows.

16.1.4 File Object Creation

These functions create new *file objects*. (See also `open()` for opening file descriptors.)

`os.fdopen(fd, *args, **kwargs)`

Return an open file object connected to the file descriptor `fd`. This is an alias of the `open()` built-in function and accepts the same arguments. The only difference is that the first argument of `fdopen()` must always be an integer.

16.1.5 File Descriptor Operations

These functions operate on I/O streams referenced using file descriptors.

File descriptors are small integers corresponding to a file that has been opened by the current process. For example, standard input is usually file descriptor 0, standard output is 1, and standard error is 2. Further files opened by a process will then be assigned 3, 4, 5, and so forth. The name "file descriptor" is slightly deceptive; on Unix platforms, sockets and pipes are also referenced by file descriptors.

The `fileno()` method can be used to obtain the file descriptor associated with a *file object* when required. Note that using the file descriptor directly will bypass the file object methods, ignoring aspects such as internal buffering of data.

`os.close(fd)`

Close file descriptor `fd`.

備 F: This function is intended for low-level I/O and must be applied to a file descriptor as returned by `os.open()` or `pipe()`. To close a "file object" returned by the built-in function `open()` or by `popen()` or `fdopen()`, use its `close()` method.

`os.closerange(fd_low, fd_high, /)`

Close all file descriptors from `fd_low` (inclusive) to `fd_high` (exclusive), ignoring errors. Equivalent to (but much faster than):

```
for fd in range(fd_low, fd_high):
    try:
        os.close(fd)
    except OSError:
        pass
```

`os.copy_file_range(src, dst, count, offset_src=None, offset_dst=None)`

Copy `count` bytes from file descriptor `src`, starting from offset `offset_src`, to file descriptor `dst`, starting from offset `offset_dst`. If `offset_src` is `None`, then `src` is read from the current position; respectively for `offset_dst`. The files pointed by `src` and `dst` must reside in the same filesystem, otherwise an `OSError` is raised with `errno` set to `errno.EXDEV`.

This copy is done without the additional cost of transferring data from the kernel to user space and then back into the kernel. Additionally, some filesystems could implement extra optimizations. The copy is done as if both files are opened as binary.

The return value is the amount of bytes copied. This could be less than the amount requested.

適用: Linux 4.5 以上且具有 glibc 2.27 以上。

在 3.8 版新加入。

`os.device_encoding(fd)`

Return a string describing the encoding of the device associated with `fd` if it is connected to a terminal; else return `None`.

On Unix, if the *Python UTF-8 Mode* is enabled, return `'UTF-8'` rather than the device encoding.

在 3.10 版的變更: On Unix, the function now implements the Python UTF-8 Mode.

`os.dup(fd, /)`

Return a duplicate of file descriptor `fd`. The new file descriptor is *non-inheritable*.

On Windows, when duplicating a standard stream (0: stdin, 1: stdout, 2: stderr), the new file descriptor is *inheritable*.

適用: 非 WASI。

在 3.4 版的變更: The new file descriptor is now non-inheritable.

`os.dup2(fd, fd2, inheritable=True)`

Duplicate file descriptor `fd` to `fd2`, closing the latter first if necessary. Return `fd2`. The new file descriptor is *inheritable* by default or non-inheritable if `inheritable` is `False`.

適用: 非 WASI。

在 3.4 版的變更: Add the optional *inheritable* parameter.

在 3.7 版的變更: Return `fd2` on success. Previously, `None` was always returned.

`os.fchmod(fd, mode)`

Change the mode of the file given by `fd` to the numeric `mode`. See the docs for `chmod()` for possible values of `mode`. As of Python 3.3, this is equivalent to `os.chmod(fd, mode)`.

引發一個附帶引數 `path`、`mode`、`dir_fd` 的稽核事件 `os.chmod`。

適用: Unix。

The function is limited on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

os.fchown(*fd*, *uid*, *gid*)

Change the owner and group id of the file given by *fd* to the numeric *uid* and *gid*. To leave one of the ids unchanged, set it to -1. See [chown\(\)](#). As of Python 3.3, this is equivalent to `os.chown(fd, uid, gid)`.

引發一個附帶引數 *path*、*uid*、*gid*、*dir_fd* 的稽核事件 `os.chown`。

適用：Unix。

The function is limited on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

os.fdatasync(*fd*)

Force write of file with filedescriptor *fd* to disk. Does not force update of metadata.

適用：Unix。

備F： This function is not available on MacOS.

os.fpathconf(*fd*, *name*, */*)

Return system configuration information relevant to an open file. *name* specifies the configuration value to retrieve; it may be a string which is the name of a defined system value; these names are specified in a number of standards (POSIX.1, Unix 95, Unix 98, and others). Some platforms define additional names as well. The names known to the host operating system are given in the `pathconf_names` dictionary. For configuration variables not included in that mapping, passing an integer for *name* is also accepted.

If *name* is a string and is not known, [ValueError](#) is raised. If a specific value for *name* is not supported by the host system, even if it is included in `pathconf_names`, an [OSError](#) is raised with `errno.EINVAL` for the error number.

As of Python 3.3, this is equivalent to `os.pathconf(fd, name)`.

適用：Unix。

os.fstat(*fd*)

Get the status of the file descriptor *fd*. Return a `stat_result` object.

As of Python 3.3, this is equivalent to `os.stat(fd)`.

也參考：

The `stat()` function.

os.fstatvfs(*fd*, */*)

Return information about the filesystem containing the file associated with file descriptor *fd*, like `statvfs()`.

As of Python 3.3, this is equivalent to `os.statvfs(fd)`.

適用：Unix。

os.fsync(*fd*)

Force write of file with filedescriptor *fd* to disk. On Unix, this calls the native `fsync()` function; on Windows, the `MS_commit()` function.

If you're starting with a buffered Python *file object* *f*, first do `f.flush()`, and then do `os.fsync(f.fileno())`, to ensure that all internal buffers associated with *f* are written to disk.

適用：Unix、Windows。

os.ftruncate(*fd*, *length*, */*)

Truncate the file corresponding to file descriptor *fd*, so that it is at most *length* bytes in size. As of Python 3.3, this is equivalent to `os.truncate(fd, length)`.

引發一個附帶引數 *fd*、*length* 的稽核事件 `os.truncate`。

適用：Unix、Windows。

在 3.5 版的變更: 新增對 Windows 的支援

`os.get_blocking(fd, /)`

Get the blocking mode of the file descriptor: `False` if the `O_NONBLOCK` flag is set, `True` if the flag is cleared.

另請參閱 `set_blocking()` 與 `socket.socket.setblocking()`。

適用: Unix。

The function is limited on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

在 3.5 版新加入。

`os.isatty(fd, /)`

Return `True` if the file descriptor `fd` is open and connected to a tty(-like) device, else `False`.

`os.lockf(fd, cmd, len, /)`

Apply, test or remove a POSIX lock on an open file descriptor. `fd` is an open file descriptor. `cmd` specifies the command to use - one of `F_LOCK`, `F_TLOCK`, `F_ULOCK` or `F_TEST`. `len` specifies the section of the file to lock.

Raises an [auditing event](#) `os.lockf` with arguments `fd`, `cmd`, `len`.

適用: Unix。

在 3.3 版新加入。

`os.F_LOCK`

`os.F_TLOCK`

`os.F_ULOCK`

`os.F_TEST`

Flags that specify what action `lockf()` will take.

適用: Unix。

在 3.3 版新加入。

`os.login_tty(fd, /)`

Prepare the tty of which `fd` is a file descriptor for a new login session. Make the calling process a session leader; make the tty the controlling tty, the stdin, the stdout, and the stderr of the calling process; close `fd`.

適用: Unix、非 Emscripten、非 WASI。

在 3.11 版新加入。

`os.lseek(fd, pos, whence, /)`

Set the current position of file descriptor `fd` to position `pos`, modified by `whence`, and return the new position in bytes relative to the start of the file. Valid values for `whence` are:

- `SEEK_SET` or 0 -- set `pos` relative to the beginning of the file
- `SEEK_CUR` or 1 -- set `pos` relative to the current file position
- `SEEK_END` or 2 -- set `pos` relative to the end of the file
- `SEEK_HOLE` -- set `pos` to the next data location, relative to `pos`
- `SEEK_DATA` -- set `pos` to the next data hole, relative to `pos`

在 3.3 版的變更: Add support for `SEEK_HOLE` and `SEEK_DATA`.

`os.SEEK_SET`

`os.SEEK_CUR`

os.SEEK_END

Parameters to the `lseek()` function and the `seek()` method on *file-like objects*, for whence to adjust the file position indicator.

SEEK_SET

Adjust the file position relative to the beginning of the file.

SEEK_CUR

Adjust the file position relative to the current file position.

SEEK_END

Adjust the file position relative to the end of the file.

Their values are 0, 1, and 2, respectively.

os.SEEK_HOLE**os.SEEK_DATA**

Parameters to the `lseek()` function and the `seek()` method on *file-like objects*, for seeking file data and holes on sparsely allocated files.

SEEK_DATA

Adjust the file offset to the next location containing data, relative to the seek position.

SEEK_HOLE

Adjust the file offset to the next location containing a hole, relative to the seek position. A hole is defined as a sequence of zeros.

備註: These operations only make sense for filesystems that support them.

Availability: Linux >= 3.1, macOS, Unix

在 3.3 版新加入。

os.open(path, flags, mode=0o777, *, dir_fd=None)

Open the file *path* and set various flags according to *flags* and possibly its mode according to *mode*. When computing *mode*, the current umask value is first masked out. Return the file descriptor for the newly opened file. The new file descriptor is *non-inheritable*.

For a description of the flag and mode values, see the C run-time documentation; flag constants (like `O_RDONLY` and `O_WRONLY`) are defined in the `os` module. In particular, on Windows adding `O_BINARY` is needed to open files in binary mode.

This function can support *paths relative to directory descriptors* with the *dir_fd* parameter.

引發一個附帶引數 *path*、*mode*、*flags* 的稽核事件 `open`。

在 3.4 版的變更: The new file descriptor is now non-inheritable.

備註: This function is intended for low-level I/O. For normal usage, use the built-in function `open()`, which returns a *file object* with `read()` and `write()` methods (and many more). To wrap a file descriptor in a file object, use `fdopen()`.

在 3.3 版的變更: 新增 *dir_fd* 參數。

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the function now retries the system call instead of raising an `InterruptedError` exception (see **PEP 475** for the rationale).

在 3.6 版的變更: Accepts a *path-like object*.

The following constants are options for the *flags* parameter to the `open()` function. They can be combined using the bitwise OR operator `|`. Some of them are not available on all platforms. For descriptions of their availability and use, consult the `open(2)` manual page on Unix or [the MSDN](#) on Windows.

`os.O_RDONLY`
`os.O_WRONLY`
`os.O_RDWR`
`os.O_APPEND`
`os.O_CREAT`
`os.O_EXCL`
`os.O_TRUNC`

The above constants are available on Unix and Windows.

`os.O_DSYNC`
`os.O_RSYNC`
`os.O_SYNC`
`os.O_NDELAY`
`os.O_NONBLOCK`
`os.O_NOCTTY`
`os.O_CLOEXEC`

The above constants are only available on Unix.

在 3.3 版的變更: Add `O_CLOEXEC` constant.

`os.O_BINARY`
`os.O_NOINHERIT`
`os.O_SHORT_LIVED`
`os.O_TEMPORARY`
`os.O_RANDOM`
`os.O_SEQUENTIAL`
`os.O_TEXT`

The above constants are only available on Windows.

`os.O_EVTONLY`
`os.O_FSYNC`
`os.O_SYMLINK`
`os.O_NOFOLLOW_ANY`

The above constants are only available on macOS.

在 3.10 版的變更: Add `O_EVTONLY`, `O_FSYNC`, `O_SYMLINK` and `O_NOFOLLOW_ANY` constants.

`os.O_ASYNC`
`os.O_DIRECT`
`os.O_DIRECTORY`
`os.O_NOFOLLOW`
`os.O_NOATIME`
`os.O_PATH`
`os.O_TMPFILE`
`os.O_SHLOCK`
`os.O_EXLOCK`

The above constants are extensions and not present if they are not defined by the C library.

在 3.4 版的變更: Add `O_PATH` on systems that support it. Add `O_TMPFILE`, only available on Linux Kernel 3.11 or newer.

os.openpty()

Open a new pseudo-terminal pair. Return a pair of file descriptors (*master*, *slave*) for the pty and the tty, respectively. The new file descriptors are *non-inheritable*. For a (slightly) more portable approach, use the *pty* module.

適用：Unix、非 Emscripten、非 WASI。

在 3.4 版的變更: The new file descriptors are now non-inheritable.

os.pipe()

Create a pipe. Return a pair of file descriptors (*r*, *w*) usable for reading and writing, respectively. The new file descriptor is *non-inheritable*.

適用：Unix、Windows。

在 3.4 版的變更: The new file descriptors are now non-inheritable.

os.pipe2(flags, /)

Create a pipe with *flags* set atomically. *flags* can be constructed by ORing together one or more of these values: *O_NONBLOCK*, *O_CLOEXEC*. Return a pair of file descriptors (*r*, *w*) usable for reading and writing, respectively.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.posix_fallocate(fd, offset, len, /)

Ensures that enough disk space is allocated for the file specified by *fd* starting from *offset* and continuing for *len* bytes.

適用：Unix、非 Emscripten。

在 3.3 版新加入。

os.posix_fadvise(fd, offset, len, advice, /)

Announces an intention to access data in a specific pattern thus allowing the kernel to make optimizations. The advice applies to the region of the file specified by *fd* starting at *offset* and continuing for *len* bytes. *advice* is one of *POSIX_FADV_NORMAL*, *POSIX_FADV_SEQUENTIAL*, *POSIX_FADV_RANDOM*, *POSIX_FADV_NOREUSE*, *POSIX_FADV_WILLNEED* or *POSIX_FADV_DONTNEED*.

適用：Unix。

在 3.3 版新加入。

os.POSIX_FADV_NORMAL**os.POSIX_FADV_SEQUENTIAL****os.POSIX_FADV_RANDOM****os.POSIX_FADV_NOREUSE****os.POSIX_FADV_WILLNEED****os.POSIX_FADV_DONTNEED**

Flags that can be used in *advice* in *posix_fadvise()* that specify the access pattern that is likely to be used.

適用：Unix。

在 3.3 版新加入。

os.pread(fd, n, offset, /)

Read at most *n* bytes from file descriptor *fd* at a position of *offset*, leaving the file offset unchanged.

Return a bytestring containing the bytes read. If the end of the file referred to by *fd* has been reached, an empty bytes object is returned.

適用：Unix。

在 3.3 版新加入。

`os.preadv` (*fd*, *buffers*, *offset*, *flags=0*, */*)

Read from a file descriptor *fd* at a position of *offset* into mutable *bytes-like objects buffers*, leaving the file offset unchanged. Transfer data into each buffer until it is full and then move on to the next buffer in the sequence to hold the rest of the data.

The *flags* argument contains a bitwise OR of zero or more of the following flags:

- `RWF_HIPRI`
- `RWF_NOWAIT`

Return the total number of bytes actually read which can be less than the total capacity of all the objects.

The operating system may set a limit (`sysconf()` value `'SC_IOV_MAX'`) on the number of buffers that can be used.

Combine the functionality of `os.readv()` and `os.pread()`.

適用：Linux 2.6.30 以上、FreeBSD 6.0 以上、OpenBSD 2.7 以上、AIX 7.1 以上。

Using flags requires Linux >= 4.6.

在 3.7 版新加入。

`os.RWF_NOWAIT`

Do not wait for data which is not immediately available. If this flag is specified, the system call will return instantly if it would have to read data from the backing storage or wait for a lock.

If some data was successfully read, it will return the number of bytes read. If no bytes were read, it will return `-1` and set `errno` to `errno.EAGAIN`.

適用：Linux 4.14 以上。

在 3.7 版新加入。

`os.RWF_HIPRI`

High priority read/write. Allows block-based filesystems to use polling of the device, which provides lower latency, but may use additional resources.

Currently, on Linux, this feature is usable only on a file descriptor opened using the `O_DIRECT` flag.

適用：Linux 4.6 以上。

在 3.7 版新加入。

`os.pwrite` (*fd*, *str*, *offset*, */*)

Write the bytestring in *str* to file descriptor *fd* at position of *offset*, leaving the file offset unchanged.

Return the number of bytes actually written.

適用：Unix。

在 3.3 版新加入。

`os.pwritev` (*fd*, *buffers*, *offset*, *flags=0*, */*)

Write the *buffers* contents to file descriptor *fd* at a offset *offset*, leaving the file offset unchanged. *buffers* must be a sequence of *bytes-like objects*. Buffers are processed in array order. Entire contents of the first buffer is written before proceeding to the second, and so on.

The *flags* argument contains a bitwise OR of zero or more of the following flags:

- `RWF_DSYNC`
- `RWF_SYNC`
- `RWF_APPEND`

Return the total number of bytes actually written.

The operating system may set a limit (`sysconf()` value `'SC_IOV_MAX'`) on the number of buffers that can be used.

Combine the functionality of `os.writev()` and `os.pwrite()`.

適用：Linux 2.6.30 以上、FreeBSD 6.0 以上、OpenBSD 2.7 以上、AIX 7.1 以上。

Using flags requires Linux >= 4.6.

在 3.7 版新加入。

os.RWF_DSYNC

Provide a per-write equivalent of the `O_DSYNC` `os.open()` flag. This flag effect applies only to the data range written by the system call.

適用：Linux 4.7 以上。

在 3.7 版新加入。

os.RWF_SYNC

Provide a per-write equivalent of the `O_SYNC` `os.open()` flag. This flag effect applies only to the data range written by the system call.

適用：Linux 4.7 以上。

在 3.7 版新加入。

os.RWF_APPEND

Provide a per-write equivalent of the `O_APPEND` `os.open()` flag. This flag is meaningful only for `os.pwritev()`, and its effect applies only to the data range written by the system call. The `offset` argument does not affect the write operation; the data is always appended to the end of the file. However, if the `offset` argument is `-1`, the current file `offset` is updated.

適用：Linux 4.16 以上。

在 3.10 版新加入。

os.read(fd, n, /)

Read at most `n` bytes from file descriptor `fd`.

Return a bytearray containing the bytes read. If the end of the file referred to by `fd` has been reached, an empty bytes object is returned.

備 F: This function is intended for low-level I/O and must be applied to a file descriptor as returned by `os.open()` or `pipe()`. To read a "file object" returned by the built-in function `open()` or by `popen()` or `fdopen()`, or `sys.stdin`, use its `read()` or `readline()` methods.

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the function now retries the system call instead of raising an `InterruptedError` exception (see [PEP 475](#) for the rationale).

os.sendfile(out_fd, in_fd, offset, count)

os.sendfile(out_fd, in_fd, offset, count, headers=(), trailers=(), flags=0)

Copy `count` bytes from file descriptor `in_fd` to file descriptor `out_fd` starting at `offset`. Return the number of bytes sent. When EOF is reached return 0.

The first function notation is supported by all platforms that define `sendfile()`.

On Linux, if `offset` is given as `None`, the bytes are read from the current position of `in_fd` and the position of `in_fd` is updated.

The second case may be used on macOS and FreeBSD where `headers` and `trailers` are arbitrary sequences of buffers that are written before and after the data from `in_fd` is written. It returns the same as the first case.

On macOS and FreeBSD, a value of 0 for `count` specifies to send until the end of `in_fd` is reached.

All platforms support sockets as `out_fd` file descriptor, and some platforms allow other types (e.g. regular file, pipe) as well.

Cross-platform applications should not use *headers*, *trailers* and *flags* arguments.

適用：Unix、非 Emscripten、非 WASI。

備：For a higher-level wrapper of `sendfile()`, see `socket.socket.sendfile()`.

在 3.3 版新加入。

在 3.9 版的變更: Parameters *out* and *in* was renamed to *out_fd* and *in_fd*.

os.SF_NODISKIO

os.SF_MNOWAIT

os.SF_SYNC

Parameters to the `sendfile()` function, if the implementation supports them.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.SF_NOCACHE

Parameter to the `sendfile()` function, if the implementation supports it. The data won't be cached in the virtual memory and will be freed afterwards.

適用：Unix、非 Emscripten、非 WASI。

在 3.11 版新加入。

os.set_blocking(*fd*, *blocking*, /)

Set the blocking mode of the specified file descriptor. Set the `O_NONBLOCK` flag if *blocking* is `False`, clear the flag otherwise.

另請參閱 `get_blocking()` 與 `socket.socket.setblocking()`。

適用：Unix。

The function is limited on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

在 3.5 版新加入。

os.splice(*src*, *dst*, *count*, *offset_src=None*, *offset_dst=None*)

Transfer *count* bytes from file descriptor *src*, starting from offset *offset_src*, to file descriptor *dst*, starting from offset *offset_dst*. At least one of the file descriptors must refer to a pipe. If *offset_src* is `None`, then *src* is read from the current position; respectively for *offset_dst*. The offset associated to the file descriptor that refers to a pipe must be `None`. The files pointed by *src* and *dst* must reside in the same filesystem, otherwise an `OSError` is raised with *errno* set to `errno.EXDEV`.

This copy is done without the additional cost of transferring data from the kernel to user space and then back into the kernel. Additionally, some filesystems could implement extra optimizations. The copy is done as if both files are opened as binary.

Upon successful completion, returns the number of bytes spliced to or from the pipe. A return value of 0 means end of input. If *src* refers to a pipe, then this means that there was no data to transfer, and it would not make sense to block because there are no writers connected to the write end of the pipe.

適用：Linux 2.6.17 以上且具有 glibc 2.5 以上

在 3.10 版新加入。

os.SPLICE_F_MOVE

os.SPLICE_F_NONBLOCK

os.SPLICE_F_MORE

在 3.10 版新加入。

os.readv (*fd*, *buffers*, /)

Read from a file descriptor *fd* into a number of mutable *bytes-like objects* *buffers*. Transfer data into each buffer until it is full and then move on to the next buffer in the sequence to hold the rest of the data.

Return the total number of bytes actually read which can be less than the total capacity of all the objects.

The operating system may set a limit (*sysconf()* value 'SC_IOV_MAX') on the number of buffers that can be used.

適用：Unix。

在 3.3 版新加入。

os.tcgetpgrp (*fd*, /)

Return the process group associated with the terminal given by *fd* (an open file descriptor as returned by *os.open()*).

適用：Unix、非 WASI。

os.tcsetpgrp (*fd*, *pg*, /)

Set the process group associated with the terminal given by *fd* (an open file descriptor as returned by *os.open()*) to *pg*.

適用：Unix、非 WASI。

os.ttyname (*fd*, /)

Return a string which specifies the terminal device associated with file descriptor *fd*. If *fd* is not associated with a terminal device, an exception is raised.

適用：Unix。

os.write (*fd*, *str*, /)

Write the bytestring in *str* to file descriptor *fd*.

Return the number of bytes actually written.

備註： This function is intended for low-level I/O and must be applied to a file descriptor as returned by *os.open()* or *pipe()*. To write a "file object" returned by the built-in function *open()* or by *popen()* or *fdopen()*, or *sys.stdout* or *sys.stderr*, use its *write()* method.

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the function now retries the system call instead of raising an *InterruptedError* exception (see **PEP 475** for the rationale).

os.writev (*fd*, *buffers*, /)

Write the contents of *buffers* to file descriptor *fd*. *buffers* must be a sequence of *bytes-like objects*. Buffers are processed in array order. Entire contents of the first buffer is written before proceeding to the second, and so on.

Returns the total number of bytes actually written.

The operating system may set a limit (*sysconf()* value 'SC_IOV_MAX') on the number of buffers that can be used.

適用：Unix。

在 3.3 版新加入。

Querying the size of a terminal

在 3.3 版新加入。

`os.get_terminal_size(fd=STDOUT_FILENO, /)`

Return the size of the terminal window as (columns, lines), tuple of type `terminal_size`.

The optional argument `fd` (default `STDOUT_FILENO`, or standard output) specifies which file descriptor should be queried.

If the file descriptor is not connected to a terminal, an `OSError` is raised.

`shutil.get_terminal_size()` is the high-level function which should normally be used, `os.get_terminal_size` is the low-level implementation.

適用：Unix、Windows。

class `os.terminal_size`

A subclass of tuple, holding (columns, lines) of the terminal window size.

columns

Width of the terminal window in characters.

lines

Height of the terminal window in characters.

Inheritance of File Descriptors

在 3.4 版新加入。

A file descriptor has an “inheritable” flag which indicates if the file descriptor can be inherited by child processes. Since Python 3.4, file descriptors created by Python are non-inheritable by default.

On UNIX, non-inheritable file descriptors are closed in child processes at the execution of a new program, other file descriptors are inherited.

On Windows, non-inheritable handles and file descriptors are closed in child processes, except for standard streams (file descriptors 0, 1 and 2: stdin, stdout and stderr), which are always inherited. Using `spawn*` functions, all inheritable handles and all inheritable file descriptors are inherited. Using the `subprocess` module, all file descriptors except standard streams are closed, and inheritable handles are only inherited if the `close_fds` parameter is `False`.

On WebAssembly platforms `wasm32-emsripten` and `wasm32-wasi`, the file descriptor cannot be modified.

`os.get_inheritable(fd, /)`

Get the “inheritable” flag of the specified file descriptor (a boolean).

`os.set_inheritable(fd, inheritable, /)`

Set the “inheritable” flag of the specified file descriptor.

`os.get_handle_inheritable(handle, /)`

Get the “inheritable” flag of the specified handle (a boolean).

適用：Windows。

`os.set_handle_inheritable(handle, inheritable, /)`

Set the “inheritable” flag of the specified handle.

適用：Windows。

16.1.6 Files and Directories

On some Unix platforms, many of these functions support one or more of these features:

- **specifying a file descriptor:** Normally the *path* argument provided to functions in the `os` module must be a string specifying a file path. However, some functions now alternatively accept an open file descriptor for their *path* argument. The function will then operate on the file referred to by the descriptor. (For POSIX systems, Python will call the variant of the function prefixed with `f` (e.g. call `fchdir` instead of `chdir`).)

You can check whether or not *path* can be specified as a file descriptor for a particular function on your platform using `os.supports_fd`. If this functionality is unavailable, using it will raise a `NotImplementedError`.

If the function also supports *dir_fd* or *follow_symlinks* arguments, it's an error to specify one of those when supplying *path* as a file descriptor.

- **paths relative to directory descriptors:** If *dir_fd* is not `None`, it should be a file descriptor referring to a directory, and the path to operate on should be relative; path will then be relative to that directory. If the path is absolute, *dir_fd* is ignored. (For POSIX systems, Python will call the variant of the function with an `at` suffix and possibly prefixed with `f` (e.g. call `faccessat` instead of `access`).

You can check whether or not *dir_fd* is supported for a particular function on your platform using `os.supports_dir_fd`. If it's unavailable, using it will raise a `NotImplementedError`.

- **not following symlinks:** If *follow_symlinks* is `False`, and the last element of the path to operate on is a symbolic link, the function will operate on the symbolic link itself rather than the file pointed to by the link. (For POSIX systems, Python will call the `l...` variant of the function.)

You can check whether or not *follow_symlinks* is supported for a particular function on your platform using `os.supports_follow_symlinks`. If it's unavailable, using it will raise a `NotImplementedError`.

`os.access(path, mode, *, dir_fd=None, effective_ids=False, follow_symlinks=True)`

Use the real uid/gid to test for access to *path*. Note that most operations will use the effective uid/gid, therefore this routine can be used in a `suid/sgid` environment to test if the invoking user has the specified access to *path*. *mode* should be `F_OK` to test the existence of *path*, or it can be the inclusive OR of one or more of `R_OK`, `W_OK`, and `X_OK` to test permissions. Return `True` if access is allowed, `False` if not. See the Unix man page `access(2)` for more information.

This function can support specifying *paths relative to directory descriptors* and *not following symlinks*.

If *effective_ids* is `True`, `access()` will perform its access checks using the effective uid/gid instead of the real uid/gid. *effective_ids* may not be supported on your platform; you can check whether or not it is available using `os.supports_effective_ids`. If it is unavailable, using it will raise a `NotImplementedError`.

備 F: Using `access()` to check if a user is authorized to e.g. open a file before actually doing so using `open()` creates a security hole, because the user might exploit the short time interval between checking and opening the file to manipulate it. It's preferable to use *EAFP* techniques. For example:

```
if os.access("myfile", os.R_OK):
    with open("myfile") as fp:
        return fp.read()
return "some default data"
```

is better written as:

```
try:
    fp = open("myfile")
except PermissionError:
    return "some default data"
else:
    with fp:
        return fp.read()
```

備 F: I/O operations may fail even when `access()` indicates that they would succeed, particularly for operations on network filesystems which may have permissions semantics beyond the usual POSIX permission-bit model.

在 3.3 版的變更: 新增 `dir_fd`、`effective_ids` 與 `follow_symlinks` 參數。

在 3.6 版的變更: Accepts a *path-like object*.

os.F_OK

os.R_OK

os.W_OK

os.X_OK

Values to pass as the *mode* parameter of `access()` to test the existence, readability, writability and executability of *path*, respectively.

os.chdir(*path*)

Change the current working directory to *path*.

This function can support *specifying a file descriptor*. The descriptor must refer to an opened directory, not an open file.

This function can raise `OSError` and subclasses such as `FileNotFoundError`, `PermissionError`, and `NotADirectoryError`.

引發一個附帶引數 *path* 的稽核事件 `os.chdir`。

在 3.3 版的變更: Added support for specifying *path* as a file descriptor on some platforms.

在 3.6 版的變更: Accepts a *path-like object*.

os.chflags(*path*, *flags*, *, *follow_symlinks*=True)

Set the flags of *path* to the numeric *flags*. *flags* may take a combination (bitwise OR) of the following values (as defined in the `stat` module):

- `stat.UF_NODUMP`
- `stat.UF_IMMUTABLE`
- `stat.UF_APPEND`
- `stat.UF_OPAQUE`
- `stat.UF_NOUNLINK`
- `stat.UF_COMPRESSED`
- `stat.UF_HIDDEN`
- `stat.SF_ARCHIVED`
- `stat.SF_IMMUTABLE`
- `stat.SF_APPEND`
- `stat.SF_NOUNLINK`
- `stat.SF_SNAPSHOT`

This function can support *not following symlinks*.

引發一個附帶引數 *path*、*flags* 的稽核事件 `os.chflags`。

適用: Unix、非 Emscripten、非 WASI。

在 3.3 版的變更: Added the `follow_symlinks` parameter.

在 3.6 版的變更: Accepts a *path-like object*.

os.chmod(path, mode, *, dir_fd=None, follow_symlinks=True)

Change the mode of *path* to the numeric *mode*. *mode* may take one of the following values (as defined in the *stat* module) or bitwise ORed combinations of them:

- stat.S_ISUID
- stat.S_ISGID
- stat.S_ENFMT
- stat.S_ISVTX
- stat.S_IREAD
- stat.S_IWRITE
- stat.S_IEXEC
- stat.S_IRWXU
- stat.S_IRUSR
- stat.S_IWUSR
- stat.S_IXUSR
- stat.S_IRWXG
- stat.S_IRGRP
- stat.S_IWGRP
- stat.S_IXGRP
- stat.S_IRWXO
- stat.S_IROTH
- stat.S_IWOTH
- stat.S_IXOTH

This function can support *specifying a file descriptor, paths relative to directory descriptors* and *not following symlinks*.

備 F: Although Windows supports `chmod()`, you can only set the file's read-only flag with it (via the `stat.S_IWRITE` and `stat.S_IREAD` constants or a corresponding integer value). All other bits are ignored.

The function is limited on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

引發一個附帶引數 `path`、`mode`、`dir_fd` 的稽核事件 `os.chmod`。

在 3.3 版新加入: Added support for specifying *path* as an open file descriptor, and the *dir_fd* and *follow_symlinks* arguments.

在 3.6 版的變更: Accepts a *path-like object*.

os.chown(path, uid, gid, *, dir_fd=None, follow_symlinks=True)

Change the owner and group id of *path* to the numeric *uid* and *gid*. To leave one of the ids unchanged, set it to -1.

This function can support *specifying a file descriptor, paths relative to directory descriptors* and *not following symlinks*.

See `shutil.chown()` for a higher-level function that accepts names in addition to numeric ids.

引發一個附帶引數 `path`、`uid`、`gid`、`dir_fd` 的稽核事件 `os.chown`。

適用: Unix。

The function is limited on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

在 3.3 版新加入: Added support for specifying *path* as an open file descriptor, and the *dir_fd* and *follow_symlinks* arguments.

在 3.6 版的變更: Supports a *path-like object*.

`os.chroot(path)`

Change the root directory of the current process to *path*.

適用: Unix、非 Emscripten、非 WASI。

在 3.6 版的變更: Accepts a *path-like object*.

`os.fchdir(fd)`

Change the current working directory to the directory represented by the file descriptor *fd*. The descriptor must refer to an opened directory, not an open file. As of Python 3.3, this is equivalent to `os.chdir(fd)`.

引發一個附帶引數 *path* 的稽核事件 `os.chdir`。

適用: Unix。

`os.getcwd()`

Return a string representing the current working directory.

`os.getcwdb()`

Return a bytestring representing the current working directory.

在 3.8 版的變更: The function now uses the UTF-8 encoding on Windows, rather than the ANSI code page: see [PEP 529](#) for the rationale. The function is no longer deprecated on Windows.

`os.lchflags(path, flags)`

Set the flags of *path* to the numeric *flags*, like `chflags()`, but do not follow symbolic links. As of Python 3.3, this is equivalent to `os.chflags(path, flags, follow_symlinks=False)`.

引發一個附帶引數 *path*、*flags* 的稽核事件 `os.chflags`。

適用: Unix、非 Emscripten、非 WASI。

在 3.6 版的變更: Accepts a *path-like object*.

`os.lchmod(path, mode)`

Change the mode of *path* to the numeric *mode*. If *path* is a symlink, this affects the symlink rather than the target. See the docs for `chmod()` for possible values of *mode*. As of Python 3.3, this is equivalent to `os.chmod(path, mode, follow_symlinks=False)`.

`lchmod()` is not part of POSIX, but Unix implementations may have it if changing the mode of symbolic links is supported.

引發一個附帶引數 *path*、*mode*、*dir_fd* 的稽核事件 `os.chmod`。

Availability: Unix, not Linux, FreeBSD >= 1.3, NetBSD >= 1.3, not OpenBSD

在 3.6 版的變更: Accepts a *path-like object*.

`os.lchown(path, uid, gid)`

Change the owner and group id of *path* to the numeric *uid* and *gid*. This function will not follow symbolic links. As of Python 3.3, this is equivalent to `os.chown(path, uid, gid, follow_symlinks=False)`.

引發一個附帶引數 *path*、*uid*、*gid*、*dir_fd* 的稽核事件 `os.chown`。

適用: Unix。

在 3.6 版的變更: Accepts a *path-like object*.

`os.link(src, dst, *, src_dir_fd=None, dst_dir_fd=None, follow_symlinks=True)`

Create a hard link pointing to *src* named *dst*.

This function can support specifying *src_dir_fd* and/or *dst_dir_fd* to supply *paths relative to directory descriptors*, and *not following symlinks*.

引發一個附帶引數 `src`、`dst`、`src_dir_fd`、`dst_dir_fd` 的稽核事件 `os.link`。

Availability: Unix, Windows, not Emscripten.

在 3.2 版的變更: 新支援 Windows。

在 3.3 版的變更: Added the `src_dir_fd`, `dst_dir_fd`, and `follow_symlinks` parameters.

在 3.6 版的變更: Accepts a *path-like object* for `src` and `dst`.

`os.listdir (path='.')`

Return a list containing the names of the entries in the directory given by *path*. The list is in arbitrary order, and does not include the special entries `'.'` and `'..'` even if they are present in the directory. If a file is removed from or added to the directory during the call of this function, whether a name for that file be included is unspecified.

path may be a *path-like object*. If *path* is of type `bytes` (directly or indirectly through the *PathLike* interface), the filenames returned will also be of type `bytes`; in all other circumstances, they will be of type `str`.

This function can also support *specifying a file descriptor*; the file descriptor must refer to a directory.

引發一個附帶引數 `path` 的稽核事件 `os.listdir`。

備註: To encode `str` filenames to `bytes`, use `fsencode()`.

也參考:

The `scandir()` function returns directory entries along with file attribute information, giving better performance for many common use cases.

在 3.2 版的變更: The *path* parameter became optional.

在 3.3 版新加入: Added support for specifying *path* as an open file descriptor.

在 3.6 版的變更: Accepts a *path-like object*.

`os.lstat (path, *, dir_fd=None)`

Perform the equivalent of an `lstat()` system call on the given path. Similar to `stat()`, but does not follow symbolic links. Return a *stat_result* object.

On platforms that do not support symbolic links, this is an alias for `stat()`.

As of Python 3.3, this is equivalent to `os.stat(path, dir_fd=dir_fd, follow_symlinks=False)`.

This function can also support *paths relative to directory descriptors*.

也參考:

The `stat()` function.

在 3.2 版的變更: Added support for Windows 6.0 (Vista) symbolic links.

在 3.3 版的變更: 新增 `dir_fd` 參數。

在 3.6 版的變更: Accepts a *path-like object*.

在 3.8 版的變更: On Windows, now opens reparse points that represent another path (name surrogates), including symbolic links and directory junctions. Other kinds of reparse points are resolved by the operating system as for `stat()`.

`os.mkdir (path, mode=0o777, *, dir_fd=None)`

Create a directory named *path* with numeric mode *mode*.

If the directory already exists, `FileExistsError` is raised. If a parent directory in the path does not exist, `FileNotFoundError` is raised.

On some systems, *mode* is ignored. Where it is used, the current umask value is first masked out. If bits other than the last 9 (i.e. the last 3 digits of the octal representation of the *mode*) are set, their meaning is platform-dependent. On some platforms, they are ignored and you should call `chmod()` explicitly to set them.

This function can also support *paths relative to directory descriptors*.

It is also possible to create temporary directories; see the `tempfile` module's `tempfile.mkdtemp()` function.

引發一個附帶引數 `path`、`mode`、`dir_fd` 的稽核事件 `os.mkdir`。

在 3.3 版的變更: 新增 `dir_fd` 參數。

在 3.6 版的變更: Accepts a *path-like object*.

`os.makedirs` (*name*, *mode*=0o777, *exist_ok*=False)

Recursive directory creation function. Like `mkdir()`, but makes all intermediate-level directories needed to contain the leaf directory.

The *mode* parameter is passed to `mkdir()` for creating the leaf directory; see *the mkdir() description* for how it is interpreted. To set the file permission bits of any newly created parent directories you can set the umask before invoking `makedirs()`. The file permission bits of existing parent directories are not changed.

If *exist_ok* is False (the default), a `FileExistsError` is raised if the target directory already exists.

備 F: `makedirs()` will become confused if the path elements to create include *pardir* (eg. `..` on UNIX systems).

This function handles UNC paths correctly.

引發一個附帶引數 `path`、`mode`、`dir_fd` 的稽核事件 `os.mkdir`。

在 3.2 版的變更: Added the *exist_ok* parameter.

在 3.4.1 版的變更: Before Python 3.4.1, if *exist_ok* was True and the directory existed, `makedirs()` would still raise an error if *mode* did not match the mode of the existing directory. Since this behavior was impossible to implement safely, it was removed in Python 3.4.1. See [bpo-21082](#).

在 3.6 版的變更: Accepts a *path-like object*.

在 3.7 版的變更: The *mode* argument no longer affects the file permission bits of newly created intermediate-level directories.

`os.mkfifo` (*path*, *mode*=0o666, *, *dir_fd*=None)

Create a FIFO (a named pipe) named *path* with numeric mode *mode*. The current umask value is first masked out from the mode.

This function can also support *paths relative to directory descriptors*.

FIFOs are pipes that can be accessed like regular files. FIFOs exist until they are deleted (for example with `os.unlink()`). Generally, FIFOs are used as rendezvous between "client" and "server" type processes: the server opens the FIFO for reading, and the client opens it for writing. Note that `mkfifo()` doesn't open the FIFO --- it just creates the rendezvous point.

適用: Unix、非 Emscripten、非 WASI。

在 3.3 版的變更: 新增 `dir_fd` 參數。

在 3.6 版的變更: Accepts a *path-like object*.

`os.mknod` (*path*, *mode*=0o600, *device*=0, *, *dir_fd*=None)

Create a filesystem node (file, device special file or named pipe) named *path*. *mode* specifies both the permissions to use and the type of node to be created, being combined (bitwise OR) with one of `stat.S_IFREG`, `stat.S_IFCHR`, `stat.S_IFBLK`, and `stat.S_IFIFO` (those constants are available in `stat`). For `stat.S_IFCHR` and `stat.S_IFBLK`, *device* defines the newly created device special file (probably using `os.makedev()`), otherwise it is ignored.

This function can also support *paths relative to directory descriptors*.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版的變更：新增 `dir_fd` 參數。

在 3.6 版的變更：Accepts a *path-like object*.

`os.major(device, /)`

Extract the device major number from a raw device number (usually the `st_dev` or `st_rdev` field from `stat`).

`os.minor(device, /)`

Extract the device minor number from a raw device number (usually the `st_dev` or `st_rdev` field from `stat`).

`os.makedev(major, minor, /)`

Compose a raw device number from the major and minor device numbers.

`os.pathconf(path, name)`

Return system configuration information relevant to a named file. *name* specifies the configuration value to retrieve; it may be a string which is the name of a defined system value; these names are specified in a number of standards (POSIX.1, Unix 95, Unix 98, and others). Some platforms define additional names as well. The names known to the host operating system are given in the `pathconf_names` dictionary. For configuration variables not included in that mapping, passing an integer for *name* is also accepted.

If *name* is a string and is not known, `ValueError` is raised. If a specific value for *name* is not supported by the host system, even if it is included in `pathconf_names`, an `OSError` is raised with `errno.EINVAL` for the error number.

This function can support *specifying a file descriptor*.

適用：Unix。

在 3.6 版的變更：Accepts a *path-like object*.

`os.pathconf_names`

Dictionary mapping names accepted by `pathconf()` and `fpathconf()` to the integer values defined for those names by the host operating system. This can be used to determine the set of names known to the system.

適用：Unix。

`os.readlink(path, *, dir_fd=None)`

Return a string representing the path to which the symbolic link points. The result may be either an absolute or relative pathname; if it is relative, it may be converted to an absolute pathname using `os.path.join(os.path.dirname(path), result)`.

If the *path* is a string object (directly or indirectly through a *PathLike* interface), the result will also be a string object, and the call may raise a `UnicodeDecodeError`. If the *path* is a bytes object (direct or indirectly), the result will be a bytes object.

This function can also support *paths relative to directory descriptors*.

When trying to resolve a path that may contain links, use `realpath()` to properly handle recursion and platform differences.

適用：Unix、Windows。

在 3.2 版的變更：Added support for Windows 6.0 (Vista) symbolic links.

在 3.3 版的變更：新增 `dir_fd` 參數。

在 3.6 版的變更：Accepts a *path-like object* on Unix.

在 3.8 版的變更：Accepts a *path-like object* and a bytes object on Windows.

Added support for directory junctions, and changed to return the substitution path (which typically includes `\\?\\` prefix) rather than the optional "print name" field that was previously returned.

`os.remove(path, *, dir_fd=None)`

Remove (delete) the file *path*. If *path* is a directory, an *OSError* is raised. Use *rmdir()* to remove directories. If the file does not exist, a *FileNotFoundError* is raised.

This function can support *paths relative to directory descriptors*.

On Windows, attempting to remove a file that is in use causes an exception to be raised; on Unix, the directory entry is removed but the storage allocated to the file is not made available until the original file is no longer in use.

This function is semantically identical to *unlink()*.

引發一個附帶引數 *path*、*dir_fd* 的稽核事件 `os.remove`。

在 3.3 版的變更: 新增 *dir_fd* 參數。

在 3.6 版的變更: Accepts a *path-like object*.

`os.removedirs(name)`

Remove directories recursively. Works like *rmdir()* except that, if the leaf directory is successfully removed, *removedirs()* tries to successively remove every parent directory mentioned in *path* until an error is raised (which is ignored, because it generally means that a parent directory is not empty). For example, `os.removedirs('foo/bar/baz')` will first remove the directory 'foo/bar/baz', and then remove 'foo/bar' and 'foo' if they are empty. Raises *OSError* if the leaf directory could not be successfully removed.

引發一個附帶引數 *path*、*dir_fd* 的稽核事件 `os.remove`。

在 3.6 版的變更: Accepts a *path-like object*.

`os.rename(src, dst, *, src_dir_fd=None, dst_dir_fd=None)`

Rename the file or directory *src* to *dst*. If *dst* exists, the operation will fail with an *OSError* subclass in a number of cases:

On Windows, if *dst* exists a *FileExistsError* is always raised. The operation may fail if *src* and *dst* are on different filesystems. Use *shutil.move()* to support moves to a different filesystem.

On Unix, if *src* is a file and *dst* is a directory or vice-versa, an *IsADirectoryError* or a *NotADirectoryError* will be raised respectively. If both are directories and *dst* is empty, *dst* will be silently replaced. If *dst* is a non-empty directory, an *OSError* is raised. If both are files, *dst* will be replaced silently if the user has permission. The operation may fail on some Unix flavors if *src* and *dst* are on different filesystems. If successful, the renaming will be an atomic operation (this is a POSIX requirement).

This function can support specifying *src_dir_fd* and/or *dst_dir_fd* to supply *paths relative to directory descriptors*.

If you want cross-platform overwriting of the destination, use *replace()*.

引發一個附帶引數 *src*、*dst*、*src_dir_fd*、*dst_dir_fd* 的稽核事件 `os.rename`。

在 3.3 版的變更: Added the *src_dir_fd* and *dst_dir_fd* parameters.

在 3.6 版的變更: Accepts a *path-like object* for *src* and *dst*.

`os.renames(old, new)`

Recursive directory or file renaming function. Works like *rename()*, except creation of any intermediate directories needed to make the new pathname good is attempted first. After the rename, directories corresponding to rightmost path segments of the old name will be pruned away using *removedirs()*.

備 F: This function can fail with the new directory structure made if you lack permissions needed to remove the leaf directory or file.

引發一個附帶引數 *src*、*dst*、*src_dir_fd*、*dst_dir_fd* 的稽核事件 `os.rename`。

在 3.6 版的變更: Accepts a *path-like object* for *old* and *new*.

`os.replace(src, dst, *, src_dir_fd=None, dst_dir_fd=None)`

Rename the file or directory *src* to *dst*. If *dst* is a non-empty directory, *OSError* will be raised. If *dst* exists and is a file, it will be replaced silently if the user has permission. The operation may fail if *src* and *dst* are on different filesystems. If successful, the renaming will be an atomic operation (this is a POSIX requirement).

This function can support specifying *src_dir_fd* and/or *dst_dir_fd* to supply *paths relative to directory descriptors*.

引發一個附帶引數 *src*、*dst*、*src_dir_fd*、*dst_dir_fd* 的稽核事件 `os.rename`。

在 3.3 版新加入。

在 3.6 版的變更: Accepts a *path-like object* for *src* and *dst*.

`os.rmdir(path, *, dir_fd=None)`

Remove (delete) the directory *path*. If the directory does not exist or is not empty, a *FileNotFoundError* or an *OSError* is raised respectively. In order to remove whole directory trees, *shutil.rmtree()* can be used.

This function can support *paths relative to directory descriptors*.

引發一個附帶引數 *path*、*dir_fd* 的稽核事件 `os.rmdir`。

在 3.3 版的變更: 新增 *dir_fd* 參數。

在 3.6 版的變更: Accepts a *path-like object*.

`os.scandir(path='.')`

Return an iterator of *os.DirEntry* objects corresponding to the entries in the directory given by *path*. The entries are yielded in arbitrary order, and the special entries *'.'* and *'..'* are not included. If a file is removed from or added to the directory after creating the iterator, whether an entry for that file be included is unspecified.

Using *scandir()* instead of *listdir()* can significantly increase the performance of code that also needs file type or file attribute information, because *os.DirEntry* objects expose this information if the operating system provides it when scanning a directory. All *os.DirEntry* methods may perform a system call, but *is_dir()* and *is_file()* usually only require a system call for symbolic links; *os.DirEntry.stat()* always requires a system call on Unix but only requires one for symbolic links on Windows.

path may be a *path-like object*. If *path* is of type *bytes* (directly or indirectly through the *PathLike* interface), the type of the *name* and *path* attributes of each *os.DirEntry* will be *bytes*; in all other circumstances, they will be of type *str*.

This function can also support *specifying a file descriptor*; the file descriptor must refer to a directory.

引發一個附帶引數 *path* 的稽核事件 `os.scandir`。

The *scandir()* iterator supports the *context manager* protocol and has the following method:

`scandir.close()`

Close the iterator and free acquired resources.

This is called automatically when the iterator is exhausted or garbage collected, or when an error happens during iterating. However it is advisable to call it explicitly or use the *with* statement.

在 3.6 版新加入。

The following example shows a simple use of *scandir()* to display all the files (excluding directories) in the given *path* that don't start with *'.'*. The *entry.is_file()* call will generally not make an additional system call:

```
with os.scandir(path) as it:
    for entry in it:
        if not entry.name.startswith('.') and entry.is_file():
            print(entry.name)
```

備 F: On Unix-based systems, `scandir()` uses the system's `opendir()` and `readdir()` functions. On Windows, it uses the Win32 `FindFirstFileW` and `FindNextFileW` functions.

在 3.5 版新加入。

在 3.6 版的變更: Added support for the *context manager* protocol and the `close()` method. If a `scandir()` iterator is neither exhausted nor explicitly closed a `ResourceWarning` will be emitted in its destructor.

The function accepts a *path-like object*.

在 3.7 版的變更: Added support for *file descriptors* on Unix.

class `os.DirEntry`

Object yielded by `scandir()` to expose the file path and other file attributes of a directory entry.

`scandir()` will provide as much of this information as possible without making additional system calls. When a `stat()` or `lstat()` system call is made, the `os.DirEntry` object will cache the result.

`os.DirEntry` instances are not intended to be stored in long-lived data structures; if you know the file metadata has changed or if a long time has elapsed since calling `scandir()`, call `os.stat(entry.path)` to fetch up-to-date information.

Because the `os.DirEntry` methods can make operating system calls, they may also raise `OSError`. If you need very fine-grained control over errors, you can catch `OSError` when calling one of the `os.DirEntry` methods and handle as appropriate.

To be directly usable as a *path-like object*, `os.DirEntry` implements the *PathLike* interface.

Attributes and methods on a `os.DirEntry` instance are as follows:

name

The entry's base filename, relative to the `scandir()` *path* argument.

The *name* attribute will be `bytes` if the `scandir()` *path* argument is of type `bytes` and `str` otherwise. Use `fsdecode()` to decode byte filenames.

path

The entry's full path name: equivalent to `os.path.join(scandir_path, entry.name)` where `scandir_path` is the `scandir()` *path* argument. The path is only absolute if the `scandir()` *path* argument was absolute. If the `scandir()` *path* argument was a *file descriptor*, the *path* attribute is the same as the *name* attribute.

The *path* attribute will be `bytes` if the `scandir()` *path* argument is of type `bytes` and `str` otherwise. Use `fsdecode()` to decode byte filenames.

inode()

Return the inode number of the entry.

The result is cached on the `os.DirEntry` object. Use `os.stat(entry.path, follow_symlinks=False).st_ino` to fetch up-to-date information.

On the first, uncached call, a system call is required on Windows but not on Unix.

is_dir(*, follow_symlinks=True)

Return `True` if this entry is a directory or a symbolic link pointing to a directory; return `False` if the entry is or points to any other kind of file, or if it doesn't exist anymore.

If `follow_symlinks` is `False`, return `True` only if this entry is a directory (without following symlinks); return `False` if the entry is any other kind of file or if it doesn't exist anymore.

The result is cached on the `os.DirEntry` object, with a separate cache for `follow_symlinks` `True` and `False`. Call `os.stat()` along with `stat.S_ISDIR()` to fetch up-to-date information.

On the first, uncached call, no system call is required in most cases. Specifically, for non-symlinks, neither Windows or Unix require a system call, except on certain Unix file systems, such as network file

systems, that return `dirent.d_type == DT_UNKNOWN`. If the entry is a symlink, a system call will be required to follow the symlink unless `follow_symlinks` is `False`.

This method can raise `OSError`, such as `PermissionError`, but `FileNotFoundError` is caught and not raised.

is_file (*, *follow_symlinks=True*)

Return `True` if this entry is a file or a symbolic link pointing to a file; return `False` if the entry is or points to a directory or other non-file entry, or if it doesn't exist anymore.

If `follow_symlinks` is `False`, return `True` only if this entry is a file (without following symlinks); return `False` if the entry is a directory or other non-file entry, or if it doesn't exist anymore.

The result is cached on the `os.DirEntry` object. Caching, system calls made, and exceptions raised are as per `is_dir()`.

is_symlink ()

Return `True` if this entry is a symbolic link (even if broken); return `False` if the entry points to a directory or any kind of file, or if it doesn't exist anymore.

The result is cached on the `os.DirEntry` object. Call `os.path.islink()` to fetch up-to-date information.

On the first, uncached call, no system call is required in most cases. Specifically, neither Windows or Unix require a system call, except on certain Unix file systems, such as network file systems, that return `dirent.d_type == DT_UNKNOWN`.

This method can raise `OSError`, such as `PermissionError`, but `FileNotFoundError` is caught and not raised.

stat (*, *follow_symlinks=True*)

Return a `stat_result` object for this entry. This method follows symbolic links by default; to stat a symbolic link add the `follow_symlinks=False` argument.

On Unix, this method always requires a system call. On Windows, it only requires a system call if `follow_symlinks` is `True` and the entry is a reparse point (for example, a symbolic link or directory junction).

On Windows, the `st_ino`, `st_dev` and `st_nlink` attributes of the `stat_result` are always set to zero. Call `os.stat()` to get these attributes.

The result is cached on the `os.DirEntry` object, with a separate cache for `follow_symlinks` `True` and `False`. Call `os.stat()` to fetch up-to-date information.

Note that there is a nice correspondence between several attributes and methods of `os.DirEntry` and of `pathlib.Path`. In particular, the `name` attribute has the same meaning, as do the `is_dir()`, `is_file()`, `is_symlink()` and `stat()` methods.

在 3.5 版新加入.

在 3.6 版的變更: Added support for the `PathLike` interface. Added support for `bytes` paths on Windows.

os.stat (path, *, *dir_fd=None*, *follow_symlinks=True*)

Get the status of a file or a file descriptor. Perform the equivalent of a `stat()` system call on the given path. `path` may be specified as either a string or bytes -- directly or indirectly through the `PathLike` interface -- or as an open file descriptor. Return a `stat_result` object.

This function normally follows symlinks; to stat a symlink add the argument `follow_symlinks=False`, or use `lstat()`.

This function can support *specifying a file descriptor* and *not following symlinks*.

On Windows, passing `follow_symlinks=False` will disable following all name-surrogate reparse points, which includes symlinks and directory junctions. Other types of reparse points that do not resemble links or that the operating system is unable to follow will be opened directly. When following a chain of multiple links, this may result in the original link being returned instead of the non-link that prevented full traversal. To obtain stat results for the final path in this case, use the `os.path.realpath()` function to resolve the path name

as far as possible and call `lstat()` on the result. This does not apply to dangling symlinks or junction points, which will raise the usual exceptions.

範例：

```
>>> import os
>>> statinfo = os.stat('somefile.txt')
>>> statinfo
os.stat_result(st_mode=33188, st_ino=7876932, st_dev=234881026,
st_nlink=1, st_uid=501, st_gid=501, st_size=264, st_atime=1297230295,
st_mtime=1297230027, st_ctime=1297230027)
>>> statinfo.st_size
264
```

也參考：

`fstat()` 和 `lstat()` 函式。

在 3.3 版的變更: Added the `dir_fd` and `follow_symlinks` parameters, specifying a file descriptor instead of a path.

在 3.6 版的變更: Accepts a *path-like object*.

在 3.8 版的變更: On Windows, all reparse points that can be resolved by the operating system are now followed, and passing `follow_symlinks=False` disables following all name surrogate reparse points. If the operating system reaches a reparse point that it is not able to follow, `stat` now returns the information for the original path as if `follow_symlinks=False` had been specified instead of raising an error.

class `os.stat_result`

Object whose attributes correspond roughly to the members of the `stat` structure. It is used for the result of `os.stat()`, `os.fstat()` and `os.lstat()`.

Attributes:

st_mode

File mode: file type and file mode bits (permissions).

st_ino

Platform dependent, but if non-zero, uniquely identifies the file for a given value of `st_dev`. Typically:

- the inode number on Unix,
- the file index on Windows

st_dev

Identifier of the device on which this file resides.

st_nlink

Number of hard links.

st_uid

User identifier of the file owner.

st_gid

Group identifier of the file owner.

st_size

Size of the file in bytes, if it is a regular file or a symbolic link. The size of a symbolic link is the length of the pathname it contains, without a terminating null byte.

Timestamps:

st_atime

Time of most recent access expressed in seconds.

st_mtime

Time of most recent content modification expressed in seconds.

st_ctime

Platform dependent:

- the time of most recent metadata change on Unix,
- the time of creation on Windows, expressed in seconds.

st_atime_ns

Time of most recent access expressed in nanoseconds as an integer.

在 3.3 版新加入。

st_mtime_ns

Time of most recent content modification expressed in nanoseconds as an integer.

在 3.3 版新加入。

st_ctime_ns

Platform dependent:

- the time of most recent metadata change on Unix,
- the time of creation on Windows, expressed in nanoseconds as an integer.

在 3.3 版新加入。

備註: The exact meaning and resolution of the *st_atime*, *st_mtime*, and *st_ctime* attributes depend on the operating system and the file system. For example, on Windows systems using the FAT or FAT32 file systems, *st_mtime* has 2-second resolution, and *st_atime* has only 1-day resolution. See your operating system documentation for details.

Similarly, although *st_atime_ns*, *st_mtime_ns*, and *st_ctime_ns* are always expressed in nanoseconds, many systems do not provide nanosecond precision. On systems that do provide nanosecond precision, the floating-point object used to store *st_atime*, *st_mtime*, and *st_ctime* cannot preserve all of it, and as such will be slightly inexact. If you need the exact timestamps you should always use *st_atime_ns*, *st_mtime_ns*, and *st_ctime_ns*.

On some Unix systems (such as Linux), the following attributes may also be available:

st_blocks

Number of 512-byte blocks allocated for file. This may be smaller than *st_size*/512 when the file has holes.

st_blksize

“Preferred” blocksize for efficient file system I/O. Writing to a file in smaller chunks may cause an inefficient read-modify-rewrite.

st_rdev

Type of device if an inode device.

st_flags

User defined flags for file.

On other Unix systems (such as FreeBSD), the following attributes may be available (but may be only filled out if root tries to use them):

st_gen

File generation number.

st_birthtime

Time of file creation.

On Solaris and derivatives, the following attributes may also be available:

st_fstype

String that uniquely identifies the type of the filesystem that contains the file.

On macOS systems, the following attributes may also be available:

st_rsize

Real size of the file.

st_creator

Creator of the file.

st_type

File type.

On Windows systems, the following attributes are also available:

st_file_attributes

Windows file attributes: `dwFileAttributes` member of the `BY_HANDLE_FILE_INFORMATION` structure returned by `GetFileInformationByHandle()`. See the `FILE_ATTRIBUTE_*` <`stat.FILE_ATTRIBUTE_ARCHIVE`> constants in the `stat` module.

在 3.5 版新加入.

st_reparse_tag

When `st_file_attributes` has the `FILE_ATTRIBUTE_REPARSE_POINT` set, this field contains the tag identifying the type of reparse point. See the `IO_REPARSE_TAG_*` constants in the `stat` module.

The standard module `stat` defines functions and constants that are useful for extracting information from a `stat` structure. (On Windows, some items are filled with dummy values.)

For backward compatibility, a `stat_result` instance is also accessible as a tuple of at least 10 integers giving the most important (and portable) members of the `stat` structure, in the order `st_mode`, `st_ino`, `st_dev`, `st_nlink`, `st_uid`, `st_gid`, `st_size`, `st_atime`, `st_mtime`, `st_ctime`. More items may be added at the end by some implementations. For compatibility with older Python versions, accessing `stat_result` as a tuple always returns integers.

在 3.5 版的變更: Windows now returns the file index as `st_ino` when available.

在 3.7 版的變更: Added the `st_fstype` member to Solaris/derivatives.

在 3.8 版的變更: Added the `st_reparse_tag` member on Windows.

在 3.8 版的變更: On Windows, the `st_mode` member now identifies special files as `S_IFCHR`, `S_IFIFO` or `S_IFBLK` as appropriate.

os.statvfs(path)

Perform a `statvfs()` system call on the given path. The return value is an object whose attributes describe the filesystem on the given path, and correspond to the members of the `statvfs` structure, namely: `f_bsize`, `f_frsize`, `f_blocks`, `f_bfree`, `f_bavail`, `f_files`, `f_ffree`, `f_favail`, `f_flag`, `f_namemax`, `f_fsid`.

Two module-level constants are defined for the `f_flag` attribute's bit-flags: if `ST_RDONLY` is set, the filesystem is mounted read-only, and if `ST_NOSUID` is set, the semantics of `setuid`/`setgid` bits are disabled or not supported.

Additional module-level constants are defined for GNU/glibc based systems. These are `ST_NODEV` (disallow access to device special files), `ST_NOEXEC` (disallow program execution), `ST_SYNCHRONOUS` (writes are synced at once), `ST_MANDLOCK` (allow mandatory locks on an FS), `ST_WRITE` (write on file/directory/symlink), `ST_APPEND` (append-only file), `ST_IMMUTABLE` (immutable file), `ST_NOATIME`

(do not update access times), `ST_NODIRATIME` (do not update directory access times), `ST_RELATIVE` (update atime relative to mtime/ctime).

This function can support *specifying a file descriptor*.

適用：Unix。

在 3.2 版的變更：新增 `ST_RDONLY` 與 `ST_NOSUID` 常數。

在 3.3 版的變更：Added support for specifying *path* as an open file descriptor.

在 3.4 版的變更：The `ST_NODEV`, `ST_NOEXEC`, `ST_SYNCHRONOUS`, `ST_MANDLOCK`, `ST_WRITE`, `ST_APPEND`, `ST_IMMUTABLE`, `ST_NOATIME`, `ST_NODIRATIME`, and `ST_RELATIVE` constants were added.

在 3.6 版的變更：Accepts a *path-like object*.

在 3.7 版的變更：Added the `f_fsid` attribute.

`os.supports_dir_fd`

A *set* object indicating which functions in the `os` module accept an open file descriptor for their *dir_fd* parameter. Different platforms provide different features, and the underlying functionality Python uses to implement the *dir_fd* parameter is not available on all platforms Python supports. For consistency's sake, functions that may support *dir_fd* always allow specifying the parameter, but will throw an exception if the functionality is used when it's not locally available. (Specifying `None` for *dir_fd* is always supported on all platforms.)

To check whether a particular function accepts an open file descriptor for its *dir_fd* parameter, use the `in` operator on `supports_dir_fd`. As an example, this expression evaluates to `True` if `os.stat()` accepts open file descriptors for *dir_fd* on the local platform:

```
os.stat in os.supports_dir_fd
```

Currently *dir_fd* parameters only work on Unix platforms; none of them work on Windows.

在 3.3 版新加入。

`os.supports_effective_ids`

A *set* object indicating whether `os.access()` permits specifying `True` for its *effective_ids* parameter on the local platform. (Specifying `False` for *effective_ids* is always supported on all platforms.) If the local platform supports it, the collection will contain `os.access()`; otherwise it will be empty.

This expression evaluates to `True` if `os.access()` supports *effective_ids=True* on the local platform:

```
os.access in os.supports_effective_ids
```

Currently *effective_ids* is only supported on Unix platforms; it does not work on Windows.

在 3.3 版新加入。

`os.supports_fd`

A *set* object indicating which functions in the `os` module permit specifying their *path* parameter as an open file descriptor on the local platform. Different platforms provide different features, and the underlying functionality Python uses to accept open file descriptors as *path* arguments is not available on all platforms Python supports.

To determine whether a particular function permits specifying an open file descriptor for its *path* parameter, use the `in` operator on `supports_fd`. As an example, this expression evaluates to `True` if `os.chdir()` accepts open file descriptors for *path* on your local platform:

```
os.chdir in os.supports_fd
```

在 3.3 版新加入。

os.supports_follow_symlinks

A *set* object indicating which functions in the *os* module accept *False* for their *follow_symlinks* parameter on the local platform. Different platforms provide different features, and the underlying functionality Python uses to implement *follow_symlinks* is not available on all platforms Python supports. For consistency's sake, functions that may support *follow_symlinks* always allow specifying the parameter, but will throw an exception if the functionality is used when it's not locally available. (Specifying *True* for *follow_symlinks* is always supported on all platforms.)

To check whether a particular function accepts *False* for its *follow_symlinks* parameter, use the *in* operator on *supports_follow_symlinks*. As an example, this expression evaluates to *True* if you may specify *follow_symlinks=False* when calling *os.stat()* on the local platform:

```
os.stat in os.supports_follow_symlinks
```

在 3.3 版新加入。

os.symlink (*src*, *dst*, *target_is_directory=False*, *, *dir_fd=None*)

Create a symbolic link pointing to *src* named *dst*.

On Windows, a symlink represents either a file or a directory, and does not morph to the target dynamically. If the target is present, the type of the symlink will be created to match. Otherwise, the symlink will be created as a directory if *target_is_directory* is *True* or a file symlink (the default) otherwise. On non-Windows platforms, *target_is_directory* is ignored.

This function can support *paths relative to directory descriptors*.

備 F: On newer versions of Windows 10, unprivileged accounts can create symlinks if Developer Mode is enabled. When Developer Mode is not available/enabled, the *SeCreateSymbolicLinkPrivilege* privilege is required, or the process must be run as an administrator.

OSError is raised when the function is called by an unprivileged user.

引發一個附帶引數 *src*、*dst*、*dir_fd* 的稽核事件 *os.symlink*。

適用：Unix、Windows。

The function is limited on Emscripten and WASI, see [WebAssembly 平台](#) for more information.

在 3.2 版的變更: Added support for Windows 6.0 (Vista) symbolic links.

在 3.3 版的變更: Added the *dir_fd* parameter, and now allow *target_is_directory* on non-Windows platforms.

在 3.6 版的變更: Accepts a *path-like object* for *src* and *dst*.

在 3.8 版的變更: Added support for unelevated symlinks on Windows with Developer Mode.

os.sync()

Force write of everything to disk.

適用：Unix。

在 3.3 版新加入。

os.truncate (*path*, *length*)

Truncate the file corresponding to *path*, so that it is at most *length* bytes in size.

This function can support *specifying a file descriptor*.

引發一個附帶引數 *path*、*length* 的稽核事件 *os.truncate*。

適用：Unix、Windows。

在 3.3 版新加入。

在 3.5 版的變更: 新增對 Windows 的支援

在 3.6 版的變更: Accepts a *path-like object*.

`os.unlink(path, *, dir_fd=None)`

Remove (delete) the file *path*. This function is semantically identical to `remove()`; the `unlink` name is its traditional Unix name. Please see the documentation for `remove()` for further information.

引發一個附帶引數 *path*、*dir_fd* 的稽核事件 `os.remove`。

在 3.3 版的變更: 新增 *dir_fd* 參數。

在 3.6 版的變更: Accepts a *path-like object*.

`os.utime(path, times=None, *, [ns,]dir_fd=None, follow_symlinks=True)`

Set the access and modified times of the file specified by *path*.

`utime()` takes two optional parameters, *times* and *ns*. These specify the times set on *path* and are used as follows:

- If *ns* is specified, it must be a 2-tuple of the form (*atime_ns*, *mtime_ns*) where each member is an int expressing nanoseconds.
- If *times* is not `None`, it must be a 2-tuple of the form (*atime*, *mtime*) where each member is an int or float expressing seconds.
- If *times* is `None` and *ns* is unspecified, this is equivalent to specifying *ns*=(*atime_ns*, *mtime_ns*) where both times are the current time.

It is an error to specify tuples for both *times* and *ns*.

Note that the exact times you set here may not be returned by a subsequent `stat()` call, depending on the resolution with which your operating system records access and modification times; see `stat()`. The best way to preserve exact times is to use the *st_atime_ns* and *st_mtime_ns* fields from the `os.stat()` result object with the *ns* parameter to `utime()`.

This function can support *specifying a file descriptor*, *paths relative to directory descriptors* and *not following symlinks*.

引發一個附帶引數 *path*、*times*、*ns*、*dir_fd* 的稽核事件 `os.utime`。

在 3.3 版的變更: Added support for specifying *path* as an open file descriptor, and the *dir_fd*, *follow_symlinks*, and *ns* parameters.

在 3.6 版的變更: Accepts a *path-like object*.

`os.walk(top, topdown=True, onerror=None, followlinks=False)`

Generate the file names in a directory tree by walking the tree either top-down or bottom-up. For each directory in the tree rooted at directory *top* (including *top* itself), it yields a 3-tuple (*dirpath*, *dirnames*, *filenames*).

dirpath is a string, the path to the directory. *dirnames* is a list of the names of the subdirectories in *dirpath* (including symlinks to directories, and excluding '.' and '..'). *filenames* is a list of the names of the non-directory files in *dirpath*. Note that the names in the lists contain no path components. To get a full path (which begins with *top*) to a file or directory in *dirpath*, do `os.path.join(dirpath, name)`. Whether or not the lists are sorted depends on the file system. If a file is removed from or added to the *dirpath* directory during generating the lists, whether a name for that file be included is unspecified.

If optional argument *topdown* is `True` or not specified, the triple for a directory is generated before the triples for any of its subdirectories (directories are generated top-down). If *topdown* is `False`, the triple for a directory is generated after the triples for all of its subdirectories (directories are generated bottom-up). No matter the value of *topdown*, the list of subdirectories is retrieved before the tuples for the directory and its subdirectories are generated.

When *topdown* is `True`, the caller can modify the *dirnames* list in-place (perhaps using `del` or slice assignment), and `walk()` will only recurse into the subdirectories whose names remain in *dirnames*; this can be used to prune the search, impose a specific order of visiting, or even to inform `walk()` about directories the caller creates or renames before it resumes `walk()` again. Modifying *dirnames* when *topdown* is `False` has no effect on the behavior of the walk, because in bottom-up mode the directories in *dirnames* are generated before *dirpath* itself is generated.

By default, errors from the `scandir()` call are ignored. If optional argument `onerror` is specified, it should be a function; it will be called with one argument, an `OSError` instance. It can report the error to continue with the walk, or raise the exception to abort the walk. Note that the filename is available as the `filename` attribute of the exception object.

By default, `walk()` will not walk down into symbolic links that resolve to directories. Set `followlinks` to `True` to visit directories pointed to by symlinks, on systems that support them.

備 備: Be aware that setting `followlinks` to `True` can lead to infinite recursion if a link points to a parent directory of itself. `walk()` does not keep track of the directories it visited already.

備 備: If you pass a relative pathname, don't change the current working directory between resumptions of `walk()`. `walk()` never changes the current directory, and assumes that its caller doesn't either.

This example displays the number of bytes taken by non-directory files in each directory under the starting directory, except that it doesn't look under any CVS subdirectory:

```
import os
from os.path import join, getsize
for root, dirs, files in os.walk('python/Lib/email'):
    print(root, "consumes", end=" ")
    print(sum(getsize(join(root, name)) for name in files), end=" ")
    print("bytes in", len(files), "non-directory files")
    if 'CVS' in dirs:
        dirs.remove('CVS') # don't visit CVS directories
```

In the next example (simple implementation of `shutil.rmtree()`), walking the tree bottom-up is essential, `rmdir()` doesn't allow deleting a directory before the directory is empty:

```
# Delete everything reachable from the directory named in "top",
# assuming there are no symbolic links.
# CAUTION: This is dangerous! For example, if top == '/', it
# could delete all your disk files.
import os
for root, dirs, files in os.walk(top, topdown=False):
    for name in files:
        os.remove(os.path.join(root, name))
    for name in dirs:
        os.rmdir(os.path.join(root, name))
```

引發一個附帶引數 `top`、`topdown`、`onerror`、`followlinks` 的稽核事件 `os.walk`。

在 3.5 版的變更: This function now calls `os.scandir()` instead of `os.listdir()`, making it faster by reducing the number of calls to `os.stat()`.

在 3.6 版的變更: Accepts a *path-like object*.

`os.fwalk` (`top='.'`, `topdown=True`, `onerror=None`, *, `follow_symlinks=False`, `dir_fd=None`)

This behaves exactly like `walk()`, except that it yields a 4-tuple (`dirpath`, `dirnames`, `filenames`, `dirfd`), and it supports `dir_fd`.

`dirpath`, `dirnames` and `filenames` are identical to `walk()` output, and `dirfd` is a file descriptor referring to the directory `dirpath`.

This function always supports *paths relative to directory descriptors* and *not following symlinks*. Note however that, unlike other functions, the `fwalk()` default value for `follow_symlinks` is `False`.

備 備: Since `fwalk()` yields file descriptors, those are only valid until the next iteration step, so you should duplicate them (e.g. with `dup()`) if you want to keep them longer.

This example displays the number of bytes taken by non-directory files in each directory under the starting directory, except that it doesn't look under any CVS subdirectory:

```
import os
for root, dirs, files, rootfd in os.fwalk('python/Lib/email'):
    print(root, "consumes", end="")
    print(sum([os.stat(name, dir_fd=rootfd).st_size for name in files]),
          end="")
    print("bytes in", len(files), "non-directory files")
    if 'CVS' in dirs:
        dirs.remove('CVS') # don't visit CVS directories
```

In the next example, walking the tree bottom-up is essential: `rmdir()` doesn't allow deleting a directory before the directory is empty:

```
# Delete everything reachable from the directory named in "top",
# assuming there are no symbolic links.
# CAUTION: This is dangerous! For example, if top == '/', it
# could delete all your disk files.
import os
for root, dirs, files, rootfd in os.fwalk(top, topdown=False):
    for name in files:
        os.unlink(name, dir_fd=rootfd)
    for name in dirs:
        os.rmdir(name, dir_fd=rootfd)
```

引發一個附帶引數 `top`、`topdown`、`onerror`、`follow_symlinks`、`dir_fd` 的稽核事件 `os.fwalk`。

適用：Unix。

在 3.3 版新加入。

在 3.6 版的變更: Accepts a *path-like object*.

在 3.7 版的變更: Added support for *bytes* paths.

`os.memfd_create(name[, flags=os.MFD_CLOEXEC])`

Create an anonymous file and return a file descriptor that refers to it. *flags* must be one of the `os.MFD_*` constants available on the system (or a bitwise ORed combination of them). By default, the new file descriptor is *non-inheritable*.

The name supplied in *name* is used as a filename and will be displayed as the target of the corresponding symbolic link in the directory `/proc/self/fd/`. The displayed name is always prefixed with `memfd:` and serves only for debugging purposes. Names do not affect the behavior of the file descriptor, and as such multiple files can have the same name without any side effects.

適用：Linux 3.17 以上且具有 glibc 2.27 以上。

在 3.8 版新加入。

```
os.MFD_CLOEXEC
os.MFD_ALLOW_SEALING
os.MFD_HUGETLB
os.MFD_HUGE_SHIFT
os.MFD_HUGE_MASK
os.MFD_HUGE_64KB
os.MFD_HUGE_512KB
os.MFD_HUGE_1MB
os.MFD_HUGE_2MB
os.MFD_HUGE_8MB
os.MFD_HUGE_16MB
```

```

os.MFD_HUGE_32MB
os.MFD_HUGE_256MB
os.MFD_HUGE_512MB
os.MFD_HUGE_1GB
os.MFD_HUGE_2GB
os.MFD_HUGE_16GB

```

These flags can be passed to `memfd_create()`.

適用：Linux 3.17 以上且具有 glibc 2.27 以上

The MFD_HUGE* flags are only available since Linux 4.14.

在 3.8 版新加入。

```
os.eventfd (initval[, flags=os.EFD_CLOEXEC])
```

Create and return an event file descriptor. The file descriptors supports raw `read()` and `write()` with a buffer size of 8, `select()`, `poll()` and similar. See man page `eventfd(2)` for more information. By default, the new file descriptor is *non-inheritable*.

`initval` is the initial value of the event counter. The initial value must be an 32 bit unsigned integer. Please note that the initial value is limited to a 32 bit unsigned int although the event counter is an unsigned 64 bit integer with a maximum value of $2^{64}-2$.

`flags` can be constructed from `EFD_CLOEXEC`, `EFD_NONBLOCK`, and `EFD_SEMAPHORE`.

If `EFD_SEMAPHORE` is specified and the event counter is non-zero, `eventfd_read()` returns 1 and decrements the counter by one.

If `EFD_SEMAPHORE` is not specified and the event counter is non-zero, `eventfd_read()` returns the current event counter value and resets the counter to zero.

If the event counter is zero and `EFD_NONBLOCK` is not specified, `eventfd_read()` blocks.

`eventfd_write()` increments the event counter. Write blocks if the write operation would increment the counter to a value larger than $2^{64}-2$.

範例：

```

import os

# semaphore with start value '1'
fd = os.eventfd(1, os.EFD_SEMAPHORE | os.EFD_CLOEXEC)
try:
    # acquire semaphore
    v = os.eventfd_read(fd)
    try:
        do_work()
    finally:
        # release semaphore
        os.eventfd_write(fd, v)
finally:
    os.close(fd)

```

適用：Linux 2.6.27 以上且具有 glibc 2.8 以上

在 3.10 版新加入。

```
os.eventfd_read (fd)
```

Read value from an `eventfd()` file descriptor and return a 64 bit unsigned int. The function does not verify that `fd` is an `eventfd()`.

適用：Linux 2.6.27 以上

在 3.10 版新加入。

`os.eventfd_write(fd, value)`

Add value to an `eventfd()` file descriptor. *value* must be a 64 bit unsigned int. The function does not verify that *fd* is an `eventfd()`.

適用：Linux 2.6.27 以上

在 3.10 版新加入。

`os.EFD_CLOEXEC`

Set close-on-exec flag for new `eventfd()` file descriptor.

適用：Linux 2.6.27 以上

在 3.10 版新加入。

`os.EFD_NONBLOCK`

Set `O_NONBLOCK` status flag for new `eventfd()` file descriptor.

適用：Linux 2.6.27 以上

在 3.10 版新加入。

`os.EFD_SEMAPHORE`

Provide semaphore-like semantics for reads from a `eventfd()` file descriptor. On read the internal counter is decremented by one.

適用：Linux 2.6.30 以上

在 3.10 版新加入。

Linux extended attributes

在 3.3 版新加入。

These functions are all available on Linux only.

`os.getxattr(path, attribute, *, follow_symlinks=True)`

Return the value of the extended filesystem attribute *attribute* for *path*. *attribute* can be bytes or str (directly or indirectly through the `PathLike` interface). If it is str, it is encoded with the filesystem encoding.

This function can support *specifying a file descriptor* and *not following symlinks*.

引發一個附帶引數 *path*、*attribute* 的稽核事件 `os.getxattr`。

在 3.6 版的變更: Accepts a *path-like object* for *path* and *attribute*.

`os.listdirxattr(path=None, *, follow_symlinks=True)`

Return a list of the extended filesystem attributes on *path*. The attributes in the list are represented as strings decoded with the filesystem encoding. If *path* is None, `listxattr()` will examine the current directory.

This function can support *specifying a file descriptor* and *not following symlinks*.

引發一個附帶引數 *path* 的稽核事件 `os.listdirxattr`。

在 3.6 版的變更: Accepts a *path-like object*.

`os.removexattr(path, attribute, *, follow_symlinks=True)`

Removes the extended filesystem attribute *attribute* from *path*. *attribute* should be bytes or str (directly or indirectly through the `PathLike` interface). If it is a string, it is encoded with the *filesystem encoding and error handler*.

This function can support *specifying a file descriptor* and *not following symlinks*.

引發一個附帶引數 *path*、*attribute* 的稽核事件 `os.removexattr`。

在 3.6 版的變更: Accepts a *path-like object* for *path* and *attribute*.

`os.setxattr(path, attribute, value, flags=0, *, follow_symlinks=True)`

Set the extended filesystem attribute *attribute* on *path* to *value*. *attribute* must be a bytes or str with no embedded NULs (directly or indirectly through the *PathLike* interface). If it is a str, it is encoded with the *filesystem encoding and error handler*. *flags* may be `XATTR_REPLACE` or `XATTR_CREATE`. If `XATTR_REPLACE` is given and the attribute does not exist, `ENODATA` will be raised. If `XATTR_CREATE` is given and the attribute already exists, the attribute will not be created and `EEXIST` will be raised.

This function can support *specifying a file descriptor* and *not following symlinks*.

備^F: A bug in Linux kernel versions less than 2.6.39 caused the flags argument to be ignored on some filesystems.

引發一個附帶引數 `path`、`attribute`、`value`、`flags` 的稽核事件 `os.setxattr`。

在 3.6 版的變更: Accepts a *path-like object* for *path* and *attribute*.

`os.XATTR_SIZE_MAX`

The maximum size the value of an extended attribute can be. Currently, this is 64 KiB on Linux.

`os.XATTR_CREATE`

This is a possible value for the flags argument in `setxattr()`. It indicates the operation must create an attribute.

`os.XATTR_REPLACE`

This is a possible value for the flags argument in `setxattr()`. It indicates the operation must replace an existing attribute.

16.1.7 Process Management

These functions may be used to create and manage processes.

The various *exec** functions take a list of arguments for the new program loaded into the process. In each case, the first of these arguments is passed to the new program as its own name rather than as an argument a user may have typed on a command line. For the C programmer, this is the `argv[0]` passed to a program's `main()`. For example, `os.execv('/bin/echo', ['foo', 'bar'])` will only print `bar` on standard output; `foo` will seem to be ignored.

`os.abort()`

Generate a `SIGABRT` signal to the current process. On Unix, the default behavior is to produce a core dump; on Windows, the process immediately returns an exit code of 3. Be aware that calling this function will not call the Python signal handler registered for `SIGABRT` with `signal.signal()`.

`os.add_dll_directory(path)`

Add a path to the DLL search path.

This search path is used when resolving dependencies for imported extension modules (the module itself is resolved through `sys.path`), and also by `ctypes`.

Remove the directory by calling `close()` on the returned object or using it in a `with` statement.

See the [Microsoft documentation](#) for more information about how DLLs are loaded.

引發一個附帶引數 `path` 的稽核事件 `os.add_dll_directory`。

適用: Windows。

在 3.8 版新加入: Previous versions of CPython would resolve DLLs using the default behavior for the current process. This led to inconsistencies, such as only sometimes searching `PATH` or the current working directory, and OS functions such as `AddDllDirectory` having no effect.

In 3.8, the two primary ways DLLs are loaded now explicitly override the process-wide behavior to ensure consistency. See the porting notes for information on updating libraries.

```

os.exec1(path, arg0, arg1, ...)
os.execle(path, arg0, arg1, ..., env)
os.execlp(file, arg0, arg1, ...)
os.execlpe(file, arg0, arg1, ..., env)
os.execv(path, args)
os.execve(path, args, env)
os.execvp(file, args)
os.execvpe(file, args, env)

```

These functions all execute a new program, replacing the current process; they do not return. On Unix, the new executable is loaded into the current process, and will have the same process id as the caller. Errors will be reported as `OSError` exceptions.

The current process is replaced immediately. Open file objects and descriptors are not flushed, so if there may be data buffered on these open files, you should flush them using `sys.stdout.flush()` or `os.fsync()` before calling an `exec*` function.

The "l" and "v" variants of the `exec*` functions differ in how command-line arguments are passed. The "l" variants are perhaps the easiest to work with if the number of parameters is fixed when the code is written; the individual parameters simply become additional parameters to the `exec1*` functions. The "v" variants are good when the number of parameters is variable, with the arguments being passed in a list or tuple as the `args` parameter. In either case, the arguments to the child process should start with the name of the command being run, but this is not enforced.

The variants which include a "p" near the end (`execlp()`, `execlpe()`, `execvp()`, and `execvpe()`) will use the `PATH` environment variable to locate the program *file*. When the environment is being replaced (using one of the `exec*e` variants, discussed in the next paragraph), the new environment is used as the source of the `PATH` variable. The other variants, `exec1()`, `execle()`, `execv()`, and `execve()`, will not use the `PATH` variable to locate the executable; *path* must contain an appropriate absolute or relative path.

For `execle()`, `execlpe()`, `execve()`, and `execvpe()` (note that these all end in "e"), the *env* parameter must be a mapping which is used to define the environment variables for the new process (these are used instead of the current process' environment); the functions `exec1()`, `execlp()`, `execv()`, and `execvp()` all cause the new process to inherit the environment of the current process.

For `execve()` on some platforms, *path* may also be specified as an open file descriptor. This functionality may not be supported on your platform; you can check whether or not it is available using `os.supports_fd`. If it is unavailable, using it will raise a `NotImplementedError`.

引發一個附帶引數 *path*、*args*、*env* 的稽核事件 `os.exec`。

適用：Unix、Windows、非 Emscripten、非 WASI。

在 3.3 版的變更：Added support for specifying *path* as an open file descriptor for `execve()`。

在 3.6 版的變更：Accepts a *path-like object*。

```
os._exit(n)
```

Exit the process with status *n*, without calling cleanup handlers, flushing stdio buffers, etc.

備 F：The standard way to exit is `sys.exit(n)`. `_exit()` should normally only be used in the child process after a `fork()`.

The following exit codes are defined and can be used with `_exit()`, although they are not required. These are typically used for system programs written in Python, such as a mail server's external command delivery program.

備 F：Some of these may not be available on all Unix platforms, since there is some variation. These constants are defined where they are defined by the underlying platform.

os.EX_OK

Exit code that means no error occurred. May be taken from the defined value of `EXIT_SUCCESS` on some platforms. Generally has a value of zero.

適用：Unix、Windows。

os.EX_USAGE

Exit code that means the command was used incorrectly, such as when the wrong number of arguments are given.

適用：Unix、非 Emscripten、非 WASI。

os.EX_DATAERR

Exit code that means the input data was incorrect.

適用：Unix、非 Emscripten、非 WASI。

os.EX_NOINPUT

Exit code that means an input file did not exist or was not readable.

適用：Unix、非 Emscripten、非 WASI。

os.EX_NOUSER

Exit code that means a specified user did not exist.

適用：Unix、非 Emscripten、非 WASI。

os.EX_NOHOST

Exit code that means a specified host did not exist.

適用：Unix、非 Emscripten、非 WASI。

os.EX_UNAVAILABLE

Exit code that means that a required service is unavailable.

適用：Unix、非 Emscripten、非 WASI。

os.EX_SOFTWARE

Exit code that means an internal software error was detected.

適用：Unix、非 Emscripten、非 WASI。

os.EX_OSERR

Exit code that means an operating system error was detected, such as the inability to fork or create a pipe.

適用：Unix、非 Emscripten、非 WASI。

os.EX_OSFILE

Exit code that means some system file did not exist, could not be opened, or had some other kind of error.

適用：Unix、非 Emscripten、非 WASI。

os.EX_CANTCREAT

Exit code that means a user specified output file could not be created.

適用：Unix、非 Emscripten、非 WASI。

os.EX_IOERR

Exit code that means that an error occurred while doing I/O on some file.

適用：Unix、非 Emscripten、非 WASI。

os.EX_TEMPFAIL

Exit code that means a temporary failure occurred. This indicates something that may not really be an error, such as a network connection that couldn't be made during a retryable operation.

適用：Unix、非 Emscripten、非 WASI。

os.EX_PROTOCOL

Exit code that means that a protocol exchange was illegal, invalid, or not understood.

適用：Unix、非 Emscripten、非 WASI。

os.EX_NOPERM

Exit code that means that there were insufficient permissions to perform the operation (but not intended for file system problems).

適用：Unix、非 Emscripten、非 WASI。

os.EX_CONFIG

Exit code that means that some kind of configuration error occurred.

適用：Unix、非 Emscripten、非 WASI。

os.EX_NOTFOUND

Exit code that means something like "an entry was not found".

適用：Unix、非 Emscripten、非 WASI。

os.fork()

Fork a child process. Return 0 in the child and the child's process id in the parent. If an error occurs *OSError* is raised.

Note that some platforms including FreeBSD <= 6.3 and Cygwin have known issues when using `fork()` from a thread.

引發一個不附帶引數的稽核事件 `os.fork`。

警告： On macOS the use of this function is unsafe when mixed with using higher-level system APIs, and that includes using `urllib.request`.

在 3.8 版的變更: Calling `fork()` in a subinterpreter is no longer supported (*RuntimeError* is raised).

警告： See `ssl` for applications that use the SSL module with `fork()`.

適用：Unix、非 Emscripten、非 WASI。

os.forkpty()

Fork a child process, using a new pseudo-terminal as the child's controlling terminal. Return a pair of (*pid*, *fd*), where *pid* is 0 in the child, the new child's process id in the parent, and *fd* is the file descriptor of the master end of the pseudo-terminal. For a more portable approach, use the `pty` module. If an error occurs *OSError* is raised.

引發一個不附帶引數的稽核事件 `os.forkpty`。

警告： On macOS the use of this function is unsafe when mixed with using higher-level system APIs, and that includes using `urllib.request`.

在 3.8 版的變更: Calling `forkpty()` in a subinterpreter is no longer supported (*RuntimeError* is raised).

適用：Unix、非 Emscripten、非 WASI。

os.kill(pid, sig, /)

Send signal *sig* to the process *pid*. Constants for the specific signals available on the host platform are defined in the `signal` module.

Windows: The `signal.CTRL_C_EVENT` and `signal.CTRL_BREAK_EVENT` signals are special signals which can only be sent to console processes which share a common console window, e.g., some subprocesses. Any other value for `sig` will cause the process to be unconditionally killed by the `TerminateProcess` API, and the exit code will be set to `sig`. The Windows version of `kill()` additionally takes process handles to be killed.

另請參閱 `signal.pthread_kill()`。

引發一個附帶引數 `pid`、`sig` 的稽核事件 `os.kill`。

適用：Unix、Windows、非 Emscripten、非 WASI。

在 3.2 版的變更：新支援 Windows。

`os.killpg(pgid, sig, /)`

Send the signal `sig` to the process group `pgid`.

引發一個附帶引數 `pgid`、`sig` 的稽核事件 `os.killpg`。

適用：Unix、非 Emscripten、非 WASI。

`os.nice(increment, /)`

Add `increment` to the process's "niceness". Return the new niceness.

適用：Unix、非 Emscripten、非 WASI。

`os.pidfd_open(pid, flags=0)`

Return a file descriptor referring to the process `pid`. This descriptor can be used to perform process management without races and signals. The `flags` argument is provided for future extensions; no flag values are currently defined.

更多細節請見 `pidfd_open(2)` 手冊頁。

適用：Linux 5.3 以上

在 3.9 版新加入。

`os.lock(op, /)`

Lock program segments into memory. The value of `op` (defined in `<sys/lock.h>`) determines which segments are locked.

適用：Unix、非 Emscripten、非 WASI。

`os.popen(cmd, mode='r', buffering=-1)`

Open a pipe to or from command `cmd`. The return value is an open file object connected to the pipe, which can be read or written depending on whether `mode` is `'r'` (default) or `'w'`. The `buffering` argument have the same meaning as the corresponding argument to the built-in `open()` function. The returned file object reads or writes text strings rather than bytes.

The `close` method returns `None` if the subprocess exited successfully, or the subprocess's return code if there was an error. On POSIX systems, if the return code is positive it represents the return value of the process left-shifted by one byte. If the return code is negative, the process was terminated by the signal given by the negated value of the return code. (For example, the return value might be `- signal.SIGKILL` if the subprocess was killed.) On Windows systems, the return value contains the signed integer return code from the child process.

On Unix, `waitstatus_to_exitcode()` can be used to convert the `close` method result (exit status) into an exit code if it is not `None`. On Windows, the `close` method result is directly the exit code (or `None`).

This is implemented using `subprocess.Popen`; see that class's documentation for more powerful ways to manage and communicate with subprocesses.

適用：非 Emscripten、非 WASI。

備註：The `Python UTF-8 Mode` affects encodings used for `cmd` and pipe contents.

`popen()` is a simple wrapper around `subprocess.Popen`. Use `subprocess.Popen` or `subprocess.run()` to control options like encodings.

`os.posix_spawn(path, argv, env, *, file_actions=None, setpgroup=None, resetids=False, setsid=False, setsigmask=(), setsigdef=(), scheduler=None)`

Wraps the `posix_spawn()` C library API for use from Python.

Most users should use `subprocess.run()` instead of `posix_spawn()`.

The positional-only arguments `path`, `args`, and `env` are similar to `execve()`.

The `path` parameter is the path to the executable file. The `path` should contain a directory. Use `posix_spawnnp()` to pass an executable file without directory.

The `file_actions` argument may be a sequence of tuples describing actions to take on specific file descriptors in the child process between the C library implementation's `fork()` and `exec()` steps. The first item in each tuple must be one of the three type indicator listed below describing the remaining tuple elements:

`os.POSIX_SPAWN_OPEN`

`(os.POSIX_SPAWN_OPEN, fd, path, flags, mode)`

Performs `os.dup2(os.open(path, flags, mode), fd)`.

`os.POSIX_SPAWN_CLOSE`

`(os.POSIX_SPAWN_CLOSE, fd)`

Performs `os.close(fd)`.

`os.POSIX_SPAWN_DUP2`

`(os.POSIX_SPAWN_DUP2, fd, new_fd)`

Performs `os.dup2(fd, new_fd)`.

These tuples correspond to the C library `posix_spawn_file_actions_addopen()`, `posix_spawn_file_actions_addclose()`, and `posix_spawn_file_actions_adddup2()` API calls used to prepare for the `posix_spawn()` call itself.

The `setpgroup` argument will set the process group of the child to the value specified. If the value specified is 0, the child's process group ID will be made the same as its process ID. If the value of `setpgroup` is not set, the child will inherit the parent's process group ID. This argument corresponds to the C library `POSIX_SPAWN_SETPGROUP` flag.

If the `resetids` argument is `True` it will reset the effective UID and GID of the child to the real UID and GID of the parent process. If the argument is `False`, then the child retains the effective UID and GID of the parent. In either case, if the set-user-ID and set-group-ID permission bits are enabled on the executable file, their effect will override the setting of the effective UID and GID. This argument corresponds to the C library `POSIX_SPAWN_RESETIDS` flag.

If the `setsid` argument is `True`, it will create a new session ID for `posix_spawn`. `setsid` requires `POSIX_SPAWN_SETSID` or `POSIX_SPAWN_SETSID_NP` flag. Otherwise, `NotImplementedError` is raised.

The `setsigmask` argument will set the signal mask to the signal set specified. If the parameter is not used, then the child inherits the parent's signal mask. This argument corresponds to the C library `POSIX_SPAWN_SETSIGMASK` flag.

The `sigdef` argument will reset the disposition of all signals in the set specified. This argument corresponds to the C library `POSIX_SPAWN_SETSIGDEF` flag.

The `scheduler` argument must be a tuple containing the (optional) scheduler policy and an instance of `sched_param` with the scheduler parameters. A value of `None` in the place of the scheduler policy indicates that is not being provided. This argument is a combination of the C library `POSIX_SPAWN_SETSCHEDPARAM` and `POSIX_SPAWN_SETSCHEDULER` flags.

引發一個附帶引數 `path`、`argv`、`env` 的稽核事件 `os.posix_spawn`。

在 3.8 版新加入。

適用：Unix、非 Emscripten、非 WASI。

`os.posix_spawn`(*path, argv, env, *, file_actions=None, setpgroup=None, resetids=False, setsid=False, setsigmask=(), setsigdef=(), scheduler=None*)

Wraps the `posix_spawn()` C library API for use from Python.

Similar to `posix_spawn()` except that the system searches for the *executable* file in the list of directories specified by the `PATH` environment variable (in the same way as for `execvp(3)`).

引發一個附帶引數 `path`、`argv`、`env` 的稽核事件 `os.posix_spawn`。

在 3.8 版新加入。

適用：POSIX、非 Emscripten、非 WASI。

See `posix_spawn()` documentation.

`os.register_at_fork`(**, before=None, after_in_parent=None, after_in_child=None*)

Register callables to be executed when a new child process is forked using `os.fork()` or similar process cloning APIs. The parameters are optional and keyword-only. Each specifies a different call point.

- *before* is a function called before forking a child process.
- *after_in_parent* is a function called from the parent process after forking a child process.
- *after_in_child* is a function called from the child process.

These calls are only made if control is expected to return to the Python interpreter. A typical *subprocess* launch will not trigger them as the child is not going to re-enter the interpreter.

Functions registered for execution before forking are called in reverse registration order. Functions registered for execution after forking (either in the parent or in the child) are called in registration order.

Note that `fork()` calls made by third-party C code may not call those functions, unless it explicitly calls `PyOS_BeforeFork()`, `PyOS_AfterFork_Parent()` and `PyOS_AfterFork_Child()`.

There is no way to unregister a function.

適用：Unix、非 Emscripten、非 WASI。

在 3.7 版新加入。

`os.spawnl`(*mode, path, ...*)

`os.spawnle`(*mode, path, ..., env*)

`os.spawnlp`(*mode, file, ...*)

`os.spawnlpe`(*mode, file, ..., env*)

`os.spawnv`(*mode, path, args*)

`os.spawnve`(*mode, path, args, env*)

`os.spawnvp`(*mode, file, args*)

`os.spawnvpe`(*mode, file, args, env*)

Execute the program *path* in a new process.

(Note that the *subprocess* module provides more powerful facilities for spawning new processes and retrieving their results; using that module is preferable to using these functions. Check especially the *Replacing Older Functions with the subprocess Module* section.)

If *mode* is `P_NOWAIT`, this function returns the process id of the new process; if *mode* is `P_WAIT`, returns the process's exit code if it exits normally, or `-signal`, where *signal* is the signal that killed the process. On Windows, the process id will actually be the process handle, so can be used with the `waitpid()` function.

Note on VxWorks, this function doesn't return `-signal` when the new process is killed. Instead it raises `OSError` exception.

The "l" and "v" variants of the *spawn** functions differ in how command-line arguments are passed. The "l" variants are perhaps the easiest to work with if the number of parameters is fixed when the code is written; the

individual parameters simply become additional parameters to the `spawnl*()` functions. The "v" variants are good when the number of parameters is variable, with the arguments being passed in a list or tuple as the `args` parameter. In either case, the arguments to the child process must start with the name of the command being run.

The variants which include a second "p" near the end (`spawnlp()`, `spawnlpe()`, `spawnvp()`, and `spawnvpe()`) will use the `PATH` environment variable to locate the program *file*. When the environment is being replaced (using one of the `spawn*e` variants, discussed in the next paragraph), the new environment is used as the source of the `PATH` variable. The other variants, `spawnl()`, `spawnle()`, `spawnv()`, and `spawnve()`, will not use the `PATH` variable to locate the executable; *path* must contain an appropriate absolute or relative path.

For `spawnle()`, `spawnlpe()`, `spawnve()`, and `spawnvpe()` (note that these all end in "e"), the `env` parameter must be a mapping which is used to define the environment variables for the new process (they are used instead of the current process' environment); the functions `spawnl()`, `spawnlp()`, `spawnv()`, and `spawnvp()` all cause the new process to inherit the environment of the current process. Note that keys and values in the `env` dictionary must be strings; invalid keys or values will cause the function to fail, with a return value of 127.

As an example, the following calls to `spawnlp()` and `spawnvpe()` are equivalent:

```
import os
os.spawnlp(os.P_WAIT, 'cp', 'cp', 'index.html', '/dev/null')

L = ['cp', 'index.html', '/dev/null']
os.spawnvpe(os.P_WAIT, 'cp', L, os.environ)
```

引發一個附帶引數 `mode`、`path`、`args`、`env` 的稽核事件 `os.spawn`。

適用：Unix、Windows、非 Emscripten、非 WASI。

`spawnlp()`, `spawnlpe()`, `spawnvp()` and `spawnvpe()` are not available on Windows. `spawnle()` and `spawnve()` are not thread-safe on Windows; we advise you to use the `subprocess` module instead.

在 3.6 版的變更: Accepts a *path-like object*.

os.P_NOWAIT

os.P_NOWAITO

Possible values for the *mode* parameter to the `spawn*` family of functions. If either of these values is given, the `spawn*` functions will return as soon as the new process has been created, with the process id as the return value.

適用：Unix、Windows。

os.P_WAIT

Possible value for the *mode* parameter to the `spawn*` family of functions. If this is given as *mode*, the `spawn*` functions will not return until the new process has run to completion and will return the exit code of the process the run is successful, or `-signal` if a signal kills the process.

適用：Unix、Windows。

os.P_DETACH

os.P_OVERLAY

Possible values for the *mode* parameter to the `spawn*` family of functions. These are less portable than those listed above. `P_DETACH` is similar to `P_NOWAIT`, but the new process is detached from the console of the calling process. If `P_OVERLAY` is used, the current process will be replaced; the `spawn*` function will not return.

適用：Windows。

os.startfile(*path*[, *operation*][, *arguments*][, *cwd*][, *show_cmd*])

Start a file with its associated application.

When *operation* is not specified or 'open', this acts like double-clicking the file in Windows Explorer, or giving the file name as an argument to the **start** command from the interactive command shell: the file is opened with whatever application (if any) its extension is associated.

When another *operation* is given, it must be a "command verb" that specifies what should be done with the file. Common verbs documented by Microsoft are 'print' and 'edit' (to be used on files) as well as 'explore' and 'find' (to be used on directories).

When launching an application, specify *arguments* to be passed as a single string. This argument may have no effect when using this function to launch a document.

The default working directory is inherited, but may be overridden by the *cwd* argument. This should be an absolute path. A relative *path* will be resolved against this argument.

Use *show_cmd* to override the default window style. Whether this has any effect will depend on the application being launched. Values are integers as supported by the Win32 `ShellExecute()` function.

`startfile()` returns as soon as the associated application is launched. There is no option to wait for the application to close, and no way to retrieve the application's exit status. The *path* parameter is relative to the current directory or *cwd*. If you want to use an absolute path, make sure the first character is not a slash ('/') Use `pathlib` or the `os.path.normpath()` function to ensure that paths are properly encoded for Win32.

To reduce interpreter startup overhead, the `Win32 ShellExecute()` function is not resolved until this function is first called. If the function cannot be resolved, `NotImplementedError` will be raised.

引發一個附帶引數 *path*、*operation* 的稽核事件 `os.startfile`。

引發一個附帶引數 *path*、*operation*、*arguments*、*cwd*、*show_cmd* 的稽核事件 `os.startfile/2`。

適用：Windows。

在 3.10 版的變更: Added the *arguments*, *cwd* and *show_cmd* arguments, and the `os.startfile/2` audit event.

`os.system (command)`

Execute the command (a string) in a subshell. This is implemented by calling the Standard C function `system()`, and has the same limitations. Changes to `sys.stdin`, etc. are not reflected in the environment of the executed command. If *command* generates any output, it will be sent to the interpreter standard output stream. The C standard does not specify the meaning of the return value of the C function, so the return value of the Python function is system-dependent.

On Unix, the return value is the exit status of the process encoded in the format specified for `wait()`.

On Windows, the return value is that returned by the system shell after running *command*. The shell is given by the Windows environment variable `COMSPEC`: it is usually `cmd.exe`, which returns the exit status of the command run; on systems using a non-native shell, consult your shell documentation.

The `subprocess` module provides more powerful facilities for spawning new processes and retrieving their results; using that module is preferable to using this function. See the *Replacing Older Functions with the subprocess Module* section in the `subprocess` documentation for some helpful recipes.

On Unix, `waitstatus_to_exitcode()` can be used to convert the result (exit status) into an exit code. On Windows, the result is directly the exit code.

引發一個附帶引數 *command* 的稽核事件 `os.system`。

適用：Unix、Windows、非 Emscripten、非 WASI。

`os.times ()`

Returns the current global process times. The return value is an object with five attributes:

- `user` - user time
- `system` - 系統時間
- `children_user` - user time of all child processes

- `children_system` - system time of all child processes
- `elapsed` - elapsed real time since a fixed point in the past

For backwards compatibility, this object also behaves like a five-tuple containing `user`, `system`, `children_user`, `children_system`, and `elapsed` in that order.

See the Unix manual page *times(2)* and *times(3)* manual page on Unix or the [GetProcessTimes MSDN](#) on Windows. On Windows, only `user` and `system` are known; the other attributes are zero.

適用：Unix、Windows。

在 3.3 版的變更: Return type changed from a tuple to a tuple-like object with named attributes.

`os.wait()`

Wait for completion of a child process, and return a tuple containing its pid and exit status indication: a 16-bit number, whose low byte is the signal number that killed the process, and whose high byte is the exit status (if the signal number is zero); the high bit of the low byte is set if a core file was produced.

If there are no children that could be waited for, *ChildProcessError* is raised.

waitstatus_to_exitcode() can be used to convert the exit status into an exit code.

適用：Unix、非 Emscripten、非 WASI。

也參考:

The other `wait*()` functions documented below can be used to wait for the completion of a specific child process and have more options. *waitpid()* is the only one also available on Windows.

`os.waitid(idtype, id, options, /)`

Wait for the completion of a child process.

idtype can be *P_PID*, *P_PGID*, *P_ALL*, or (on Linux) *P_PIDFD*. The interpretation of *id* depends on it; see their individual descriptions.

options is an OR combination of flags. At least one of *WEXITED*, *WSTOPPED* or *WCONTINUED* is required; *WNOHANG* and *WNOWAIT* are additional optional flags.

The return value is an object representing the data contained in the `siginfo_t` structure with the following attributes:

- `si_pid` (process ID)
- `si_uid` (real user ID of the child)
- `si_signo` (always *SIGCHLD*)
- `si_status` (the exit status or signal number, depending on `si_code`)
- `si_code` (see *CLD_EXITED* for possible values)

If *WNOHANG* is specified and there are no matching children in the requested state, `None` is returned. Otherwise, if there are no matching children that could be waited for, *ChildProcessError* is raised.

適用：Unix、非 Emscripten、非 WASI。

備註: This function is not available on macOS.

在 3.3 版新加入。

`os.waitpid(pid, options, /)`

The details of this function differ on Unix and Windows.

On Unix: Wait for completion of a child process given by process id *pid*, and return a tuple containing its process id and exit status indication (encoded as for *wait()*). The semantics of the call are affected by the value of the integer *options*, which should be 0 for normal operation.

If *pid* is greater than 0, `waitpid()` requests status information for that specific process. If *pid* is 0, the request is for the status of any child in the process group of the current process. If *pid* is -1, the request pertains to any child of the current process. If *pid* is less than -1, status is requested for any process in the process group -*pid* (the absolute value of *pid*).

options is an OR combination of flags. If it contains `WNOHANG` and there are no matching children in the requested state, (0, 0) is returned. Otherwise, if there are no matching children that could be waited for, `ChildProcessError` is raised. Other options that can be used are `WUNTRACED` and `WCONTINUED`.

On Windows: Wait for completion of a process given by process handle *pid*, and return a tuple containing *pid*, and its exit status shifted left by 8 bits (shifting makes cross-platform use of the function easier). A *pid* less than or equal to 0 has no special meaning on Windows, and raises an exception. The value of integer *options* has no effect. *pid* can refer to any process whose id is known, not necessarily a child process. The `spawn*` functions called with `P_NOWAIT` return suitable process handles.

`waitstatus_to_exitcode()` can be used to convert the exit status into an exit code.

適用：Unix、Windows、非 Emscripten、非 WASI。

在 3.5 版的變更：If the system call is interrupted and the signal handler does not raise an exception, the function now retries the system call instead of raising an `InterruptedError` exception (see [PEP 475](#) for the rationale).

os.wait3(*options*)

Similar to `waitpid()`, except no process id argument is given and a 3-element tuple containing the child's process id, exit status indication, and resource usage information is returned. Refer to `resource.getrusage()` for details on resource usage information. The *options* argument is the same as that provided to `waitpid()` and `wait4()`.

`waitstatus_to_exitcode()` can be used to convert the exit status into an exitcode.

適用：Unix、非 Emscripten、非 WASI。

os.wait4(*pid*, *options*)

Similar to `waitpid()`, except a 3-element tuple, containing the child's process id, exit status indication, and resource usage information is returned. Refer to `resource.getrusage()` for details on resource usage information. The arguments to `wait4()` are the same as those provided to `waitpid()`.

`waitstatus_to_exitcode()` can be used to convert the exit status into an exitcode.

適用：Unix、非 Emscripten、非 WASI。

os.P_PID

os.P_PGID

os.P_ALL

os.P_PIDFD

These are the possible values for *idtype* in `waitid()`. They affect how *id* is interpreted:

- `P_PID` - wait for the child whose PID is *id*.
- `P_PGID` - wait for any child whose progress group ID is *id*.
- `P_ALL` - wait for any child; *id* is ignored.
- `P_PIDFD` - wait for the child identified by the file descriptor *id* (a process file descriptor created with `pidfd_open()`).

適用：Unix、非 Emscripten、非 WASI。

備註： `P_PIDFD` is only available on Linux >= 5.4.

在 3.3 版新加入。

在 3.9 版新加入：The `P_PIDFD` constant.

os.WCONTINUED

This *options* flag for `waitpid()`, `wait3()`, `wait4()`, and `waitid()` causes child processes to be reported if they have been continued from a job control stop since they were last reported.

適用：Unix、非 Emscripten、非 WASI。

os.WEXITED

This *options* flag for `waitid()` causes child processes that have terminated to be reported.

The other `wait*` functions always report children that have terminated, so this option is not available for them.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.WSTOPPED

This *options* flag for `waitid()` causes child processes that have been stopped by the delivery of a signal to be reported.

This option is not available for the other `wait*` functions.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

os.WUNTRACED

This *options* flag for `waitpid()`, `wait3()`, and `wait4()` causes child processes to also be reported if they have been stopped but their current state has not been reported since they were stopped.

This option is not available for `waitid()`.

適用：Unix、非 Emscripten、非 WASI。

os.WNOHANG

This *options* flag causes `waitpid()`, `wait3()`, `wait4()`, and `waitid()` to return right away if no child process status is available immediately.

適用：Unix、非 Emscripten、非 WASI。

os.WNOWAIT

This *options* flag causes `waitid()` to leave the child in a waitable state, so that a later `wait*()` call can be used to retrieve the child status information again.

This option is not available for the other `wait*` functions.

適用：Unix、非 Emscripten、非 WASI。

os.CLD_EXITED**os.CLD_KILLED****os.CLD_DUMPED****os.CLD_TRAPPED****os.CLD_STOPPED****os.CLD_CONTINUED**

These are the possible values for `si_code` in the result returned by `waitid()`.

適用：Unix、非 Emscripten、非 WASI。

在 3.3 版新加入。

在 3.9 版的變更: Added `CLD_KILLED` and `CLD_STOPPED` values.

os.waitstatus_to_exitcode(status)

Convert a wait status to an exit code.

On Unix:

- If the process exited normally (if `WIFEXITED(status)` is true), return the process exit status (return `WEXITSTATUS(status)`): result greater than or equal to 0.
- If the process was terminated by a signal (if `WIFSIGNALED(status)` is true), return `-signum` where *signum* is the number of the signal that caused the process to terminate (return `-WTERMSIG(status)`): result less than 0.
- Otherwise, raise a `ValueError`.

On Windows, return *status* shifted right by 8 bits.

On Unix, if the process is being traced or if `waitpid()` was called with `WUNTRACED` option, the caller must first check if `WIFSTOPPED(status)` is true. This function must not be called if `WIFSTOPPED(status)` is true.

也參考:

`WIFEXITED()`, `WEXITSTATUS()`, `WIFSIGNALED()`, `WTERMSIG()`, `WIFSTOPPED()`, `WSTOPSIG()` functions.

適用: Unix、Windows、非 Emscripten、非 WASI。

在 3.9 版新加入。

The following functions take a process status code as returned by `system()`, `wait()`, or `waitpid()` as a parameter. They may be used to determine the disposition of a process.

os.WCOREDUMP(*status*, /)

Return True if a core dump was generated for the process, otherwise return False.

This function should be employed only if `WIFSIGNALED()` is true.

適用: Unix、非 Emscripten、非 WASI。

os.WIFCONTINUED(*status*)

Return True if a stopped child has been resumed by delivery of `SIGCONT` (if the process has been continued from a job control stop), otherwise return False.

參閱 `WCONTINUED` 選項。

適用: Unix、非 Emscripten、非 WASI。

os.WIFSTOPPED(*status*)

Return True if the process was stopped by delivery of a signal, otherwise return False.

`WIFSTOPPED()` only returns True if the `waitpid()` call was done using `WUNTRACED` option or when the process is being traced (see `ptrace(2)`).

適用: Unix、非 Emscripten、非 WASI。

os.WIFSIGNALED(*status*)

Return True if the process was terminated by a signal, otherwise return False.

適用: Unix、非 Emscripten、非 WASI。

os.WIFEXITED(*status*)

Return True if the process exited terminated normally, that is, by calling `exit()` or `_exit()`, or by returning from `main()`; otherwise return False.

適用: Unix、非 Emscripten、非 WASI。

os.WEXITSTATUS(*status*)

Return the process exit status.

This function should be employed only if `WIFEXITED()` is true.

適用: Unix、非 Emscripten、非 WASI。

os.WSTOPSIG (*status*)

Return the signal which caused the process to stop.

This function should be employed only if `WIFSTOPPED()` is true.

適用：Unix、非 Emscripten、非 WASI。

os.WTERMSIG (*status*)

Return the number of the signal that caused the process to terminate.

This function should be employed only if `WIFSIGNALED()` is true.

適用：Unix、非 Emscripten、非 WASI。

16.1.8 Interface to the scheduler

These functions control how a process is allocated CPU time by the operating system. They are only available on some Unix platforms. For more detailed information, consult your Unix manpages.

在 3.3 版新加入。

The following scheduling policies are exposed if they are supported by the operating system.

os.SCHED_OTHER

The default scheduling policy.

os.SCHED_BATCH

Scheduling policy for CPU-intensive processes that tries to preserve interactivity on the rest of the computer.

os.SCHED_IDLE

Scheduling policy for extremely low priority background tasks.

os.SCHED_SPORADIC

Scheduling policy for sporadic server programs.

os.SCHED_FIFO

A First In First Out scheduling policy.

os.SCHED_RR

A round-robin scheduling policy.

os.SCHED_RESET_ON_FORK

This flag can be OR'ed with any other scheduling policy. When a process with this flag set forks, its child's scheduling policy and priority are reset to the default.

class os.sched_param (*sched_priority*)

This class represents tunable scheduling parameters used in `sched_setparam()`, `sched_setscheduler()`, and `sched_getparam()`. It is immutable.

At the moment, there is only one possible parameter:

sched_priority

The scheduling priority for a scheduling policy.

os.sched_get_priority_min (*policy*)

Get the minimum priority value for *policy*. *policy* is one of the scheduling policy constants above.

os.sched_get_priority_max (*policy*)

Get the maximum priority value for *policy*. *policy* is one of the scheduling policy constants above.

os.sched_setscheduler (*pid*, *policy*, *param*, /)

Set the scheduling policy for the process with PID *pid*. A *pid* of 0 means the calling process. *policy* is one of the scheduling policy constants above. *param* is a `sched_param` instance.

`os.sched_getscheduler(pid, /)`

Return the scheduling policy for the process with PID *pid*. A *pid* of 0 means the calling process. The result is one of the scheduling policy constants above.

`os.sched_setparam(pid, param, /)`

Set the scheduling parameters for the process with PID *pid*. A *pid* of 0 means the calling process. *param* is a `sched_param` instance.

`os.sched_getparam(pid, /)`

Return the scheduling parameters as a `sched_param` instance for the process with PID *pid*. A *pid* of 0 means the calling process.

`os.sched_rr_get_interval(pid, /)`

Return the round-robin quantum in seconds for the process with PID *pid*. A *pid* of 0 means the calling process.

`os.sched_yield()`

Voluntarily relinquish the CPU.

`os.sched_setaffinity(pid, mask, /)`

Restrict the process with PID *pid* (or the current process if zero) to a set of CPUs. *mask* is an iterable of integers representing the set of CPUs to which the process should be restricted.

`os.sched_getaffinity(pid, /)`

Return the set of CPUs the process with PID *pid* is restricted to.

If *pid* is zero, return the set of CPUs the calling thread of the current process is restricted to.

16.1.9 Miscellaneous System Information

`os.confstr(name, /)`

Return string-valued system configuration values. *name* specifies the configuration value to retrieve; it may be a string which is the name of a defined system value; these names are specified in a number of standards (POSIX, Unix 95, Unix 98, and others). Some platforms define additional names as well. The names known to the host operating system are given as the keys of the `confstr_names` dictionary. For configuration variables not included in that mapping, passing an integer for *name* is also accepted.

If the configuration value specified by *name* isn't defined, `None` is returned.

If *name* is a string and is not known, `ValueError` is raised. If a specific value for *name* is not supported by the host system, even if it is included in `confstr_names`, an `OSError` is raised with `errno.EINVAL` for the error number.

適用： Unix。

`os.confstr_names`

Dictionary mapping names accepted by `confstr()` to the integer values defined for those names by the host operating system. This can be used to determine the set of names known to the system.

適用： Unix。

`os.cpu_count()`

Return the number of logical CPUs in the system. Returns `None` if undetermined.

This number is not equivalent to the number of logical CPUs the current process can use. `len(os.sched_getaffinity(0))` gets the number of logical CPUs the calling thread of the current process is restricted to

在 3.4 版新加入。

os.getloadavg()

Return the number of processes in the system run queue averaged over the last 1, 5, and 15 minutes or raises *OSError* if the load average was unobtainable.

適用：Unix。

os.sysconf(name, /)

Return integer-valued system configuration values. If the configuration value specified by *name* isn't defined, *-1* is returned. The comments regarding the *name* parameter for *confstr()* apply here as well; the dictionary that provides information on the known names is given by *sysconf_names*.

適用：Unix。

os.sysconf_names

Dictionary mapping names accepted by *sysconf()* to the integer values defined for those names by the host operating system. This can be used to determine the set of names known to the system.

適用：Unix。

在 3.11 版的變更: Add 'SC_MINSIGSTKSZ' name.

The following data values are used to support path manipulation operations. These are defined for all platforms.

Higher-level operations on pathnames are defined in the *os.path* module.

os.curdir

The constant string used by the operating system to refer to the current directory. This is *'.'* for Windows and POSIX. Also available via *os.path*.

os.pardir

The constant string used by the operating system to refer to the parent directory. This is *'..'* for Windows and POSIX. Also available via *os.path*.

os.sep

The character used by the operating system to separate pathname components. This is *'/'* for POSIX and *'\\'* for Windows. Note that knowing this is not sufficient to be able to parse or concatenate pathnames --- use *os.path.split()* and *os.path.join()* --- but it is occasionally useful. Also available via *os.path*.

os.altsep

An alternative character used by the operating system to separate pathname components, or *None* if only one separator character exists. This is set to *'/'* on Windows systems where *sep* is a backslash. Also available via *os.path*.

os.extsep

The character which separates the base filename from the extension; for example, the *'.'* in *os.py*. Also available via *os.path*.

os.pathsep

The character conventionally used by the operating system to separate search path components (as in *PATH*), such as *':'* for POSIX or *';'* for Windows. Also available via *os.path*.

os.defpath

The default search path used by *exec*p** and *spawn*p** if the environment doesn't have a *'PATH'* key. Also available via *os.path*.

os.linesep

The string used to separate (or, rather, terminate) lines on the current platform. This may be a single character, such as *'\n'* for POSIX, or multiple characters, for example, *'\r\n'* for Windows. Do not use *os.linesep* as a line terminator when writing files opened in text mode (the default); use a single *'\n'* instead, on all platforms.

`os.devnull`

The file path of the null device. For example: `'/dev/null'` for POSIX, `'nul'` for Windows. Also available via `os.path`.

`os.RTLD_LAZY`

`os.RTLD_NOW`

`os.RTLD_GLOBAL`

`os.RTLD_LOCAL`

`os.RTLD_NODELETE`

`os.RTLD_NOLOAD`

`os.RTLD_DEEPBIND`

Flags for use with the `setdlopenflags()` and `getdlopenflags()` functions. See the Unix manual page `dlopen(3)` for what the different flags mean.

在 3.3 版新加入。

16.1.10 Random numbers

`os.getrandom(size, flags=0)`

Get up to *size* random bytes. The function can return less bytes than requested.

These bytes can be used to seed user-space random number generators or for cryptographic purposes.

`getrandom()` relies on entropy gathered from device drivers and other sources of environmental noise. Unnecessarily reading large quantities of data will have a negative impact on other users of the `/dev/random` and `/dev/urandom` devices.

The flags argument is a bit mask that can contain zero or more of the following values ORed together: `os.GRND_RANDOM` and `GRND_NONBLOCK`.

See also the [Linux getrandom\(\) manual page](#).

適用：Linux 3.17 以上。

在 3.6 版新加入。

`os.urandom(size, /)`

Return a bytearray of *size* random bytes suitable for cryptographic use.

This function returns random bytes from an OS-specific randomness source. The returned data should be unpredictable enough for cryptographic applications, though its exact quality depends on the OS implementation.

On Linux, if the `getrandom()` syscall is available, it is used in blocking mode: block until the system urandom entropy pool is initialized (128 bits of entropy are collected by the kernel). See the [PEP 524](#) for the rationale. On Linux, the `getrandom()` function can be used to get random bytes in non-blocking mode (using the `GRND_NONBLOCK` flag) or to poll until the system urandom entropy pool is initialized.

On a Unix-like system, random bytes are read from the `/dev/urandom` device. If the `/dev/urandom` device is not available or not readable, the `NotImplementedError` exception is raised.

On Windows, it will use `BCryptGenRandom()`.

也參考：

The `secrets` module provides higher level functions. For an easy-to-use interface to the random number generator provided by your platform, please see [random.SystemRandom](#).

在 3.5 版的變更：On Linux 3.17 and newer, the `getrandom()` syscall is now used when available. On OpenBSD 5.6 and newer, the C `getentropy()` function is now used. These functions avoid the usage of an internal file descriptor.

在 3.5.2 版的變更：On Linux, if the `getrandom()` syscall blocks (the urandom entropy pool is not initialized yet), fall back on reading `/dev/urandom`.

在 3.6 版的變更: On Linux, `getrandom()` is now used in blocking mode to increase the security.

在 3.11 版的變更: On Windows, `BCryptGenRandom()` is used instead of `CryptGenRandom()` which is deprecated.

`os.GRND_NONBLOCK`

By default, when reading from `/dev/random`, `getrandom()` blocks if no random bytes are available, and when reading from `/dev/urandom`, it blocks if the entropy pool has not yet been initialized.

If the `GRND_NONBLOCK` flag is set, then `getrandom()` does not block in these cases, but instead immediately raises `BlockingIOError`.

在 3.6 版新加入。

`os.GRND_RANDOM`

If this bit is set, then random bytes are drawn from the `/dev/random` pool instead of the `/dev/urandom` pool.

在 3.6 版新加入。

16.2 `io` — 處理資料串流的核心工具

原始碼: [Lib/io.py](#)

16.2.1 總覽

The `io` module provides Python's main facilities for dealing with various types of I/O. There are three main types of I/O: *text I/O*, *binary I/O* and *raw I/O*. These are generic categories, and various backing stores can be used for each of them. A concrete object belonging to any of these categories is called a *file object*. Other common terms are *stream* and *file-like object*.

Independent of its category, each concrete stream object will also have various capabilities: it can be read-only, write-only, or read-write. It can also allow arbitrary random access (seeking forwards or backwards to any location), or only sequential access (for example in the case of a socket or pipe).

All streams are careful about the type of data you give to them. For example giving a `str` object to the `write()` method of a binary stream will raise a `TypeError`. So will giving a `bytes` object to the `write()` method of a text stream.

在 3.3 版的變更: 原本會引發 `IOError` 的操作, 現在將改成引發 `OSError`。因 `IOError` 現在是 `OSError` 的別名。

文字 I/O

Text I/O expects and produces `str` objects. This means that whenever the backing store is natively made of bytes (such as in the case of a file), encoding and decoding of data is made transparently as well as optional translation of platform-specific newline characters.

建立文字資料串流最簡單的方法是使用 `open()`, 可選擇性地指定編碼:

```
f = open("myfile.txt", "r", encoding="utf-8")
```

記憶體中的文字資料串流也可以使用 `StringIO` 物件建立:

```
f = io.StringIO("some initial text data")
```

文字資料串流 API 的詳細說明在 `TextIOBase` 文件當中。

二進位 (Binary) I/O

Binary I/O (also called *buffered I/O*) expects *bytes-like objects* and produces *bytes* objects. No encoding, decoding, or newline translation is performed. This category of streams can be used for all kinds of non-text data, and also when manual control over the handling of text data is desired.

建立二進位資料串流最簡單的方法是使用 `open()`，在 `mode` 字串中加入 `'b'`：

```
f = open("myfile.jpg", "rb")
```

記憶體的二進位資料串流也可以透過 `BytesIO` 物件來建立：

```
f = io.BytesIO(b"some initial binary data: \x00\x01")
```

二進位資料串流 API 的詳細說明在 `BufferedIOBase` 文件當中。

其它函式庫模組可能提供額外的方法來建立文字或二進位資料串流。例如 `socket.socket.makefile()`。

原始 (Raw) I/O

Raw I/O (also called *unbuffered I/O*) is generally used as a low-level building-block for binary and text streams; it is rarely useful to directly manipulate a raw stream from user code. Nevertheless, you can create a raw stream by opening a file in binary mode with buffering disabled:

```
f = open("myfile.jpg", "rb", buffering=0)
```

原始串流 API 在 `RawIOBase` 文件中有詳細描述。

16.2.2 文字編碼

`TextIOWrapper` 和 `open()` 預設編碼是根據區域設定的 (locale-specific) (`locale.getencoding()`)。

然而，許多開發人員在開以 UTF-8 編碼的文字檔案（例如：JSON、TOML、Markdown 等）時忘記指定編碼，因多數 Unix 平台預設使用 UTF-8 區域設定。這會導致錯誤，因對於大多數 Windows 使用者來，預設地區編碼非 UTF-8。舉例來：

```
# May not work on Windows when non-ASCII characters in the file.
with open("README.md") as f:
    long_description = f.read()
```

因此，烈建議在開文字檔案時，明確指定編碼。若你想使用 UTF-8 編碼，請傳入 `encoding="utf-8"`。若想使用目前的地區編碼，Python 3.10 以後的版本支援使用 `encoding="locale"`。

也參考：

Python UTF-8 Mode

在 Python UTF-8 模式下，可以將預設編碼從特定地區編碼改 UTF-8。

PEP 686

Python 3.15 將預設使用 *Python UTF-8 Mode*。

選擇性加入的編碼警告

在 3.10 版新加入: 更多資訊請見 [PEP 597](#)。

To find where the default locale encoding is used, you can enable the `-X warn_default_encoding` command line option or set the `PYTHONWARNDEFAULTENCODING` environment variable, which will emit an *EncodingWarning* when the default encoding is used.

If you are providing an API that uses `open()` or `TextIOWrapper` and passes `encoding=None` as a parameter, you can use `text_encoding()` so that callers of the API will emit an *EncodingWarning* if they don't pass an encoding. However, please consider using UTF-8 by default (i.e. `encoding="utf-8"`) for new APIs.

16.2.3 高階模組介面

`io.DEFAULT_BUFFER_SIZE`

An int containing the default buffer size used by the module's buffered I/O classes. `open()` uses the file's `blksiz` (as obtained by `os.stat()`) if possible.

`io.open(file, mode='r', buffering=-1, encoding=None, errors=None, newline=None, closefd=True, opener=None)`

這是 `open()` 的 `__name__`。

引發一個附帶引數 `path`、`mode`、`flags` 的稽核事件 `open`。

`io.open_code(path)`

以 `'rb'` 模式開 `path` 提供的檔案。此函式應用於意圖將內容視作可執行的程式碼的情況下。

`path` should be a *str* and an absolute path.

The behavior of this function may be overridden by an earlier call to the `PyFile_SetOpenCodeHook()`. However, assuming that `path` is a *str* and an absolute path, `open_code(path)` should always behave the same as `open(path, 'rb')`. Overriding the behavior is intended for additional validation or preprocessing of the file.

在 3.8 版新加入。

`io.text_encoding(encoding, stacklevel=2, /)`

This is a helper function for callables that use `open()` or `TextIOWrapper` and have an `encoding=None` parameter.

This function returns `encoding` if it is not `None`. Otherwise, it returns `"locale"` or `"utf-8"` depending on *UTF-8 Mode*.

This function emits an *EncodingWarning* if `sys.flags.warn_default_encoding` is true and `encoding` is `None`. `stacklevel` specifies where the warning is emitted. For example:

```
def read_text(path, encoding=None):
    encoding = io.text_encoding(encoding) # stacklevel=2
    with open(path, encoding) as f:
        return f.read()
```

In this example, an *EncodingWarning* is emitted for the caller of `read_text()`.

更多資訊請見 [文字編碼](#)。

在 3.10 版新加入。

在 3.11 版的變更: `text_encoding()` returns `"utf-8"` when UTF-8 mode is enabled and `encoding` is `None`.

`exception io.BlockingIOError`

This is a compatibility alias for the builtin *BlockingIOError* exception.

exception `io.UnsupportedOperation`

An exception inheriting `OSError` and `ValueError` that is raised when an unsupported operation is called on a stream.

也參考:

sys

contains the standard IO streams: `sys.stdin`, `sys.stdout`, and `sys.stderr`.

16.2.4 Class hierarchy

The implementation of I/O streams is organized as a hierarchy of classes. First *abstract base classes* (ABCs), which are used to specify the various categories of streams, then concrete classes providing the standard stream implementations.

備註: The abstract base classes also provide default implementations of some methods in order to help implementation of concrete stream classes. For example, `BufferedIOBase` provides unoptimized implementations of `readinto()` and `readline()`.

At the top of the I/O hierarchy is the abstract base class `IOBase`. It defines the basic interface to a stream. Note, however, that there is no separation between reading and writing to streams; implementations are allowed to raise `UnsupportedOperation` if they do not support a given operation.

The `RawIOBase` ABC extends `IOBase`. It deals with the reading and writing of bytes to a stream. `FileIO` subclasses `RawIOBase` to provide an interface to files in the machine's file system.

The `BufferedIOBase` ABC extends `IOBase`. It deals with buffering on a raw binary stream (`RawIOBase`). Its subclasses, `BufferedWriter`, `BufferedReader`, and `BufferedRWPair` buffer raw binary streams that are writable, readable, and both readable and writable, respectively. `BufferedRandom` provides a buffered interface to seekable streams. Another `BufferedIOBase` subclass, `BytesIO`, is a stream of in-memory bytes.

The `TextIOBase` ABC extends `IOBase`. It deals with streams whose bytes represent text, and handles encoding and decoding to and from strings. `TextIOWrapper`, which extends `TextIOBase`, is a buffered text interface to a buffered raw stream (`BufferedIOBase`). Finally, `StringIO` is an in-memory stream for text.

Argument names are not part of the specification, and only the arguments of `open()` are intended to be used as keyword arguments.

The following table summarizes the ABCs provided by the `io` module:

ABC	Inherits	Stub Methods	Mixin Methods and Properties
<code>IOBase</code>		<code>fileno</code> , <code>seek</code> 和 <code>truncate</code>	<code>close</code> , <code>closed</code> , <code>__enter__</code> , <code>__exit__</code> , <code>flush</code> , <code>isatty</code> , <code>__iter__</code> , <code>__next__</code> , <code>readable</code> , <code>readline</code> , <code>readlines</code> , <code>seekable</code> , <code>tell</code> , <code>writable</code> , and <code>writelines</code>
<code>RawIOBase</code>	<code>IOBase</code>	<code>readinto</code> 和 <code>write</code>	Inherited <code>IOBase</code> methods, <code>read</code> , and <code>readall</code>
<code>BufferedIOBase</code>	<code>IOBase</code>	<code>detach</code> , <code>read</code> , <code>read1</code> 和 <code>write</code>	Inherited <code>IOBase</code> methods, <code>readinto</code> , and <code>readinto1</code>
<code>TextIOBase</code>	<code>IOBase</code>	<code>detach</code> , <code>read</code> , <code>readline</code> 和 <code>write</code>	Inherited <code>IOBase</code> methods, <code>encoding</code> , <code>errors</code> , and <code>newlines</code>

I/O Base Classes

class `io.IOBase`

The abstract base class for all I/O classes.

This class provides empty abstract implementations for many methods that derived classes can override selectively; the default implementations represent a file that cannot be read, written or seeked.

Even though *IOBase* does not declare `read()` or `write()` because their signatures will vary, implementations and clients should consider those methods part of the interface. Also, implementations may raise a *ValueError* (or *UnsupportedOperation*) when operations they do not support are called.

The basic type used for binary data read from or written to a file is *bytes*. Other *bytes-like objects* are accepted as method arguments too. Text I/O classes work with *str* data.

Note that calling any method (even inquiries) on a closed stream is undefined. Implementations may raise *ValueError* in this case.

IOBase (and its subclasses) supports the iterator protocol, meaning that an *IOBase* object can be iterated over yielding the lines in a stream. Lines are defined slightly differently depending on whether the stream is a binary stream (yielding bytes), or a text stream (yielding character strings). See `readline()` below.

IOBase is also a context manager and therefore supports the `with` statement. In this example, *file* is closed after the `with` statement's suite is finished---even if an exception occurs:

```
with open('spam.txt', 'w') as file:
    file.write('Spam and eggs!')
```

IOBase provides these data attributes and methods:

close()

Flush and close this stream. This method has no effect if the file is already closed. Once the file is closed, any operation on the file (e.g. reading or writing) will raise a *ValueError*.

As a convenience, it is allowed to call this method more than once; only the first call, however, will have an effect.

closed

True if the stream is closed.

fileno()

Return the underlying file descriptor (an integer) of the stream if it exists. An *OSError* is raised if the IO object does not use a file descriptor.

flush()

Flush the write buffers of the stream if applicable. This does nothing for read-only and non-blocking streams.

isatty()

Return True if the stream is interactive (i.e., connected to a terminal/tty device).

readable()

Return True if the stream can be read from. If False, `read()` will raise *OSError*.

readline (*size=-1*, */*)

Read and return one line from the stream. If *size* is specified, at most *size* bytes will be read.

The line terminator is always `b'\n'` for binary files; for text files, the *newline* argument to `open()` can be used to select the line terminator(s) recognized.

readlines (*hint=-1*, */*)

Read and return a list of lines from the stream. *hint* can be specified to control the number of lines read: no more lines will be read if the total size (in bytes/characters) of all lines so far exceeds *hint*.

hint values of 0 or less, as well as `None`, are treated as no hint.

Note that it's already possible to iterate on file objects using `for line in file: ...` without calling `file.readlines()`.

seek (*offset*, *whence*=`os.SEEK_SET`, /)

Change the stream position to the given byte *offset*, interpreted relative to the position indicated by *whence*, and return the new absolute position. Values for *whence* are:

- `os.SEEK_SET` or 0 -- start of the stream (the default); *offset* should be zero or positive
- `os.SEEK_CUR` or 1 -- current stream position; *offset* may be negative
- `os.SEEK_END` or 2 -- end of the stream; *offset* is usually negative

在 3.1 版新加入: The `SEEK_*` constants.

在 3.3 版新加入: Some operating systems could support additional values, like `os.SEEK_HOLE` or `os.SEEK_DATA`. The valid values for a file could depend on it being open in text or binary mode.

seekable ()

Return `True` if the stream supports random access. If `False`, `seek()`, `tell()` and `truncate()` will raise `OSError`.

tell ()

Return the current stream position.

truncate (*size*=`None`, /)

Resize the stream to the given *size* in bytes (or the current position if *size* is not specified). The current stream position isn't changed. This resizing can extend or reduce the current file size. In case of extension, the contents of the new file area depend on the platform (on most systems, additional bytes are zero-filled). The new file size is returned.

在 3.5 版的變更: Windows will now zero-fill files when extending.

writable ()

Return `True` if the stream supports writing. If `False`, `write()` and `truncate()` will raise `OSError`.

writelines (*lines*, /)

Write a list of lines to the stream. Line separators are not added, so it is usual for each of the lines provided to have a line separator at the end.

__del__ ()

Prepare for object destruction. `IOBase` provides a default implementation of this method that calls the instance's `close()` method.

class io.RawIOBase

Base class for raw binary streams. It inherits from `IOBase`.

Raw binary streams typically provide low-level access to an underlying OS device or API, and do not try to encapsulate it in high-level primitives (this functionality is done at a higher-level in buffered binary streams and text streams, described later in this page).

`RawIOBase` provides these methods in addition to those from `IOBase`:

read (*size*=-1, /)

Read up to *size* bytes from the object and return them. As a convenience, if *size* is unspecified or -1, all bytes until EOF are returned. Otherwise, only one system call is ever made. Fewer than *size* bytes may be returned if the operating system call returns fewer than *size* bytes.

If 0 bytes are returned, and *size* was not 0, this indicates end of file. If the object is in non-blocking mode and no bytes are available, `None` is returned.

The default implementation defers to `readall()` and `readinto()`.

readall()

Read and return all the bytes from the stream until EOF, using multiple calls to the stream if necessary.

readinto(b, /)

Read bytes into a pre-allocated, writable *bytes-like object* *b*, and return the number of bytes read. For example, *b* might be a *bytearray*. If the object is in non-blocking mode and no bytes are available, *None* is returned.

write(b, /)

Write the given *bytes-like object*, *b*, to the underlying raw stream, and return the number of bytes written. This can be less than the length of *b* in bytes, depending on specifics of the underlying raw stream, and especially if it is in non-blocking mode. *None* is returned if the raw stream is set not to block and no single byte could be readily written to it. The caller may release or mutate *b* after this method returns, so the implementation should only access *b* during the method call.

class io.BufferedReader

Base class for binary streams that support some kind of buffering. It inherits from *IOBase*.

The main difference with *RawIOBase* is that methods *read()*, *readinto()* and *write()* will try (respectively) to read as much input as requested or to consume all given output, at the expense of making perhaps more than one system call.

In addition, those methods can raise *BlockingIOError* if the underlying raw stream is in non-blocking mode and cannot take or give enough data; unlike their *RawIOBase* counterparts, they will never return *None*.

Besides, the *read()* method does not have a default implementation that defers to *readinto()*.

A typical *BufferedReader* implementation should not inherit from a *RawIOBase* implementation, but wrap one, like *BufferedWriter* and *BufferedReader* do.

BufferedReader provides or overrides these data attributes and methods in addition to those from *IOBase*:

raw

The underlying raw stream (a *RawIOBase* instance) that *BufferedReader* deals with. This is not part of the *BufferedReader* API and may not exist on some implementations.

detach()

Separate the underlying raw stream from the buffer and return it.

After the raw stream has been detached, the buffer is in an unusable state.

Some buffers, like *BytesIO*, do not have the concept of a single raw stream to return from this method. They raise *UnsupportedOperation*.

在 3.1 版新加入。

read(size=-1, /)

Read and return up to *size* bytes. If the argument is omitted, *None*, or negative, data is read and returned until EOF is reached. An empty *bytes* object is returned if the stream is already at EOF.

If the argument is positive, and the underlying raw stream is not interactive, multiple raw reads may be issued to satisfy the byte count (unless EOF is reached first). But for interactive raw streams, at most one raw read will be issued, and a short result does not imply that EOF is imminent.

A *BlockingIOError* is raised if the underlying raw stream is in non blocking-mode, and has no data available at the moment.

read1(size=-1, /)

Read and return up to *size* bytes, with at most one call to the underlying raw stream's *read()* (or *readinto()*) method. This can be useful if you are implementing your own buffering on top of a *BufferedReader* object.

If *size* is *-1* (the default), an arbitrary number of bytes are returned (more than zero unless EOF is reached).

readinto (*b*, /)

Read bytes into a pre-allocated, writable *bytes-like object* *b* and return the number of bytes read. For example, *b* might be a *bytearray*.

Like *read()*, multiple reads may be issued to the underlying raw stream, unless the latter is interactive.

A *BlockingIOError* is raised if the underlying raw stream is in non blocking-mode, and has no data available at the moment.

readinto1 (*b*, /)

Read bytes into a pre-allocated, writable *bytes-like object* *b*, using at most one call to the underlying raw stream's *read()* (or *readinto()*) method. Return the number of bytes read.

A *BlockingIOError* is raised if the underlying raw stream is in non blocking-mode, and has no data available at the moment.

在 3.5 版新加入.

write (*b*, /)

Write the given *bytes-like object*, *b*, and return the number of bytes written (always equal to the length of *b* in bytes, since if the write fails an *OSError* will be raised). Depending on the actual implementation, these bytes may be readily written to the underlying stream, or held in a buffer for performance and latency reasons.

When in non-blocking mode, a *BlockingIOError* is raised if the data needed to be written to the raw stream but it couldn't accept all the data without blocking.

The caller may release or mutate *b* after this method returns, so the implementation should only access *b* during the method call.

Raw File I/O

class `io.FileIO` (*name*, *mode*='r', *closefd*=True, *opener*=None)

A raw binary stream representing an OS-level file containing bytes data. It inherits from *RawIOBase*.

The *name* can be one of two things:

- a character string or *bytes* object representing the path to the file which will be opened. In this case *closefd* must be *True* (the default) otherwise an error will be raised.
- an integer representing the number of an existing OS-level file descriptor to which the resulting *FileIO* object will give access. When the *FileIO* object is closed this *fd* will be closed as well, unless *closefd* is set to *False*.

The *mode* can be 'r', 'w', 'x' or 'a' for reading (default), writing, exclusive creation or appending. The file will be created if it doesn't exist when opened for writing or appending; it will be truncated when opened for writing. *FileExistsError* will be raised if it already exists when opened for creating. Opening a file for creating implies writing, so this mode behaves in a similar way to 'w'. Add a '+' to the mode to allow simultaneous reading and writing.

The *read()* (when called with a positive argument), *readinto()* and *write()* methods on this class will only make one system call.

A custom opener can be used by passing a callable as *opener*. The underlying file descriptor for the file object is then obtained by calling *opener* with (*name*, *flags*). *opener* must return an open file descriptor (passing *os.open* as *opener* results in functionality similar to passing *None*).

The newly created file is *non-inheritable*.

See the *open()* built-in function for examples on using the *opener* parameter.

在 3.3 版的變更: The *opener* parameter was added. The 'x' mode was added.

在 3.4 版的變更: The file is now non-inheritable.

FileIO provides these data attributes in addition to those from *RawIOBase* and *IOBase*:

mode

The mode as given in the constructor.

name

The file name. This is the file descriptor of the file when no name is given in the constructor.

Buffered Streams

Buffered I/O streams provide a higher-level interface to an I/O device than raw I/O does.

class `io.BytesIO (initial_bytes=b'')`

A binary stream using an in-memory bytes buffer. It inherits from `BufferedIOBase`. The buffer is discarded when the `close()` method is called.

The optional argument `initial_bytes` is a *bytes-like object* that contains initial data.

`BytesIO` provides or overrides these methods in addition to those from `BufferedIOBase` and `IOBase`:

getbuffer()

Return a readable and writable view over the contents of the buffer without copying them. Also, mutating the view will transparently update the contents of the buffer:

```
>>> b = io.BytesIO(b"abcdef")
>>> view = b.getbuffer()
>>> view[2:4] = b"56"
>>> b.getvalue()
b'ab56ef'
```

備註: As long as the view exists, the `BytesIO` object cannot be resized or closed.

在 3.2 版新加入。

getvalue()

Return *bytes* containing the entire contents of the buffer.

read1 (size=-1, /)

In `BytesIO`, this is the same as `read()`.

在 3.7 版的變更: The `size` argument is now optional.

readinto1 (b, /)

In `BytesIO`, this is the same as `readinto()`.

在 3.5 版新加入。

class `io.BufferedReader (raw, buffer_size=DEFAULT_BUFFER_SIZE)`

A buffered binary stream providing higher-level access to a readable, non seekable `RawIOBase` raw binary stream. It inherits from `BufferedIOBase`.

When reading data from this object, a larger amount of data may be requested from the underlying raw stream, and kept in an internal buffer. The buffered data can then be returned directly on subsequent reads.

The constructor creates a `BufferedReader` for the given readable `raw` stream and `buffer_size`. If `buffer_size` is omitted, `DEFAULT_BUFFER_SIZE` is used.

`BufferedReader` provides or overrides these methods in addition to those from `BufferedIOBase` and `IOBase`:

peek (size=0, /)

Return bytes from the stream without advancing the position. At most one single read on the raw stream is done to satisfy the call. The number of bytes returned may be less or more than requested.

read (*size*=-1, /)

Read and return *size* bytes, or if *size* is not given or negative, until EOF or if the read call would block in non-blocking mode.

read1 (*size*=-1, /)

Read and return up to *size* bytes with only one call on the raw stream. If at least one byte is buffered, only buffered bytes are returned. Otherwise, one raw stream read call is made.

在 3.7 版的變更: The *size* argument is now optional.

class `io.BufferedWriter` (*raw*, *buffer_size*=`DEFAULT_BUFFER_SIZE`)

A buffered binary stream providing higher-level access to a writeable, non seekable `RawIOBase` raw binary stream. It inherits from `BufferedIOBase`.

When writing to this object, data is normally placed into an internal buffer. The buffer will be written out to the underlying `RawIOBase` object under various conditions, including:

- when the buffer gets too small for all pending data;
- when `flush()` is called;
- when a `seek()` is requested (for `BufferedRandom` objects);
- when the `BufferedWriter` object is closed or destroyed.

The constructor creates a `BufferedWriter` for the given writeable *raw* stream. If the *buffer_size* is not given, it defaults to `DEFAULT_BUFFER_SIZE`.

`BufferedWriter` provides or overrides these methods in addition to those from `BufferedIOBase` and `IOBase`:

flush ()

Force bytes held in the buffer into the raw stream. A `BlockingIOError` should be raised if the raw stream blocks.

write (*b*, /)

Write the *bytes-like object*, *b*, and return the number of bytes written. When in non-blocking mode, a `BlockingIOError` is raised if the buffer needs to be written out but the raw stream blocks.

class `io.BufferedRandom` (*raw*, *buffer_size*=`DEFAULT_BUFFER_SIZE`)

A buffered binary stream providing higher-level access to a seekable `RawIOBase` raw binary stream. It inherits from `BufferedReader` and `BufferedWriter`.

The constructor creates a reader and writer for a seekable raw stream, given in the first argument. If the *buffer_size* is omitted it defaults to `DEFAULT_BUFFER_SIZE`.

`BufferedRandom` is capable of anything `BufferedReader` or `BufferedWriter` can do. In addition, `seek()` and `tell()` are guaranteed to be implemented.

class `io.BufferedRWPair` (*reader*, *writer*, *buffer_size*=`DEFAULT_BUFFER_SIZE`, /)

A buffered binary stream providing higher-level access to two non seekable `RawIOBase` raw binary streams--one readable, the other writeable. It inherits from `BufferedIOBase`.

reader and *writer* are `RawIOBase` objects that are readable and writeable respectively. If the *buffer_size* is omitted it defaults to `DEFAULT_BUFFER_SIZE`.

`BufferedRWPair` implements all of `BufferedIOBase`'s methods except for `detach()`, which raises `UnsupportedOperation`.

警告: `BufferedRWPair` does not attempt to synchronize accesses to its underlying raw streams. You should not pass it the same object as reader and writer; use `BufferedRandom` instead.

文字 I/O

class `io.TextIOBase`

Base class for text streams. This class provides a character and line based interface to stream I/O. It inherits from `IOBase`.

`TextIOBase` provides or overrides these data attributes and methods in addition to those from `IOBase`:

encoding

The name of the encoding used to decode the stream's bytes into strings, and to encode strings into bytes.

errors

The error setting of the decoder or encoder.

newlines

A string, a tuple of strings, or `None`, indicating the newlines translated so far. Depending on the implementation and the initial constructor flags, this may not be available.

buffer

The underlying binary buffer (a `BufferedIOBase` instance) that `TextIOBase` deals with. This is not part of the `TextIOBase` API and may not exist in some implementations.

detach()

Separate the underlying binary buffer from the `TextIOBase` and return it.

After the underlying buffer has been detached, the `TextIOBase` is in an unusable state.

Some `TextIOBase` implementations, like `StringIO`, may not have the concept of an underlying buffer and calling this method will raise `UnsupportedOperation`.

在 3.1 版新加入.

read (*size=-1, /*)

Read and return at most *size* characters from the stream as a single `str`. If *size* is negative or `None`, reads until EOF.

readline (*size=-1, /*)

Read until newline or EOF and return a single `str`. If the stream is already at EOF, an empty string is returned.

If *size* is specified, at most *size* characters will be read.

seek (*offset, whence=SEEK_SET, /*)

Change the stream position to the given *offset*. Behaviour depends on the *whence* parameter. The default value for *whence* is `SEEK_SET`.

- `SEEK_SET` or 0: seek from the start of the stream (the default); *offset* must either be a number returned by `TextIOBase.tell()`, or zero. Any other *offset* value produces undefined behaviour.
- `SEEK_CUR` or 1: "seek" to the current position; *offset* must be zero, which is a no-operation (all other values are unsupported).
- `SEEK_END` or 2: seek to the end of the stream; *offset* must be zero (all other values are unsupported).

Return the new absolute position as an opaque number.

在 3.1 版新加入: The `SEEK_*` constants.

tell ()

Return the current stream position as an opaque number. The number does not usually represent a number of bytes in the underlying binary storage.

write (*s, /*)

Write the string *s* to the stream and return the number of characters written.

```
class io.TextIOWrapper (buffer, encoding=None, errors=None, newline=None, line_buffering=False,
                        write_through=False)
```

A buffered text stream providing higher-level access to a *BufferedIOBase* buffered binary stream. It inherits from *TextIOBase*.

encoding gives the name of the encoding that the stream will be decoded or encoded with. It defaults to *locale.getencoding()*. *encoding="locale"* can be used to specify the current locale's encoding explicitly. See 文字編碼 for more information.

errors is an optional string that specifies how encoding and decoding errors are to be handled. Pass 'strict' to raise a *ValueError* exception if there is an encoding error (the default of None has the same effect), or pass 'ignore' to ignore errors. (Note that ignoring encoding errors can lead to data loss.) 'replace' causes a replacement marker (such as '?') to be inserted where there is malformed data. 'backslashreplace' causes malformed data to be replaced by a backslashed escape sequence. When writing, 'xmlcharrefreplace' (replace with the appropriate XML character reference) or 'namereplace' (replace with `\N{...}` escape sequences) can be used. Any other error handling name that has been registered with *codecs.register_error()* is also valid.

newline controls how line endings are handled. It can be None, '', '\n', '\r', and '\r\n'. It works as follows:

- When reading input from the stream, if *newline* is None, *universal newlines* mode is enabled. Lines in the input can end in '\n', '\r', or '\r\n', and these are translated into '\n' before being returned to the caller. If *newline* is '', universal newlines mode is enabled, but line endings are returned to the caller untranslating. If *newline* has any of the other legal values, input lines are only terminated by the given string, and the line ending is returned to the caller untranslating.
- When writing output to the stream, if *newline* is None, any '\n' characters written are translated to the system default line separator, *os.linesep*. If *newline* is '' or '\n', no translation takes place. If *newline* is any of the other legal values, any '\n' characters written are translated to the given string.

If *line_buffering* is True, *flush()* is implied when a call to write contains a newline character or a carriage return.

If *write_through* is True, calls to *write()* are guaranteed not to be buffered: any data written on the *TextIOWrapper* object is immediately handled to its underlying binary *buffer*.

在 3.3 版的變更: The *write_through* argument has been added.

在 3.3 版的變更: The default *encoding* is now *locale.getpreferredencoding(False)* instead of *locale.getpreferredencoding()*. Don't change temporary the locale encoding using *locale.setlocale()*, use the current locale encoding instead of the user preferred encoding.

在 3.10 版的變更: The *encoding* argument now supports the "locale" dummy encoding name.

TextIOWrapper provides these data attributes and methods in addition to those from *TextIOBase* and *IOBase*:

line_buffering

Whether line buffering is enabled.

write_through

Whether writes are passed immediately to the underlying binary buffer.

在 3.7 版新加入.

```
reconfigure (*, encoding=None, errors=None, newline=None, line_buffering=None,
              write_through=None)
```

Reconfigure this text stream using new settings for *encoding*, *errors*, *newline*, *line_buffering* and *write_through*.

Parameters not specified keep current settings, except *errors='strict'* is used when *encoding* is specified but *errors* is not specified.

It is not possible to change the encoding or newline if some data has already been read from the stream. On the other hand, changing encoding after write is possible.

This method does an implicit stream flush before setting the new parameters.

在 3.7 版新加入。

在 3.11 版的變更: The method supports `encoding="locale"` option.

seek (*cookie*, *whence*=`os.SEEK_SET`, /)

Set the stream position. Return the new stream position as an *int*.

Four operations are supported, given by the following argument combinations:

- `seek(0, SEEK_SET)`: Rewind to the start of the stream.
- `seek(cookie, SEEK_SET)`: Restore a previous position; *cookie* **must be** a number returned by `tell()`.
- `seek(0, SEEK_END)`: Fast-forward to the end of the stream.
- `seek(0, SEEK_CUR)`: Leave the current stream position unchanged.

Any other argument combinations are invalid, and may raise exceptions.

也參考:

`os.SEEK_SET`, `os.SEEK_CUR`, and `os.SEEK_END`.

tell ()

Return the stream position as an opaque number. The return value of `tell()` can be given as input to `seek()`, to restore a previous stream position.

class `io.StringIO` (*initial_value*="", *newline*='\n')

A text stream using an in-memory text buffer. It inherits from `TextIOBase`.

The text buffer is discarded when the `close()` method is called.

The initial value of the buffer can be set by providing *initial_value*. If newline translation is enabled, newlines will be encoded as if by `write()`. The stream is positioned at the start of the buffer which emulates opening an existing file in a `w+` mode, making it ready for an immediate write from the beginning or for a write that would overwrite the initial value. To emulate opening a file in an `a+` mode ready for appending, use `f.seek(0, io.SEEK_END)` to reposition the stream at the end of the buffer.

The *newline* argument works like that of `TextIOWrapper`, except that when writing output to the stream, if *newline* is `None`, newlines are written as `\n` on all platforms.

`StringIO` provides this method in addition to those from `TextIOBase` and `IOBase`:

getvalue ()

Return a *str* containing the entire contents of the buffer. Newlines are decoded as if by `read()`, although the stream position is not changed.

使用範例:

```
import io

output = io.StringIO()
output.write('First line.\n')
print('Second line.', file=output)

# Retrieve file contents -- this will be
# 'First line.\nSecond line.\n'
contents = output.getvalue()

# Close object and discard memory buffer --
# .getvalue() will now raise an exception.
output.close()
```

class `io.IncrementalNewlineDecoder`

A helper codec that decodes newlines for *universal newlines* mode. It inherits from `codecs.IncrementalDecoder`.

16.2.5 Performance

This section discusses the performance of the provided concrete I/O implementations.

二進位 (Binary) I/O

By reading and writing only large chunks of data even when the user asks for a single byte, buffered I/O hides any inefficiency in calling and executing the operating system's unbuffered I/O routines. The gain depends on the OS and the kind of I/O which is performed. For example, on some modern OSes such as Linux, unbuffered disk I/O can be as fast as buffered I/O. The bottom line, however, is that buffered I/O offers predictable performance regardless of the platform and the backing device. Therefore, it is almost always preferable to use buffered I/O rather than unbuffered I/O for binary data.

文字 I/O

Text I/O over a binary storage (such as a file) is significantly slower than binary I/O over the same storage, because it requires conversions between unicode and binary data using a character codec. This can become noticeable handling huge amounts of text data like large log files. Also, `tell()` and `seek()` are both quite slow due to the reconstruction algorithm used.

`StringIO`, however, is a native in-memory unicode container and will exhibit similar speed to `BytesIO`.

Multi-threading

`FileIO` objects are thread-safe to the extent that the operating system calls (such as `read(2)` under Unix) they wrap are thread-safe too.

Binary buffered objects (instances of `BufferedReader`, `BufferedWriter`, `BufferedRandom` and `BufferedRWPair`) protect their internal structures using a lock; it is therefore safe to call them from multiple threads at once.

`TextIOWrapper` objects are not thread-safe.

Reentrancy

Binary buffered objects (instances of `BufferedReader`, `BufferedWriter`, `BufferedRandom` and `BufferedRWPair`) are not reentrant. While reentrant calls will not happen in normal situations, they can arise from doing I/O in a *signal* handler. If a thread tries to re-enter a buffered object which it is already accessing, a `RuntimeError` is raised. Note this doesn't prohibit a different thread from entering the buffered object.

The above implicitly extends to text files, since the `open()` function will wrap a buffered object inside a `TextIOWrapper`. This includes standard streams and therefore affects the built-in `print()` function as well.

16.3 `time` --- Time access and conversions

This module provides various time-related functions. For related functionality, see also the `datetime` and `calendar` modules.

Although this module is always available, not all functions are available on all platforms. Most of the functions defined in this module call platform C library functions with the same name. It may sometimes be helpful to consult the platform documentation, because the semantics of these functions varies among platforms.

An explanation of some terminology and conventions is in order.

- The *epoch* is the point where the time starts, the return value of `time.gmtime(0)`. It is January 1, 1970, 00:00:00 (UTC) on all platforms.
- The term *seconds since the epoch* refers to the total number of elapsed seconds since the epoch, typically excluding *leap seconds*. Leap seconds are excluded from this total on all POSIX-compliant platforms.
- The functions in this module may not handle dates and times before the *epoch* or far in the future. The cut-off point in the future is determined by the C library; for 32-bit systems, it is typically in 2038.
- Function `strptime()` can parse 2-digit years when given `%Y` format code. When 2-digit years are parsed, they are converted according to the POSIX and ISO C standards: values 69--99 are mapped to 1969--1999, and values 0--68 are mapped to 2000--2068.
- UTC is Coordinated Universal Time (formerly known as Greenwich Mean Time, or GMT). The acronym UTC is not a mistake but a compromise between English and French.
- DST is Daylight Saving Time, an adjustment of the timezone by (usually) one hour during part of the year. DST rules are magic (determined by local law) and can change from year to year. The C library has a table containing the local rules (often it is read from a system file for flexibility) and is the only source of True Wisdom in this respect.
- The precision of the various real-time functions may be less than suggested by the units in which their value or argument is expressed. E.g. on most Unix systems, the clock "ticks" only 50 or 100 times a second.
- On the other hand, the precision of `time()` and `sleep()` is better than their Unix equivalents: times are expressed as floating point numbers, `time()` returns the most accurate time available (using Unix `gettimeofday()` where available), and `sleep()` will accept a time with a nonzero fraction (Unix `select()` is used to implement this, where available).
- The time value as returned by `gmtime()`, `localtime()`, and `strptime()`, and accepted by `asctime()`, `mktime()` and `strftime()`, is a sequence of 9 integers. The return values of `gmtime()`, `localtime()`, and `strptime()` also offer attribute names for individual fields.

關於這些物件的圖述請見 `struct_time`。

在 3.3 版的變更: The `struct_time` type was extended to provide the `tm_gmtoff` and `tm_zone` attributes when platform supports corresponding `struct tm` members.

在 3.6 版的變更: The `struct_time` attributes `tm_gmtoff` and `tm_zone` are now available on all platforms.

- Use the following functions to convert between time representations:

From	To	Use
seconds since the epoch	<code>struct_time</code> in UTC	<code>gmtime()</code>
seconds since the epoch	<code>struct_time</code> in local time	<code>localtime()</code>
<code>struct_time</code> in UTC	seconds since the epoch	<code>calendar.timegm()</code>
<code>struct_time</code> in local time	seconds since the epoch	<code>mktime()</code>

16.3.1 函式

`time.asctime([t])`

Convert a tuple or *struct_time* representing a time as returned by *gmtime()* or *localtime()* to a string of the following form: 'Sun Jun 20 23:21:05 1993'. The day field is two characters long and is space padded if the day is a single digit, e.g.: 'Wed Jun 9 04:26:40 1993'.

If *t* is not provided, the current time as returned by *localtime()* is used. Locale information is not used by *asctime()*.

備 F: Unlike the C function of the same name, *asctime()* does not add a trailing newline.

`time.thread_getcpuclockid(thread_id)`

Return the *clk_id* of the thread-specific CPU-time clock for the specified *thread_id*.

Use *threading.get_ident()* or the *ident* attribute of *threading.Thread* objects to get a suitable value for *thread_id*.

警告: Passing an invalid or expired *thread_id* may result in undefined behavior, such as segmentation fault.

適用: Unix

See the man page for *pthread_getcpuclockid(3)* for further information.

在 3.7 版新加入.

`time.clock_getres(clk_id)`

Return the resolution (precision) of the specified clock *clk_id*. Refer to *Clock ID Constants* for a list of accepted values for *clk_id*.

適用: Unix。

在 3.3 版新加入.

`time.clock_gettime(clk_id) → float`

Return the time of the specified clock *clk_id*. Refer to *Clock ID Constants* for a list of accepted values for *clk_id*.

Use *clock_gettime_ns()* to avoid the precision loss caused by the *float* type.

適用: Unix。

在 3.3 版新加入.

`time.clock_gettime_ns(clk_id) → int`

Similar to *clock_gettime()* but return time as nanoseconds.

適用: Unix。

在 3.7 版新加入.

`time.clock_settime(clk_id, time: float)`

Set the time of the specified clock *clk_id*. Currently, *CLOCK_REALTIME* is the only accepted value for *clk_id*.

Use *clock_settime_ns()* to avoid the precision loss caused by the *float* type.

適用: Unix。

在 3.3 版新加入.

`time.clock_settime_ns (clk_id, time: int)`

Similar to `clock_settime()` but set time with nanoseconds.

適用: Unix。

在 3.7 版新加入。

`time.ctime ([secs])`

Convert a time expressed in seconds since the *epoch* to a string of a form: 'Sun Jun 20 23:21:05 1993' representing local time. The day field is two characters long and is space padded if the day is a single digit, e.g.: 'Wed Jun 9 04:26:40 1993'.

If *secs* is not provided or *None*, the current time as returned by `time()` is used. `ctime(secs)` is equivalent to `asctime(localtime(secs))`. Locale information is not used by `ctime()`.

`time.get_clock_info (name)`

Get information on the specified clock as a namespace object. Supported clock names and the corresponding functions to read their value are:

- 'monotonic': `time.monotonic()`
- 'perf_counter': `time.perf_counter()`
- 'process_time': `time.process_time()`
- 'thread_time': `time.thread_time()`
- 'time': `time.time()`

The result has the following attributes:

- *adjustable*: True if the clock can be changed automatically (e.g. by a NTP daemon) or manually by the system administrator, False otherwise
- *implementation*: The name of the underlying C function used to get the clock value. Refer to *Clock ID Constants* for possible values.
- *monotonic*: True if the clock cannot go backward, False otherwise
- *resolution*: The resolution of the clock in seconds (*float*)

在 3.3 版新加入。

`time.gmtime ([secs])`

Convert a time expressed in seconds since the *epoch* to a *struct_time* in UTC in which the dst flag is always zero. If *secs* is not provided or *None*, the current time as returned by `time()` is used. Fractions of a second are ignored. See above for a description of the *struct_time* object. See `calendar.timegm()` for the inverse of this function.

`time.localtime ([secs])`

Like `gmtime()` but converts to local time. If *secs* is not provided or *None*, the current time as returned by `time()` is used. The dst flag is set to 1 when DST applies to the given time.

`localtime()` may raise *OverflowError*, if the timestamp is outside the range of values supported by the platform C `localtime()` or `gmtime()` functions, and *OSError* on `localtime()` or `gmtime()` failure. It's common for this to be restricted to years between 1970 and 2038.

`time.mktime (t)`

This is the inverse function of `localtime()`. Its argument is the *struct_time* or full 9-tuple (since the dst flag is needed; use -1 as the dst flag if it is unknown) which expresses the time in *local* time, not UTC. It returns a floating point number, for compatibility with `time()`. If the input value cannot be represented as a valid time, either *OverflowError* or *ValueError* will be raised (which depends on whether the invalid value is caught by Python or the underlying C libraries). The earliest date for which it can generate a time is platform-dependent.

`time.monotonic()` → *float*

Return the value (in fractional seconds) of a monotonic clock, i.e. a clock that cannot go backwards. The clock is not affected by system clock updates. The reference point of the returned value is undefined, so that only the difference between the results of two calls is valid.

Use `monotonic_ns()` to avoid the precision loss caused by the *float* type.

在 3.3 版新加入。

在 3.5 版的變更: The function is now always available and always system-wide.

在 3.10 版的變更: On macOS, the function is now system-wide.

`time.monotonic_ns()` → *int*

Similar to `monotonic()`, but return time as nanoseconds.

在 3.7 版新加入。

`time.perf_counter()` → *float*

Return the value (in fractional seconds) of a performance counter, i.e. a clock with the highest available resolution to measure a short duration. It does include time elapsed during sleep and is system-wide. The reference point of the returned value is undefined, so that only the difference between the results of two calls is valid.

Use `perf_counter_ns()` to avoid the precision loss caused by the *float* type.

在 3.3 版新加入。

在 3.10 版的變更: On Windows, the function is now system-wide.

`time.perf_counter_ns()` → *int*

Similar to `perf_counter()`, but return time as nanoseconds.

在 3.7 版新加入。

`time.process_time()` → *float*

Return the value (in fractional seconds) of the sum of the system and user CPU time of the current process. It does not include time elapsed during sleep. It is process-wide by definition. The reference point of the returned value is undefined, so that only the difference between the results of two calls is valid.

Use `process_time_ns()` to avoid the precision loss caused by the *float* type.

在 3.3 版新加入。

`time.process_time_ns()` → *int*

Similar to `process_time()` but return time as nanoseconds.

在 3.7 版新加入。

`time.sleep(secs)`

Suspend execution of the calling thread for the given number of seconds. The argument may be a floating point number to indicate a more precise sleep time.

If the sleep is interrupted by a signal and no exception is raised by the signal handler, the sleep is restarted with a recomputed timeout.

The suspension time may be longer than requested by an arbitrary amount, because of the scheduling of other activity in the system.

On Windows, if *secs* is zero, the thread relinquishes the remainder of its time slice to any other thread that is ready to run. If there are no other threads ready to run, the function returns immediately, and the thread continues execution. On Windows 8.1 and newer the implementation uses a [high-resolution timer](#) which provides resolution of 100 nanoseconds. If *secs* is zero, `Sleep(0)` is used.

Unix implementation:

- Use `clock_nanosleep()` if available (resolution: 1 nanosecond);

- Or use `nanosleep()` if available (resolution: 1 nanosecond);
- Or use `select()` (resolution: 1 microsecond).

在 3.5 版的變更: The function now sleeps at least *secs* even if the sleep is interrupted by a signal, except if the signal handler raises an exception (see [PEP 475](#) for the rationale).

在 3.11 版的變更: On Unix, the `clock_nanosleep()` and `nanosleep()` functions are now used if available. On Windows, a waitable timer is now used.

`time.strptime(format[, t])`

Convert a tuple or `struct_time` representing a time as returned by `gmtime()` or `localtime()` to a string as specified by the *format* argument. If *t* is not provided, the current time as returned by `localtime()` is used. *format* must be a string. `ValueError` is raised if any field in *t* is outside of the allowed range.

0 is a legal argument for any position in the time tuple; if it is normally illegal the value is forced to a correct one.

The following directives can be embedded in the *format* string. They are shown without the optional field width and precision specification, and are replaced by the indicated characters in the `strptime()` result:

Directive	Meaning	解F
%a	Locale's abbreviated weekday name.	
%A	Locale's full weekday name.	
%b	Locale's abbreviated month name.	
%B	Locale's full month name.	
%c	Locale's appropriate date and time representation.	
%d	Day of the month as a decimal number [01,31].	
%f	Microseconds as a decimal number [000000,999999].	(1)
%H	Hour (24-hour clock) as a decimal number [00,23].	
%I	Hour (12-hour clock) as a decimal number [01,12].	
%j	Day of the year as a decimal number [001,366].	
%m	Month as a decimal number [01,12].	
%M	Minute as a decimal number [00,59].	
%p	Locale's equivalent of either AM or PM.	(2)
%S	Second as a decimal number [00,61].	(3)
%U	Week number of the year (Sunday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Sunday are considered to be in week 0.	(4)
%w	Weekday as a decimal number [0(Sunday),6].	
%W	Week number of the year (Monday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Monday are considered to be in week 0.	(4)
%x	Locale's appropriate date representation.	
%X	Locale's appropriate time representation.	
%y	Year without century as a decimal number [00,99].	
%Y	Year with century as a decimal number.	
%Z	Time zone offset indicating a positive or negative time difference from UTC/GMT of the form +HHMM or -HHMM, where H represents decimal hour digits and M represents decimal minute digits [-23:59, +23:59]. ¹	
%z	Time zone name (no characters if no time zone exists). Deprecated. ^{Page 683, 1}	
%%	A literal '%' character.	

解:

- (1) The `%f` format directive only applies to `strptime()`, not to `strftime()`. However, see also `datetime.datetime.strptime()` and `datetime.datetime.strftime()` where the `%f` format directive *applies to microseconds*.
- (2) When used with the `strptime()` function, the `%p` directive only affects the output hour field if the `%I` directive is used to parse the hour.
- (3) The range really is 0 to 61; value 60 is valid in timestamps representing *leap seconds* and value 61 is supported for historical reasons.
- (4) When used with the `strptime()` function, `%U` and `%W` are only used in calculations when the day of the week and the year are specified.

Here is an example, a format for dates compatible with that specified in the **RFC 2822** Internet email standard.^{Page 683, 1}

```
>>> from time import gmtime, strftime
>>> strftime("%a, %d %b %Y %H:%M:%S +0000", gmtime())
'Thu, 28 Jun 2001 14:17:15 +0000'
```

Additional directives may be supported on certain platforms, but only the ones listed here have a meaning standardized by ANSI C. To see the full set of format codes supported on your platform, consult the `strftime(3)` documentation.

On some platforms, an optional field width and precision specification can immediately follow the initial `'%'` of a directive in the following order; this is also not portable. The field width is normally 2 except for `%j` where it is 3.

`time.strptime(string[, format])`

Parse a string representing a time according to a format. The return value is a `struct_time` as returned by `gmtime()` or `localtime()`.

The `format` parameter uses the same directives as those used by `strftime()`; it defaults to `"%a %b %d %H:%M:%S %Y"` which matches the formatting returned by `ctime()`. If `string` cannot be parsed according to `format`, or if it has excess data after parsing, `ValueError` is raised. The default values used to fill in any missing data when more accurate values cannot be inferred are (1900, 1, 1, 0, 0, 0, 0, 1, -1). Both `string` and `format` must be strings.

For example:

```
>>> import time
>>> time.strptime("30 Nov 00", "%d %b %y")
time.struct_time(tm_year=2000, tm_mon=11, tm_mday=30, tm_hour=0, tm_min=0,
                  tm_sec=0, tm_wday=3, tm_yday=335, tm_isdst=-1)
```

Support for the `%Z` directive is based on the values contained in `tzname` and whether `daylight` is true. Because of this, it is platform-specific except for recognizing UTC and GMT which are always known (and are considered to be non-daylight savings timezones).

Only the directives specified in the documentation are supported. Because `strftime()` is implemented per platform it can sometimes offer more directives than those listed. But `strptime()` is independent of any platform and thus does not necessarily support all directives available that are not documented as supported.

class `time.struct_time`

The type of the time value sequence returned by `gmtime()`, `localtime()`, and `strptime()`. It is an object with a *named tuple* interface: values can be accessed by index and by attribute name. The following values are present:

¹ The use of `%Z` is now deprecated, but the `%z` escape that expands to the preferred hour/minute offset is not supported by all ANSI C libraries. Also, a strict reading of the original 1982 **RFC 822** standard calls for a two-digit year (`%y` rather than `%Y`), but practice moved to 4-digit years long before the year 2000. After that, **RFC 822** became obsolete and the 4-digit year has been first recommended by **RFC 1123** and then mandated by **RFC 2822**.

Index	屬性	Values
0	<code>tm_year</code>	(for example, 1993)
1	<code>tm_mon</code>	range [1, 12]
2	<code>tm_day</code>	range [1, 31]
3	<code>tm_hour</code>	range [0, 23]
4	<code>tm_min</code>	range [0, 59]
5	<code>tm_sec</code>	range [0, 61]; see <i>Note (2)</i> in <code>strptime()</code>
6	<code>tm_wday</code>	range [0, 6]; Monday is 0
7	<code>tm_yday</code>	range [1, 366]
8	<code>tm_isdst</code>	0, 1 or -1; see below
N/A	<code>tm_zone</code>	abbreviation of timezone name
N/A	<code>tm_gmtoff</code>	offset east of UTC in seconds

Note that unlike the C structure, the month value is a range of [1, 12], not [0, 11].

In calls to `mktime()`, `tm_isdst` may be set to 1 when daylight savings time is in effect, and 0 when it is not. A value of -1 indicates that this is not known, and will usually result in the correct state being filled in.

When a tuple with an incorrect length is passed to a function expecting a `struct_time`, or having elements of the wrong type, a `TypeError` is raised.

`time.time()` → *float*

Return the time in seconds since the *epoch* as a floating point number. The handling of *leap seconds* is platform dependent. On Windows and most Unix systems, the leap seconds are not counted towards the time in seconds since the *epoch*. This is commonly referred to as *Unix time*.

Note that even though the time is always returned as a floating point number, not all systems provide time with a better precision than 1 second. While this function normally returns non-decreasing values, it can return a lower value than a previous call if the system clock has been set back between the two calls.

The number returned by `time()` may be converted into a more common time format (i.e. year, month, day, hour, etc...) in UTC by passing it to `gmtime()` function or in local time by passing it to the `localtime()` function. In both cases a `struct_time` object is returned, from which the components of the calendar date may be accessed as attributes.

Use `time_ns()` to avoid the precision loss caused by the *float* type.

`time.time_ns()` → *int*

Similar to `time()` but returns time as an integer number of nanoseconds since the *epoch*.

在 3.7 版新加入。

`time.thread_time()` → *float*

Return the value (in fractional seconds) of the sum of the system and user CPU time of the current thread. It does not include time elapsed during sleep. It is thread-specific by definition. The reference point of the returned value is undefined, so that only the difference between the results of two calls in the same thread is valid.

Use `thread_time_ns()` to avoid the precision loss caused by the *float* type.

適用：Linux、Unix、Windows。

Unix systems supporting `CLOCK_THREAD_CPUTIME_ID`.

在 3.7 版新加入。

`time.thread_time_ns()` → *int*

Similar to `thread_time()` but return time as nanoseconds.

在 3.7 版新加入。

`time.tzset()`

Reset the time conversion rules used by the library routines. The environment variable `TZ` specifies how this is done. It will also set the variables `tzname` (from the `TZ` environment variable), `timezone` (non-DST seconds West of UTC), `altzone` (DST seconds west of UTC) and `daylight` (to 0 if this timezone does not have any daylight saving time rules, or to nonzero if there is a time, past, present or future when daylight saving time applies).

適用：Unix。

備註：Although in many cases, changing the `TZ` environment variable may affect the output of functions like `localtime()` without calling `tzset()`, this behavior should not be relied on.

The `TZ` environment variable should contain no whitespace.

The standard format of the `TZ` environment variable is (whitespace added for clarity):

```
std offset [dst [offset [,start[/time], end[/time]]]]
```

Where the components are:

std 和 dst

Three or more alphanumerics giving the timezone abbreviations. These will be propagated into `time.tzname`

offset

The offset has the form: `± hh[:mm[:ss]]`. This indicates the value added the local time to arrive at UTC. If preceded by a '-', the timezone is east of the Prime Meridian; otherwise, it is west. If no offset follows `dst`, summer time is assumed to be one hour ahead of standard time.

start[/time], end[/time]

Indicates when to change to and back from DST. The format of the start and end dates are one of the following:

Jn

The Julian day *n* ($1 \leq n \leq 365$). Leap days are not counted, so in all years February 28 is day 59 and March 1 is day 60.

n

The zero-based Julian day ($0 \leq n \leq 365$). Leap days are counted, and it is possible to refer to February 29.

Mm.n.d

The d 'th day ($0 \leq d \leq 6$) of week n of month m of the year ($1 \leq n \leq 5$, $1 \leq m \leq 12$, where week 5 means "the last d day in month m " which may occur in either the fourth or the fifth week). Week 1 is the first week in which the d 'th day occurs. Day zero is a Sunday.

`time` has the same format as `offset` except that no leading sign ('-' or '+') is allowed. The default, if time is not given, is 02:00:00.

```
>>> os.environ['TZ'] = 'EST+05EDT,M4.1.0,M10.5.0'
>>> time.tzset()
>>> time.strftime('%X %x %Z')
'02:07:36 05/08/03 EDT'
>>> os.environ['TZ'] = 'AEST-10AEDT-11,M10.5.0,M3.5.0'
>>> time.tzset()
>>> time.strftime('%X %x %Z')
'16:08:12 05/08/03 AEST'
```

On many Unix systems (including *BSD, Linux, Solaris, and Darwin), it is more convenient to use the system's zoneinfo (`tzfile(5)`) database to specify the timezone rules. To do this, set the TZ environment variable to the path of the required timezone datafile, relative to the root of the systems 'zoneinfo' timezone database, usually located at `/usr/share/zoneinfo`. For example, 'US/Eastern', 'Australia/Melbourne', 'Egypt' or 'Europe/Amsterdam'.

```
>>> os.environ['TZ'] = 'US/Eastern'
>>> time.tzset()
>>> time.tzname
('EST', 'EDT')
>>> os.environ['TZ'] = 'Egypt'
>>> time.tzset()
>>> time.tzname
('EET', 'EEST')
```

16.3.2 Clock ID Constants

These constants are used as parameters for `clock_getres()` and `clock_gettime()`.

`time.CLOCK_BOOTTIME`

Identical to `CLOCK_MONOTONIC`, except it also includes any time that the system is suspended.

This allows applications to get a suspend-aware monotonic clock without having to deal with the complications of `CLOCK_REALTIME`, which may have discontinuities if the time is changed using `settimeofday()` or similar.

適用：Linux 2.6.39 以上。

在 3.7 版新加入。

`time.CLOCK_HIGHRES`

The Solaris OS has a `CLOCK_HIGHRES` timer that attempts to use an optimal hardware source, and may give close to nanosecond resolution. `CLOCK_HIGHRES` is the nonadjustable, high-resolution clock.

適用：Solaris。

在 3.3 版新加入。

`time.CLOCK_MONOTONIC`

Clock that cannot be set and represents monotonic time since some unspecified starting point.

適用：Unix。

在 3.3 版新加入。

time.CLOCK_MONOTONIC_RAW

Similar to [CLOCK_MONOTONIC](#), but provides access to a raw hardware-based time that is not subject to NTP adjustments.

適用：Linux 2.6.28 以上、macOS 10.12 以上。

在 3.3 版新加入。

time.CLOCK_PROCESS_CPUTIME_ID

High-resolution per-process timer from the CPU.

適用：Unix。

在 3.3 版新加入。

time.CLOCK_PROF

High-resolution per-process timer from the CPU.

適用：FreeBSD、NetBSD 7 以上、OpenBSD。

在 3.7 版新加入。

time.CLOCK_TAI

International Atomic Time

The system must have a current leap second table in order for this to give the correct answer. PTP or NTP software can maintain a leap second table.

適用：Linux。

在 3.9 版新加入。

time.CLOCK_THREAD_CPUTIME_ID

Thread-specific CPU-time clock.

適用：Unix。

在 3.3 版新加入。

time.CLOCK_UPTIME

Time whose absolute value is the time the system has been running and not suspended, providing accurate uptime measurement, both absolute and interval.

適用：FreeBSD、OpenBSD 5.5 以上。

在 3.7 版新加入。

time.CLOCK_UPTIME_RAW

Clock that increments monotonically, tracking the time since an arbitrary point, unaffected by frequency or time adjustments and not incremented while the system is asleep.

適用：macOS 10.12 以上。

在 3.8 版新加入。

The following constant is the only parameter that can be sent to `clock_settime()`.

time.CLOCK_REALTIME

System-wide real-time clock. Setting this clock requires appropriate privileges.

適用：Unix。

在 3.3 版新加入。

16.3.3 Timezone Constants

`time.altzone`

The offset of the local DST timezone, in seconds west of UTC, if one is defined. This is negative if the local DST timezone is east of UTC (as in Western Europe, including the UK). Only use this if `daylight` is nonzero. See note below.

`time.daylight`

Nonzero if a DST timezone is defined. See note below.

`time.timezone`

The offset of the local (non-DST) timezone, in seconds west of UTC (negative in most of Western Europe, positive in the US, zero in the UK). See note below.

`time.tzname`

A tuple of two strings: the first is the name of the local non-DST timezone, the second is the name of the local DST timezone. If no DST timezone is defined, the second string should not be used. See note below.

備[Ⓕ]: For the above Timezone constants (`altzone`, `daylight`, `timezone`, and `tzname`), the value is determined by the timezone rules in effect at module load time or the last time `tzset()` is called and may be incorrect for times in the past. It is recommended to use the `tm_gmtoff` and `tm_zone` results from `localtime()` to obtain timezone information.

也參考:

`datetime` 模組

More object-oriented interface to dates and times.

`locale` 模組

Internationalization services. The locale setting affects the interpretation of many format specifiers in `strftime()` and `strptime()`.

`calendar` 模組

General calendar-related functions. `timegm()` is the inverse of `gmtime()` from this module.

解[Ⓕ]

16.4 `argparse` --- Parser for command-line options, arguments and sub-commands

在 3.2 版新加入.

原始碼: [Lib/argparse.py](#)

教學

This page contains the API reference information. For a more gentle introduction to Python command-line parsing, have a look at the [argparse tutorial](#).

The `argparse` module makes it easy to write user-friendly command-line interfaces. The program defines what arguments it requires, and `argparse` will figure out how to parse those out of `sys.argv`. The `argparse` module also automatically generates help and usage messages. The module will also issue errors when users give the program invalid arguments.

16.4.1 Core Functionality

The `argparse` module's support for command-line interfaces is built around an instance of `argparse.ArgumentParser`. It is a container for argument specifications and has options that apply the parser as whole:

```
parser = argparse.ArgumentParser(
    prog='ProgramName',
    description='What the program does',
    epilog='Text at the bottom of help')
```

The `ArgumentParser.add_argument()` method attaches individual argument specifications to the parser. It supports positional arguments, options that accept values, and on/off flags:

```
parser.add_argument('filename')           # positional argument
parser.add_argument('-c', '--count')      # option that takes a value
parser.add_argument('-v', '--verbose',
                    action='store_true')   # on/off flag
```

The `ArgumentParser.parse_args()` method runs the parser and places the extracted data in a `argparse.Namespace` object:

```
args = parser.parse_args()
print(args.filename, args.count, args.verbose)
```

16.4.2 Quick Links for `add_argument()`

名 稱	描述	數值
<i>action</i>	Specify how an argument should be handled	'store', 'store_const', 'store_true', 'append', 'append_const', 'count', 'help', 'version'
<i>choice</i>	Limit values to a specific set of choices	['foo', 'bar'], range(1, 10), or <i>Container</i> instance
<i>const</i>	Store a constant value	
<i>default</i>	Default value used when an argument is not provided	Defaults to None
<i>dest</i>	Specify the attribute name used in the result namespace	
<i>help</i>	Help message for an argument	
<i>metavar</i>	Alternate display name for the argument as shown in help	
<i>nargs</i>	Number of times the argument can be used	int, '?', '*', or '+'
<i>required</i>	Indicate whether an argument is required or optional	True 或 False
<i>type</i>	Automatically convert an argument to the given type	int, float, argparse.FileType('w') 或可呼叫的函式

16.4.3 范例

The following code is a Python program that takes a list of integers and produces either the sum or the max:

```
import argparse

parser = argparse.ArgumentParser(description='Process some integers.')
parser.add_argument('integers', metavar='N', type=int, nargs='+',
                    help='an integer for the accumulator')
parser.add_argument('--sum', dest='accumulate', action='store_const',
                    const=sum, default=max,
                    help='sum the integers (default: find the max)')

args = parser.parse_args()
print(args.accumulate(args.integers))
```

Assuming the above Python code is saved into a file called `prog.py`, it can be run at the command line and it provides useful help messages:

```
$ python prog.py -h
usage: prog.py [-h] [--sum] N [N ...]

Process some integers.

positional arguments:
  N                an integer for the accumulator

options:
  -h, --help      show this help message and exit
  --sum           sum the integers (default: find the max)
```

When run with the appropriate arguments, it prints either the sum or the max of the command-line integers:

```
$ python prog.py 1 2 3 4
4

$ python prog.py 1 2 3 4 --sum
10
```

If invalid arguments are passed in, an error will be displayed:

```
$ python prog.py a b c
usage: prog.py [-h] [--sum] N [N ...]
prog.py: error: argument N: invalid int value: 'a'
```

The following sections walk you through this example.

建立一個剖析器

The first step in using the `argparse` is creating an `ArgumentParser` object:

```
>>> parser = argparse.ArgumentParser(description='Process some integers.')
```

The `ArgumentParser` object will hold all the information necessary to parse the command line into Python data types.

增加引數

Filling an `ArgumentParser` with information about program arguments is done by making calls to the `add_argument()` method. Generally, these calls tell the `ArgumentParser` how to take the strings on the command line and turn them into objects. This information is stored and used when `parse_args()` is called. For example:

```
>>> parser.add_argument('integers', metavar='N', type=int, nargs='+',
...                     help='an integer for the accumulator')
>>> parser.add_argument('--sum', dest='accumulate', action='store_const',
...                     const=sum, default=max,
...                     help='sum the integers (default: find the max)')
```

Later, calling `parse_args()` will return an object with two attributes, `integers` and `accumulate`. The `integers` attribute will be a list of one or more integers, and the `accumulate` attribute will be either the `sum()` function, if `--sum` was specified at the command line, or the `max()` function if it was not.

剖析引數

`ArgumentParser` parses arguments through the `parse_args()` method. This will inspect the command line, convert each argument to the appropriate type and then invoke the appropriate action. In most cases, this means a simple `Namespace` object will be built up from attributes parsed out of the command line:

```
>>> parser.parse_args(['--sum', '7', '-1', '42'])
Namespace(accumulate=<built-in function sum>, integers=[7, -1, 42])
```

In a script, `parse_args()` will typically be called with no arguments, and the `ArgumentParser` will automatically determine the command-line arguments from `sys.argv`.

16.4.4 ArgumentParser 物件

```
class argparse.ArgumentParser (prog=None, usage=None, description=None, epilog=None,
                                parents=[], formatter_class=argparse.HelpFormatter,
                                prefix_chars='-', fromfile_prefix_chars=None,
                                argument_default=None, conflict_handler='error', add_help=True,
                                allow_abbrev=True, exit_on_error=True)
```

Create a new `ArgumentParser` object. All parameters should be passed as keyword arguments. Each parameter has its own more detailed description below, but in short they are:

- `prog` - The name of the program (default: `os.path.basename(sys.argv[0])`)
- `usage` - The string describing the program usage (default: generated from arguments added to parser)
- `description` - Text to display before the argument help (by default, no text)
- `epilog` - Text to display after the argument help (by default, no text)
- `parents` - A list of `ArgumentParser` objects whose arguments should also be included
- `formatter_class` - A class for customizing the help output
- `prefix_chars` - The set of characters that prefix optional arguments (default: '-')
- `fromfile_prefix_chars` - The set of characters that prefix files from which additional arguments should be read (default: None)
- `argument_default` - The global default value for arguments (default: None)
- `conflict_handler` - The strategy for resolving conflicting optionals (usually unnecessary)
- `add_help` - Add a `-h/--help` option to the parser (default: True)
- `allow_abbrev` - Allows long options to be abbreviated if the abbreviation is unambiguous. (default: True)

- `exit_on_error` - Determines whether or not `ArgumentParser` exits with error info when an error occurs. (default: `True`)

在 3.5 版的變更: 新增 `allow_abbrev` 參數。

在 3.8 版的變更: In previous versions, `allow_abbrev` also disabled grouping of short flags such as `-vv` to mean `-v -v`.

在 3.9 版的變更: 新增 `exit_on_error` 參數。

The following sections describe how each of these are used.

prog

By default, `ArgumentParser` objects use `sys.argv[0]` to determine how to display the name of the program in help messages. This default is almost always desirable because it will make the help messages match how the program was invoked on the command line. For example, consider a file named `myprogram.py` with the following code:

```
import argparse
parser = argparse.ArgumentParser()
parser.add_argument('--foo', help='foo help')
args = parser.parse_args()
```

The help for this program will display `myprogram.py` as the program name (regardless of where the program was invoked from):

```
$ python myprogram.py --help
usage: myprogram.py [-h] [--foo FOO]

options:
  -h, --help  show this help message and exit
  --foo FOO   foo help
$ cd ..
$ python subdir/myprogram.py --help
usage: myprogram.py [-h] [--foo FOO]

options:
  -h, --help  show this help message and exit
  --foo FOO   foo help
```

To change this default behavior, another value can be supplied using the `prog=` argument to `ArgumentParser`:

```
>>> parser = argparse.ArgumentParser(prog='myprogram')
>>> parser.print_help()
usage: myprogram [-h]

options:
  -h, --help  show this help message and exit
```

Note that the program name, whether determined from `sys.argv[0]` or from the `prog=` argument, is available to help messages using the `%(prog)s` format specifier.

```
>>> parser = argparse.ArgumentParser(prog='myprogram')
>>> parser.add_argument('--foo', help='foo of the %(prog)s program')
>>> parser.print_help()
usage: myprogram [-h] [--foo FOO]

options:
  -h, --help  show this help message and exit
  --foo FOO   foo of the myprogram program
```

usage

By default, *ArgumentParser* calculates the usage message from the arguments it contains:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('--foo', nargs='?', help='foo help')
>>> parser.add_argument('bar', nargs='+', help='bar help')
>>> parser.print_help()
usage: PROG [-h] [--foo [FOO]] bar [bar ...]

positional arguments:
  bar                bar help

options:
  -h, --help        show this help message and exit
  --foo [FOO]       foo help
```

The default message can be overridden with the `usage=` keyword argument:

```
>>> parser = argparse.ArgumentParser(prog='PROG', usage='% (prog)s [options]')
>>> parser.add_argument('--foo', nargs='?', help='foo help')
>>> parser.add_argument('bar', nargs='+', help='bar help')
>>> parser.print_help()
usage: PROG [options]

positional arguments:
  bar                bar help

options:
  -h, --help        show this help message and exit
  --foo [FOO]       foo help
```

The `% (prog)s` format specifier is available to fill in the program name in your usage messages.

描述

Most calls to the *ArgumentParser* constructor will use the `description=` keyword argument. This argument gives a brief description of what the program does and how it works. In help messages, the description is displayed between the command-line usage string and the help messages for the various arguments:

```
>>> parser = argparse.ArgumentParser(description='A foo that bars')
>>> parser.print_help()
usage: argparse.py [-h]

A foo that bars

options:
  -h, --help  show this help message and exit
```

By default, the description will be line-wrapped so that it fits within the given space. To change this behavior, see the *formatter_class* argument.

epilog

Some programs like to display additional description of the program after the description of the arguments. Such text can be specified using the `epilog=` argument to *ArgumentParser*:

```
>>> parser = argparse.ArgumentParser(
...     description='A foo that bars',
...     epilog="And that's how you'd foo a bar")
>>> parser.print_help()
usage: argparse.py [-h]

A foo that bars

options:
  -h, --help  show this help message and exit

And that's how you'd foo a bar
```

As with the *description* argument, the `epilog=` text is by default line-wrapped, but this behavior can be adjusted with the *formatter_class* argument to *ArgumentParser*.

parents

Sometimes, several parsers share a common set of arguments. Rather than repeating the definitions of these arguments, a single parser with all the shared arguments and passed to `parents=` argument to *ArgumentParser* can be used. The `parents=` argument takes a list of *ArgumentParser* objects, collects all the positional and optional actions from them, and adds these actions to the *ArgumentParser* object being constructed:

```
>>> parent_parser = argparse.ArgumentParser(add_help=False)
>>> parent_parser.add_argument('--parent', type=int)

>>> foo_parser = argparse.ArgumentParser(parents=[parent_parser])
>>> foo_parser.add_argument('foo')
>>> foo_parser.parse_args(['--parent', '2', 'XXX'])
Namespace(foo='XXX', parent=2)

>>> bar_parser = argparse.ArgumentParser(parents=[parent_parser])
>>> bar_parser.add_argument('--bar')
>>> bar_parser.parse_args(['--bar', 'YYY'])
Namespace(bar='YYY', parent=None)
```

Note that most parent parsers will specify `add_help=False`. Otherwise, the *ArgumentParser* will see two `-h/--help` options (one in the parent and one in the child) and raise an error.

備F: You must fully initialize the parsers before passing them via `parents=`. If you change the parent parsers after the child parser, those changes will not be reflected in the child.

formatter_class

ArgumentParser objects allow the help formatting to be customized by specifying an alternate formatting class. Currently, there are four such classes:

```
class argparse.RawDescriptionHelpFormatter
class argparse.RawTextHelpFormatter
class argparse.ArgumentDefaultsHelpFormatter
class argparse.MetavarTypeHelpFormatter
```

RawDescriptionHelpFormatter and *RawTextHelpFormatter* give more control over how textual descriptions are displayed. By default, *ArgumentParser* objects line-wrap the *description* and *epilog* texts in command-line help messages:

```
>>> parser = argparse.ArgumentParser(
...     prog='PROG',
...     description='''this description
...         was indented weird
...         but that is okay''',
...     epilog='''
...         likewise for this epilog whose whitespace will
...         be cleaned up and whose words will be wrapped
...         across a couple lines''')
>>> parser.print_help()
usage: PROG [-h]

this description was indented weird but that is okay

options:
  -h, --help  show this help message and exit

likewise for this epilog whose whitespace will be cleaned up and whose words
will be wrapped across a couple lines
```

Passing *RawDescriptionHelpFormatter* as `formatter_class=` indicates that *description* and *epilog* are already correctly formatted and should not be line-wrapped:

```
>>> parser = argparse.ArgumentParser(
...     prog='PROG',
...     formatter_class=argparse.RawDescriptionHelpFormatter,
...     description=textwrap.dedent('''\
...         Please do not mess up this text!
...         -----
...         I have indented it
...         exactly the way
...         I want it
...         '''))
>>> parser.print_help()
usage: PROG [-h]

Please do not mess up this text!
-----
    I have indented it
    exactly the way
    I want it

options:
  -h, --help  show this help message and exit
```

RawTextHelpFormatter maintains whitespace for all sorts of help text, including argument descriptions. However, multiple new lines are replaced with one. If you wish to preserve multiple blank lines, add spaces between the newlines.

ArgumentDefaultsHelpFormatter automatically adds information about default values to each of the argument help messages:

```
>>> parser = argparse.ArgumentParser(
...     prog='PROG',
...     formatter_class=argparse.ArgumentDefaultsHelpFormatter)
>>> parser.add_argument('--foo', type=int, default=42, help='FOO!')
>>> parser.add_argument('bar', nargs='*', default=[1, 2, 3], help='BAR!')
>>> parser.print_help()
usage: PROG [-h] [--foo FOO] [bar ...]

positional arguments:
  bar          BAR! (default: [1, 2, 3])

options:
  -h, --help  show this help message and exit
  --foo FOO   FOO! (default: 42)
```

MetavarTypeHelpFormatter uses the name of the *type* argument for each argument as the display name for its values (rather than using the *dest* as the regular formatter does):

```
>>> parser = argparse.ArgumentParser(
...     prog='PROG',
...     formatter_class=argparse.MetavarTypeHelpFormatter)
>>> parser.add_argument('--foo', type=int)
>>> parser.add_argument('bar', type=float)
>>> parser.print_help()
usage: PROG [-h] [--foo int] float

positional arguments:
  float

options:
  -h, --help  show this help message and exit
  --foo int
```

prefix_chars

Most command-line options will use `-` as the prefix, e.g. `-f/--foo`. Parsers that need to support different or additional prefix characters, e.g. for options like `+f` or `/foo`, may specify them using the `prefix_chars=` argument to the `ArgumentParser` constructor:

```
>>> parser = argparse.ArgumentParser(prog='PROG', prefix_chars='+-')
>>> parser.add_argument('+f')
>>> parser.add_argument('++bar')
>>> parser.parse_args('+f X ++bar Y'.split())
Namespace(bar='Y', f='X')
```

The `prefix_chars=` argument defaults to `'-'`. Supplying a set of characters that does not include `-` will cause `-f/--foo` options to be disallowed.

fromfile_prefix_chars

Sometimes, when dealing with a particularly long argument list, it may make sense to keep the list of arguments in a file rather than typing it out at the command line. If the `fromfile_prefix_chars=` argument is given to the `ArgumentParser` constructor, then arguments that start with any of the specified characters will be treated as files, and will be replaced by the arguments they contain. For example:

```
>>> with open('args.txt', 'w') as fp:
...     fp.write('-f\nbar')
>>> parser = argparse.ArgumentParser(fromfile_prefix_chars='@')
>>> parser.add_argument('-f')
>>> parser.parse_args(['-f', 'foo', '@args.txt'])
Namespace(f='bar')
```

Arguments read from a file must by default be one per line (but see also `convert_arg_line_to_args()`) and are treated as if they were in the same place as the original file referencing argument on the command line. So in the example above, the expression `['-f', 'foo', '@args.txt']` is considered equivalent to the expression `['-f', 'foo', '-f', 'bar']`.

The `fromfile_prefix_chars=` argument defaults to `None`, meaning that arguments will never be treated as file references.

argument_default

Generally, argument defaults are specified either by passing a default to `add_argument()` or by calling the `set_defaults()` methods with a specific set of name-value pairs. Sometimes however, it may be useful to specify a single parser-wide default for arguments. This can be accomplished by passing the `argument_default=` keyword argument to `ArgumentParser`. For example, to globally suppress attribute creation on `parse_args()` calls, we supply `argument_default=SUPPRESS`:

```
>>> parser = argparse.ArgumentParser(argument_default=argparse.SUPPRESS)
>>> parser.add_argument('--foo')
>>> parser.add_argument('bar', nargs='?')
>>> parser.parse_args(['--foo', '1', 'BAR'])
Namespace(bar='BAR', foo='1')
>>> parser.parse_args([])
Namespace()
```

allow_abbrev

Normally, when you pass an argument list to the `parse_args()` method of an `ArgumentParser`, it *recognizes abbreviations* of long options.

This feature can be disabled by setting `allow_abbrev` to `False`:

```
>>> parser = argparse.ArgumentParser(prog='PROG', allow_abbrev=False)
>>> parser.add_argument('--foobar', action='store_true')
>>> parser.add_argument('--foonley', action='store_false')
>>> parser.parse_args(['--foon'])
usage: PROG [-h] [--foobar] [--foonley]
PROG: error: unrecognized arguments: --foon
```

在 3.5 版新加入。

conflict_handler

ArgumentParser objects do not allow two actions with the same option string. By default, *ArgumentParser* objects raise an exception if an attempt is made to create an argument with an option string that is already in use:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-f', '--foo', help='old foo help')
>>> parser.add_argument('--foo', help='new foo help')
Traceback (most recent call last):
..
ArgumentError: argument --foo: conflicting option string(s): --foo
```

Sometimes (e.g. when using *parents*) it may be useful to simply override any older arguments with the same option string. To get this behavior, the value 'resolve' can be supplied to the *conflict_handler*= argument of *ArgumentParser*:

```
>>> parser = argparse.ArgumentParser(prog='PROG', conflict_handler='resolve')
>>> parser.add_argument('-f', '--foo', help='old foo help')
>>> parser.add_argument('--foo', help='new foo help')
>>> parser.print_help()
usage: PROG [-h] [-f FOO] [--foo FOO]

options:
-h, --help  show this help message and exit
-f FOO      old foo help
--foo FOO   new foo help
```

Note that *ArgumentParser* objects only remove an action if all of its option strings are overridden. So, in the example above, the old *-f/--foo* action is retained as the *-f* action, because only the *--foo* option string was overridden.

add_help

By default, *ArgumentParser* objects add an option which simply displays the parser's help message. For example, consider a file named *myprogram.py* containing the following code:

```
import argparse
parser = argparse.ArgumentParser()
parser.add_argument('--foo', help='foo help')
args = parser.parse_args()
```

If *-h* or *--help* is supplied at the command line, the *ArgumentParser* help will be printed:

```
$ python myprogram.py --help
usage: myprogram.py [-h] [--foo FOO]

options:
-h, --help  show this help message and exit
--foo FOO   foo help
```

Occasionally, it may be useful to disable the addition of this help option. This can be achieved by passing *False* as the *add_help*= argument to *ArgumentParser*:

```
>>> parser = argparse.ArgumentParser(prog='PROG', add_help=False)
>>> parser.add_argument('--foo', help='foo help')
>>> parser.print_help()
usage: PROG [--foo FOO]

options:
--foo FOO  foo help
```

The help option is typically `-h/--help`. The exception to this is if the `prefix_chars=` is specified and does not include `-`, in which case `-h` and `--help` are not valid options. In this case, the first character in `prefix_chars` is used to prefix the help options:

```
>>> parser = argparse.ArgumentParser(prog='PROG', prefix_chars='+/')
>>> parser.print_help()
usage: PROG [+h]

options:
  +h, ++help  show this help message and exit
```

exit_on_error

Normally, when you pass an invalid argument list to the `parse_args()` method of an `ArgumentParser`, it will exit with error info.

If the user would like to catch errors manually, the feature can be enabled by setting `exit_on_error` to `False`:

```
>>> parser = argparse.ArgumentParser(exit_on_error=False)
>>> parser.add_argument('--integers', type=int)
_StoreAction(option_strings=['--integers'], dest='integers', nargs=None,
↳const=None, default=None, type=<class 'int'>, choices=None, help=None,
↳metavar=None)
>>> try:
...     parser.parse_args('--integers a'.split())
... except argparse.ArgumentError:
...     print('Catching an argumentError')
...
Catching an argumentError
```

在 3.9 版新加入.

16.4.5 The add_argument() method

`ArgumentParser.add_argument` (*name or flags...* [, *action*] [, *nargs*] [, *const*] [, *default*] [, *type*] [, *choices*] [, *required*] [, *help*] [, *metavar*] [, *dest*])

Define how a single command-line argument should be parsed. Each parameter has its own more detailed description below, but in short they are:

- *name or flags* - Either a name or a list of option strings, e.g. `foo` or `-f`, `--foo`.
- *action* - The basic type of action to be taken when this argument is encountered at the command line.
- *nargs* - The number of command-line arguments that should be consumed.
- *const* - A constant value required by some *action* and *nargs* selections.
- *default* - The value produced if the argument is absent from the command line and if it is absent from the namespace object.
- *type* - The type to which the command-line argument should be converted.
- *choices* - A sequence of the allowable values for the argument.
- *required* - Whether or not the command-line option may be omitted (optionals only).
- *help* - A brief description of what the argument does.
- *metavar* - A name for the argument in usage messages.
- *dest* - The name of the attribute to be added to the object returned by `parse_args()`.

The following sections describe how each of these are used.

name or flags

The `add_argument()` method must know whether an optional argument, like `-f` or `--foo`, or a positional argument, like a list of filenames, is expected. The first arguments passed to `add_argument()` must therefore be either a series of flags, or a simple argument name.

For example, an optional argument could be created like:

```
>>> parser.add_argument('-f', '--foo')
```

while a positional argument could be created like:

```
>>> parser.add_argument('bar')
```

When `parse_args()` is called, optional arguments will be identified by the `-` prefix, and the remaining arguments will be assumed to be positional:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-f', '--foo')
>>> parser.add_argument('bar')
>>> parser.parse_args(['BAR'])
Namespace(bar='BAR', foo=None)
>>> parser.parse_args(['BAR', '--foo', 'FOO'])
Namespace(bar='BAR', foo='FOO')
>>> parser.parse_args(['--foo', 'FOO'])
usage: PROG [-h] [-f FOO] bar
PROG: error: the following arguments are required: bar
```

action

`ArgumentParser` objects associate command-line arguments with actions. These actions can do just about anything with the command-line arguments associated with them, though most actions simply add an attribute to the object returned by `parse_args()`. The `action` keyword argument specifies how the command-line arguments should be handled. The supplied actions are:

- `'store'` - This just stores the argument's value. This is the default action. For example:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo')
>>> parser.parse_args('--foo 1'.split())
Namespace(foo='1')
```

- `'store_const'` - This stores the value specified by the `const` keyword argument; note that the `const` keyword argument defaults to `None`. The `'store_const'` action is most commonly used with optional arguments that specify some sort of flag. For example:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', action='store_const', const=42)
>>> parser.parse_args(['--foo'])
Namespace(foo=42)
```

- `'store_true'` and `'store_false'` - These are special cases of `'store_const'` used for storing the values `True` and `False` respectively. In addition, they create default values of `False` and `True` respectively. For example:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', action='store_true')
>>> parser.add_argument('--bar', action='store_false')
>>> parser.add_argument('--baz', action='store_false')
>>> parser.parse_args('--foo --bar'.split())
Namespace(foo=True, bar=False, baz=True)
```

- 'append' - This stores a list, and appends each argument value to the list. It is useful to allow an option to be specified multiple times. If the default value is non-empty, the default elements will be present in the parsed value for the option, with any values from the command line appended after those default values. Example usage:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', action='append')
>>> parser.parse_args('--foo 1 --foo 2'.split())
Namespace(foo=['1', '2'])
```

- 'append_const' - This stores a list, and appends the value specified by the *const* keyword argument to the list; note that the *const* keyword argument defaults to None. The 'append_const' action is typically useful when multiple arguments need to store constants to the same list. For example:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--str', dest='types', action='append_const',
    ↪const=str)
>>> parser.add_argument('--int', dest='types', action='append_const',
    ↪const=int)
>>> parser.parse_args('--str --int'.split())
Namespace(types=[<class 'str'>, <class 'int'>])
```

- 'count' - This counts the number of times a keyword argument occurs. For example, this is useful for increasing verbosity levels:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--verbose', '-v', action='count', default=0)
>>> parser.parse_args(['-vvv'])
Namespace(verbose=3)
```

Note, the *default* will be None unless explicitly set to 0.

- 'help' - This prints a complete help message for all the options in the current parser and then exits. By default a help action is automatically added to the parser. See *ArgumentParser* for details of how the output is created.
- 'version' - This expects a version= keyword argument in the *add_argument()* call, and prints version information and exits when invoked:

```
>>> import argparse
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('--version', action='version', version='% (prog)s 2.0')
>>> parser.parse_args(['--version'])
PROG 2.0
```

- 'extend' - This stores a list, and extends each argument value to the list. Example usage:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument("--foo", action="extend", nargs="+", type=str)
>>> parser.parse_args(["--foo", "f1", "--foo", "f2", "f3", "f4"])
Namespace(foo=['f1', 'f2', 'f3', 'f4'])
```

在 3.8 版新加入.

You may also specify an arbitrary action by passing an Action subclass or other object that implements the same interface. The *BooleanOptionalAction* is available in *argparse* and adds support for boolean actions such as `--foo` and `--no-foo`:

```
>>> import argparse
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', action=argparse.BooleanOptionalAction)
>>> parser.parse_args(['--no-foo'])
Namespace(foo=False)
```

在 3.9 版新加入。

The recommended way to create a custom action is to extend [Action](#), overriding the `__call__` method and optionally the `__init__` and `format_usage` methods.

An example of a custom action:

```
>>> class FooAction(argparse.Action):
...     def __init__(self, option_strings, dest, nargs=None, **kwargs):
...         if nargs is not None:
...             raise ValueError("nargs not allowed")
...         super().__init__(option_strings, dest, **kwargs)
...     def __call__(self, parser, namespace, values, option_string=None):
...         print('%r %r %r' % (namespace, values, option_string))
...         setattr(namespace, self.dest, values)
...
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', action=FooAction)
>>> parser.add_argument('bar', action=FooAction)
>>> args = parser.parse_args('1 --foo 2'.split())
Namespace(bar=None, foo=None) '1' None
Namespace(bar='1', foo=None) '2' '--foo'
>>> args
Namespace(bar='1', foo='2')
```

For more details, see [Action](#).

nargs

`ArgumentParser` objects usually associate a single command-line argument with a single action to be taken. The `nargs` keyword argument associates a different number of command-line arguments with a single action. The supported values are:

- `N` (an integer). `N` arguments from the command line will be gathered together into a list. For example:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', nargs=2)
>>> parser.add_argument('bar', nargs=1)
>>> parser.parse_args('c --foo a b'.split())
Namespace(bar=['c'], foo=['a', 'b'])
```

Note that `nargs=1` produces a list of one item. This is different from the default, in which the item is produced by itself.

- `'?'`. One argument will be consumed from the command line if possible, and produced as a single item. If no command-line argument is present, the value from [default](#) will be produced. Note that for optional arguments, there is an additional case - the option string is present but not followed by a command-line argument. In this case the value from [const](#) will be produced. Some examples to illustrate this:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', nargs='?', const='c', default='d')
>>> parser.add_argument('bar', nargs='?', default='d')
>>> parser.parse_args(['XX', '--foo', 'YY'])
Namespace(bar='XX', foo='YY')
>>> parser.parse_args(['XX', '--foo'])
Namespace(bar='XX', foo='c')
>>> parser.parse_args([])
Namespace(bar='d', foo='d')
```

One of the more common uses of `nargs='?'` is to allow optional input and output files:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('infile', nargs='?', type=argparse.FileType('r'),
...                     default=sys.stdin)
>>> parser.add_argument('outfile', nargs='?', type=argparse.FileType('w'),
...                     default=sys.stdout)
>>> parser.parse_args(['input.txt', 'output.txt'])
Namespace(infile=<_io.TextIOWrapper name='input.txt' encoding='UTF-8'>,
          outfile=<_io.TextIOWrapper name='output.txt' encoding='UTF-8'>)
>>> parser.parse_args([])
Namespace(infile=<_io.TextIOWrapper name='<stdin>' encoding='UTF-8'>,
          outfile=<_io.TextIOWrapper name='<stdout>' encoding='UTF-8'>)
```

- `'*'`. All command-line arguments present are gathered into a list. Note that it generally doesn't make much sense to have more than one positional argument with `nargs='*'`, but multiple optional arguments with `nargs='*'` is possible. For example:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', nargs='*')
>>> parser.add_argument('--bar', nargs='*')
>>> parser.add_argument('baz', nargs='*')
>>> parser.parse_args('a b --foo x y --bar 1 2'.split())
Namespace(bar=['1', '2'], baz=['a', 'b'], foo=['x', 'y'])
```

- `'+'`. Just like `'*'`, all command-line args present are gathered into a list. Additionally, an error message will be generated if there wasn't at least one command-line argument present. For example:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('foo', nargs='+')
>>> parser.parse_args(['a', 'b'])
Namespace(foo=['a', 'b'])
>>> parser.parse_args([])
usage: PROG [-h] foo [foo ...]
PROG: error: the following arguments are required: foo
```

If the `nargs` keyword argument is not provided, the number of arguments consumed is determined by the [action](#). Generally this means a single command-line argument will be consumed and a single item (not a list) will be produced.

const

The `const` argument of `add_argument()` is used to hold constant values that are not read from the command line but are required for the various `ArgumentParser` actions. The two most common uses of it are:

- When `add_argument()` is called with `action='store_const'` or `action='append_const'`. These actions add the `const` value to one of the attributes of the object returned by `parse_args()`. See the [action](#) description for examples. If `const` is not provided to `add_argument()`, it will receive a default value of `None`.
- When `add_argument()` is called with option strings (like `-f` or `--foo`) and `nargs='?'`. This creates an optional argument that can be followed by zero or one command-line arguments. When parsing the command line, if the option string is encountered with no command-line argument following it, the value of `const` will be assumed to be `None` instead. See the [nargs](#) description for examples.

在 3.11 版的變更: `const=None` by default, including when `action='append_const'` or `action='store_const'`.

default

All optional arguments and some positional arguments may be omitted at the command line. The `default` keyword argument of `add_argument()`, whose value defaults to `None`, specifies what value should be used if the command-line argument is not present. For optional arguments, the `default` value is used when the option string was not present at the command line:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', default=42)
>>> parser.parse_args(['--foo', '2'])
Namespace(foo='2')
>>> parser.parse_args([])
Namespace(foo=42)
```

If the target namespace already has an attribute set, the action *default* will not over write it:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', default=42)
>>> parser.parse_args([], namespace=argparse.Namespace(foo=101))
Namespace(foo=101)
```

If the `default` value is a string, the parser parses the value as if it were a command-line argument. In particular, the parser applies any *type* conversion argument, if provided, before setting the attribute on the *Namespace* return value. Otherwise, the parser uses the value as is:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--length', default='10', type=int)
>>> parser.add_argument('--width', default=10.5, type=int)
>>> parser.parse_args()
Namespace(length=10, width=10.5)
```

For positional arguments with *nargs* equal to `?` or `*`, the `default` value is used when no command-line argument was present:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('foo', nargs='?', default=42)
>>> parser.parse_args(['a'])
Namespace(foo='a')
>>> parser.parse_args([])
Namespace(foo=42)
```

Providing `default=argparse.SUPPRESS` causes no attribute to be added if the command-line argument was not present:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', default=argparse.SUPPRESS)
>>> parser.parse_args([])
Namespace()
>>> parser.parse_args(['--foo', '1'])
Namespace(foo='1')
```


type

By default, the parser reads command-line arguments in as simple strings. However, quite often the command-line string should instead be interpreted as another type, such as a *float* or *int*. The `type` keyword for `add_argument()` allows any necessary type-checking and type conversions to be performed.

If the `type` keyword is used with the `default` keyword, the type converter is only applied if the default is a string.

The argument to `type` can be any callable that accepts a single string. If the function raises *ArgumentTypeError*, *TypeError*, or *ValueError*, the exception is caught and a nicely formatted error message is displayed. No other exception types are handled.

Common built-in types and functions can be used as type converters:

```
import argparse
import pathlib

parser = argparse.ArgumentParser()
parser.add_argument('count', type=int)
parser.add_argument('distance', type=float)
parser.add_argument('street', type=ascii)
parser.add_argument('code_point', type=ord)
parser.add_argument('source_file', type=open)
parser.add_argument('dest_file', type=argparse.FileType('w', encoding='latin-1'))
parser.add_argument('datapath', type=pathlib.Path)
```

User defined functions can be used as well:

```
>>> def hyphenated(string):
...     return '-'.join([word[:4] for word in string.casefold().split()])
...
>>> parser = argparse.ArgumentParser()
>>> _ = parser.add_argument('short_title', type=hyphenated)
>>> parser.parse_args(['The Tale of Two Cities'])
Namespace(short_title='the-tale-of-two-citi')
```

The `bool()` function is not recommended as a type converter. All it does is convert empty strings to *False* and non-empty strings to *True*. This is usually not what is desired.

In general, the `type` keyword is a convenience that should only be used for simple conversions that can only raise one of the three supported exceptions. Anything with more interesting error-handling or resource management should be done downstream after the arguments are parsed.

For example, JSON or YAML conversions have complex error cases that require better reporting than can be given by the `type` keyword. A *JSONDecodeError* would not be well formatted and a *FileNotFoundError* exception would not be handled at all.

Even *FileType* has its limitations for use with the `type` keyword. If one argument uses *FileType* and then a subsequent argument fails, an error is reported but the file is not automatically closed. In this case, it would be better to wait until after the parser has run and then use the `with`-statement to manage the files.

For type checkers that simply check against a fixed set of values, consider using the *choices* keyword instead.

choices

Some command-line arguments should be selected from a restricted set of values. These can be handled by passing a sequence object as the *choices* keyword argument to `add_argument()`. When the command line is parsed, argument values will be checked, and an error message will be displayed if the argument was not one of the acceptable values:

```
>>> parser = argparse.ArgumentParser(prog='game.py')
>>> parser.add_argument('move', choices=['rock', 'paper', 'scissors'])
>>> parser.parse_args(['rock'])
Namespace(move='rock')
>>> parser.parse_args(['fire'])
usage: game.py [-h] {rock,paper,scissors}
game.py: error: argument move: invalid choice: 'fire' (choose from 'rock',
'paper', 'scissors')
```

Note that inclusion in the *choices* sequence is checked after any *type* conversions have been performed, so the type of the objects in the *choices* sequence should match the *type* specified:

```
>>> parser = argparse.ArgumentParser(prog='doors.py')
>>> parser.add_argument('door', type=int, choices=range(1, 4))
>>> print(parser.parse_args(['3']))
Namespace(door=3)
>>> parser.parse_args(['4'])
usage: doors.py [-h] {1,2,3}
doors.py: error: argument door: invalid choice: 4 (choose from 1, 2, 3)
```

Any sequence can be passed as the *choices* value, so *list* objects, *tuple* objects, and custom sequences are all supported.

Use of `enum.Enum` is not recommended because it is difficult to control its appearance in usage, help, and error messages.

Formatted choices override the default *metavar* which is normally derived from *dest*. This is usually what you want because the user never sees the *dest* parameter. If this display isn't desirable (perhaps because there are many choices), just specify an explicit *metavar*.

required

In general, the `argparse` module assumes that flags like `-f` and `--bar` indicate *optional* arguments, which can always be omitted at the command line. To make an option *required*, `True` can be specified for the `required=` keyword argument to `add_argument()`:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', required=True)
>>> parser.parse_args(['--foo', 'BAR'])
Namespace(foo='BAR')
>>> parser.parse_args([])
usage: [-h] --foo FOO
: error: the following arguments are required: --foo
```

As the example shows, if an option is marked as required, `parse_args()` will report an error if that option is not present at the command line.

備F: Required options are generally considered bad form because users expect *options* to be *optional*, and thus they should be avoided when possible.

幫助

The help value is a string containing a brief description of the argument. When a user requests help (usually by using `-h` or `--help` at the command line), these help descriptions will be displayed with each argument:

```
>>> parser = argparse.ArgumentParser(prog='frobble')
>>> parser.add_argument('--foo', action='store_true',
...                       help='foo the bars before frobbling')
>>> parser.add_argument('bar', nargs='+',
...                       help='one of the bars to be frobbled')
>>> parser.parse_args(['-h'])
usage: frobble [-h] [--foo] bar [bar ...]

positional arguments:
  bar      one of the bars to be frobbled

options:
  -h, --help  show this help message and exit
  --foo      foo the bars before frobbling
```

The help strings can include various format specifiers to avoid repetition of things like the program name or the argument *default*. The available specifiers include the program name, `%(prog)s` and most keyword arguments to `add_argument()`, e.g. `%(default)s`, `%(type)s`, etc.:

```
>>> parser = argparse.ArgumentParser(prog='frobble')
>>> parser.add_argument('bar', nargs='?', type=int, default=42,
...                       help='the bar to %(prog)s (default: %(default)s)')
>>> parser.print_help()
usage: frobble [-h] [bar]

positional arguments:
  bar      the bar to frobble (default: 42)

options:
  -h, --help  show this help message and exit
```

As the help string supports %-formatting, if you want a literal % to appear in the help string, you must escape it as %%.

`argparse` supports silencing the help entry for certain options, by setting the help value to `argparse.SUPPRESS`:

```
>>> parser = argparse.ArgumentParser(prog='frobble')
>>> parser.add_argument('--foo', help=argparse.SUPPRESS)
>>> parser.print_help()
usage: frobble [-h]

options:
  -h, --help  show this help message and exit
```

metavar

When `ArgumentParser` generates help messages, it needs some way to refer to each expected argument. By default, `ArgumentParser` objects use the *dest* value as the "name" of each object. By default, for positional argument actions, the *dest* value is used directly, and for optional argument actions, the *dest* value is uppercased. So, a single positional argument with *dest*='bar' will be referred to as `bar`. A single optional argument `--foo` that should be followed by a single command-line argument will be referred to as `FOO`. An example:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo')
```

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```
>>> parser.add_argument('bar')
>>> parser.parse_args('X --foo Y'.split())
Namespace(bar='X', foo='Y')
>>> parser.print_help()
usage: [-h] [--foo FOO] bar

positional arguments:
  bar

options:
  -h, --help  show this help message and exit
  --foo FOO
```

An alternative name can be specified with `metavar`:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', metavar='YYY')
>>> parser.add_argument('bar', metavar='XXX')
>>> parser.parse_args('X --foo Y'.split())
Namespace(bar='X', foo='Y')
>>> parser.print_help()
usage: [-h] [--foo YYY] XXX

positional arguments:
  XXX

options:
  -h, --help  show this help message and exit
  --foo YYY
```

Note that `metavar` only changes the *displayed* name - the name of the attribute on the `parse_args()` object is still determined by the `dest` value.

Different values of `nargs` may cause the `metavar` to be used multiple times. Providing a tuple to `metavar` specifies a different display for each of the arguments:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-x', nargs=2)
>>> parser.add_argument('--foo', nargs=2, metavar=('bar', 'baz'))
>>> parser.print_help()
usage: PROG [-h] [-x X X] [--foo bar baz]

options:
  -h, --help      show this help message and exit
  -x X X
  --foo bar baz
```

dest

Most `ArgumentParser` actions add some value as an attribute of the object returned by `parse_args()`. The name of this attribute is determined by the `dest` keyword argument of `add_argument()`. For positional argument actions, `dest` is normally supplied as the first argument to `add_argument()`:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('bar')
>>> parser.parse_args(['XXX'])
Namespace(bar='XXX')
```

For optional argument actions, the value of `dest` is normally inferred from the option strings. `ArgumentParser` generates the value of `dest` by taking the first long option string and stripping away the initial `--` string. If no

long option strings were supplied, `dest` will be derived from the first short option string by stripping the initial `-` character. Any internal `-` characters will be converted to `_` characters to make sure the string is a valid attribute name. The examples below illustrate this behavior:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('-f', '--foo-bar', '--foo')
>>> parser.add_argument('-x', '-y')
>>> parser.parse_args('-f 1 -x 2'.split())
Namespace(foo_bar='1', x='2')
>>> parser.parse_args('--foo 1 -y 2'.split())
Namespace(foo_bar='1', x='2')
```

`dest` allows a custom attribute name to be provided:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', dest='bar')
>>> parser.parse_args('--foo XXX'.split())
Namespace(bar='XXX')
```

Action classes

Action classes implement the Action API, a callable which returns a callable which processes arguments from the command-line. Any object which follows this API may be passed as the `action` parameter to `add_argument()`.

class `argparse.Action` (*option_strings*, *dest*, *nargs=None*, *const=None*, *default=None*, *type=None*, *choices=None*, *required=False*, *help=None*, *metavar=None*)

Action objects are used by an `ArgumentParser` to represent the information needed to parse a single argument from one or more strings from the command line. The Action class must accept the two positional arguments plus any keyword arguments passed to `ArgumentParser.add_argument()` except for the action itself.

Instances of `Action` (or return value of any callable to the `action` parameter) should have attributes `"dest"`, `"option_strings"`, `"default"`, `"type"`, `"required"`, `"help"`, etc. defined. The easiest way to ensure these attributes are defined is to call `Action.__init__`.

Action instances should be callable, so subclasses must override the `__call__` method, which should accept four parameters:

- `parser` - The `ArgumentParser` object which contains this action.
- `namespace` - The `Namespace` object that will be returned by `parse_args()`. Most actions add an attribute to this object using `setattr()`.
- `values` - The associated command-line arguments, with any type conversions applied. Type conversions are specified with the `type` keyword argument to `add_argument()`.
- `option_string` - The option string that was used to invoke this action. The `option_string` argument is optional, and will be absent if the action is associated with a positional argument.

The `__call__` method may perform arbitrary actions, but will typically set attributes on the `namespace` based on `dest` and `values`.

Action subclasses can define a `format_usage` method that takes no argument and return a string which will be used when printing the usage of the program. If such method is not provided, a sensible default will be used.

16.4.6 The `parse_args()` method

`ArgumentParser.parse_args(args=None, namespace=None)`

Convert argument strings to objects and assign them as attributes of the namespace. Return the populated namespace.

Previous calls to `add_argument()` determine exactly what objects are created and how they are assigned. See the documentation for `add_argument()` for details.

- `args` - List of strings to parse. The default is taken from `sys.argv`.
- `namespace` - An object to take the attributes. The default is a new empty `Namespace` object.

Option value syntax

The `parse_args()` method supports several ways of specifying the value of an option (if it takes one). In the simplest case, the option and its value are passed as two separate arguments:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-x')
>>> parser.add_argument('--foo')
>>> parser.parse_args(['-x', 'X'])
Namespace(foo=None, x='X')
>>> parser.parse_args(['--foo', 'FOO'])
Namespace(foo='FOO', x=None)
```

For long options (options with names longer than a single character), the option and value can also be passed as a single command-line argument, using `=` to separate them:

```
>>> parser.parse_args(['--foo=FOO'])
Namespace(foo='FOO', x=None)
```

For short options (options only one character long), the option and its value can be concatenated:

```
>>> parser.parse_args(['-xX'])
Namespace(foo=None, x='X')
```

Several short options can be joined together, using only a single `-` prefix, as long as only the last option (or none of them) requires a value:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-x', action='store_true')
>>> parser.add_argument('-y', action='store_true')
>>> parser.add_argument('-z')
>>> parser.parse_args(['-xyzZ'])
Namespace(x=True, y=True, z='Z')
```

Invalid arguments

While parsing the command line, `parse_args()` checks for a variety of errors, including ambiguous options, invalid types, invalid options, wrong number of positional arguments, etc. When it encounters such an error, it exits and prints the error along with a usage message:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('--foo', type=int)
>>> parser.add_argument('bar', nargs='?')

>>> # invalid type
>>> parser.parse_args(['--foo', 'spam'])
```

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```
usage: PROG [-h] [--foo FOO] [bar]
PROG: error: argument --foo: invalid int value: 'spam'

>>> # invalid option
>>> parser.parse_args(['--bar'])
usage: PROG [-h] [--foo FOO] [bar]
PROG: error: no such option: --bar

>>> # wrong number of arguments
>>> parser.parse_args(['spam', 'badger'])
usage: PROG [-h] [--foo FOO] [bar]
PROG: error: extra arguments found: badger
```

Arguments containing –

The `parse_args()` method attempts to give errors whenever the user has clearly made a mistake, but some situations are inherently ambiguous. For example, the command-line argument `-1` could either be an attempt to specify an option or an attempt to provide a positional argument. The `parse_args()` method is cautious here: positional arguments may only begin with `-` if they look like negative numbers and there are no options in the parser that look like negative numbers:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-x')
>>> parser.add_argument('foo', nargs='?')

>>> # no negative number options, so -1 is a positional argument
>>> parser.parse_args(['-x', '-1'])
Namespace(foo=None, x='-1')

>>> # no negative number options, so -1 and -5 are positional arguments
>>> parser.parse_args(['-x', '-1', '-5'])
Namespace(foo='-5', x='-1')

>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-1', dest='one')
>>> parser.add_argument('foo', nargs='?')

>>> # negative number options present, so -1 is an option
>>> parser.parse_args(['-1', 'X'])
Namespace(foo=None, one='X')

>>> # negative number options present, so -2 is an option
>>> parser.parse_args(['-2'])
usage: PROG [-h] [-1 ONE] [foo]
PROG: error: no such option: -2

>>> # negative number options present, so both -1s are options
>>> parser.parse_args(['-1', '-1'])
usage: PROG [-h] [-1 ONE] [foo]
PROG: error: argument -1: expected one argument
```

If you have positional arguments that must begin with `-` and don't look like negative numbers, you can insert the pseudo-argument `--` which tells `parse_args()` that everything after that is a positional argument:

```
>>> parser.parse_args(['--', '-f'])
Namespace(foo='-f', one=None)
```

Argument abbreviations (prefix matching)

The `parse_args()` method *by default* allows long options to be abbreviated to a prefix, if the abbreviation is unambiguous (the prefix matches a unique option):

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('-bacon')
>>> parser.add_argument('-badger')
>>> parser.parse_args(['-bac MMM'.split()])
Namespace(bacon='MMM', badger=None)
>>> parser.parse_args(['-bad WOOD'.split()])
Namespace(bacon=None, badger='WOOD')
>>> parser.parse_args(['-ba BA'.split()])
usage: PROG [-h] [-bacon BACON] [-badger BADGER]
PROG: error: ambiguous option: -ba could match -badger, -bacon
```

An error is produced for arguments that could produce more than one options. This feature can be disabled by setting `allow_abbrev` to `False`.

Beyond `sys.argv`

Sometimes it may be useful to have an `ArgumentParser` parse arguments other than those of `sys.argv`. This can be accomplished by passing a list of strings to `parse_args()`. This is useful for testing at the interactive prompt:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument(
...     'integers', metavar='int', type=int, choices=range(10),
...     nargs='+', help='an integer in the range 0..9')
>>> parser.add_argument(
...     '--sum', dest='accumulate', action='store_const', const=sum,
...     default=max, help='sum the integers (default: find the max)')
>>> parser.parse_args(['1', '2', '3', '4'])
Namespace(accumulate=<built-in function max>, integers=[1, 2, 3, 4])
>>> parser.parse_args(['1', '2', '3', '4', '--sum'])
Namespace(accumulate=<built-in function sum>, integers=[1, 2, 3, 4])
```

The Namespace object

`class argparse.Namespace`

Simple class used by default by `parse_args()` to create an object holding attributes and return it.

This class is deliberately simple, just an *object* subclass with a readable string representation. If you prefer to have dict-like view of the attributes, you can use the standard Python idiom, `vars()`:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo')
>>> args = parser.parse_args(['--foo', 'BAR'])
>>> vars(args)
{'foo': 'BAR'}
```

It may also be useful to have an `ArgumentParser` assign attributes to an already existing object, rather than a new `Namespace` object. This can be achieved by specifying the `namespace=` keyword argument:

```
>>> class C:
...     pass
...
>>> c = C()
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo')
```

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```
>>> parser.parse_args(args=['--foo', 'BAR'], namespace=c)
>>> c.foo
'BAR'
```

16.4.7 Other utilities

Sub-commands

`ArgumentParser.add_subparsers` (*[title][, description][, prog][, parser_class][, action][, option_strings][, dest][, required][, help][, metavar]*)

Many programs split up their functionality into a number of sub-commands, for example, the `svn` program can invoke sub-commands like `svn checkout`, `svn update`, and `svn commit`. Splitting up functionality this way can be a particularly good idea when a program performs several different functions which require different kinds of command-line arguments. `ArgumentParser` supports the creation of such sub-commands with the `add_subparsers()` method. The `add_subparsers()` method is normally called with no arguments and returns a special action object. This object has a single method, `add_parser()`, which takes a command name and any `ArgumentParser` constructor arguments, and returns an `ArgumentParser` object that can be modified as usual.

Description of parameters:

- `title` - title for the sub-parser group in help output; by default "subcommands" if description is provided, otherwise uses title for positional arguments
- `description` - description for the sub-parser group in help output, by default `None`
- `prog` - usage information that will be displayed with sub-command help, by default the name of the program and any positional arguments before the subparser argument
- `parser_class` - class which will be used to create sub-parser instances, by default the class of the current parser (e.g. `ArgumentParser`)
- `action` - the basic type of action to be taken when this argument is encountered at the command line
- `dest` - name of the attribute under which sub-command name will be stored; by default `None` and no value is stored
- `required` - Whether or not a subcommand must be provided, by default `False` (added in 3.7)
- `help` - help for sub-parser group in help output, by default `None`
- `metavar` - string presenting available sub-commands in help; by default it is `None` and presents sub-commands in form `{cmd1, cmd2, ..}`

一些使用範例：

```
>>> # create the top-level parser
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> parser.add_argument('--foo', action='store_true', help='foo help')
>>> subparsers = parser.add_subparsers(help='sub-command help')
>>>
>>> # create the parser for the "a" command
>>> parser_a = subparsers.add_parser('a', help='a help')
>>> parser_a.add_argument('bar', type=int, help='bar help')
>>>
>>> # create the parser for the "b" command
>>> parser_b = subparsers.add_parser('b', help='b help')
>>> parser_b.add_argument('--baz', choices='XYZ', help='baz help')
>>>
>>> # parse some argument lists
>>> parser.parse_args(['a', '12'])
```

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```
Namespace(bar=12, foo=False)
>>> parser.parse_args(['--foo', 'b', '--baz', 'Z'])
Namespace(baz='Z', foo=True)
```

Note that the object returned by `parse_args()` will only contain attributes for the main parser and the subparser that was selected by the command line (and not any other subparsers). So in the example above, when the `a` command is specified, only the `foo` and `bar` attributes are present, and when the `b` command is specified, only the `foo` and `baz` attributes are present.

Similarly, when a help message is requested from a subparser, only the help for that particular parser will be printed. The help message will not include parent parser or sibling parser messages. (A help message for each subparser command, however, can be given by supplying the `help=` argument to `add_parser()` as above.)

```
>>> parser.parse_args(['--help'])
usage: PROG [-h] [--foo] {a,b} ...

positional arguments:
  {a,b}      sub-command help
    a        a help
    b        b help

options:
  -h, --help  show this help message and exit
  --foo       foo help

>>> parser.parse_args(['a', '--help'])
usage: PROG a [-h] bar

positional arguments:
  bar      bar help

options:
  -h, --help  show this help message and exit

>>> parser.parse_args(['b', '--help'])
usage: PROG b [-h] [--baz {X,Y,Z}]

options:
  -h, --help      show this help message and exit
  --baz {X,Y,Z}  baz help
```

The `add_subparsers()` method also supports `title` and `description` keyword arguments. When either is present, the subparser's commands will appear in their own group in the help output. For example:

```
>>> parser = argparse.ArgumentParser()
>>> subparsers = parser.add_subparsers(title='subcommands',
...                                   description='valid subcommands',
...                                   help='additional help')
>>> subparsers.add_parser('foo')
>>> subparsers.add_parser('bar')
>>> parser.parse_args(['-h'])
usage: [-h] {foo,bar} ...

options:
  -h, --help  show this help message and exit

subcommands:
  valid subcommands

  {foo,bar}  additional help
```

Furthermore, `add_parser` supports an additional `aliases` argument, which allows multiple strings to

refer to the same subparser. This example, like `svn`, aliases `co` as a shorthand for `checkout`:

```
>>> parser = argparse.ArgumentParser()
>>> subparsers = parser.add_subparsers()
>>> checkout = subparsers.add_parser('checkout', aliases=['co'])
>>> checkout.add_argument('foo')
>>> parser.parse_args(['co', 'bar'])
Namespace(foo='bar')
```

One particularly effective way of handling sub-commands is to combine the use of the `add_subparsers()` method with calls to `set_defaults()` so that each subparser knows which Python function it should execute. For example:

```
>>> # sub-command functions
>>> def foo(args):
...     print(args.x * args.y)
...
>>> def bar(args):
...     print('((%s))' % args.z)
...
>>> # create the top-level parser
>>> parser = argparse.ArgumentParser()
>>> subparsers = parser.add_subparsers(required=True)
>>>
>>> # create the parser for the "foo" command
>>> parser_foo = subparsers.add_parser('foo')
>>> parser_foo.add_argument('-x', type=int, default=1)
>>> parser_foo.add_argument('y', type=float)
>>> parser_foo.set_defaults(func=foo)
>>>
>>> # create the parser for the "bar" command
>>> parser_bar = subparsers.add_parser('bar')
>>> parser_bar.add_argument('z')
>>> parser_bar.set_defaults(func=bar)
>>>
>>> # parse the args and call whatever function was selected
>>> args = parser.parse_args('foo 1 -x 2'.split())
>>> args.func(args)
2.0
>>>
>>> # parse the args and call whatever function was selected
>>> args = parser.parse_args('bar XYZYX'.split())
>>> args.func(args)
((XYZYX))
```

This way, you can let `parse_args()` do the job of calling the appropriate function after argument parsing is complete. Associating functions with actions like this is typically the easiest way to handle the different actions for each of your subparsers. However, if it is necessary to check the name of the subparser that was invoked, the `dest` keyword argument to the `add_subparsers()` call will work:

```
>>> parser = argparse.ArgumentParser()
>>> subparsers = parser.add_subparsers(dest='subparser_name')
>>> subparser1 = subparsers.add_parser('1')
>>> subparser1.add_argument('-x')
>>> subparser2 = subparsers.add_parser('2')
>>> subparser2.add_argument('y')
>>> parser.parse_args(['2', 'frobble'])
Namespace(subparser_name='2', y='frobble')
```

在 3.7 版的變更: New *required* keyword argument.

FileType 物件

class `argparse.FileType` (*mode='r', bufsize=-1, encoding=None, errors=None*)

The *FileType* factory creates objects that can be passed to the type argument of *ArgumentParser.add_argument()*. Arguments that have *FileType* objects as their type will open command-line arguments as files with the requested modes, buffer sizes, encodings and error handling (see the *open()* function for more details):

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--raw', type=argparse.FileType('wb', 0))
>>> parser.add_argument('out', type=argparse.FileType('w', encoding='UTF-8'))
>>> parser.parse_args(['--raw', 'raw.dat', 'file.txt'])
Namespace(out=<_io.TextIOWrapper name='file.txt' mode='w' encoding='UTF-8'>,
raw=<_io.FileIO name='raw.dat' mode='wb'>)
```

FileType objects understand the pseudo-argument '-' and automatically convert this into *sys.stdin* for readable *FileType* objects and *sys.stdout* for writable *FileType* objects:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('infile', type=argparse.FileType('r'))
>>> parser.parse_args(['-'])
Namespace(infile=<_io.TextIOWrapper name='<stdin>' encoding='UTF-8'>)
```

在 3.4 版的變更: Added the *encodings* and *errors* parameters.

Argument groups

`ArgumentParser.add_argument_group` (*title=None, description=None*)

By default, *ArgumentParser* groups command-line arguments into "positional arguments" and "options" when displaying help messages. When there is a better conceptual grouping of arguments than this default one, appropriate groups can be created using the *add_argument_group()* method:

```
>>> parser = argparse.ArgumentParser(prog='PROG', add_help=False)
>>> group = parser.add_argument_group('group')
>>> group.add_argument('--foo', help='foo help')
>>> group.add_argument('bar', help='bar help')
>>> parser.print_help()
usage: PROG [--foo FOO] bar

group:
  bar      bar help
  --foo FOO  foo help
```

The *add_argument_group()* method returns an argument group object which has an *add_argument()* method just like a regular *ArgumentParser*. When an argument is added to the group, the parser treats it just like a normal argument, but displays the argument in a separate group for help messages. The *add_argument_group()* method accepts *title* and *description* arguments which can be used to customize this display:

```
>>> parser = argparse.ArgumentParser(prog='PROG', add_help=False)
>>> group1 = parser.add_argument_group('group1', 'group1 description')
>>> group1.add_argument('foo', help='foo help')
>>> group2 = parser.add_argument_group('group2', 'group2 description')
>>> group2.add_argument('--bar', help='bar help')
>>> parser.print_help()
usage: PROG [--bar BAR] foo

group1:
  group1 description
```

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```
foo      foo help

group2:
  group2 description

--bar BAR  bar help
```

Note that any arguments not in your user-defined groups will end up back in the usual “positional arguments” and “optional arguments” sections.

在 3.11 版的變更: Calling `add_argument_group()` on an argument group is deprecated. This feature was never supported and does not always work correctly. The function exists on the API by accident through inheritance and will be removed in the future.

Mutual exclusion

`ArgumentParser.add_mutually_exclusive_group(required=False)`

Create a mutually exclusive group. `argparse` will make sure that only one of the arguments in the mutually exclusive group was present on the command line:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> group = parser.add_mutually_exclusive_group()
>>> group.add_argument('--foo', action='store_true')
>>> group.add_argument('--bar', action='store_false')
>>> parser.parse_args(['--foo'])
Namespace(bar=True, foo=True)
>>> parser.parse_args(['--bar'])
Namespace(bar=False, foo=False)
>>> parser.parse_args(['--foo', '--bar'])
usage: PROG [-h] [--foo | --bar]
PROG: error: argument --bar: not allowed with argument --foo
```

The `add_mutually_exclusive_group()` method also accepts a `required` argument, to indicate that at least one of the mutually exclusive arguments is required:

```
>>> parser = argparse.ArgumentParser(prog='PROG')
>>> group = parser.add_mutually_exclusive_group(required=True)
>>> group.add_argument('--foo', action='store_true')
>>> group.add_argument('--bar', action='store_false')
>>> parser.parse_args([])
usage: PROG [-h] (--foo | --bar)
PROG: error: one of the arguments --foo --bar is required
```

Note that currently mutually exclusive argument groups do not support the `title` and `description` arguments of `add_argument_group()`.

在 3.11 版的變更: Calling `add_argument_group()` or `add_mutually_exclusive_group()` on a mutually exclusive group is deprecated. These features were never supported and do not always work correctly. The functions exist on the API by accident through inheritance and will be removed in the future.

Parser defaults

`ArgumentParser.set_defaults(**kwargs)`

Most of the time, the attributes of the object returned by `parse_args()` will be fully determined by inspecting the command-line arguments and the argument actions. `set_defaults()` allows some additional attributes that are determined without any inspection of the command line to be added:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('foo', type=int)
>>> parser.set_defaults(bar=42, baz='badger')
>>> parser.parse_args(['736'])
Namespace(bar=42, baz='badger', foo=736)
```

Note that parser-level defaults always override argument-level defaults:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', default='bar')
>>> parser.set_defaults(foo='spam')
>>> parser.parse_args([])
Namespace(foo='spam')
```

Parser-level defaults can be particularly useful when working with multiple parsers. See the `add_subparsers()` method for an example of this type.

`ArgumentParser.get_default(dest)`

Get the default value for a namespace attribute, as set by either `add_argument()` or by `set_defaults()`:

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', default='badger')
>>> parser.get_default('foo')
'badger'
```

Printing help

In most typical applications, `parse_args()` will take care of formatting and printing any usage or error messages. However, several formatting methods are available:

`ArgumentParser.print_usage(file=None)`

Print a brief description of how the `ArgumentParser` should be invoked on the command line. If `file` is `None`, `sys.stdout` is assumed.

`ArgumentParser.print_help(file=None)`

Print a help message, including the program usage and information about the arguments registered with the `ArgumentParser`. If `file` is `None`, `sys.stdout` is assumed.

There are also variants of these methods that simply return a string instead of printing it:

`ArgumentParser.format_usage()`

Return a string containing a brief description of how the `ArgumentParser` should be invoked on the command line.

`ArgumentParser.format_help()`

Return a string containing a help message, including the program usage and information about the arguments registered with the `ArgumentParser`.

Partial parsing

`ArgumentParser.parse_known_args(args=None, namespace=None)`

Sometimes a script may only parse a few of the command-line arguments, passing the remaining arguments on to another script or program. In these cases, the `parse_known_args()` method can be useful. It works much like `parse_args()` except that it does not produce an error when extra arguments are present. Instead, it returns a two item tuple containing the populated namespace and the list of remaining argument strings.

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo', action='store_true')
>>> parser.add_argument('bar')
>>> parser.parse_known_args(['--foo', '--badger', 'BAR', 'spam'])
(Namespace(bar='BAR', foo=True), ['--badger', 'spam'])
```

警告: *Prefix matching* rules apply to `parse_known_args()`. The parser may consume an option even if it's just a prefix of one of its known options, instead of leaving it in the remaining arguments list.

Customizing file parsing

`ArgumentParser.convert_arg_line_to_args(arg_line)`

Arguments that are read from a file (see the `fromfile_prefix_chars` keyword argument to the `ArgumentParser` constructor) are read one argument per line. `convert_arg_line_to_args()` can be overridden for fancier reading.

This method takes a single argument `arg_line` which is a string read from the argument file. It returns a list of arguments parsed from this string. The method is called once per line read from the argument file, in order.

A useful override of this method is one that treats each space-separated word as an argument. The following example demonstrates how to do this:

```
class MyArgumentParser(argparse.ArgumentParser):
    def convert_arg_line_to_args(self, arg_line):
        return arg_line.split()
```

Exiting methods

`ArgumentParser.exit(status=0, message=None)`

This method terminates the program, exiting with the specified `status` and, if given, it prints a `message` before that. The user can override this method to handle these steps differently:

```
class ErrorCatchingArgumentParser(argparse.ArgumentParser):
    def exit(self, status=0, message=None):
        if status:
            raise Exception(f'Exiting because of an error: {message}')
        exit(status)
```

`ArgumentParser.error(message)`

This method prints a usage message including the `message` to the standard error and terminates the program with a status code of 2.

Intermixed parsing

`ArgumentParser.parse_intermixed_args(args=None, namespace=None)`

`ArgumentParser.parse_known_intermixed_args(args=None, namespace=None)`

A number of Unix commands allow the user to intermix optional arguments with positional arguments. The `parse_intermixed_args()` and `parse_known_intermixed_args()` methods support this parsing style.

These parsers do not support all the `argparse` features, and will raise exceptions if unsupported features are used. In particular, subparsers, and mutually exclusive groups that include both optionals and positionals are not supported.

The following example shows the difference between `parse_known_args()` and `parse_intermixed_args()`: the former returns `['2', '3']` as unparsed arguments, while the latter collects all the positionals into `rest`.

```
>>> parser = argparse.ArgumentParser()
>>> parser.add_argument('--foo')
>>> parser.add_argument('cmd')
>>> parser.add_argument('rest', nargs='*', type=int)
>>> parser.parse_known_args('doit 1 --foo bar 2 3'.split())
(Namespace(cmd='doit', foo='bar', rest=[1]), ['2', '3'])
>>> parser.parse_intermixed_args('doit 1 --foo bar 2 3'.split())
Namespace(cmd='doit', foo='bar', rest=[1, 2, 3])
```

`parse_known_intermixed_args()` returns a two item tuple containing the populated namespace and the list of remaining argument strings. `parse_intermixed_args()` raises an error if there are any remaining unparsed argument strings.

在 3.7 版新加入。

16.4.8 Upgrading optparse code

Originally, the `argparse` module had attempted to maintain compatibility with `optparse`. However, `optparse` was difficult to extend transparently, particularly with the changes required to support the new `nargs=` specifiers and better usage messages. When most everything in `optparse` had either been copy-pasted over or monkey-patched, it no longer seemed practical to try to maintain the backwards compatibility.

The `argparse` module improves on the standard library `optparse` module in a number of ways including:

- Handling positional arguments.
- Supporting sub-commands.
- Allowing alternative option prefixes like `+` and `/`.
- Handling zero-or-more and one-or-more style arguments.
- Producing more informative usage messages.
- Providing a much simpler interface for custom type and action.

A partial upgrade path from `optparse` to `argparse`:

- Replace all `optparse.OptionParser.add_option()` calls with `ArgumentParser.add_argument()` calls.
- Replace `(options, args) = parser.parse_args()` with `args = parser.parse_args()` and add additional `ArgumentParser.add_argument()` calls for the positional arguments. Keep in mind that what was previously called `options`, now in the `argparse` context is called `args`.
- Replace `optparse.OptionParser.disable_interspersed_args()` by using `parse_intermixed_args()` instead of `parse_args()`.

- Replace callback actions and the `callback_*` keyword arguments with `type` or `action` arguments.
- Replace string names for `type` keyword arguments with the corresponding type objects (e.g. `int`, `float`, `complex`, etc).
- Replace `optparse.Values` with `Namespace` and `optparse.OptionError` and `optparse.OptionValueError` with `ArgumentError`.
- Replace strings with implicit arguments such as `%default` or `%prog` with the standard Python syntax to use dictionaries to format strings, that is, `%(default)s` and `%(prog)s`.
- Replace the `OptionParser` constructor `version` argument with a call to `parser.add_argument('--version', action='version', version='<the version>')`.

16.4.9 Exceptions

exception `argparse.ArgumentError`

An error from creating or using an argument (optional or positional).

The string value of this exception is the message, augmented with information about the argument that caused it.

exception `argparse.ArgumentTypeError`

Raised when something goes wrong converting a command line string to a type.

16.5 getopt --- C-style parser for command line options

原始碼: [Lib/getopt.py](#)

備註: The `getopt` module is a parser for command line options whose API is designed to be familiar to users of the C `getopt()` function. Users who are unfamiliar with the C `getopt()` function or who would like to write less code and get better help and error messages should consider using the `argparse` module instead.

This module helps scripts to parse the command line arguments in `sys.argv`. It supports the same conventions as the Unix `getopt()` function (including the special meanings of arguments of the form `'-'` and `'--'`). Long options similar to those supported by GNU software may be used as well via an optional third argument.

This module provides two functions and an exception:

`getopt.getopt(args, shortopts, longopts=[])`

Parses command line options and parameter list. *args* is the argument list to be parsed, without the leading reference to the running program. Typically, this means `sys.argv[1:]`. *shortopts* is the string of option letters that the script wants to recognize, with options that require an argument followed by a colon (':'); i.e., the same format that Unix `getopt()` uses).

備註: Unlike GNU `getopt()`, after a non-option argument, all further arguments are considered also non-options. This is similar to the way non-GNU Unix systems work.

longopts, if specified, must be a list of strings with the names of the long options which should be supported. The leading `'--'` characters should not be included in the option name. Long options which require an argument should be followed by an equal sign ('='). Optional arguments are not supported. To accept only long options, *shortopts* should be an empty string. Long options on the command line can be recognized so long as they provide a prefix of the option name that matches exactly one of the accepted options. For example, if *longopts* is `['foo', 'frob']`, the option `--fo` will match as `--foo`, but `--f` will not match uniquely, so `GetoptError` will be raised.

The return value consists of two elements: the first is a list of (option, value) pairs; the second is the list of program arguments left after the option list was stripped (this is a trailing slice of *args*). Each option-and-value pair returned has the option as its first element, prefixed with a hyphen for short options (e.g., '-x') or two hyphens for long options (e.g., '--long-option'), and the option argument as its second element, or an empty string if the option has no argument. The options occur in the list in the same order in which they were found, thus allowing multiple occurrences. Long and short options may be mixed.

`getopt.gnu_getopt(args, shortopts, longopts=[])`

This function works like `getopt()`, except that GNU style scanning mode is used by default. This means that option and non-option arguments may be intermixed. The `getopt()` function stops processing options as soon as a non-option argument is encountered.

If the first character of the option string is '+', or if the environment variable `POSIIXLY_CORRECT` is set, then option processing stops as soon as a non-option argument is encountered.

exception `getopt.GetoptError`

This is raised when an unrecognized option is found in the argument list or when an option requiring an argument is given none. The argument to the exception is a string indicating the cause of the error. For long options, an argument given to an option which does not require one will also cause this exception to be raised. The attributes `msg` and `opt` give the error message and related option; if there is no specific option to which the exception relates, `opt` is an empty string.

exception `getopt.error`

Alias for `GetoptError`; for backward compatibility.

An example using only Unix style options:

```
>>> import getopt
>>> args = '-a -b -cfoo -d bar a1 a2'.split()
>>> args
['-a', '-b', '-cfoo', '-d', 'bar', 'a1', 'a2']
>>> optlist, args = getopt.getopt(args, 'abc:d:')
>>> optlist
[('-a', ''), ('-b', ''), ('-c', 'foo'), ('-d', 'bar')]
>>> args
['a1', 'a2']
```

Using long option names is equally easy:

```
>>> s = '--condition=foo --testing --output-file abc.def -x a1 a2'
>>> args = s.split()
>>> args
['--condition=foo', '--testing', '--output-file', 'abc.def', '-x', 'a1', 'a2']
>>> optlist, args = getopt.getopt(args, 'x', [
...     'condition=', 'output-file=', 'testing'])
>>> optlist
[('--condition', 'foo'), ('--testing', ''), ('--output-file', 'abc.def'), ('-x', 'a1')]
>>> args
['a2']
```

In a script, typical usage is something like this:

```
import getopt, sys

def main():
    try:
        opts, args = getopt.getopt(sys.argv[1:], "ho:v", ["help", "output="])
    except getopt.GetoptError as err:
        # print help information and exit:
        print(err) # will print something like "option -a not recognized"
        usage()
```

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```

    sys.exit(2)
    output = None
    verbose = False
    for o, a in opts:
        if o == "-v":
            verbose = True
        elif o in ("-h", "--help"):
            usage()
            sys.exit()
        elif o in ("-o", "--output"):
            output = a
        else:
            assert False, "unhandled option"
    # ...

if __name__ == "__main__":
    main()

```

Note that an equivalent command line interface could be produced with less code and more informative help and error messages by using the `argparse` module:

```

import argparse

if __name__ == '__main__':
    parser = argparse.ArgumentParser()
    parser.add_argument('-o', '--output')
    parser.add_argument('-v', dest='verbose', action='store_true')
    args = parser.parse_args()
    # ... do something with args.output ...
    # ... do something with args.verbose ..

```

也參考:

`argparse` 模組

Alternative command line option and argument parsing library.

16.6 logging --- Logging facility for Python

原始碼: [Lib/logging/__init__.py](#)

Important

This page contains the API reference information. For tutorial information and discussion of more advanced topics, see

- 基礎教學
- 進階教學
- Logging Cookbook

This module defines functions and classes which implement a flexible event logging system for applications and libraries.

The key benefit of having the logging API provided by a standard library module is that all Python modules can participate in logging, so your application log can include your own messages integrated with messages from third-party modules.

Here's a simple example of idiomatic usage:

```
# myapp.py
import logging
import mylib
logger = logging.getLogger(__name__)

def main():
    logging.basicConfig(filename='myapp.log', level=logging.INFO)
    logger.info('Started')
    mylib.do_something()
    logger.info('Finished')

if __name__ == '__main__':
    main()
```

```
# mylib.py
import logging
logger = logging.getLogger(__name__)

def do_something():
    logger.info('Doing something')
```

If you run *myapp.py*, you should see this in *myapp.log*:

```
INFO:__main__:Started
INFO:mylib:Doing something
INFO:__main__:Finished
```

The key features of this idiomatic usage is that the majority of code is simply creating a module level logger with `getLogger(__name__)`, and using that logger to do any needed logging. This is concise while allowing downstream code fine grained control if needed. Logged messages to the module-level logger get forwarded up to handlers of loggers in higher-level modules, all the way up to the root logger; for this reason this approach is known as hierarchical logging.

For logging to be useful, it needs to be configured: setting the levels and destinations for each logger, potentially changing how specific modules log, often based on command-line arguments or application configuration. In most cases, like the one above, only the root logger needs to be so configured, since all the lower level loggers at module level eventually forward their messages to its handlers. `basicConfig()` provides a quick way to configure the root logger that handles many use cases.

The module provides a lot of functionality and flexibility. If you are unfamiliar with logging, the best way to get to grips with it is to view the tutorials (**see the links above and on the right**).

The basic classes defined by the module, together with their functions, are listed below.

- Loggers expose the interface that application code directly uses.
- Handlers send the log records (created by loggers) to the appropriate destination.
- Filters provide a finer grained facility for determining which log records to output.
- Formatters specify the layout of log records in the final output.

16.6.1 Logger Objects

Loggers have the following attributes and methods. Note that Loggers should *NEVER* be instantiated directly, but always through the module-level function `logging.getLogger(name)`. Multiple calls to `getLogger()` with the same name will always return a reference to the same Logger object.

The `name` is potentially a period-separated hierarchical value, like `foo.bar.baz` (though it could also be just plain `foo`, for example). Loggers that are further down in the hierarchical list are children of loggers higher up in the list. For example, given a logger with a name of `foo`, loggers with names of `foo.bar`, `foo.bar.baz`, and `foo.bam` are all descendants of `foo`. The logger name hierarchy is analogous to the Python package hierarchy, and identical to it if you organise your loggers on a per-module basis using the recommended construction `logging.getLogger(__name__)`. That's because in a module, `__name__` is the module's name in the Python package namespace.

class `logging.Logger`

name

This is the logger's name, and is the value that was passed to `getLogger()` to obtain the logger.

備F: This attribute should be treated as read-only.

level

The threshold of this logger, as set by the `setLevel()` method.

備F: Do not set this attribute directly - always use `setLevel()`, which has checks for the level passed to it.

parent

The parent logger of this logger. It may change based on later instantiation of loggers which are higher up in the namespace hierarchy.

備F: This value should be treated as read-only.

propagate

If this attribute evaluates to true, events logged to this logger will be passed to the handlers of higher level (ancestor) loggers, in addition to any handlers attached to this logger. Messages are passed directly to the ancestor loggers' handlers - neither the level nor filters of the ancestor loggers in question are considered.

If this evaluates to false, logging messages are not passed to the handlers of ancestor loggers.

Spelling it out with an example: If the `propagate` attribute of the logger named `A.B.C` evaluates to true, any event logged to `A.B.C` via a method call such as `logging.getLogger('A.B.C').error(...)` will [subject to passing that logger's level and filter settings] be passed in turn to any handlers attached to loggers named `A.B`, `A` and the root logger, after first being passed to any handlers attached to `A.B.C`. If any logger in the chain `A.B.C`, `A.B`, `A` has its `propagate` attribute set to false, then that is the last logger whose handlers are offered the event to handle, and propagation stops at that point.

The constructor sets this attribute to `True`.

備F: If you attach a handler to a logger *and* one or more of its ancestors, it may emit the same record multiple times. In general, you should not need to attach a handler to more than one logger - if you just attach it to the appropriate logger which is highest in the logger hierarchy, then it will see all events logged by all descendant loggers, provided that their `propagate` setting is left set to `True`. A common scenario is to attach handlers only to the root logger, and to let propagation take care of the rest.

handlers

The list of handlers directly attached to this logger instance.

備 F: This attribute should be treated as read-only; it is normally changed via the `addHandler()` and `removeHandler()` methods, which use locks to ensure thread-safe operation.

disabled

This attribute disables handling of any events. It is set to `False` in the initializer, and only changed by logging configuration code.

備 F: This attribute should be treated as read-only.

setLevel(*level*)

Sets the threshold for this logger to *level*. Logging messages which are less severe than *level* will be ignored; logging messages which have severity *level* or higher will be emitted by whichever handler or handlers service this logger, unless a handler's level has been set to a higher severity level than *level*.

When a logger is created, the level is set to `NOTSET` (which causes all messages to be processed when the logger is the root logger, or delegation to the parent when the logger is a non-root logger). Note that the root logger is created with level `WARNING`.

The term 'delegation to the parent' means that if a logger has a level of `NOTSET`, its chain of ancestor loggers is traversed until either an ancestor with a level other than `NOTSET` is found, or the root is reached.

If an ancestor is found with a level other than `NOTSET`, then that ancestor's level is treated as the effective level of the logger where the ancestor search began, and is used to determine how a logging event is handled.

If the root is reached, and it has a level of `NOTSET`, then all messages will be processed. Otherwise, the root's level will be used as the effective level.

層級清單請見 [Logging Levels](#)。

在 3.2 版的變更: The *level* parameter now accepts a string representation of the level such as 'INFO' as an alternative to the integer constants such as `INFO`. Note, however, that levels are internally stored as integers, and methods such as e.g. `getEffectiveLevel()` and `isEnabledFor()` will return/expect to be passed integers.

isEnabledFor(*level*)

Indicates if a message of severity *level* would be processed by this logger. This method checks first the module-level level set by `logging.disable(level)` and then the logger's effective level as determined by `getEffectiveLevel()`.

getEffectiveLevel()

Indicates the effective level for this logger. If a value other than `NOTSET` has been set using `setLevel()`, it is returned. Otherwise, the hierarchy is traversed towards the root until a value other than `NOTSET` is found, and that value is returned. The value returned is an integer, typically one of `logging.DEBUG`, `logging.INFO` etc.

getChild(*suffix*)

Returns a logger which is a descendant to this logger, as determined by the suffix. Thus, `logging.getLogger('abc').getChild('def.ghi')` would return the same logger as would be returned by `logging.getLogger('abc.def.ghi')`. This is a convenience method, useful when the parent logger is named using e.g. `__name__` rather than a literal string.

在 3.2 版新加入。

debug (*msg*, **args*, ***kwargs*)

Logs a message with level `DEBUG` on this logger. The *msg* is the message format string, and the *args* are the arguments which are merged into *msg* using the string formatting operator. (Note that this means that you can use keywords in the format string, together with a single dictionary argument.) No % formatting operation is performed on *msg* when no *args* are supplied.

There are four keyword arguments in *kwargs* which are inspected: *exc_info*, *stack_info*, *stacklevel* and *extra*.

If *exc_info* does not evaluate as false, it causes exception information to be added to the logging message. If an exception tuple (in the format returned by `sys.exc_info()`) or an exception instance is provided, it is used; otherwise, `sys.exc_info()` is called to get the exception information.

The second optional keyword argument is *stack_info*, which defaults to `False`. If true, stack information is added to the logging message, including the actual logging call. Note that this is not the same stack information as that displayed through specifying *exc_info*: The former is stack frames from the bottom of the stack up to the logging call in the current thread, whereas the latter is information about stack frames which have been unwound, following an exception, while searching for exception handlers.

You can specify *stack_info* independently of *exc_info*, e.g. to just show how you got to a certain point in your code, even when no exceptions were raised. The stack frames are printed following a header line which says:

```
Stack (most recent call last):
```

This mimics the `Traceback (most recent call last):` which is used when displaying exception frames.

The third optional keyword argument is *stacklevel*, which defaults to 1. If greater than 1, the corresponding number of stack frames are skipped when computing the line number and function name set in the `LogRecord` created for the logging event. This can be used in logging helpers so that the function name, filename and line number recorded are not the information for the helper function/method, but rather its caller. The name of this parameter mirrors the equivalent one in the `warnings` module.

The fourth keyword argument is *extra* which can be used to pass a dictionary which is used to populate the `__dict__` of the `LogRecord` created for the logging event with user-defined attributes. These custom attributes can then be used as you like. For example, they could be incorporated into logged messages. For example:

```
FORMAT = '%(asctime)s %(clientip)-15s %(user)-8s %(message)s'
logging.basicConfig(format=FORMAT)
d = {'clientip': '192.168.0.1', 'user': 'fbloggs'}
logger = logging.getLogger('tcpserver')
logger.warning('Protocol problem: %s', 'connection reset', extra=d)
```

would print something like

```
2006-02-08 22:20:02,165 192.168.0.1 fbloggs Protocol problem: connection_
↪reset
```

The keys in the dictionary passed in *extra* should not clash with the keys used by the logging system. (See the section on `LogRecord attributes` for more information on which keys are used by the logging system.)

If you choose to use these attributes in logged messages, you need to exercise some care. In the above example, for instance, the `Formatter` has been set up with a format string which expects 'clientip' and 'user' in the attribute dictionary of the `LogRecord`. If these are missing, the message will not be logged because a string formatting exception will occur. So in this case, you always need to pass the *extra* dictionary with these keys.

While this might be annoying, this feature is intended for use in specialized circumstances, such as multi-threaded servers where the same code executes in many contexts, and interesting conditions which arise are dependent on this context (such as remote client IP address and authenticated user name, in the above

example). In such circumstances, it is likely that specialized *Formatters* would be used with particular *Handlers*.

If no handler is attached to this logger (or any of its ancestors, taking into account the relevant *Logger.propagate* attributes), the message will be sent to the handler set on *lastResort*.

在 3.2 版的變更: 新增 *stack_info* 參數。

在 3.5 版的變更: The *exc_info* parameter can now accept exception instances.

在 3.8 版的變更: 新增 *stacklevel* 參數。

info (*msg*, **args*, ***kwargs*)

Logs a message with level *INFO* on this logger. The arguments are interpreted as for *debug()*.

warning (*msg*, **args*, ***kwargs*)

Logs a message with level *WARNING* on this logger. The arguments are interpreted as for *debug()*.

備 F: There is an obsolete method *warn* which is functionally identical to *warning*. As *warn* is deprecated, please do not use it - use *warning* instead.

error (*msg*, **args*, ***kwargs*)

Logs a message with level *ERROR* on this logger. The arguments are interpreted as for *debug()*.

critical (*msg*, **args*, ***kwargs*)

Logs a message with level *CRITICAL* on this logger. The arguments are interpreted as for *debug()*.

log (*level*, *msg*, **args*, ***kwargs*)

Logs a message with integer level *level* on this logger. The other arguments are interpreted as for *debug()*.

exception (*msg*, **args*, ***kwargs*)

Logs a message with level *ERROR* on this logger. The arguments are interpreted as for *debug()*. Exception info is added to the logging message. This method should only be called from an exception handler.

addFilter (*filter*)

Adds the specified filter *filter* to this logger.

removeFilter (*filter*)

Removes the specified filter *filter* from this logger.

filter (*record*)

Apply this logger's filters to the record and return *True* if the record is to be processed. The filters are consulted in turn, until one of them returns a false value. If none of them return a false value, the record will be processed (passed to handlers). If one returns a false value, no further processing of the record occurs.

addHandler (*hdlr*)

Adds the specified handler *hdlr* to this logger.

removeHandler (*hdlr*)

Removes the specified handler *hdlr* from this logger.

findCaller (*stack_info=False*, *stacklevel=1*)

Finds the caller's source filename and line number. Returns the filename, line number, function name and stack information as a 4-element tuple. The stack information is returned as *None* unless *stack_info* is *True*.

The *stacklevel* parameter is passed from code calling the *debug()* and other APIs. If greater than 1, the excess is used to skip stack frames before determining the values to be returned. This will generally be useful when calling logging APIs from helper/wrapper code, so that the information in the event log refers not to the helper/wrapper code, but to the code that calls it.

handle (*record*)

Handles a record by passing it to all handlers associated with this logger and its ancestors (until a false value of *propagate* is found). This method is used for unpickled records received from a socket, as well as those created locally. Logger-level filtering is applied using *filter()*.

makeRecord (*name, level, fn, lno, msg, args, exc_info, func=None, extra=None, sinfo=None*)

This is a factory method which can be overridden in subclasses to create specialized *LogRecord* instances.

hasHandlers ()

Checks to see if this logger has any handlers configured. This is done by looking for handlers in this logger and its parents in the logger hierarchy. Returns *True* if a handler was found, else *False*. The method stops searching up the hierarchy whenever a logger with the 'propagate' attribute set to false is found - that will be the last logger which is checked for the existence of handlers.

在 3.2 版新加入。

在 3.7 版的變更: Loggers can now be pickled and unpickled.

16.6.2 Logging Levels

The numeric values of logging levels are given in the following table. These are primarily of interest if you want to define your own levels, and need them to have specific values relative to the predefined levels. If you define a level with the same numeric value, it overwrites the predefined value; the predefined name is lost.

Level	Numeric value	What it means / When to use it
<code>logging.NOTSET</code>	0	When set on a logger, indicates that ancestor loggers are to be consulted to determine the effective level. If that still resolves to <i>NOTSET</i> , then all events are logged. When set on a handler, all events are handled.
<code>logging.DEBUG</code>	10	Detailed information, typically only of interest to a developer trying to diagnose a problem.
<code>logging.INFO</code>	20	Confirmation that things are working as expected.
<code>logging.WARNING</code>	30	An indication that something unexpected happened, or that a problem might occur in the near future (e.g. 'disk space low'). The software is still working as expected.
<code>logging.ERROR</code>	40	Due to a more serious problem, the software has not been able to perform some function.
<code>logging.CRITICAL</code>	50	A serious error, indicating that the program itself may be unable to continue running.

16.6.3 Handler Objects

Handlers have the following attributes and methods. Note that *Handler* is never instantiated directly; this class acts as a base for more useful subclasses. However, the `__init__()` method in subclasses needs to call *Handler*.
`__init__()`.

class `logging.Handler`

__init__ (*level*=*NOTSET*)

Initializes the *Handler* instance by setting its level, setting the list of filters to the empty list and creating a lock (using `createLock()`) for serializing access to an I/O mechanism.

createLock ()

Initializes a thread lock which can be used to serialize access to underlying I/O functionality which may not be threadsafe.

acquire ()

Acquires the thread lock created with `createLock()`.

release ()

Releases the thread lock acquired with `acquire()`.

setLevel (*level*)

Sets the threshold for this handler to *level*. Logging messages which are less severe than *level* will be ignored. When a handler is created, the level is set to *NOTSET* (which causes all messages to be processed).

層級清單請見 *Logging Levels*.

在 3.2 版的變更: The *level* parameter now accepts a string representation of the level such as 'INFO' as an alternative to the integer constants such as *INFO*.

setFormatter (*fmt*)

Sets the *Formatter* for this handler to *fmt*.

addFilter (*filter*)

Adds the specified filter *filter* to this handler.

removeFilter (*filter*)

Removes the specified filter *filter* from this handler.

filter (*record*)

Apply this handler's filters to the record and return `True` if the record is to be processed. The filters are consulted in turn, until one of them returns a false value. If none of them return a false value, the record will be emitted. If one returns a false value, the handler will not emit the record.

flush ()

Ensure all logging output has been flushed. This version does nothing and is intended to be implemented by subclasses.

close ()

Tidy up any resources used by the handler. This version does no output but removes the handler from an internal list of handlers which is closed when `shutdown()` is called. Subclasses should ensure that this gets called from overridden `close()` methods.

handle (*record*)

Conditionally emits the specified logging record, depending on filters which may have been added to the handler. Wraps the actual emission of the record with acquisition/release of the I/O thread lock.

handleError (*record*)

This method should be called from handlers when an exception is encountered during an `emit()` call. If the module-level attribute `raiseExceptions` is `False`, exceptions get silently ignored. This is what is mostly wanted for a logging system - most users will not care about errors in the logging system,

they are more interested in application errors. You could, however, replace this with a custom handler if you wish. The specified record is the one which was being processed when the exception occurred. (The default value of `raiseExceptions` is `True`, as that is more useful during development).

format (*record*)

Do formatting for a record - if a formatter is set, use it. Otherwise, use the default formatter for the module.

emit (*record*)

Do whatever it takes to actually log the specified logging record. This version is intended to be implemented by subclasses and so raises a `NotImplementedError`.

警告: This method is called after a handler-level lock is acquired, which is released after this method returns. When you override this method, note that you should be careful when calling anything that invokes other parts of the logging API which might do locking, because that might result in a deadlock. Specifically:

- Logging configuration APIs acquire the module-level lock, and then individual handler-level locks as those handlers are configured.
- Many logging APIs lock the module-level lock. If such an API is called from this method, it could cause a deadlock if a configuration call is made on another thread, because that thread will try to acquire the module-level lock *before* the handler-level lock, whereas this thread tries to acquire the module-level lock *after* the handler-level lock (because in this method, the handler-level lock has already been acquired).

For a list of handlers included as standard, see `logging.handlers`.

16.6.4 Formatter Objects

`Formatter` objects have the following attributes and methods. They are responsible for converting a `LogRecord` to (usually) a string which can be interpreted by either a human or an external system. The base `Formatter` allows a formatting string to be specified. If none is supplied, the default value of `'%(message)s'` is used, which just includes the message in the logging call. To have additional items of information in the formatted output (such as a timestamp), keep reading.

A `Formatter` can be initialized with a format string which makes use of knowledge of the `LogRecord` attributes - such as the default value mentioned above making use of the fact that the user's message and arguments are pre-formatted into a `LogRecord`'s `message` attribute. This format string contains standard Python %-style mapping keys. See section [printf-style String Formatting](#) for more information on string formatting.

The useful mapping keys in a `LogRecord` are given in the section on [LogRecord attributes](#).

class `logging.Formatter` (*fmt=None*, *datefmt=None*, *style='%'*, *validate=True*, ***, *defaults=None*)

Returns a new instance of the `Formatter` class. The instance is initialized with a format string for the message as a whole, as well as a format string for the date/time portion of a message. If no *fmt* is specified, `'%(message)s'` is used. If no *datefmt* is specified, a format is used which is described in the `formatTime()` documentation.

The *style* parameter can be one of `'%'`, `'{'` or `'$'` and determines how the format string will be merged with its data: using one of %-formatting, `str.format()` or `string.Template`. This only applies to the format string *fmt* (e.g. `'%(message)s'` or `{message}`), not to the actual log messages passed to `Logger`, `debug` etc; see [formatting-styles](#) for more information on using `{-}` and `$-` formatting for log messages.

The *defaults* parameter can be a dictionary with default values to use in custom fields. For example: `logging.Formatter('%(ip)s %(message)s', defaults={"ip": None})`

在 3.2 版的變更: 新增 *style* 參數。

在 3.8 版的變更: The *validate* parameter was added. Incorrect or mismatched style and fmt will raise a *ValueError*. For example: `logging.Formatter('%(asctime)s - %(message)s', style='{')'`.

在 3.10 版的變更: 新增 *defaults* 參數。

format (*record*)

The record's attribute dictionary is used as the operand to a string formatting operation. Returns the resulting string. Before formatting the dictionary, a couple of preparatory steps are carried out. The *message* attribute of the record is computed using *msg % args*. If the formatting string contains '*(asctime)*', *formatTime()* is called to format the event time. If there is exception information, it is formatted using *formatException()* and appended to the message. Note that the formatted exception information is cached in attribute *exc_text*. This is useful because the exception information can be pickled and sent across the wire, but you should be careful if you have more than one *Formatter* subclass which customizes the formatting of exception information. In this case, you will have to clear the cached value (by setting the *exc_text* attribute to *None*) after a formatter has done its formatting, so that the next formatter to handle the event doesn't use the cached value, but recalculates it afresh.

If stack information is available, it's appended after the exception information, using *formatStack()* to transform it if necessary.

formatTime (*record*, *datefmt=None*)

This method should be called from *format()* by a formatter which wants to make use of a formatted time. This method can be overridden in formatters to provide for any specific requirement, but the basic behavior is as follows: if *datefmt* (a string) is specified, it is used with *time.strftime()* to format the creation time of the record. Otherwise, the format '%Y-%m-%d %H:%M:%S,uuu' is used, where the uuu part is a millisecond value and the other letters are as per the *time.strftime()* documentation. An example time in this format is 2003-01-23 00:29:50,411. The resulting string is returned.

This function uses a user-configurable function to convert the creation time to a tuple. By default, *time.localtime()* is used; to change this for a particular formatter instance, set the *converter* attribute to a function with the same signature as *time.localtime()* or *time.gmtime()*. To change it for all formatters, for example if you want all logging times to be shown in GMT, set the *converter* attribute in the *Formatter* class.

在 3.3 版的變更: Previously, the default format was hard-coded as in this example: 2010-09-06 22:38:15,292 where the part before the comma is handled by a strftime format string ('%Y-%m-%d %H:%M:%S'), and the part after the comma is a millisecond value. Because strftime does not have a format placeholder for milliseconds, the millisecond value is appended using another format string, '%s,%03d' --- and both of these format strings have been hardcoded into this method. With the change, these strings are defined as class-level attributes which can be overridden at the instance level when desired. The names of the attributes are *default_time_format* (for the strftime format string) and *default_msec_format* (for appending the millisecond value).

在 3.9 版的變更: The *default_msec_format* can be *None*.

formatException (*exc_info*)

Formats the specified exception information (a standard exception tuple as returned by *sys.exc_info()*) as a string. This default implementation just uses *traceback.print_exception()*. The resulting string is returned.

formatStack (*stack_info*)

Formats the specified stack information (a string as returned by *traceback.print_stack()*, but with the last newline removed) as a string. This default implementation just returns the input value.

class logging.**BufferingFormatter** (*linefmt=None*)

A base formatter class suitable for subclassing when you want to format a number of records. You can pass a *Formatter* instance which you want to use to format each line (that corresponds to a single record). If not specified, the default formatter (which just outputs the event message) is used as the line formatter.

formatHeader (*records*)

Return a header for a list of *records*. The base implementation just returns the empty string. You will

need to override this method if you want specific behaviour, e.g. to show the count of records, a title or a separator line.

formatFooter (*records*)

Return a footer for a list of *records*. The base implementation just returns the empty string. You will need to override this method if you want specific behaviour, e.g. to show the count of records or a separator line.

format (*records*)

Return formatted text for a list of *records*. The base implementation just returns the empty string if there are no records; otherwise, it returns the concatenation of the header, each record formatted with the line formatter, and the footer.

16.6.5 Filter Objects

Filters can be used by Handlers and Loggers for more sophisticated filtering than is provided by levels. The base filter class only allows events which are below a certain point in the logger hierarchy. For example, a filter initialized with 'A.B' will allow events logged by loggers 'A.B', 'A.B.C', 'A.B.C.D', 'A.B.D' etc. but not 'A.BB', 'B.A.B' etc. If initialized with the empty string, all events are passed.

class logging.**Filter** (*name=""*)

Returns an instance of the *Filter* class. If *name* is specified, it names a logger which, together with its children, will have its events allowed through the filter. If *name* is the empty string, allows every event.

filter (*record*)

Is the specified record to be logged? Returns zero for no, nonzero for yes. If deemed appropriate, the record may be modified in-place by this method.

Note that filters attached to handlers are consulted before an event is emitted by the handler, whereas filters attached to loggers are consulted whenever an event is logged (using *debug()*, *info()*, etc.), before sending an event to handlers. This means that events which have been generated by descendant loggers will not be filtered by a logger's filter setting, unless the filter has also been applied to those descendant loggers.

You don't actually need to subclass *Filter*: you can pass any instance which has a *filter* method with the same semantics.

在 3.2 版的變更: You don't need to create specialized *Filter* classes, or use other classes with a *filter* method: you can use a function (or other callable) as a filter. The filtering logic will check to see if the filter object has a *filter* attribute: if it does, it's assumed to be a *Filter* and its *filter()* method is called. Otherwise, it's assumed to be a callable and called with the record as the single parameter. The returned value should conform to that returned by *filter()*.

Although filters are used primarily to filter records based on more sophisticated criteria than levels, they get to see every record which is processed by the handler or logger they're attached to: this can be useful if you want to do things like counting how many records were processed by a particular logger or handler, or adding, changing or removing attributes in the *LogRecord* being processed. Obviously changing the *LogRecord* needs to be done with some care, but it does allow the injection of contextual information into logs (see filters-contextual).

16.6.6 LogRecord 物件

LogRecord instances are created automatically by the *Logger* every time something is logged, and can be created manually via *makeLogRecord()* (for example, from a pickled event received over the wire).

class logging.**LogRecord** (*name, level, pathname, lineno, msg, args, exc_info, func=None, sinfo=None*)

Contains all the information pertinent to the event being logged.

The primary information is passed in *msg* and *args*, which are combined using *msg % args* to create the message attribute of the record.

參數

- **name** (*str*) -- The name of the logger used to log the event represented by this *LogRecord*. Note that the logger name in the *LogRecord* will always have this value, even though it may be emitted by a handler attached to a different (ancestor) logger.
- **level** (*int*) -- The *numeric level* of the logging event (such as 10 for *DEBUG*, 20 for *INFO*, etc). Note that this is converted to *two* attributes of the *LogRecord*: *levelname* for the numeric value and *levelname* for the corresponding level name.
- **pathname** (*str*) -- The full string path of the source file where the logging call was made.
- **lineno** (*int*) -- The line number in the source file where the logging call was made.
- **msg** (*Any*) -- The event description message, which can be a %-format string with placeholders for variable data, or an arbitrary object (see arbitrary-object-messages).
- **args** (*tuple* / *dict*[*str*, *Any*]) -- Variable data to merge into the *msg* argument to obtain the event description.
- **exc_info** (*tuple*[*type*[*BaseException*], *BaseException*, *types.TracebackType*] / *None*) -- An exception tuple with the current exception information, as returned by *sys.exc_info()*, or *None* if no exception information is available.
- **func** (*str* / *None*) -- The name of the function or method from which the logging call was invoked.
- **sinfo** (*str* / *None*) -- A text string representing stack information from the base of the stack in the current thread, up to the logging call.

getMessage()

Returns the message for this *LogRecord* instance after merging any user-supplied arguments with the message. If the user-supplied message argument to the logging call is not a string, *str()* is called on it to convert it to a string. This allows use of user-defined classes as messages, whose *__str__* method can return the actual format string to be used.

在 3.2 版的變更: The creation of a *LogRecord* has been made more configurable by providing a factory which is used to create the record. The factory can be set using *getLogRecordFactory()* and *setLogRecordFactory()* (see this for the factory's signature).

This functionality can be used to inject your own values into a *LogRecord* at creation time. You can use the following pattern:

```
old_factory = logging.getLogRecordFactory()

def record_factory(*args, **kwargs):
    record = old_factory(*args, **kwargs)
    record.custom_attribute = 0xdeadbeef
    return record

logging.setLogRecordFactory(record_factory)
```

With this pattern, multiple factories could be chained, and as long as they don't overwrite each other's attributes or unintentionally overwrite the standard attributes listed above, there should be no surprises.

16.6.7 LogRecord attributes

The LogRecord has a number of attributes, most of which are derived from the parameters to the constructor. (Note that the names do not always correspond exactly between the LogRecord constructor parameters and the LogRecord attributes.) These attributes can be used to merge data from the record into the format string. The following table lists (in alphabetical order) the attribute names, their meanings and the corresponding placeholder in a %-style format string.

If you are using {}-formatting (`str.format()`), you can use {attrname} as the placeholder in the format string. If you are using \$-formatting (`string.Template`), use the form \${attrname}. In both cases, of course, replace attrname with the actual attribute name you want to use.

In the case of {}-formatting, you can specify formatting flags by placing them after the attribute name, separated from it with a colon. For example: a placeholder of {msecs:03.0f} would format a millisecond value of 4 as 004. Refer to the `str.format()` documentation for full details on the options available to you.

At-tribute name	格式	描述
args	You shouldn't need to format this yourself.	The tuple of arguments merged into <code>msg</code> to produce <code>message</code> , or a dict whose values are used for the merge (when there is only one argument, and it is a dictionary).
asctime	<code>%(asctime)s</code>	Human-readable time when the <i>LogRecord</i> was created. By default this is of the form '2003-07-08 16:49:45,896' (the numbers after the comma are millisecond portion of the time).
created	<code>%(created)f</code>	Time when the <i>LogRecord</i> was created (as returned by <code>time.time()</code>).
exc_info	You shouldn't need to format this yourself.	Exception tuple (à la <code>sys.exc_info</code>) or, if no exception has occurred, <code>None</code> .
filename	<code>%(filename)s</code>	Filename portion of <code>pathname</code> .
funcName	<code>%(funcName)s</code>	Name of function containing the logging call.
levelname	<code>%(levelname)s</code>	Text logging level for the message ('DEBUG', 'INFO', 'WARNING', 'ERROR', 'CRITICAL').
levelno	<code>%(levelno)s</code>	Numeric logging level for the message (<i>DEBUG</i> , <i>INFO</i> , <i>WARNING</i> , <i>ERROR</i> , <i>CRITICAL</i>).
lineno	<code>%(lineno)d</code>	Source line number where the logging call was issued (if available).
message	<code>%(message)s</code>	The logged message, computed as <code>msg % args</code> . This is set when <i>Formatter.format()</i> is invoked.
模組	<code>%(module)s</code>	Module (name portion of <code>filename</code>).
msecs	<code>%(msecs)d</code>	Millisecond portion of the time when the <i>LogRecord</i> was created.
msg	You shouldn't need to format this yourself.	The format string passed in the original logging call. Merged with <code>args</code> to produce <code>message</code> , or an arbitrary object (see arbitrary-object-messages).
name	<code>%(name)s</code>	Name of the logger used to log the call.
pathname	<code>%(pathname)s</code>	Full pathname of the source file where the logging call was issued (if available).
process	<code>%(process)d</code>	Process ID (if available).
process-Name	<code>%(processName</code>	Process name (if available).
relative-Created	<code>%(relativeCre</code>	Time in milliseconds when the <i>LogRecord</i> was created, relative to the time the logging module was loaded.
stack_in	You shouldn't need to format this yourself.	Stack frame information (where available) from the bottom of the stack in the current thread, up to and including the stack frame of the logging call which resulted in the creation of this record.
thread	<code>%(thread)d</code>	Thread ID (if available).
thread-Name	<code>%(threadName)</code>	Thread name (if available).

在 3.1 版的變更: 新增 *processName*。

16.6.8 LoggerAdapter 物件

LoggerAdapter instances are used to conveniently pass contextual information into logging calls. For a usage example, see the section on adding contextual information to your logging output.

class `logging.LoggerAdapter` (*logger*, *extra*)

Returns an instance of *LoggerAdapter* initialized with an underlying *Logger* instance and a dict-like object.

process (*msg*, *kwargs*)

Modifies the message and/or keyword arguments passed to a logging call in order to insert contextual information. This implementation takes the object passed as *extra* to the constructor and adds it to *kwargs* using key 'extra'. The return value is a (*msg*, *kwargs*) tuple which has the (possibly modified) versions of the arguments passed in.

manager

Delegates to the underlying `manager`` on *logger*.

_log

Delegates to the underlying `_log`()` method on *logger*.

In addition to the above, *LoggerAdapter* supports the following methods of *Logger*: `debug()`, `info()`, `warning()`, `error()`, `exception()`, `critical()`, `log()`, `isEnabledFor()`, `getEffectiveLevel()`, `setLevel()` and `hasHandlers()`. These methods have the same signatures as their counterparts in *Logger*, so you can use the two types of instances interchangeably.

在 3.2 版的變更: The `isEnabledFor()`, `getEffectiveLevel()`, `setLevel()` and `hasHandlers()` methods were added to *LoggerAdapter*. These methods delegate to the underlying logger.

在 3.6 版的變更: Attribute `manager` and method `_log()` were added, which delegate to the underlying logger and allow adapters to be nested.

16.6.9 Thread Safety

The logging module is intended to be thread-safe without any special work needing to be done by its clients. It achieves this though using threading locks; there is one lock to serialize access to the module's shared data, and each handler also creates a lock to serialize access to its underlying I/O.

If you are implementing asynchronous signal handlers using the *signal* module, you may not be able to use logging from within such handlers. This is because lock implementations in the *threading* module are not always re-entrant, and so cannot be invoked from such signal handlers.

16.6.10 Module-Level Functions

In addition to the classes described above, there are a number of module-level functions.

`logging.getLogger` (*name=None*)

Return a logger with the specified name or, if *name* is `None`, return a logger which is the root logger of the hierarchy. If specified, the name is typically a dot-separated hierarchical name like 'a', 'a.b' or 'a.b.c.d'. Choice of these names is entirely up to the developer who is using logging.

All calls to this function with a given name return the same logger instance. This means that logger instances never need to be passed between different parts of an application.

`logging.getLoggerClass` ()

Return either the standard *Logger* class, or the last class passed to `setLoggerClass()`. This function may be called from within a new class definition, to ensure that installing a customized *Logger* class will not undo customizations already applied by other code. For example:

```
class MyLogger(logging.getLoggerClass()):  
    # ... override behaviour here
```

`logging.getLogRecordFactory()`

Return a callable which is used to create a *LogRecord*.

在 3.2 版新加入: This function has been provided, along with *setLogRecordFactory()*, to allow developers more control over how the *LogRecord* representing a logging event is constructed.

See *setLogRecordFactory()* for more information about the how the factory is called.

`logging.debug(msg, *args, **kwargs)`

This is a convenience function that calls *Logger.debug()*, on the root logger. The handling of the arguments is in every way identical to what is described in that method.

The only difference is that if the root logger has no handlers, then *basicConfig()* is called, prior to calling *debug* on the root logger.

For very short scripts or quick demonstrations of logging facilities, *debug* and the other module-level functions may be convenient. However, most programs will want to carefully and explicitly control the logging configuration, and should therefore prefer creating a module-level logger and calling *Logger.debug()* (or other level-specific methods) on it, as described at the beginning of this documentation.

`logging.info(msg, *args, **kwargs)`

Logs a message with level *INFO* on the root logger. The arguments and behavior are otherwise the same as for *debug()*.

`logging.warning(msg, *args, **kwargs)`

Logs a message with level *WARNING* on the root logger. The arguments and behavior are otherwise the same as for *debug()*.

備 F: There is an obsolete function *warn* which is functionally identical to *warning*. As *warn* is deprecated, please do not use it - use *warning* instead.

`logging.error(msg, *args, **kwargs)`

Logs a message with level *ERROR* on the root logger. The arguments and behavior are otherwise the same as for *debug()*.

`logging.critical(msg, *args, **kwargs)`

Logs a message with level *CRITICAL* on the root logger. The arguments and behavior are otherwise the same as for *debug()*.

`logging.exception(msg, *args, **kwargs)`

Logs a message with level *ERROR* on the root logger. The arguments and behavior are otherwise the same as for *debug()*. Exception info is added to the logging message. This function should only be called from an exception handler.

`logging.log(level, msg, *args, **kwargs)`

Logs a message with level *level* on the root logger. The arguments and behavior are otherwise the same as for *debug()*.

`logging.disable(level=CRITICAL)`

Provides an overriding level *level* for all loggers which takes precedence over the logger's own level. When the need arises to temporarily throttle logging output down across the whole application, this function can be useful. Its effect is to disable all logging calls of severity *level* and below, so that if you call it with a value of *INFO*, then all *INFO* and *DEBUG* events would be discarded, whereas those of severity *WARNING* and above would be processed according to the logger's effective level. If *logging.disable(logging.NOTSET)* is called, it effectively removes this overriding level, so that logging output again depends on the effective levels of individual loggers.

Note that if you have defined any custom logging level higher than `CRITICAL` (this is not recommended), you won't be able to rely on the default value for the *level* parameter, but will have to explicitly supply a suitable value.

在 3.7 版的變更: The *level* parameter was defaulted to level `CRITICAL`. See [bpo-28524](#) for more information about this change.

`logging.addLevelName (level, levelName)`

Associates level *level* with text *levelName* in an internal dictionary, which is used to map numeric levels to a textual representation, for example when a *Formatter* formats a message. This function can also be used to define your own levels. The only constraints are that all levels used must be registered using this function, levels should be positive integers and they should increase in increasing order of severity.

備註: If you are thinking of defining your own levels, please see the section on custom-levels.

`logging.getLevelNamesMapping ()`

Returns a mapping from level names to their corresponding logging levels. For example, the string "CRITICAL" maps to `CRITICAL`. The returned mapping is copied from an internal mapping on each call to this function.

在 3.11 版新加入.

`logging.getLevelName (level)`

Returns the textual or numeric representation of logging level *level*.

If *level* is one of the predefined levels `CRITICAL`, `ERROR`, `WARNING`, `INFO` or `DEBUG` then you get the corresponding string. If you have associated levels with names using `addLevelName ()` then the name you have associated with *level* is returned. If a numeric value corresponding to one of the defined levels is passed in, the corresponding string representation is returned.

The *level* parameter also accepts a string representation of the level such as 'INFO'. In such cases, this functions returns the corresponding numeric value of the level.

If no matching numeric or string value is passed in, the string 'Level %s' % level is returned.

備註: Levels are internally integers (as they need to be compared in the logging logic). This function is used to convert between an integer level and the level name displayed in the formatted log output by means of the `%(levelname)s` format specifier (see *LogRecord attributes*), and vice versa.

在 3.4 版的變更: In Python versions earlier than 3.4, this function could also be passed a text level, and would return the corresponding numeric value of the level. This undocumented behaviour was considered a mistake, and was removed in Python 3.4, but reinstated in 3.4.2 due to retain backward compatibility.

`logging.makeLogRecord (attrdict)`

Creates and returns a new *LogRecord* instance whose attributes are defined by *attrdict*. This function is useful for taking a pickled *LogRecord* attribute dictionary, sent over a socket, and reconstituting it as a *LogRecord* instance at the receiving end.

`logging.basicConfig (**kwargs)`

Does basic configuration for the logging system by creating a *StreamHandler* with a default *Formatter* and adding it to the root logger. The functions `debug()`, `info()`, `warning()`, `error()` and `critical()` will call `basicConfig()` automatically if no handlers are defined for the root logger.

This function does nothing if the root logger already has handlers configured, unless the keyword argument *force* is set to `True`.

備註: This function should be called from the main thread before other threads are started. In versions of Python prior to 2.7.1 and 3.2, if this function is called from multiple threads, it is possible (in rare circum-

在 3.2 版新加入: This function has been provided, along with `getLogRecordFactory()`, to allow developers more control over how the `LogRecord` representing a logging event is constructed.

The factory has the following signature:

```
factory(name, level, fn, lno, msg, args, exc_info, func=None,
        sinfo=None, **kwargs)
```

name

The logger name.

level

The logging level (numeric).

fn

The full pathname of the file where the logging call was made.

lno

The line number in the file where the logging call was made.

msg

The logging message.

args

The arguments for the logging message.

exc_info

An exception tuple, or None.

func

The name of the function or method which invoked the logging call.

sinfo

A stack traceback such as is provided by `traceback.print_stack()`, showing the call hierarchy.

kwargs

額外的關鍵字引數。

16.6.11 Module-Level Attributes

`logging.lastResort`

A “handler of last resort” is available through this attribute. This is a `StreamHandler` writing to `sys.stderr` with a level of `WARNING`, and is used to handle logging events in the absence of any logging configuration. The end result is to just print the message to `sys.stderr`. This replaces the earlier error message saying that “no handlers could be found for logger XYZ”. If you need the earlier behaviour for some reason, `lastResort` can be set to `None`.

在 3.2 版新加入.

`logging.raiseExceptions`

Used to see if exceptions during handling should be propagated.

Default: `True`.

If `raiseExceptions` is `False`, exceptions get silently ignored. This is what is mostly wanted for a logging system - most users will not care about errors in the logging system, they are more interested in application errors.

16.6.12 Integration with the warnings module

The `captureWarnings()` function can be used to integrate `logging` with the `warnings` module.

`logging.captureWarnings(capture)`

This function is used to turn the capture of warnings by logging on and off.

If `capture` is `True`, warnings issued by the `warnings` module will be redirected to the logging system. Specifically, a warning will be formatted using `warnings.formatwarning()` and the resulting string logged to a logger named `'py.warnings'` with a severity of `WARNING`.

If `capture` is `False`, the redirection of warnings to the logging system will stop, and warnings will be redirected to their original destinations (i.e. those in effect before `captureWarnings(True)` was called).

也參考:

Module `logging.config`

Configuration API for the logging module.

Module `logging.handlers`

Useful handlers included with the logging module.

PEP 282 - A Logging System

The proposal which described this feature for inclusion in the Python standard library.

Original Python logging package

This is the original source for the `logging` package. The version of the package available from this site is suitable for use with Python 1.5.2, 2.1.x and 2.2.x, which do not include the `logging` package in the standard library.

16.7 logging.config --- Logging configuration

原始碼: [Lib/logging/config.py](#)

Important

This page contains only reference information. For tutorials, please see

- 基礎教學
- 進階教學
- Logging Cookbook

This section describes the API for configuring the logging module.

16.7.1 Configuration functions

The following functions configure the logging module. They are located in the `logging.config` module. Their use is optional --- you can configure the logging module using these functions or by making calls to the main API (defined in `logging` itself) and defining handlers which are declared either in `logging` or `logging.handlers`.

`logging.config.dictConfig(config)`

Takes the logging configuration from a dictionary. The contents of this dictionary are described in *Configuration dictionary schema* below.

If an error is encountered during configuration, this function will raise a `ValueError`, `TypeError`, `AttributeError` or `ImportError` with a suitably descriptive message. The following is a (possibly incomplete) list of conditions which will raise an error:

- A level which is not a string or which is a string not corresponding to an actual logging level.
- A propagate value which is not a boolean.
- An id which does not have a corresponding destination.
- A non-existent handler id found during an incremental call.
- An invalid logger name.
- Inability to resolve to an internal or external object.

Parsing is performed by the `DictConfigurator` class, whose constructor is passed the dictionary used for configuration, and has a `configure()` method. The `logging.config` module has a callable attribute `dictConfigClass` which is initially set to `DictConfigurator`. You can replace the value of `dictConfigClass` with a suitable implementation of your own.

`dictConfig()` calls `dictConfigClass` passing the specified dictionary, and then calls the `configure()` method on the returned object to put the configuration into effect:

```
def dictConfig(config):
    dictConfigClass(config).configure()
```

For example, a subclass of `DictConfigurator` could call `DictConfigurator.__init__()` in its own `__init__()`, then set up custom prefixes which would be usable in the subsequent `configure()` call. `dictConfigClass` would be bound to this new subclass, and then `dictConfig()` could be called exactly as in the default, uncustomized state.

在 3.2 版新加入.

`logging.config.fileConfig(fname, defaults=None, disable_existing_loggers=True, encoding=None)`

Reads the logging configuration from a `configparser`-format file. The format of the file should be as described in [Configuration file format](#). This function can be called several times from an application, allowing an end user to select from various pre-canned configurations (if the developer provides a mechanism to present the choices and load the chosen configuration).

It will raise `FileNotFoundError` if the file doesn't exist and `RuntimeError` if the file is invalid or empty.

參數

- **fname** -- A filename, or a file-like object, or an instance derived from `RawConfigParser`. If a `RawConfigParser`-derived instance is passed, it is used as is. Otherwise, a `ConfigParser` is instantiated, and the configuration read by it from the object passed in `fname`. If that has a `readline()` method, it is assumed to be a file-like object and read using `read_file()`; otherwise, it is assumed to be a filename and passed to `read()`.
- **defaults** -- Defaults to be passed to the `ConfigParser` can be specified in this argument.
- **disable_existing_loggers** -- If specified as `False`, loggers which exist when this call is made are left enabled. The default is `True` because this enables old behaviour in a backward-compatible way. This behaviour is to disable any existing non-root loggers unless they or their ancestors are explicitly named in the logging configuration.
- **encoding** -- The encoding used to open file when `fname` is filename.

在 3.4 版的變更: An instance of a subclass of `RawConfigParser` is now accepted as a value for `fname`. This facilitates:

- Use of a configuration file where logging configuration is just part of the overall application configuration.

- Use of a configuration read from a file, and then modified by the using application (e.g. based on command-line parameters or other aspects of the runtime environment) before being passed to `fileConfig`.

在 3.10 版的變更: Added the *encoding* parameter.

在 3.11.4 版的變更: An exception will be thrown if the provided file doesn't exist or is invalid or empty.

`logging.config.listen(port=DEFAULT_LOGGING_CONFIG_PORT, verify=None)`

Starts up a socket server on the specified port, and listens for new configurations. If no port is specified, the module's default `DEFAULT_LOGGING_CONFIG_PORT` is used. Logging configurations will be sent as a file suitable for processing by `dictConfig()` or `fileConfig()`. Returns a `Thread` instance on which you can call `start()` to start the server, and which you can `join()` when appropriate. To stop the server, call `stopListening()`.

The `verify` argument, if specified, should be a callable which should verify whether bytes received across the socket are valid and should be processed. This could be done by encrypting and/or signing what is sent across the socket, such that the `verify` callable can perform signature verification and/or decryption. The `verify` callable is called with a single argument - the bytes received across the socket - and should return the bytes to be processed, or `None` to indicate that the bytes should be discarded. The returned bytes could be the same as the passed in bytes (e.g. when only verification is done), or they could be completely different (perhaps if decryption were performed).

To send a configuration to the socket, read in the configuration file and send it to the socket as a sequence of bytes preceded by a four-byte length string packed in binary using `struct.pack('>L', n)`.

備註: Because portions of the configuration are passed through `eval()`, use of this function may open its users to a security risk. While the function only binds to a socket on `localhost`, and so does not accept connections from remote machines, there are scenarios where untrusted code could be run under the account of the process which calls `listen()`. Specifically, if the process calling `listen()` runs on a multi-user machine where users cannot trust each other, then a malicious user could arrange to run essentially arbitrary code in a victim user's process, simply by connecting to the victim's `listen()` socket and sending a configuration which runs whatever code the attacker wants to have executed in the victim's process. This is especially easy to do if the default port is used, but not hard even if a different port is used. To avoid the risk of this happening, use the `verify` argument to `listen()` to prevent unrecognised configurations from being applied.

在 3.4 版的變更: 新增 `verify` 引數。

備註: If you want to send configurations to the listener which don't disable existing loggers, you will need to use a JSON format for the configuration, which will use `dictConfig()` for configuration. This method allows you to specify `disable_existing_loggers` as `False` in the configuration you send.

`logging.config.stopListening()`

Stops the listening server which was created with a call to `listen()`. This is typically called before calling `join()` on the return value from `listen()`.

16.7.2 Security considerations

The logging configuration functionality tries to offer convenience, and in part this is done by offering the ability to convert text in configuration files into Python objects used in logging configuration - for example, as described in *User-defined objects*. However, these same mechanisms (importing callables from user-defined modules and calling them with parameters from the configuration) could be used to invoke any code you like, and for this reason you should treat configuration files from untrusted sources with *extreme caution* and satisfy yourself that nothing bad can happen if you load them, before actually loading them.

16.7.3 Configuration dictionary schema

Describing a logging configuration requires listing the various objects to create and the connections between them; for example, you may create a handler named 'console' and then say that the logger named 'startup' will send its messages to the 'console' handler. These objects aren't limited to those provided by the *logging* module because you might write your own formatter or handler class. The parameters to these classes may also need to include external objects such as `sys.stderr`. The syntax for describing these objects and connections is defined in *Object connections* below.

Dictionary Schema Details

The dictionary passed to *dictConfig()* must contain the following keys:

- *version* - to be set to an integer value representing the schema version. The only valid value at present is 1, but having this key allows the schema to evolve while still preserving backwards compatibility.

All other keys are optional, but if present they will be interpreted as described below. In all cases below where a 'configuring dict' is mentioned, it will be checked for the special '()' key to see if a custom instantiation is required. If so, the mechanism described in *User-defined objects* below is used to create an instance; otherwise, the context is used to determine what to instantiate.

- *formatters* - the corresponding value will be a dict in which each key is a formatter id and each value is a dict describing how to configure the corresponding *Formatter* instance.

The configuring dict is searched for the following optional keys which correspond to the arguments passed to create a *Formatter* object:

- *format*
- *datefmt*
- *style*
- *validate* (since version >=3.8)

An optional *class* key indicates the name of the formatter's class (as a dotted module and class name). The instantiation arguments are as for *Formatter*, thus this key is most useful for instantiating a customised subclass of *Formatter*. For example, the alternative class might present exception tracebacks in an expanded or condensed format. If your formatter requires different or extra configuration keys, you should use *User-defined objects*.

- *filters* - the corresponding value will be a dict in which each key is a filter id and each value is a dict describing how to configure the corresponding *Filter* instance.

The configuring dict is searched for the key *name* (defaulting to the empty string) and this is used to construct a *logging.Filter* instance.

- *handlers* - the corresponding value will be a dict in which each key is a handler id and each value is a dict describing how to configure the corresponding *Handler* instance.

The configuring dict is searched for the following keys:

- *class* (mandatory). This is the fully qualified name of the handler class.
- *level* (optional). The level of the handler.
- *formatter* (optional). The id of the formatter for this handler.
- *filters* (optional). A list of ids of the filters for this handler.

在 3.11 版的變更: *filters* can take filter instances in addition to ids.

All *other* keys are passed through as keyword arguments to the handler's constructor. For example, given the snippet:

```

handlers:
  console:
    class : logging.StreamHandler
    formatter: brief
    level : INFO
    filters: [allow_foo]
    stream : ext://sys.stdout
  file:
    class : logging.handlers.RotatingFileHandler
    formatter: precise
    filename: logconfig.log
    maxBytes: 1024
    backupCount: 3

```

the handler with id `console` is instantiated as a `logging.StreamHandler`, using `sys.stdout` as the underlying stream. The handler with id `file` is instantiated as a `logging.handlers.RotatingFileHandler` with the keyword arguments `filename='logconfig.log'`, `maxBytes=1024`, `backupCount=3`.

- *loggers* - the corresponding value will be a dict in which each key is a logger name and each value is a dict describing how to configure the corresponding Logger instance.

The configuring dict is searched for the following keys:

- `level` (optional). The level of the logger.
- `propagate` (optional). The propagation setting of the logger.
- `filters` (optional). A list of ids of the filters for this logger.
在 3.11 版的變更: `filters` can take filter instances in addition to ids.
- `handlers` (optional). A list of ids of the handlers for this logger.

The specified loggers will be configured according to the level, propagation, filters and handlers specified.

- *root* - this will be the configuration for the root logger. Processing of the configuration will be as for any logger, except that the `propagate` setting will not be applicable.
- *incremental* - whether the configuration is to be interpreted as incremental to the existing configuration. This value defaults to `False`, which means that the specified configuration replaces the existing configuration with the same semantics as used by the existing `fileConfig()` API.

If the specified value is `True`, the configuration is processed as described in the section on *Incremental Configuration*.

- *disable_existing_loggers* - whether any existing non-root loggers are to be disabled. This setting mirrors the parameter of the same name in `fileConfig()`. If absent, this parameter defaults to `True`. This value is ignored if *incremental* is `True`.

Incremental Configuration

It is difficult to provide complete flexibility for incremental configuration. For example, because objects such as filters and formatters are anonymous, once a configuration is set up, it is not possible to refer to such anonymous objects when augmenting a configuration.

Furthermore, there is not a compelling case for arbitrarily altering the object graph of loggers, handlers, filters, formatters at run-time, once a configuration is set up; the verbosity of loggers and handlers can be controlled just by setting levels (and, in the case of loggers, propagation flags). Changing the object graph arbitrarily in a safe way is problematic in a multi-threaded environment; while not impossible, the benefits are not worth the complexity it adds to the implementation.

Thus, when the `incremental` key of a configuration dict is present and is `True`, the system will completely ignore any `formatters` and `filters` entries, and process only the `level` settings in the `handlers` entries, and the `level` and `propagate` settings in the `loggers` and `root` entries.

Using a value in the configuration dict lets configurations to be sent over the wire as pickled dicts to a socket listener. Thus, the logging verbosity of a long-running application can be altered over time with no need to stop and restart the application.

Object connections

The schema describes a set of logging objects - loggers, handlers, formatters, filters - which are connected to each other in an object graph. Thus, the schema needs to represent connections between the objects. For example, say that, once configured, a particular logger has attached to it a particular handler. For the purposes of this discussion, we can say that the logger represents the source, and the handler the destination, of a connection between the two. Of course in the configured objects this is represented by the logger holding a reference to the handler. In the configuration dict, this is done by giving each destination object an id which identifies it unambiguously, and then using the id in the source object's configuration to indicate that a connection exists between the source and the destination object with that id.

So, for example, consider the following YAML snippet:

```
formatters:
  brief:
    # configuration for formatter with id 'brief' goes here
  precise:
    # configuration for formatter with id 'precise' goes here
handlers:
  h1: #This is an id
    # configuration of handler with id 'h1' goes here
    formatter: brief
  h2: #This is another id
    # configuration of handler with id 'h2' goes here
    formatter: precise
loggers:
  foo.bar.baz:
    # other configuration for logger 'foo.bar.baz'
    handlers: [h1, h2]
```

(Note: YAML used here because it's a little more readable than the equivalent Python source form for the dictionary.)

The ids for loggers are the logger names which would be used programmatically to obtain a reference to those loggers, e.g. `foo.bar.baz`. The ids for Formatters and Filters can be any string value (such as `brief`, `precise` above) and they are transient, in that they are only meaningful for processing the configuration dictionary and used to determine connections between objects, and are not persisted anywhere when the configuration call is complete.

The above snippet indicates that logger named `foo.bar.baz` should have two handlers attached to it, which are described by the handler ids `h1` and `h2`. The formatter for `h1` is that described by id `brief`, and the formatter for `h2` is that described by id `precise`.

User-defined objects

The schema supports user-defined objects for handlers, filters and formatters. (Loggers do not need to have different types for different instances, so there is no support in this configuration schema for user-defined logger classes.)

Objects to be configured are described by dictionaries which detail their configuration. In some places, the logging system will be able to infer from the context how an object is to be instantiated, but when a user-defined object is to be instantiated, the system will not know how to do this. In order to provide complete flexibility for user-defined object instantiation, the user needs to provide a 'factory' - a callable which is called with a configuration dictionary and which returns the instantiated object. This is signalled by an absolute import path to the factory being made available under the special key '()' . Here's a concrete example:

```
formatters:
  brief:
    format: '%(message)s'
```

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```

default:
  format: '%(asctime)s %(levelname)-8s %(name)-15s %(message)s'
  datefmt: '%Y-%m-%d %H:%M:%S'
custom:
  (): my.package.customFormatterFactory
  bar: baz
  spam: 99.9
  answer: 42

```

The above YAML snippet defines three formatters. The first, with id `brief`, is a standard `logging.Formatter` instance with the specified format string. The second, with id `default`, has a longer format and also defines the time format explicitly, and will result in a `logging.Formatter` initialized with those two format strings. Shown in Python source form, the `brief` and `default` formatters have configuration sub-dictionaries:

```

{
  'format' : '%(message)s'
}

```

和:

```

{
  'format' : '%(asctime)s %(levelname)-8s %(name)-15s %(message)s',
  'datefmt' : '%Y-%m-%d %H:%M:%S'
}

```

respectively, and as these dictionaries do not contain the special key '()', the instantiation is inferred from the context: as a result, standard `logging.Formatter` instances are created. The configuration sub-dictionary for the third formatter, with id `custom`, is:

```

{
  '()' : 'my.package.customFormatterFactory',
  'bar' : 'baz',
  'spam' : 99.9,
  'answer' : 42
}

```

and this contains the special key '()', which means that user-defined instantiation is wanted. In this case, the specified factory callable will be used. If it is an actual callable it will be used directly - otherwise, if you specify a string (as in the example) the actual callable will be located using normal import mechanisms. The callable will be called with the **remaining** items in the configuration sub-dictionary as keyword arguments. In the above example, the formatter with id `custom` will be assumed to be returned by the call:

```
my.package.customFormatterFactory(bar='baz', spam=99.9, answer=42)
```

警告: The values for keys such as `bar`, `spam` and `answer` in the above example should not be configuration dictionaries or references such as `cfg://foo` or `ext://bar`, because they will not be processed by the configuration machinery, but passed to the callable as-is.

The key '()' has been used as the special key because it is not a valid keyword parameter name, and so will not clash with the names of the keyword arguments used in the call. The '()' also serves as a mnemonic that the corresponding value is a callable.

在 3.11 版的變更: The `filters` member of `handlers` and `loggers` can take filter instances in addition to `ids`.

You can also specify a special key '.' whose value is a dictionary is a mapping of attribute names to values. If found, the specified attributes will be set on the user-defined object before it is returned. Thus, with the following configuration:

```
{
  '()' : 'my.package.customFormatterFactory',
  'bar' : 'baz',
  'spam' : 99.9,
  'answer' : 42,
  '.' : {
    'foo' : 'bar',
    'baz' : 'bozz'
  }
}
```

the returned formatter will have attribute `foo` set to `'bar'` and attribute `baz` set to `'bozz'`.

警告: The values for attributes such as `foo` and `baz` in the above example should not be configuration dictionaries or references such as `cfg://foo` or `ext://bar`, because they will not be processed by the configuration machinery, but set as attribute values as-is.

Handler configuration order

Handlers are configured in alphabetical order of their keys, and a configured handler replaces the configuration dictionary in (a working copy of) the `handlers` dictionary in the schema. If you use a construct such as `cfg://handlers.foo`, then initially `handlers['foo']` points to the configuration dictionary for the handler named `foo`, and later (once that handler has been configured) it points to the configured handler instance. Thus, `cfg://handlers.foo` could resolve to either a dictionary or a handler instance. In general, it is wise to name handlers in a way such that dependent handlers are configured *after* any handlers they depend on; that allows something like `cfg://handlers.foo` to be used in configuring a handler that depends on handler `foo`. If that dependent handler were named `bar`, problems would result, because the configuration of `bar` would be attempted before that of `foo`, and `foo` would not yet have been configured. However, if the dependent handler were named `foobar`, it would be configured after `foo`, with the result that `cfg://handlers.foo` would resolve to configured handler `foo`, and not its configuration dictionary.

Access to external objects

There are times where a configuration needs to refer to objects external to the configuration, for example `sys.stderr`. If the configuration dict is constructed using Python code, this is straightforward, but a problem arises when the configuration is provided via a text file (e.g. JSON, YAML). In a text file, there is no standard way to distinguish `sys.stderr` from the literal string `'sys.stderr'`. To facilitate this distinction, the configuration system looks for certain special prefixes in string values and treat them specially. For example, if the literal string `'ext://sys.stderr'` is provided as a value in the configuration, then the `ext://` will be stripped off and the remainder of the value processed using normal import mechanisms.

The handling of such prefixes is done in a way analogous to protocol handling: there is a generic mechanism to look for prefixes which match the regular expression `^(?P<prefix>[a-z]+)://(?P<suffix>.*)$` whereby, if the `prefix` is recognised, the `suffix` is processed in a prefix-dependent manner and the result of the processing replaces the string value. If the prefix is not recognised, then the string value will be left as-is.

Access to internal objects

As well as external objects, there is sometimes also a need to refer to objects in the configuration. This will be done implicitly by the configuration system for things that it knows about. For example, the string value 'DEBUG' for a level in a logger or handler will automatically be converted to the value `logging.DEBUG`, and the `handlers`, `filters` and `formatter` entries will take an object id and resolve to the appropriate destination object.

However, a more generic mechanism is needed for user-defined objects which are not known to the `logging` module. For example, consider `logging.handlers.MemoryHandler`, which takes a `target` argument which is another handler to delegate to. Since the system already knows about this class, then in the configuration, the given `target` just needs to be the object id of the relevant target handler, and the system will resolve to the handler from the id. If, however, a user defines a `my.package.MyHandler` which has an alternate handler, the configuration system would not know that the `alternate` referred to a handler. To cater for this, a generic resolution system allows the user to specify:

```
handlers:
  file:
    # configuration of file handler goes here

  custom:
    (): my.package.MyHandler
    alternate: cfg://handlers.file
```

The literal string `'cfg://handlers.file'` will be resolved in an analogous way to strings with the `ext://` prefix, but looking in the configuration itself rather than the import namespace. The mechanism allows access by dot or by index, in a similar way to that provided by `str.format`. Thus, given the following snippet:

```
handlers:
  email:
    class: logging.handlers.SMTPHandler
    mailhost: localhost
    fromaddr: my_app@domain.tld
    toaddrs:
      - support_team@domain.tld
      - dev_team@domain.tld
    subject: Houston, we have a problem.
```

in the configuration, the string `'cfg://handlers'` would resolve to the dict with key `handlers`, the string `'cfg://handlers.email'` would resolve to the dict with key `email` in the `handlers` dict, and so on. The string `'cfg://handlers.email.toaddrs[1]'` would resolve to `'dev_team@domain.tld'` and the string `'cfg://handlers.email.toaddrs[0]'` would resolve to the value `'support_team@domain.tld'`. The `subject` value could be accessed using either `'cfg://handlers.email.subject'` or, equivalently, `'cfg://handlers.email[subject]'`. The latter form only needs to be used if the key contains spaces or non-alphanumeric characters. If an index value consists only of decimal digits, access will be attempted using the corresponding integer value, falling back to the string value if needed.

Given a string `cfg://handlers.myhandler.mykey.123`, this will resolve to `config_dict['handlers']['myhandler']['mykey']['123']`. If the string is specified as `cfg://handlers.myhandler.mykey[123]`, the system will attempt to retrieve the value from `config_dict['handlers']['myhandler']['mykey'][123]`, and fall back to `config_dict['handlers']['myhandler']['mykey']['123']` if that fails.

Import resolution and custom importers

Import resolution, by default, uses the builtin `__import__()` function to do its importing. You may want to replace this with your own importing mechanism: if so, you can replace the `importer` attribute of the `DictConfigurator` or its superclass, the `BaseConfigurator` class. However, you need to be careful because of the way functions are accessed from classes via descriptors. If you are using a Python callable to do your imports, and you want to define it at class level rather than instance level, you need to wrap it with `staticmethod()`. For example:

```
from importlib import import_module
from logging.config import BaseConfigurator

BaseConfigurator.importer = staticmethod(import_module)
```

You don't need to wrap with `staticmethod()` if you're setting the import callable on a configurator *instance*.

16.7.4 Configuration file format

The configuration file format understood by `fileConfig()` is based on `configparser` functionality. The file must contain sections called `[loggers]`, `[handlers]` and `[formatters]` which identify by name the entities of each type which are defined in the file. For each such entity, there is a separate section which identifies how that entity is configured. Thus, for a logger named `log01` in the `[loggers]` section, the relevant configuration details are held in a section `[logger_log01]`. Similarly, a handler called `hand01` in the `[handlers]` section will have its configuration held in a section called `[handler_hand01]`, while a formatter called `form01` in the `[formatters]` section will have its configuration specified in a section called `[formatter_form01]`. The root logger configuration must be specified in a section called `[logger_root]`.

備F: The `fileConfig()` API is older than the `dictConfig()` API and does not provide functionality to cover certain aspects of logging. For example, you cannot configure `Filter` objects, which provide for filtering of messages beyond simple integer levels, using `fileConfig()`. If you need to have instances of `Filter` in your logging configuration, you will need to use `dictConfig()`. Note that future enhancements to configuration functionality will be added to `dictConfig()`, so it's worth considering transitioning to this newer API when it's convenient to do so.

Examples of these sections in the file are given below.

```
[loggers]
keys=root,log02,log03,log04,log05,log06,log07

[handlers]
keys=hand01,hand02,hand03,hand04,hand05,hand06,hand07,hand08,hand09

[formatters]
keys=form01,form02,form03,form04,form05,form06,form07,form08,form09
```

The root logger must specify a level and a list of handlers. An example of a root logger section is given below.

```
[logger_root]
level=NOTSET
handlers=hand01
```

The `level` entry can be one of `DEBUG`, `INFO`, `WARNING`, `ERROR`, `CRITICAL` or `NOTSET`. For the root logger only, `NOTSET` means that all messages will be logged. Level values are *evaluated* in the context of the logging package's namespace.

The `handlers` entry is a comma-separated list of handler names, which must appear in the `[handlers]` section. These names must appear in the `[handlers]` section and have corresponding sections in the configuration file.

For loggers other than the root logger, some additional information is required. This is illustrated by the following example.

```
[logger_parser]
level=DEBUG
handlers=hand01
propagate=1
qualname=compiler.parser
```

The `level` and `handlers` entries are interpreted as for the root logger, except that if a non-root logger's level is specified as `NOTSET`, the system consults loggers higher up the hierarchy to determine the effective level of the logger. The `propagate` entry is set to 1 to indicate that messages must propagate to handlers higher up the logger hierarchy from this logger, or 0 to indicate that messages are **not** propagated to handlers up the hierarchy. The `qualname` entry is the hierarchical channel name of the logger, that is to say the name used by the application to get the logger.

Sections which specify handler configuration are exemplified by the following.

```
[handler_hand01]
class=StreamHandler
level=NOTSET
formatter=form01
args=(sys.stdout,)
```

The `class` entry indicates the handler's class (as determined by `eval()` in the logging package's namespace). The `level` is interpreted as for loggers, and `NOTSET` is taken to mean 'log everything'.

The `formatter` entry indicates the key name of the formatter for this handler. If blank, a default formatter (`logging._defaultFormatter`) is used. If a name is specified, it must appear in the `[formatters]` section and have a corresponding section in the configuration file.

The `args` entry, when *evaluated* in the context of the logging package's namespace, is the list of arguments to the constructor for the handler class. Refer to the constructors for the relevant handlers, or to the examples below, to see how typical entries are constructed. If not provided, it defaults to `()`.

The optional `kwargs` entry, when *evaluated* in the context of the logging package's namespace, is the keyword argument dict to the constructor for the handler class. If not provided, it defaults to `{}`.

```
[handler_hand02]
class=FileHandler
level=DEBUG
formatter=form02
args=('python.log', 'w')

[handler_hand03]
class=handlers.SocketHandler
level=INFO
formatter=form03
args=('localhost', handlers.DEFAULT_TCP_LOGGING_PORT)

[handler_hand04]
class=handlers.DatagramHandler
level=WARN
formatter=form04
args=('localhost', handlers.DEFAULT_UDP_LOGGING_PORT)

[handler_hand05]
class=handlers.SysLogHandler
level=ERROR
formatter=form05
args=('localhost', handlers.SYSLOG_UDP_PORT), handlers.SysLogHandler.LOG_USER)

[handler_hand06]
class=handlers.NTEventLogHandler
```

(繼續下一頁)

(繼續上一頁)

```

level=CRITICAL
formatter=form06
args=('Python Application', '', 'Application')

[handler_hand07]
class=handlers.SMTPHandler
level=WARN
formatter=form07
args=('localhost', 'from@abc', ['user1@abc', 'user2@xyz'], 'Logger Subject')
kwargs={'timeout': 10.0}

[handler_hand08]
class=handlers.MemoryHandler
level=NOTSET
formatter=form08
target=
args=(10, ERROR)

[handler_hand09]
class=handlers.HTTPHandler
level=NOTSET
formatter=form09
args=('localhost:9022', '/log', 'GET')
kwargs={'secure': True}

```

Sections which specify formatter configuration are typified by the following.

```

[formatter_form01]
format=F1 %(asctime)s %(levelname)s %(message)s
datefmt=
style=%
validate=True
class=logging.Formatter

```

The arguments for the formatter configuration are the same as the keys in the dictionary schema *formatters section*.

備註: Due to the use of `eval()` as described above, there are potential security risks which result from using the `listen()` to send and receive configurations via sockets. The risks are limited to where multiple users with no mutual trust run code on the same machine; see the `listen()` documentation for more information.

也參考:

logging 模組

API reference for the logging module.

logging.handlers 模組

Useful handlers included with the logging module.

16.8 logging.handlers --- Logging handlers

原始碼: [Lib/logging/handlers.py](#)

Important

This page contains only reference information. For tutorials, please see

- 基礎教學
- 進階教學
- Logging Cookbook

The following useful handlers are provided in the package. Note that three of the handlers (*StreamHandler*, *FileHandler* and *NullHandler*) are actually defined in the *logging* module itself, but have been documented here along with the other handlers.

16.8.1 StreamHandler

The *StreamHandler* class, located in the core *logging* package, sends logging output to streams such as *sys.stdout*, *sys.stderr* or any file-like object (or, more precisely, any object which supports *write()* and *flush()* methods).

class `logging.StreamHandler` (*stream=None*)

Returns a new instance of the *StreamHandler* class. If *stream* is specified, the instance will use it for logging output; otherwise, *sys.stderr* will be used.

emit (*record*)

If a formatter is specified, it is used to format the record. The record is then written to the stream followed by *terminator*. If exception information is present, it is formatted using *traceback.print_exception()* and appended to the stream.

flush ()

Flushes the stream by calling its *flush()* method. Note that the *close()* method is inherited from *Handler* and so does no output, so an explicit *flush()* call may be needed at times.

setStream (*stream*)

Sets the instance's stream to the specified value, if it is different. The old stream is flushed before the new stream is set.

參數

stream -- The stream that the handler should use.

回傳

the old stream, if the stream was changed, or *None* if it wasn't.

在 3.7 版新加入.

terminator

String used as the terminator when writing a formatted record to a stream. Default value is `'\n'`.

If you don't want a newline termination, you can set the handler instance's *terminator* attribute to the empty string.

In earlier versions, the terminator was hardcoded as `'\n'`.

在 3.2 版新加入.

16.8.2 FileHandler

The `FileHandler` class, located in the core `logging` package, sends logging output to a disk file. It inherits the output functionality from `StreamHandler`.

class `logging.FileHandler` (*filename*, *mode*='a', *encoding*=None, *delay*=False, *errors*=None)

Returns a new instance of the `FileHandler` class. The specified file is opened and used as the stream for logging. If *mode* is not specified, 'a' is used. If *encoding* is not None, it is used to open the file with that encoding. If *delay* is true, then file opening is deferred until the first call to `emit()`. By default, the file grows indefinitely. If *errors* is specified, it's used to determine how encoding errors are handled.

在 3.6 版的變更: As well as string values, `Path` objects are also accepted for the *filename* argument.

在 3.9 版的變更: 新增 *errors* 參數。

close()

Closes the file.

emit (*record*)

Outputs the record to the file.

Note that if the file was closed due to logging shutdown at exit and the file mode is 'w', the record will not be emitted (see [bpo-42378](#)).

16.8.3 NullHandler

在 3.1 版新加入.

The `NullHandler` class, located in the core `logging` package, does not do any formatting or output. It is essentially a 'no-op' handler for use by library developers.

class `logging.NullHandler`

Returns a new instance of the `NullHandler` class.

emit (*record*)

This method does nothing.

handle (*record*)

This method does nothing.

createLock ()

This method returns None for the lock, since there is no underlying I/O to which access needs to be serialized.

See `library-config` for more information on how to use `NullHandler`.

16.8.4 WatchedFileHandler

The `WatchedFileHandler` class, located in the `logging.handlers` module, is a `FileHandler` which watches the file it is logging to. If the file changes, it is closed and reopened using the file name.

A file change can happen because of usage of programs such as `newsyslog` and `logrotate` which perform log file rotation. This handler, intended for use under Unix/Linux, watches the file to see if it has changed since the last emit. (A file is deemed to have changed if its device or inode have changed.) If the file has changed, the old file stream is closed, and the file opened to get a new stream.

This handler is not appropriate for use under Windows, because under Windows open log files cannot be moved or renamed - logging opens the files with exclusive locks - and so there is no need for such a handler. Furthermore, `ST_INO` is not supported under Windows; `stat()` always returns zero for this value.

```
class logging.handlers.WatchedFileHandler (filename, mode='a', encoding=None, delay=False,
                                         errors=None)
```

Returns a new instance of the `WatchedFileHandler` class. The specified file is opened and used as the stream for logging. If `mode` is not specified, 'a' is used. If `encoding` is not `None`, it is used to open the file with that encoding. If `delay` is true, then file opening is deferred until the first call to `emit()`. By default, the file grows indefinitely. If `errors` is provided, it determines how encoding errors are handled.

在 3.6 版的變更: As well as string values, `Path` objects are also accepted for the `filename` argument.

在 3.9 版的變更: 新增 `errors` 參數。

```
reopenIfNeeded ()
```

Checks to see if the file has changed. If it has, the existing stream is flushed and closed and the file opened again, typically as a precursor to outputting the record to the file.

在 3.6 版新加入。

```
emit (record)
```

Outputs the record to the file, but first calls `reopenIfNeeded()` to reopen the file if it has changed.

16.8.5 BaseRotatingHandler

The `BaseRotatingHandler` class, located in the `logging.handlers` module, is the base class for the rotating file handlers, `RotatingFileHandler` and `TimedRotatingFileHandler`. You should not need to instantiate this class, but it has attributes and methods you may need to override.

```
class logging.handlers.BaseRotatingHandler (filename, mode, encoding=None, delay=False,
                                           errors=None)
```

The parameters are as for `FileHandler`. The attributes are:

namer

If this attribute is set to a callable, the `rotation_filename()` method delegates to this callable. The parameters passed to the callable are those passed to `rotation_filename()`.

備F: The namer function is called quite a few times during rollover, so it should be as simple and as fast as possible. It should also return the same output every time for a given input, otherwise the rollover behaviour may not work as expected.

It's also worth noting that care should be taken when using a namer to preserve certain attributes in the filename which are used during rotation. For example, `RotatingFileHandler` expects to have a set of log files whose names contain successive integers, so that rotation works as expected, and `TimedRotatingFileHandler` deletes old log files (based on the `backupCount` parameter passed to the handler's initializer) by determining the oldest files to delete. For this to happen, the filenames should be sortable using the date/time portion of the filename, and a namer needs to respect this. (If a namer is wanted that doesn't respect this scheme, it will need to be used in a subclass of `TimedRotatingFileHandler` which overrides the `getFilesToDelete()` method to fit in with the custom naming scheme.)

在 3.3 版新加入。

rotator

If this attribute is set to a callable, the `rotate()` method delegates to this callable. The parameters passed to the callable are those passed to `rotate()`.

在 3.3 版新加入。

```
rotation_filename (default_name)
```

Modify the filename of a log file when rotating.

This is provided so that a custom filename can be provided.

The default implementation calls the `'namer'` attribute of the handler, if it's callable, passing the default name to it. If the attribute isn't callable (the default is `None`), the name is returned unchanged.

參數

default_name -- The default name for the log file.

在 3.3 版新加入。

rotate (*source*, *dest*)

When rotating, rotate the current log.

The default implementation calls the `'rotator'` attribute of the handler, if it's callable, passing the source and dest arguments to it. If the attribute isn't callable (the default is `None`), the source is simply renamed to the destination.

參數

- **source** -- The source filename. This is normally the base filename, e.g. `'test.log'`.
- **dest** -- The destination filename. This is normally what the source is rotated to, e.g. `'test.log.1'`.

在 3.3 版新加入。

The reason the attributes exist is to save you having to subclass - you can use the same callables for instances of *RotatingFileHandler* and *TimedRotatingFileHandler*. If either the namer or rotator callable raises an exception, this will be handled in the same way as any other exception during an `emit()` call, i.e. via the `handleError()` method of the handler.

If you need to make more significant changes to rotation processing, you can override the methods.

For an example, see `cookbook-rotator-namer`.

16.8.6 RotatingFileHandler

The *RotatingFileHandler* class, located in the `logging.handlers` module, supports rotation of disk log files.

```
class logging.handlers.RotatingFileHandler (filename, mode='a', maxBytes=0,
                                           backupCount=0, encoding=None, delay=False,
                                           errors=None)
```

Returns a new instance of the *RotatingFileHandler* class. The specified file is opened and used as the stream for logging. If *mode* is not specified, `'a'` is used. If *encoding* is not `None`, it is used to open the file with that encoding. If *delay* is true, then file opening is deferred until the first call to `emit()`. By default, the file grows indefinitely. If *errors* is provided, it determines how encoding errors are handled.

You can use the *maxBytes* and *backupCount* values to allow the file to *rollover* at a predetermined size. When the size is about to be exceeded, the file is closed and a new file is silently opened for output. Rollover occurs whenever the current log file is nearly *maxBytes* in length; but if either of *maxBytes* or *backupCount* is zero, rollover never occurs, so you generally want to set *backupCount* to at least 1, and have a non-zero *maxBytes*. When *backupCount* is non-zero, the system will save old log files by appending the extensions `'1'`, `'2'` etc., to the filename. For example, with a *backupCount* of 5 and a base file name of `app.log`, you would get `app.log`, `app.log.1`, `app.log.2`, up to `app.log.5`. The file being written to is always `app.log`. When this file is filled, it is closed and renamed to `app.log.1`, and if files `app.log.1`, `app.log.2`, etc. exist, then they are renamed to `app.log.2`, `app.log.3` etc. respectively.

在 3.6 版的變更: As well as string values, *Path* objects are also accepted for the *filename* argument.

在 3.9 版的變更: 新增 *errors* 參數。

doRollover ()

Does a rollover, as described above.

emit (*record*)

Outputs the record to the file, catering for rollover as described previously.

16.8.7 TimedRotatingFileHandler

The `TimedRotatingFileHandler` class, located in the `logging.handlers` module, supports rotation of disk log files at certain timed intervals.

```
class logging.handlers.TimedRotatingFileHandler (filename, when='h', interval=1,
                                                backupCount=0, encoding=None,
                                                delay=False, utc=False, atTime=None,
                                                errors=None)
```

Returns a new instance of the `TimedRotatingFileHandler` class. The specified file is opened and used as the stream for logging. On rotating it also sets the filename suffix. Rotating happens based on the product of *when* and *interval*.

You can use the *when* to specify the type of *interval*. The list of possible values is below. Note that they are not case sensitive.

Value	Type of interval	If/how <i>atTime</i> is used
'S'	Seconds	Ignored
'M'	Minutes	Ignored
'H'	Hours	Ignored
'D'	Days	Ignored
'W0' - 'W6'	Weekday (0=Monday)	Used to compute initial rollover time
'midnight'	Roll over at midnight, if <i>atTime</i> not specified, else at time <i>atTime</i>	Used to compute initial rollover time

When using weekday-based rotation, specify 'W0' for Monday, 'W1' for Tuesday, and so on up to 'W6' for Sunday. In this case, the value passed for *interval* isn't used.

The system will save old log files by appending extensions to the filename. The extensions are date-and-time based, using the strftime format `%Y-%m-%d_%H-%M-%S` or a leading portion thereof, depending on the rollover interval.

When computing the next rollover time for the first time (when the handler is created), the last modification time of an existing log file, or else the current time, is used to compute when the next rotation will occur.

If the *utc* argument is true, times in UTC will be used; otherwise local time is used.

If *backupCount* is nonzero, at most *backupCount* files will be kept, and if more would be created when rollover occurs, the oldest one is deleted. The deletion logic uses the interval to determine which files to delete, so changing the interval may leave old files lying around.

If *delay* is true, then file opening is deferred until the first call to `emit()`.

If *atTime* is not `None`, it must be a `datetime.time` instance which specifies the time of day when rollover occurs, for the cases where rollover is set to happen "at midnight" or "on a particular weekday". Note that in these cases, the *atTime* value is effectively used to compute the *initial* rollover, and subsequent rollovers would be calculated via the normal interval calculation.

If *errors* is specified, it's used to determine how encoding errors are handled.

備註: Calculation of the initial rollover time is done when the handler is initialised. Calculation of subsequent rollover times is done only when rollover occurs, and rollover occurs only when emitting output. If this is not kept in mind, it might lead to some confusion. For example, if an interval of "every minute" is set, that does not mean you will always see log files with times (in the filename) separated by a minute; if, during application execution, logging output is generated more frequently than once a minute, *then* you can expect to see log files with times separated by a minute. If, on the other hand, logging messages are only output once every five minutes (say), then there will be gaps in the file times corresponding to the minutes where no output (and hence no rollover) occurred.

在 3.4 版的變更: 新增 *atTime* 參數。

在 3.6 版的變更: As well as string values, *Path* objects are also accepted for the *filename* argument.

在 3.9 版的變更: 新增 *errors* 參數。

doRollover()

Does a rollover, as described above.

emit(record)

Outputs the record to the file, catering for rollover as described above.

getFilesToDelete()

Returns a list of filenames which should be deleted as part of rollover. These are the absolute paths of the oldest backup log files written by the handler.

16.8.8 SocketHandler

The *SocketHandler* class, located in the *logging.handlers* module, sends logging output to a network socket. The base class uses a TCP socket.

class logging.handlers.SocketHandler(host, port)

Returns a new instance of the *SocketHandler* class intended to communicate with a remote machine whose address is given by *host* and *port*.

在 3.4 版的變更: If *port* is specified as *None*, a Unix domain socket is created using the value in *host* - otherwise, a TCP socket is created.

close()

Closes the socket.

emit()

Pickles the record's attribute dictionary and writes it to the socket in binary format. If there is an error with the socket, silently drops the packet. If the connection was previously lost, re-establishes the connection. To unpickle the record at the receiving end into a *LogRecord*, use the *makeLogRecord()* function.

handleError()

Handles an error which has occurred during *emit()*. The most likely cause is a lost connection. Closes the socket so that we can retry on the next event.

makeSocket()

This is a factory method which allows subclasses to define the precise type of socket they want. The default implementation creates a TCP socket (*socket.SOCK_STREAM*).

makePickle(record)

Pickles the record's attribute dictionary in binary format with a length prefix, and returns it ready for transmission across the socket. The details of this operation are equivalent to:

```
data = pickle.dumps(record_attr_dict, 1)
datalen = struct.pack('>L', len(data))
return datalen + data
```

Note that pickles aren't completely secure. If you are concerned about security, you may want to override this method to implement a more secure mechanism. For example, you can sign pickles using HMAC and then verify them on the receiving end, or alternatively you can disable unpickling of global objects on the receiving end.

send(packet)

Send a pickled byte-string *packet* to the socket. The format of the sent byte-string is as described in the documentation for *makePickle()*.

This function allows for partial sends, which can happen when the network is busy.

createSocket ()

Tries to create a socket; on failure, uses an exponential back-off algorithm. On initial failure, the handler will drop the message it was trying to send. When subsequent messages are handled by the same instance, it will not try connecting until some time has passed. The default parameters are such that the initial delay is one second, and if after that delay the connection still can't be made, the handler will double the delay each time up to a maximum of 30 seconds.

This behaviour is controlled by the following handler attributes:

- `retryStart` (initial delay, defaulting to 1.0 seconds).
- `retryFactor` (multiplier, defaulting to 2.0).
- `retryMax` (maximum delay, defaulting to 30.0 seconds).

This means that if the remote listener starts up *after* the handler has been used, you could lose messages (since the handler won't even attempt a connection until the delay has elapsed, but just silently drop messages during the delay period).

16.8.9 DatagramHandler

The `DatagramHandler` class, located in the `logging.handlers` module, inherits from `SocketHandler` to support sending logging messages over UDP sockets.

class `logging.handlers.DatagramHandler (host, port)`

Returns a new instance of the `DatagramHandler` class intended to communicate with a remote machine whose address is given by `host` and `port`.

備 F: As UDP is not a streaming protocol, there is no persistent connection between an instance of this handler and `host`. For this reason, when using a network socket, a DNS lookup might have to be made each time an event is logged, which can introduce some latency into the system. If this affects you, you can do a lookup yourself and initialize this handler using the looked-up IP address rather than the hostname.

在 3.4 版的變更: If `port` is specified as `None`, a Unix domain socket is created using the value in `host` - otherwise, a UDP socket is created.

emit ()

Pickles the record's attribute dictionary and writes it to the socket in binary format. If there is an error with the socket, silently drops the packet. To unpickle the record at the receiving end into a `LogRecord`, use the `makeLogRecord()` function.

makeSocket ()

The factory method of `SocketHandler` is here overridden to create a UDP socket (`socket.SOCK_DGRAM`).

send (s)

Send a pickled byte-string to a socket. The format of the sent byte-string is as described in the documentation for `SocketHandler.makePickle()`.

16.8.10 SysLogHandler

The *SysLogHandler* class, located in the *logging.handlers* module, supports sending logging messages to a remote or local Unix syslog.

```
class logging.handlers.SysLogHandler (address=('localhost', SYSLOG_UDP_PORT),
                                       facility=LOG_USER, socktype=socket.SOCK_DGRAM)
```

Returns a new instance of the *SysLogHandler* class intended to communicate with a remote Unix machine whose address is given by *address* in the form of a (*host*, *port*) tuple. If *address* is not specified, ('localhost', 514) is used. The address is used to open a socket. An alternative to providing a (*host*, *port*) tuple is providing an address as a string, for example '/dev/log'. In this case, a Unix domain socket is used to send the message to the syslog. If *facility* is not specified, LOG_USER is used. The type of socket opened depends on the *socktype* argument, which defaults to *socket.SOCK_DGRAM* and thus opens a UDP socket. To open a TCP socket (for use with the newer syslog daemons such as rsyslog), specify a value of *socket.SOCK_STREAM*.

Note that if your server is not listening on UDP port 514, *SysLogHandler* may appear not to work. In that case, check what address you should be using for a domain socket - it's system dependent. For example, on Linux it's usually '/dev/log' but on OS/X it's '/var/run/syslog'. You'll need to check your platform and use the appropriate address (you may need to do this check at runtime if your application needs to run on several platforms). On Windows, you pretty much have to use the UDP option.

備註: On macOS 12.x (Monterey), Apple has changed the behaviour of their syslog daemon - it no longer listens on a domain socket. Therefore, you cannot expect *SysLogHandler* to work on this system.

See [gh-91070](#) for more information.

在 3.2 版的變更: 新增 *socktype*。

close()

Closes the socket to the remote host.

createSocket()

Tries to create a socket and, if it's not a datagram socket, connect it to the other end. This method is called during handler initialization, but it's not regarded as an error if the other end isn't listening at this point - the method will be called again when emitting an event, if there is no socket at that point.

在 3.11 版新加入。

emit(record)

The record is formatted, and then sent to the syslog server. If exception information is present, it is *not* sent to the server.

在 3.2.1 版的變更: (See: [bpo-12168](#).) In earlier versions, the message sent to the syslog daemons was always terminated with a NUL byte, because early versions of these daemons expected a NUL terminated message - even though it's not in the relevant specification ([RFC 5424](#)). More recent versions of these daemons don't expect the NUL byte but strip it off if it's there, and even more recent daemons (which adhere more closely to RFC 5424) pass the NUL byte on as part of the message.

To enable easier handling of syslog messages in the face of all these differing daemon behaviours, the appending of the NUL byte has been made configurable, through the use of a class-level attribute, *append_nul*. This defaults to *True* (preserving the existing behaviour) but can be set to *False* on a *SysLogHandler* instance in order for that instance to *not* append the NUL terminator.

在 3.3 版的變更: (See: [bpo-12419](#).) In earlier versions, there was no facility for an "ident" or "tag" prefix to identify the source of the message. This can now be specified using a class-level attribute, defaulting to "" to preserve existing behaviour, but which can be overridden on a *SysLogHandler* instance in order for that instance to prepend the ident to every message handled. Note that the provided ident must be text, not bytes, and is prepended to the message exactly as is.

encodePriority (*facility, priority*)

Encodes the facility and priority into an integer. You can pass in strings or integers - if strings are passed, internal mapping dictionaries are used to convert them to integers.

The symbolic LOG_ values are defined in *SysLogHandler* and mirror the values defined in the `sys/syslog.h` header file.

Priorities

Name (string)	Symbolic value
alert	LOG_ALERT
crit 或 critical	LOG_CRIT
debug	LOG_DEBUG
emerg 或 panic	LOG_EMERG
err 或 error	LOG_ERR
info	LOG_INFO
notice	LOG_NOTICE
warn 或 warning	LOG_WARNING

Facilities

Name (string)	Symbolic value
auth	LOG_AUTH
authpriv	LOG_AUTHPRIV
cron	LOG_CRON
daemon	LOG_DAEMON
ftp	LOG_FTP
kern	LOG_KERN
lpr	LOG_LPR
mail	LOG_MAIL
news	LOG_NEWS
syslog	LOG_SYSLOG
user	LOG_USER
uucp	LOG_UUCP
local0	LOG_LOCAL0
local1	LOG_LOCAL1
local2	LOG_LOCAL2
local3	LOG_LOCAL3
local4	LOG_LOCAL4
local5	LOG_LOCAL5
local6	LOG_LOCAL6
local7	LOG_LOCAL7

mapPriority (*levelname*)

Maps a logging level name to a syslog priority name. You may need to override this if you are using custom levels, or if the default algorithm is not suitable for your needs. The default algorithm maps DEBUG, INFO, WARNING, ERROR and CRITICAL to the equivalent syslog names, and all other level names to 'warning'.

16.8.11 NTEventLogHandler

The `NTEventLogHandler` class, located in the `logging.handlers` module, supports sending logging messages to a local Windows NT, Windows 2000 or Windows XP event log. Before you can use it, you need Mark Hammond's Win32 extensions for Python installed.

class `logging.handlers.NTEventLogHandler` (*appname*, *dllname=None*, *logtype='Application'*)

Returns a new instance of the `NTEventLogHandler` class. The *appname* is used to define the application name as it appears in the event log. An appropriate registry entry is created using this name. The *dllname* should give the fully qualified pathname of a .dll or .exe which contains message definitions to hold in the log (if not specified, 'win32service.pyd' is used - this is installed with the Win32 extensions and contains some basic placeholder message definitions. Note that use of these placeholders will make your event logs big, as the entire message source is held in the log. If you want slimmer logs, you have to pass in the name of your own .dll or .exe which contains the message definitions you want to use in the event log). The *logtype* is one of 'Application', 'System' or 'Security', and defaults to 'Application'.

close ()

At this point, you can remove the application name from the registry as a source of event log entries. However, if you do this, you will not be able to see the events as you intended in the Event Log Viewer - it needs to be able to access the registry to get the .dll name. The current version does not do this.

emit (*record*)

Determines the message ID, event category and event type, and then logs the message in the NT event log.

getEventCategory (*record*)

Returns the event category for the record. Override this if you want to specify your own categories. This version returns 0.

getEventType (*record*)

Returns the event type for the record. Override this if you want to specify your own types. This version does a mapping using the handler's *typemap* attribute, which is set up in `__init__()` to a dictionary which contains mappings for DEBUG, INFO, WARNING, ERROR and CRITICAL. If you are using your own levels, you will either need to override this method or place a suitable dictionary in the handler's *typemap* attribute.

getMessageID (*record*)

Returns the message ID for the record. If you are using your own messages, you could do this by having the *msg* passed to the logger being an ID rather than a format string. Then, in here, you could use a dictionary lookup to get the message ID. This version returns 1, which is the base message ID in `win32service.pyd`.

16.8.12 SMTPHandler

The `SMTPHandler` class, located in the `logging.handlers` module, supports sending logging messages to an email address via SMTP.

class `logging.handlers.SMTPHandler` (*mailhost*, *fromaddr*, *toaddrs*, *subject*, *credentials=None*, *secure=None*, *timeout=1.0*)

Returns a new instance of the `SMTPHandler` class. The instance is initialized with the from and to addresses and subject line of the email. The *toaddrs* should be a list of strings. To specify a non-standard SMTP port, use the (host, port) tuple format for the *mailhost* argument. If you use a string, the standard SMTP port is used. If your SMTP server requires authentication, you can specify a (username, password) tuple for the *credentials* argument.

To specify the use of a secure protocol (TLS), pass in a tuple to the *secure* argument. This will only be used when authentication credentials are supplied. The tuple should be either an empty tuple, or a single-value tuple with the name of a keyfile, or a 2-value tuple with the names of the keyfile and certificate file. (This tuple is passed to the `smtpplib.SMTP.starttls()` method.)

A timeout can be specified for communication with the SMTP server using the *timeout* argument.

在 3.3 版的變更: Added the *timeout* parameter.

emit (*record*)

Formats the record and sends it to the specified addressees.

getSubject (*record*)

If you want to specify a subject line which is record-dependent, override this method.

16.8.13 MemoryHandler

The *MemoryHandler* class, located in the *logging.handlers* module, supports buffering of logging records in memory, periodically flushing them to a *target* handler. Flushing occurs whenever the buffer is full, or when an event of a certain severity or greater is seen.

MemoryHandler is a subclass of the more general *BufferingHandler*, which is an abstract class. This buffers logging records in memory. Whenever each record is added to the buffer, a check is made by calling *shouldFlush()* to see if the buffer should be flushed. If it should, then *flush()* is expected to do the flushing.

class *logging.handlers.BufferingHandler* (*capacity*)

Initializes the handler with a buffer of the specified capacity. Here, *capacity* means the number of logging records buffered.

emit (*record*)

Append the record to the buffer. If *shouldFlush()* returns true, call *flush()* to process the buffer.

flush ()

For a *BufferingHandler* instance, flushing means that it sets the buffer to an empty list. This method can be overwritten to implement more useful flushing behavior.

shouldFlush (*record*)

Return True if the buffer is up to capacity. This method can be overridden to implement custom flushing strategies.

class *logging.handlers.MemoryHandler* (*capacity*, *flushLevel=ERROR*, *target=None*,
flushOnClose=True)

Returns a new instance of the *MemoryHandler* class. The instance is initialized with a buffer size of *capacity* (number of records buffered). If *flushLevel* is not specified, *ERROR* is used. If no *target* is specified, the target will need to be set using *setTarget()* before this handler does anything useful. If *flushOnClose* is specified as *False*, then the buffer is *not* flushed when the handler is closed. If not specified or specified as *True*, the previous behaviour of flushing the buffer will occur when the handler is closed.

在 3.6 版的變更: 新增 *flushOnClose* 參數。

close ()

Calls *flush()*, sets the target to *None* and clears the buffer.

flush ()

For a *MemoryHandler* instance, flushing means just sending the buffered records to the target, if there is one. The buffer is also cleared when buffered records are sent to the target. Override if you want different behavior.

setTarget (*target*)

Sets the target handler for this handler.

shouldFlush (*record*)

Checks for buffer full or a record at the *flushLevel* or higher.

16.8.14 HTTPHandler

The `HTTPHandler` class, located in the `logging.handlers` module, supports sending logging messages to a web server, using either GET or POST semantics.

```
class logging.handlers.HTTPHandler (host, url, method='GET', secure=False, credentials=None,
                                     context=None)
```

Returns a new instance of the `HTTPHandler` class. The `host` can be of the form `host:port`, should you need to use a specific port number. If no `method` is specified, GET is used. If `secure` is true, a HTTPS connection will be used. The `context` parameter may be set to a `ssl.SSLContext` instance to configure the SSL settings used for the HTTPS connection. If `credentials` is specified, it should be a 2-tuple consisting of userid and password, which will be placed in a HTTP 'Authorization' header using Basic authentication. If you specify credentials, you should also specify `secure=True` so that your userid and password are not passed in cleartext across the wire.

在 3.5 版的變更: 新增 `context` 參數。

```
mapLogRecord (record)
```

Provides a dictionary, based on `record`, which is to be URL-encoded and sent to the web server. The default implementation just returns `record.__dict__`. This method can be overridden if e.g. only a subset of `LogRecord` is to be sent to the web server, or if more specific customization of what's sent to the server is required.

```
emit (record)
```

Sends the record to the web server as a URL-encoded dictionary. The `mapLogRecord()` method is used to convert the record to the dictionary to be sent.

備 F: Since preparing a record for sending it to a web server is not the same as a generic formatting operation, using `setFormatter()` to specify a `Formatter` for a `HTTPHandler` has no effect. Instead of calling `format()`, this handler calls `mapLogRecord()` and then `urllib.parse.urlencode()` to encode the dictionary in a form suitable for sending to a web server.

16.8.15 QueueHandler

在 3.2 版新加入。

The `QueueHandler` class, located in the `logging.handlers` module, supports sending logging messages to a queue, such as those implemented in the `queue` or `multiprocessing` modules.

Along with the `QueueListener` class, `QueueHandler` can be used to let handlers do their work on a separate thread from the one which does the logging. This is important in web applications and also other service applications where threads servicing clients need to respond as quickly as possible, while any potentially slow operations (such as sending an email via `SMTPHandler`) are done on a separate thread.

```
class logging.handlers.QueueHandler (queue)
```

Returns a new instance of the `QueueHandler` class. The instance is initialized with the queue to send messages to. The `queue` can be any queue-like object; it's used as-is by the `enqueue()` method, which needs to know how to send messages to it. The queue is not *required* to have the task tracking API, which means that you can use `SimpleQueue` instances for `queue`.

備 F: If you are using `multiprocessing`, you should avoid using `SimpleQueue` and instead use `multiprocessing.Queue`.

```
emit (record)
```

Enqueues the result of preparing the `LogRecord`. Should an exception occur (e.g. because a bounded queue has filled up), the `handleError()` method is called to handle the error. This can result in the

record silently being dropped (if `logging.raiseExceptions` is `False`) or a message printed to `sys.stderr` (if `logging.raiseExceptions` is `True`).

prepare (*record*)

Prepares a record for queuing. The object returned by this method is enqueued.

The base implementation formats the record to merge the message, arguments, exception and stack information, if present. It also removes unpickleable items from the record in-place. Specifically, it overwrites the record's `msg` and `message` attributes with the merged message (obtained by calling the handler's `format()` method), and sets the `args`, `exc_info` and `exc_text` attributes to `None`.

You might want to override this method if you want to convert the record to a dict or JSON string, or send a modified copy of the record while leaving the original intact.

備 F: The base implementation formats the message with arguments, sets the `message` and `msg` attributes to the formatted message and sets the `args` and `exc_text` attributes to `None` to allow pickling and to prevent further attempts at formatting. This means that a handler on the `QueueListener` side won't have the information to do custom formatting, e.g. of exceptions. You may wish to subclass `QueueHandler` and override this method to e.g. avoid setting `exc_text` to `None`. Note that the `message/msg/args` changes are related to ensuring the record is pickleable, and you might or might not be able to avoid doing that depending on whether your `args` are pickleable. (Note that you may have to consider not only your own code but also code in any libraries that you use.)

enqueue (*record*)

Enqueues the record on the queue using `put_nowait()`; you may want to override this if you want to use blocking behaviour, or a timeout, or a customized queue implementation.

16.8.16 QueueListener

在 3.2 版新加入。

The `QueueListener` class, located in the `logging.handlers` module, supports receiving logging messages from a queue, such as those implemented in the `queue` or `multiprocessing` modules. The messages are received from a queue in an internal thread and passed, on the same thread, to one or more handlers for processing. While `QueueListener` is not itself a handler, it is documented here because it works hand-in-hand with `QueueHandler`.

Along with the `QueueHandler` class, `QueueListener` can be used to let handlers do their work on a separate thread from the one which does the logging. This is important in web applications and also other service applications where threads servicing clients need to respond as quickly as possible, while any potentially slow operations (such as sending an email via `SMTPHandler`) are done on a separate thread.

class `logging.handlers.QueueListener` (*queue*, **handlers*, *respect_handler_level=False*)

Returns a new instance of the `QueueListener` class. The instance is initialized with the queue to send messages to and a list of handlers which will handle entries placed on the queue. The queue can be any queue-like object; it's passed as-is to the `dequeue()` method, which needs to know how to get messages from it. The queue is not *required* to have the task tracking API (though it's used if available), which means that you can use `SimpleQueue` instances for *queue*.

備 F: If you are using `multiprocessing`, you should avoid using `SimpleQueue` and instead use `multiprocessing.Queue`.

If `respect_handler_level` is `True`, a handler's level is respected (compared with the level for the message) when deciding whether to pass messages to that handler; otherwise, the behaviour is as in previous Python versions - to always pass each message to each handler.

在 3.5 版的變更: 新增 `respect_handler_level` 引數。

dequeue (*block*)

Dequeues a record and return it, optionally blocking.

The base implementation uses `get()`. You may want to override this method if you want to use timeouts or work with custom queue implementations.

prepare (*record*)

Prepare a record for handling.

This implementation just returns the passed-in record. You may want to override this method if you need to do any custom marshalling or manipulation of the record before passing it to the handlers.

handle (*record*)

Handle a record.

This just loops through the handlers offering them the record to handle. The actual object passed to the handlers is that which is returned from `prepare()`.

start ()

Starts the listener.

This starts up a background thread to monitor the queue for LogRecords to process.

stop ()

Stops the listener.

This asks the thread to terminate, and then waits for it to do so. Note that if you don't call this before your application exits, there may be some records still left on the queue, which won't be processed.

enqueue_sentinel ()

Writes a sentinel to the queue to tell the listener to quit. This implementation uses `put_nowait()`. You may want to override this method if you want to use timeouts or work with custom queue implementations.

在 3.3 版新加入。

也參考:

logging 模組

API reference for the logging module.

logging.config 模組

Configuration API for the logging module.

16.9 getpass --- 可交互式密碼輸入工具

原始碼: [Lib/getpass.py](#)

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

`getpass` 模組 (module) 提供了兩個函式:

`getpass.getpass` (*prompt='Password: ', stream=None*)

提示使用者輸入一個密碼且不會有回音 (echo)。使用者會看到字串 *prompt* 作提示，其預設值為 `'Password: '`。在 Unix 上，如有必要的話會使用替換錯誤處理函式 (replace error handler) 寫入到類檔案物件 (file-like object) *stream* 中。*stream* 預設為主控終端機 (controlling terminal) (`/dev/tty`)，如果不可用則為 `sys.stderr` (此引數在 Windows 上會被忽略)。

如果無回音輸入 (echo-free input) 無法使用則 `getpass()` 將回退印出一條警告訊息到 *stream*，從 `sys.stdin` 讀取且同時發出 `GetPassWarning`。

備：如果你從 IDLE 部呼叫 `getpass`，輸入可能會在你動 IDLE 的終端機中完成，而非在 IDLE 視窗中。

exception `getpass.GetPassWarning`

當密碼輸入可能被回音時會發出的 *UserWarning* 子類。

`getpass.getuser()`

回傳使用者的“登入名稱”。

This function checks the environment variables `LOGNAME`, `USER`, `LNAME` and `USERNAME`, in order, and returns the value of the first one which is set to a non-empty string. If none are set, the login name from the password database is returned on systems which support the *pwd* module, otherwise, an exception is raised.

大部分情況下，此函式應該要比 `os.getlogin()` 優先使用。

16.10 *curses* --- Terminal handling for character-cell displays

原始碼： [Lib/curses](#)

The *curses* module provides an interface to the curses library, the de-facto standard for portable advanced terminal handling.

While curses is most widely used in the Unix environment, versions are available for Windows, DOS, and possibly other systems as well. This extension module is designed to match the API of ncurses, an open-source curses library hosted on Linux and the BSD variants of Unix.

備：Whenever the documentation mentions a *character* it can be specified as an integer, a one-character Unicode string or a one-byte byte string.

Whenever the documentation mentions a *character string* it can be specified as a Unicode string or a byte string.

也參考：

Module *curses.ascii*

Utilities for working with ASCII characters, regardless of your locale settings.

Module *curses.panel*

A panel stack extension that adds depth to curses windows.

Module *curses.textpad*

Editable text widget for curses supporting **Emacs**-like bindings.

curses-howto

Tutorial material on using curses with Python, by Andrew Kuchling and Eric Raymond.

The [Tools/demo/](#) directory in the Python source distribution contains some example programs using the curses bindings provided by this module.

16.10.1 函式

The module `curses` defines the following exception:

exception `curses.error`

Exception raised when a curses library function returns an error.

備 F: Whenever *x* or *y* arguments to a function or a method are optional, they default to the current cursor location. Whenever *attr* is optional, it defaults to `A_NORMAL`.

The module `curses` defines the following functions:

`curses.baudrate()`

Return the output speed of the terminal in bits per second. On software terminal emulators it will have a fixed high value. Included for historical reasons; in former times, it was used to write output loops for time delays and occasionally to change interfaces depending on the line speed.

`curses.beep()`

Emit a short attention sound.

`curses.can_change_color()`

Return True or False, depending on whether the programmer can change the colors displayed by the terminal.

`curses.cbreak()`

Enter cbreak mode. In cbreak mode (sometimes called "rare" mode) normal tty line buffering is turned off and characters are available to be read one by one. However, unlike raw mode, special characters (interrupt, quit, suspend, and flow control) retain their effects on the tty driver and calling program. Calling first `raw()` then `cbreak()` leaves the terminal in cbreak mode.

`curses.color_content(color_number)`

Return the intensity of the red, green, and blue (RGB) components in the color *color_number*, which must be between 0 and `COLORS - 1`. Return a 3-tuple, containing the R,G,B values for the given color, which will be between 0 (no component) and 1000 (maximum amount of component).

`curses.color_pair(pair_number)`

Return the attribute value for displaying text in the specified color pair. Only the first 256 color pairs are supported. This attribute value can be combined with `A_STANDOUT`, `A_REVERSE`, and the other `A_*` attributes. `pair_number()` is the counterpart to this function.

`curses.curs_set(visibility)`

Set the cursor state. *visibility* can be set to 0, 1, or 2, for invisible, normal, or very visible. If the terminal supports the visibility requested, return the previous cursor state; otherwise raise an exception. On many terminals, the "visible" mode is an underline cursor and the "very visible" mode is a block cursor.

`curses.def_prog_mode()`

Save the current terminal mode as the "program" mode, the mode when the running program is using curses. (Its counterpart is the "shell" mode, for when the program is not in curses.) Subsequent calls to `reset_prog_mode()` will restore this mode.

`curses.def_shell_mode()`

Save the current terminal mode as the "shell" mode, the mode when the running program is not using curses. (Its counterpart is the "program" mode, when the program is using curses capabilities.) Subsequent calls to `reset_shell_mode()` will restore this mode.

`curses.delay_output(ms)`

Insert an *ms* millisecond pause in output.

`curses.doupdate()`

Update the physical screen. The `curses` library keeps two data structures, one representing the current physical screen contents and a virtual screen representing the desired next state. The `doupdate()` ground updates the physical screen to match the virtual screen.

The virtual screen may be updated by a `noutrefresh()` call after write operations such as `addstr()` have been performed on a window. The normal `refresh()` call is simply `noutrefresh()` followed by `doupdate()`; if you have to update multiple windows, you can speed performance and perhaps reduce screen flicker by issuing `noutrefresh()` calls on all windows, followed by a single `doupdate()`.

`curses.echo()`

Enter echo mode. In echo mode, each character input is echoed to the screen as it is entered.

`curses.endwin()`

De-initialize the library, and return terminal to normal status.

`curses.erasechar()`

Return the user's current erase character as a one-byte bytes object. Under Unix operating systems this is a property of the controlling tty of the `curses` program, and is not set by the `curses` library itself.

`curses.filter()`

The `filter()` routine, if used, must be called before `initscr()` is called. The effect is that, during those calls, `LINES` is set to 1; the capabilities `clear`, `cup`, `cud`, `cud1`, `cuu1`, `cuu`, `vpa` are disabled; and the `home` string is set to the value of `cr`. The effect is that the cursor is confined to the current line, and so are screen updates. This may be used for enabling character-at-a-time line editing without touching the rest of the screen.

`curses.flash()`

Flash the screen. That is, change it to reverse-video and then change it back in a short interval. Some people prefer such as 'visible bell' to the audible attention signal produced by `beep()`.

`curses.flushinp()`

Flush all input buffers. This throws away any typeahead that has been typed by the user and has not yet been processed by the program.

`curses.getmouse()`

After `getch()` returns `KEY_MOUSE` to signal a mouse event, this method should be called to retrieve the queued mouse event, represented as a 5-tuple (`id`, `x`, `y`, `z`, `bstate`). `id` is an ID value used to distinguish multiple devices, and `x`, `y`, `z` are the event's coordinates. (`z` is currently unused.) `bstate` is an integer value whose bits will be set to indicate the type of event, and will be the bitwise OR of one or more of the following constants, where `n` is the button number from 1 to 5: `BUTTONn_PRESSED`, `BUTTONn_RELEASED`, `BUTTONn_CLICKED`, `BUTTONn_DOUBLE_CLICKED`, `BUTTONn_TRIPLE_CLICKED`, `BUTTON_SHIFT`, `BUTTON_CTRL`, `BUTTON_ALT`.

在 3.10 版的變更: The `BUTTON5_*` constants are now exposed if they are provided by the underlying `curses` library.

`curses.getsyx()`

Return the current coordinates of the virtual screen cursor as a tuple (`y`, `x`). If `leaveok` is currently `True`, then return `(-1, -1)`.

`curses.getwin(file)`

Read window related data stored in the file by an earlier `window.putwin()` call. The routine then creates and initializes a new window using that data, returning the new window object.

`curses.has_colors()`

Return `True` if the terminal can display colors; otherwise, return `False`.

`curses.has_extended_color_support()`

Return `True` if the module supports extended colors; otherwise, return `False`. Extended color support allows more than 256 color pairs for terminals that support more than 16 colors (e.g. `xterm-256color`).

Extended color support requires ncurses version 6.1 or later.

在 3.10 版新加入.

`curses.has_ic()`

Return `True` if the terminal has insert- and delete-character capabilities. This function is included for historical reasons only, as all modern software terminal emulators have such capabilities.

`curses.has_il()`

Return `True` if the terminal has insert- and delete-line capabilities, or can simulate them using scrolling regions. This function is included for historical reasons only, as all modern software terminal emulators have such capabilities.

`curses.has_key(ch)`

Take a key value *ch*, and return `True` if the current terminal type recognizes a key with that value.

`curses.halfdelay(tenths)`

Used for half-delay mode, which is similar to `cbreak` mode in that characters typed by the user are immediately available to the program. However, after blocking for *tenths* tenths of seconds, raise an exception if nothing has been typed. The value of *tenths* must be a number between 1 and 255. Use `nocbreak()` to leave half-delay mode.

`curses.init_color(color_number, r, g, b)`

Change the definition of a color, taking the number of the color to be changed followed by three RGB values (for the amounts of red, green, and blue components). The value of *color_number* must be between 0 and `COLORS - 1`. Each of *r*, *g*, *b*, must be a value between 0 and 1000. When `init_color()` is used, all occurrences of that color on the screen immediately change to the new definition. This function is a no-op on most terminals; it is active only if `can_change_color()` returns `True`.

`curses.init_pair(pair_number, fg, bg)`

Change the definition of a color-pair. It takes three arguments: the number of the color-pair to be changed, the foreground color number, and the background color number. The value of *pair_number* must be between 1 and `COLOR_PAIRS - 1` (the 0 color pair is wired to white on black and cannot be changed). The value of *fg* and *bg* arguments must be between 0 and `COLORS - 1`, or, after calling `use_default_colors()`, -1. If the color-pair was previously initialized, the screen is refreshed and all occurrences of that color-pair are changed to the new definition.

`curses.initscr()`

Initialize the library. Return a `Window` object which represents the whole screen.

備F: If there is an error opening the terminal, the underlying curses library may cause the interpreter to exit.

`curses.is_term_resized(nlines, ncols)`

Return `True` if `resize_term()` would modify the window structure, `False` otherwise.

`curses.isendwin()`

Return `True` if `endwin()` has been called (that is, the curses library has been deinitialized).

`curses.keyname(k)`

Return the name of the key numbered *k* as a bytes object. The name of a key generating printable ASCII character is the key's character. The name of a control-key combination is a two-byte bytes object consisting of a caret (`b'^'`) followed by the corresponding printable ASCII character. The name of an alt-key combination (128--255) is a bytes object consisting of the prefix `b'M-'` followed by the name of the corresponding ASCII character.

`curses.killchar()`

Return the user's current line kill character as a one-byte bytes object. Under Unix operating systems this is a property of the controlling tty of the curses program, and is not set by the curses library itself.

`curses.longname()`

Return a bytes object containing the terminfo long name field describing the current terminal. The maximum length of a verbose description is 128 characters. It is defined only after the call to `initscr()`.

`curses.meta(flag)`

If *flag* is `True`, allow 8-bit characters to be input. If *flag* is `False`, allow only 7-bit chars.

`curses.mouseinterval(interval)`

Set the maximum time in milliseconds that can elapse between press and release events in order for them to be recognized as a click, and return the previous interval value. The default value is 200 milliseconds, or one fifth of a second.

`curses.mousemask(mousemask)`

Set the mouse events to be reported, and return a tuple (*availmask*, *oldmask*). *availmask* indicates which of the specified mouse events can be reported; on complete failure it returns 0. *oldmask* is the previous value of the given window's mouse event mask. If this function is never called, no mouse events are ever reported.

`curses.napms(ms)`

Sleep for *ms* milliseconds.

`curses.newpad(nlines, ncols)`

Create and return a pointer to a new pad data structure with the given number of lines and columns. Return a pad as a window object.

A pad is like a window, except that it is not restricted by the screen size, and is not necessarily associated with a particular part of the screen. Pads can be used when a large window is needed, and only a part of the window will be on the screen at one time. Automatic refreshes of pads (such as from scrolling or echoing of input) do not occur. The `refresh()` and `noutrefresh()` methods of a pad require 6 arguments to specify the part of the pad to be displayed and the location on the screen to be used for the display. The arguments are *pminrow*, *pmincol*, *sminrow*, *smincol*, *smaxrow*, *smaxcol*; the *p* arguments refer to the upper left corner of the pad region to be displayed and the *s* arguments define a clipping box on the screen within which the pad region is to be displayed.

`curses.newwin(nlines, ncols)`

`curses.newwin(nlines, ncols, begin_y, begin_x)`

Return a new [window](#), whose left-upper corner is at (*begin_y*, *begin_x*), and whose height/width is *nlines/ncols*.

By default, the window will extend from the specified position to the lower right corner of the screen.

`curses.nl()`

Enter newline mode. This mode translates the return key into newline on input, and translates newline into return and line-feed on output. Newline mode is initially on.

`curses.nocbreak()`

Leave cbreak mode. Return to normal "cooked" mode with line buffering.

`curses.noecho()`

Leave echo mode. Echoing of input characters is turned off.

`curses.nonl()`

Leave newline mode. Disable translation of return into newline on input, and disable low-level translation of newline into newline/return on output (but this does not change the behavior of `addch('\n')`, which always does the equivalent of return and line feed on the virtual screen). With translation off, curses can sometimes speed up vertical motion a little; also, it will be able to detect the return key on input.

`curses.noqiflush()`

When the `noqiflush()` routine is used, normal flush of input and output queues associated with the `INTR`, `QUIT` and `SUSP` characters will not be done. You may want to call `noqiflush()` in a signal handler if you want output to continue as though the interrupt had not occurred, after the handler exits.

`curses.noraw()`

Leave raw mode. Return to normal "cooked" mode with line buffering.

`curses.pair_content(pair_number)`

Return a tuple (fg, bg) containing the colors for the requested color pair. The value of *pair_number* must be between 0 and `COLOR_PAIRS - 1`.

`curses.pair_number(attr)`

Return the number of the color-pair set by the attribute value *attr*. `color_pair()` is the counterpart to this function.

`curses.putp(str)`

Equivalent to `tputs(str, 1, putchar)`; emit the value of a specified terminfo capability for the current terminal. Note that the output of `putp()` always goes to standard output.

`curses.qiflush([flag])`

If *flag* is `False`, the effect is the same as calling `noqiflush()`. If *flag* is `True`, or no argument is provided, the queues will be flushed when these control characters are read.

`curses.raw()`

Enter raw mode. In raw mode, normal line buffering and processing of interrupt, quit, suspend, and flow control keys are turned off; characters are presented to curses input functions one by one.

`curses.reset_prog_mode()`

Restore the terminal to "program" mode, as previously saved by `def_prog_mode()`.

`curses.reset_shell_mode()`

Restore the terminal to "shell" mode, as previously saved by `def_shell_mode()`.

`curses.resetty()`

Restore the state of the terminal modes to what it was at the last call to `savetty()`.

`curses.resize_term(nlines, ncols)`

Backend function used by `resizeterm()`, performing most of the work; when resizing the windows, `resize_term()` blank-fills the areas that are extended. The calling application should fill in these areas with appropriate data. The `resize_term()` function attempts to resize all windows. However, due to the calling convention of pads, it is not possible to resize these without additional interaction with the application.

`curses.resizeterm(nlines, ncols)`

Resize the standard and current windows to the specified dimensions, and adjusts other bookkeeping data used by the curses library that record the window dimensions (in particular the SIGWINCH handler).

`curses.savetty()`

Save the current state of the terminal modes in a buffer, usable by `resetty()`.

`curses.get_escdelay()`

Retrieves the value set by `set_escdelay()`.

在 3.9 版新加入.

`curses.set_escdelay(ms)`

Sets the number of milliseconds to wait after reading an escape character, to distinguish between an individual escape character entered on the keyboard from escape sequences sent by cursor and function keys.

在 3.9 版新加入.

`curses.get_tabsize()`

Retrieves the value set by `set_tabsize()`.

在 3.9 版新加入.

`curses.set_tabsize(size)`

Sets the number of columns used by the curses library when converting a tab character to spaces as it adds the tab to a window.

在 3.9 版新加入。

`curses.setsyx(y, x)`

Set the virtual screen cursor to *y*, *x*. If *y* and *x* are both `-1`, then `leaveok` is set `True`.

`curses.setupterm(term=None, fd=-1)`

Initialize the terminal. *term* is a string giving the terminal name, or `None`; if omitted or `None`, the value of the `TERM` environment variable will be used. *fd* is the file descriptor to which any initialization sequences will be sent; if not supplied or `-1`, the file descriptor for `sys.stdout` will be used.

`curses.start_color()`

Must be called if the programmer wants to use colors, and before any other color manipulation routine is called. It is good practice to call this routine right after `initscr()`.

`start_color()` initializes eight basic colors (black, red, green, yellow, blue, magenta, cyan, and white), and two global variables in the `curses` module, `COLORS` and `COLOR_PAIRS`, containing the maximum number of colors and color-pairs the terminal can support. It also restores the colors on the terminal to the values they had when the terminal was just turned on.

`curses.termattrs()`

Return a logical OR of all video attributes supported by the terminal. This information is useful when a curses program needs complete control over the appearance of the screen.

`curses.termname()`

Return the value of the environment variable `TERM`, as a bytes object, truncated to 14 characters.

`curses.tigetflag(capname)`

Return the value of the Boolean capability corresponding to the terminfo capability name *capname* as an integer. Return the value `-1` if *capname* is not a Boolean capability, or `0` if it is canceled or absent from the terminal description.

`curses.tigetnum(capname)`

Return the value of the numeric capability corresponding to the terminfo capability name *capname* as an integer. Return the value `-2` if *capname* is not a numeric capability, or `-1` if it is canceled or absent from the terminal description.

`curses.tigetstr(capname)`

Return the value of the string capability corresponding to the terminfo capability name *capname* as a bytes object. Return `None` if *capname* is not a terminfo "string capability", or is canceled or absent from the terminal description.

`curses.tparm(str[, ...])`

Instantiate the bytes object *str* with the supplied parameters, where *str* should be a parameterized string obtained from the terminfo database. E.g. `tparm(tigetstr("cup"), 5, 3)` could result in `b'\033[6;4H'`, the exact result depending on terminal type.

`curses.typeahead(fd)`

Specify that the file descriptor *fd* be used for typeahead checking. If *fd* is `-1`, then no typeahead checking is done.

The curses library does "line-breakout optimization" by looking for typeahead periodically while updating the screen. If input is found, and it is coming from a tty, the current update is postponed until `refresh` or `doupdate` is called again, allowing faster response to commands typed in advance. This function allows specifying a different file descriptor for typeahead checking.

`curses.unctrl(ch)`

Return a bytes object which is a printable representation of the character *ch*. Control characters are represented as a caret followed by the character, for example as `b'^C'`. Printing characters are left as they are.

`curses.ungetch(ch)`

Push *ch* so the next `getch()` will return it.

備註: Only one *ch* can be pushed before `getch()` is called.

`curses.update_lines_cols()`

Update the `LINES` and `COLS` module variables. Useful for detecting manual screen resize.

在 3.5 版新加入。

`curses.unget_wch(ch)`

Push *ch* so the next `get_wch()` will return it.

備註: Only one *ch* can be pushed before `get_wch()` is called.

在 3.3 版新加入。

`curses.ungetmouse(id, x, y, z, bstate)`

Push a `KEY_MOUSE` event onto the input queue, associating the given state data with it.

`curses.use_env(flag)`

If used, this function should be called before `initscr()` or `newterm` are called. When *flag* is `False`, the values of lines and columns specified in the terminfo database will be used, even if environment variables `LINES` and `COLUMNS` (used by default) are set, or if `curses` is running in a window (in which case default behavior would be to use the window size if `LINES` and `COLUMNS` are not set).

`curses.use_default_colors()`

Allow use of default values for colors on terminals supporting this feature. Use this to support transparency in your application. The default color is assigned to the color number `-1`. After calling this function, `init_pair(x, curses.COLOR_RED, -1)` initializes, for instance, color pair *x* to a red foreground color on the default background.

`curses.wrapper(func, /, *args, **kwargs)`

Initialize `curses` and call another callable object, *func*, which should be the rest of your `curses`-using application. If the application raises an exception, this function will restore the terminal to a sane state before re-raising the exception and generating a traceback. The callable object *func* is then passed the main window `'stdscr'` as its first argument, followed by any other arguments passed to `wrapper()`. Before calling *func*, `wrapper()` turns on `cbreak` mode, turns off `echo`, enables the terminal keypad, and initializes colors if the terminal has color support. On exit (whether normally or by exception) it restores cooked mode, turns on `echo`, and disables the terminal keypad.

16.10.2 Window Objects

Window objects, as returned by `initscr()` and `newwin()` above, have the following methods and attributes:

`window.addch(ch[, attr])`

`window.addch(y, x, ch[, attr])`

Paint character *ch* at (*y*, *x*) with attributes *attr*, overwriting any character previously painted at that location. By default, the character position and attributes are the current settings for the window object.

備註: Writing outside the window, subwindow, or pad raises a `curses.error`. Attempting to write to the lower right corner of a window, subwindow, or pad will cause an exception to be raised after the character is printed.

`window.addnstr(str, n[, attr])`

`window.addnstr(y, x, str, n[, attr])`

Paint at most *n* characters of the character string *str* at (*y*, *x*) with attributes *attr*, overwriting anything previously on the display.

`window.addstr(str[, attr])`

`window.addstr(y, x, str[, attr])`

Paint the character string *str* at (*y*, *x*) with attributes *attr*, overwriting anything previously on the display.

備 註:

- Writing outside the window, subwindow, or pad raises `curses.error`. Attempting to write to the lower right corner of a window, subwindow, or pad will cause an exception to be raised after the string is printed.
 - A bug in `ncurses`, the backend for this Python module, can cause SegFaults when resizing windows. This is fixed in `ncurses-6.1-20190511`. If you are stuck with an earlier `ncurses`, you can avoid triggering this if you do not call `addstr()` with a *str* that has embedded newlines. Instead, call `addstr()` separately for each line.
-

`window.attroff(attr)`

Remove attribute *attr* from the "background" set applied to all writes to the current window.

`window.attron(attr)`

Add attribute *attr* from the "background" set applied to all writes to the current window.

`window.attrset(attr)`

Set the "background" set of attributes to *attr*. This set is initially 0 (no attributes).

`window.bkgd(ch[, attr])`

Set the background property of the window to the character *ch*, with attributes *attr*. The change is then applied to every character position in that window:

- The attribute of every character in the window is changed to the new background attribute.
- Wherever the former background character appears, it is changed to the new background character.

`window.bkgdset(ch[, attr])`

Set the window's background. A window's background consists of a character and any combination of attributes. The attribute part of the background is combined (OR'ed) with all non-blank characters that are written into the window. Both the character and attribute parts of the background are combined with the blank characters. The background becomes a property of the character and moves with the character through any scrolling and insert/delete line/character operations.

`window.border([ls[, rs[, ts[, bs[, tl[, tr[, bl[, br]]]]]])`

Draw a border around the edges of the window. Each parameter specifies the character to use for a specific part of the border; see the table below for more details.

備 註: A 0 value for any parameter will cause the default character to be used for that parameter. Keyword parameters can *not* be used. The defaults are listed in this table:

參數	描述	Default value
<i>ls</i>	Left side	<i>ACS_VLINE</i>
<i>rs</i>	Right side	<i>ACS_VLINE</i>
<i>ts</i>	Top	<i>ACS_HLINE</i>
<i>bs</i>	Bottom	<i>ACS_HLINE</i>
<i>tl</i>	Upper-left corner	<i>ACS_ULCORNER</i>
<i>tr</i>	Upper-right corner	<i>ACS_URCORNER</i>
<i>bl</i>	Bottom-left corner	<i>ACS_LLCORNER</i>
<i>br</i>	Bottom-right corner	<i>ACS_LRCORNER</i>

`window.bbox([vertch, horch])`
 Similar to `border()`, but both *ls* and *rs* are *vertch* and both *ts* and *bs* are *horch*. The default corner characters are always used by this function.

`window.chgat(attr)`
`window.chgat(num, attr)`
`window.chgat(y, x, attr)`
`window.chgat(y, x, num, attr)`
 Set the attributes of *num* characters at the current cursor position, or at position (*y*, *x*) if supplied. If *num* is not given or is `-1`, the attribute will be set on all the characters to the end of the line. This function moves cursor to position (*y*, *x*) if supplied. The changed line will be touched using the `touchline()` method so that the contents will be redisplayed by the next window refresh.

`window.clear()`
 Like `erase()`, but also cause the whole window to be repainted upon next call to `refresh()`.

`window.clearok(flag)`
 If *flag* is `True`, the next call to `refresh()` will clear the window completely.

`window.clrtoobot()`
 Erase from cursor to the end of the window: all lines below the cursor are deleted, and then the equivalent of `clrtoeol()` is performed.

`window.clrtoeol()`
 Erase from cursor to the end of the line.

`window.cursyncup()`
 Update the current cursor position of all the ancestors of the window to reflect the current cursor position of the window.

`window.delch([y, x])`
 Delete any character at (*y*, *x*).

`window.deleteln()`
 Delete the line under the cursor. All following lines are moved up by one line.

`window.derwin(begin_y, begin_x)`
`window.derwin(nlines, ncols, begin_y, begin_x)`
 An abbreviation for "derive window", `derwin()` is the same as calling `subwin()`, except that *begin_y* and *begin_x* are relative to the origin of the window, rather than relative to the entire screen. Return a window object for the derived window.

`window.echochar(ch[, attr])`
 Add character *ch* with attribute *attr*, and immediately call `refresh()` on the window.

`window.enclouse(y, x)`

Test whether the given pair of screen-relative character-cell coordinates are enclosed by the given window, returning True or False. It is useful for determining what subset of the screen windows enclose the location of a mouse event.

在 3.10 版的變更: Previously it returned 1 or 0 instead of True or False.

`window.encoding`

Encoding used to encode method arguments (Unicode strings and characters). The encoding attribute is inherited from the parent window when a subwindow is created, for example with `window.subwin()`. By default, current locale encoding is used (see `locale.getencoding()`).

在 3.3 版新加入.

`window.erase()`

Clear the window.

`window.getbegyx()`

Return a tuple (y, x) of co-ordinates of upper-left corner.

`window.getbkgd()`

Return the given window's current background character/attribute pair.

`window.getch([y, x])`

Get a character. Note that the integer returned does *not* have to be in ASCII range: function keys, keypad keys and so on are represented by numbers higher than 255. In no-delay mode, return -1 if there is no input, otherwise wait until a key is pressed.

`window.get_wch([y, x])`

Get a wide character. Return a character for most keys, or an integer for function keys, keypad keys, and other special keys. In no-delay mode, raise an exception if there is no input.

在 3.3 版新加入.

`window.getkey([y, x])`

Get a character, returning a string instead of an integer, as `getch()` does. Function keys, keypad keys and other special keys return a multibyte string containing the key name. In no-delay mode, raise an exception if there is no input.

`window.getmaxyx()`

Return a tuple (y, x) of the height and width of the window.

`window.getparyx()`

Return the beginning coordinates of this window relative to its parent window as a tuple (y, x) . Return $(-1, -1)$ if this window has no parent.

`window.getstr()`

`window.getstr(n)`

`window.getstr(y, x)`

`window.getstr(y, x, n)`

Read a bytes object from the user, with primitive line editing capacity.

`window.getyx()`

Return a tuple (y, x) of current cursor position relative to the window's upper-left corner.

`window.hline(ch, n)`

`window.hline(y, x, ch, n)`

Display a horizontal line starting at (y, x) with length n consisting of the character ch .

`window.idcok(flag)`

If *flag* is `False`, `curses` no longer considers using the hardware insert/delete character feature of the terminal; if *flag* is `True`, use of character insertion and deletion is enabled. When `curses` is first initialized, use of character insert/delete is enabled by default.

`window.idlok(flag)`

If *flag* is `True`, `curses` will try and use hardware line editing facilities. Otherwise, line insertion/deletion are disabled.

`window.immedok(flag)`

If *flag* is `True`, any change in the window image automatically causes the window to be refreshed; you no longer have to call `refresh()` yourself. However, it may degrade performance considerably, due to repeated calls to `wrefresh`. This option is disabled by default.

`window.inch([y, x])`

Return the character at the given position in the window. The bottom 8 bits are the character proper, and upper bits are the attributes.

`window.insch(ch[, attr])`

`window.insch(y, x, ch[, attr])`

Paint character *ch* at (*y*, *x*) with attributes *attr*, moving the line from position *x* right by one character.

`window.insdelln(nlines)`

Insert *nlines* lines into the specified window above the current line. The *nlines* bottom lines are lost. For negative *nlines*, delete *nlines* lines starting with the one under the cursor, and move the remaining lines up. The bottom *nlines* lines are cleared. The current cursor position remains the same.

`window.insertln()`

Insert a blank line under the cursor. All following lines are moved down by one line.

`window.insnstr(str, n[, attr])`

`window.insnstr(y, x, str, n[, attr])`

Insert a character string (as many characters as will fit on the line) before the character under the cursor, up to *n* characters. If *n* is zero or negative, the entire string is inserted. All characters to the right of the cursor are shifted right, with the rightmost characters on the line being lost. The cursor position does not change (after moving to *y*, *x*, if specified).

`window.insstr(str[, attr])`

`window.insstr(y, x, str[, attr])`

Insert a character string (as many characters as will fit on the line) before the character under the cursor. All characters to the right of the cursor are shifted right, with the rightmost characters on the line being lost. The cursor position does not change (after moving to *y*, *x*, if specified).

`window.instr([n])`

`window.instr(y, x[, n])`

Return a bytes object of characters, extracted from the window starting at the current cursor position, or at *y*, *x* if specified. Attributes are stripped from the characters. If *n* is specified, `instr()` returns a string at most *n* characters long (exclusive of the trailing NUL).

`window.is_linetouched(line)`

Return `True` if the specified line was modified since the last call to `refresh()`; otherwise return `False`. Raise a `curses.error` exception if *line* is not valid for the given window.

`window.is_wintouched()`

Return `True` if the specified window was modified since the last call to `refresh()`; otherwise return `False`.

`window.keypad(flag)`

If *flag* is `True`, escape sequences generated by some keys (keypad, function keys) will be interpreted by `curses`. If *flag* is `False`, escape sequences will be left as is in the input stream.

`window.leaveok(flag)`

If *flag* is `True`, cursor is left where it is on update, instead of being at "cursor position." This reduces cursor movement where possible. If possible the cursor will be made invisible.

If *flag* is `False`, cursor will always be at "cursor position" after an update.

`window.move(new_y, new_x)`

Move cursor to `(new_y, new_x)`.

`window.mvderwin(y, x)`

Move the window inside its parent window. The screen-relative parameters of the window are not changed. This routine is used to display different parts of the parent window at the same physical position on the screen.

`window.mvwin(new_y, new_x)`

Move the window so its upper-left corner is at `(new_y, new_x)`.

`window.nodelay(flag)`

If *flag* is `True`, `getch()` will be non-blocking.

`window.notimeout(flag)`

If *flag* is `True`, escape sequences will not be timed out.

If *flag* is `False`, after a few milliseconds, an escape sequence will not be interpreted, and will be left in the input stream as is.

`window.noutrefresh()`

Mark for refresh but wait. This function updates the data structure representing the desired state of the window, but does not force an update of the physical screen. To accomplish that, call `doupdate()`.

`window.overlay(destwin[, sminrow, smincol, dminrow, dmincol, dmaxrow, dmaxcol])`

Overlay the window on top of *destwin*. The windows need not be the same size, only the overlapping region is copied. This copy is non-destructive, which means that the current background character does not overwrite the old contents of *destwin*.

To get fine-grained control over the copied region, the second form of `overlay()` can be used. *sminrow* and *smincol* are the upper-left coordinates of the source window, and the other variables mark a rectangle in the destination window.

`window.overwrite(destwin[, sminrow, smincol, dminrow, dmincol, dmaxrow, dmaxcol])`

Overwrite the window on top of *destwin*. The windows need not be the same size, in which case only the overlapping region is copied. This copy is destructive, which means that the current background character overwrites the old contents of *destwin*.

To get fine-grained control over the copied region, the second form of `overwrite()` can be used. *sminrow* and *smincol* are the upper-left coordinates of the source window, the other variables mark a rectangle in the destination window.

`window.putwin(file)`

Write all data associated with the window into the provided file object. This information can be later retrieved using the `getwin()` function.

`window.redrawln(beg, num)`

Indicate that the *num* screen lines, starting at line *beg*, are corrupted and should be completely redrawn on the next `refresh()` call.

`window.redrawwin()`

Touch the entire window, causing it to be completely redrawn on the next `refresh()` call.

`window.refresh([pminrow, pmincol, sminrow, smincol, smaxrow, smaxcol])`

Update the display immediately (sync actual screen with previous drawing/deleting methods).

The 6 optional arguments can only be specified when the window is a pad created with `newpad()`. The additional parameters are needed to indicate what part of the pad and screen are involved. *pminrow* and *pmincol* specify the upper left-hand corner of the rectangle to be displayed in the pad. *sminrow*, *smincol*, *smaxrow*, and

smaxcol specify the edges of the rectangle to be displayed on the screen. The lower right-hand corner of the rectangle to be displayed in the pad is calculated from the screen coordinates, since the rectangles must be the same size. Both rectangles must be entirely contained within their respective structures. Negative values of *pminrow*, *pmincol*, *sminrow*, or *smincol* are treated as if they were zero.

`window.resize(nlines, ncols)`

Reallocate storage for a curses window to adjust its dimensions to the specified values. If either dimension is larger than the current values, the window's data is filled with blanks that have the current background rendition (as set by `bkgdset()`) merged into them.

`window.scroll([lines=1])`

Scroll the screen or scrolling region upward by *lines* lines.

`window.scrollok(flag)`

Control what happens when the cursor of a window is moved off the edge of the window or scrolling region, either as a result of a newline action on the bottom line, or typing the last character of the last line. If *flag* is `False`, the cursor is left on the bottom line. If *flag* is `True`, the window is scrolled up one line. Note that in order to get the physical scrolling effect on the terminal, it is also necessary to call `idlok()`.

`window.setscrreg(top, bottom)`

Set the scrolling region from line *top* to line *bottom*. All scrolling actions will take place in this region.

`window.standend()`

Turn off the standout attribute. On some terminals this has the side effect of turning off all attributes.

`window.standout()`

Turn on attribute `A_STANDOUT`.

`window.subpad(begin_y, begin_x)`

`window.subpad(nlines, ncols, begin_y, begin_x)`

Return a sub-window, whose upper-left corner is at (*begin_y*, *begin_x*), and whose width/height is *ncols/nlines*.

`window.subwin(begin_y, begin_x)`

`window.subwin(nlines, ncols, begin_y, begin_x)`

Return a sub-window, whose upper-left corner is at (*begin_y*, *begin_x*), and whose width/height is *ncols/nlines*.

By default, the sub-window will extend from the specified position to the lower right corner of the window.

`window.syncdown()`

Touch each location in the window that has been touched in any of its ancestor windows. This routine is called by `refresh()`, so it should almost never be necessary to call it manually.

`window.syncok(flag)`

If *flag* is `True`, then `syncup()` is called automatically whenever there is a change in the window.

`window.syncup()`

Touch all locations in ancestors of the window that have been changed in the window.

`window.timeout(delay)`

Set blocking or non-blocking read behavior for the window. If *delay* is negative, blocking read is used (which will wait indefinitely for input). If *delay* is zero, then non-blocking read is used, and `getch()` will return `-1` if no input is waiting. If *delay* is positive, then `getch()` will block for *delay* milliseconds, and return `-1` if there is still no input at the end of that time.

`window.touchline(start, count[, changed])`

Pretend *count* lines have been changed, starting with line *start*. If *changed* is supplied, it specifies whether the affected lines are marked as having been changed (*changed*=`True`) or unchanged (*changed*=`False`).

`window.touchwin()`

Pretend the whole window has been changed, for purposes of drawing optimizations.

`window.untouchwin()`

Mark all lines in the window as unchanged since the last call to `refresh()`.

`window.vline(ch, n[, attr])`

`window.vline(y, x, ch, n[, attr])`

Display a vertical line starting at (y, x) with length n consisting of the character ch with attributes $attr$.

16.10.3 Constants

The `curses` module defines the following data members:

`curses.ERR`

Some curses routines that return an integer, such as `getch()`, return `ERR` upon failure.

`curses.OK`

Some curses routines that return an integer, such as `napms()`, return `OK` upon success.

`curses.version`

`curses.__version__`

A bytes object representing the current version of the module.

`curses.ncurses_version`

A named tuple containing the three components of the ncurses library version: *major*, *minor*, and *patch*. All values are integers. The components can also be accessed by name, so `curses.ncurses_version[0]` is equivalent to `curses.ncurses_version.major` and so on.

Availability: if the ncurses library is used.

在 3.8 版新加入.

`curses.COLORS`

The maximum number of colors the terminal can support. It is defined only after the call to `start_color()`.

`curses.COLOR_PAIRS`

The maximum number of color pairs the terminal can support. It is defined only after the call to `start_color()`.

`curses.COLS`

The width of the screen, i.e., the number of columns. It is defined only after the call to `initscr()`. Updated by `update_lines_cols()`, `resizeterm()` and `resize_term()`.

`curses.LINES`

The height of the screen, i.e., the number of lines. It is defined only after the call to `initscr()`. Updated by `update_lines_cols()`, `resizeterm()` and `resize_term()`.

Some constants are available to specify character cell attributes. The exact constants available are system dependent.

Attribute	Meaning
<code>curses.A_ALTCHARSET</code>	Alternate character set mode
<code>curses.A_BLINK</code>	Blink mode
<code>curses.A_BOLD</code>	Bold mode
<code>curses.A_DIM</code>	Dim mode
<code>curses.A_INVIS</code>	Invisible or blank mode
<code>curses.A_ITALIC</code>	Italic mode
<code>curses.A_NORMAL</code>	Normal attribute
<code>curses.A_PROTECT</code>	Protected mode
<code>curses.A_REVERSE</code>	Reverse background and foreground colors
<code>curses.A_STANDOUT</code>	Standout mode
<code>curses.A_UNDERLINE</code>	Underline mode
<code>curses.A_HORIZONTAL</code>	Horizontal highlight
<code>curses.A_LEFT</code>	Left highlight
<code>curses.A_LOW</code>	Low highlight
<code>curses.A_RIGHT</code>	Right highlight
<code>curses.A_TOP</code>	Top highlight
<code>curses.A_VERTICAL</code>	Vertical highlight

在 3.7 版新加入: `A_ITALIC` was added.

Several constants are available to extract corresponding attributes returned by some methods.

Bit-mask	Meaning
<code>curses.A_ATTRIBUTES</code>	Bit-mask to extract attributes
<code>curses.A_CHARTEXT</code>	Bit-mask to extract a character
<code>curses.A_COLOR</code>	Bit-mask to extract color-pair field information

Keys are referred to by integer constants with names starting with `KEY_`. The exact keycaps available are system dependent.

Key constant	Key
<code>curses.KEY_MIN</code>	Minimum key value
<code>curses.KEY_BREAK</code>	Break key (unreliable)
<code>curses.KEY_DOWN</code>	Down-arrow
<code>curses.KEY_UP</code>	Up-arrow
<code>curses.KEY_LEFT</code>	Left-arrow
<code>curses.KEY_RIGHT</code>	Right-arrow
<code>curses.KEY_HOME</code>	Home key (upward+left arrow)
<code>curses.KEY_BACKSPACE</code>	Backspace (unreliable)
<code>curses.KEY_F0</code>	Function keys. Up to 64 function keys are supported.
<code>curses.KEY_Fn</code>	Value of function key <i>n</i>
<code>curses.KEY_DL</code>	Delete line
<code>curses.KEY_IL</code>	Insert line

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Key constant	Key
<code>curses.KEY_DC</code>	Delete character
<code>curses.KEY_IC</code>	Insert char or enter insert mode
<code>curses.KEY_EIC</code>	Exit insert char mode
<code>curses.KEY_CLEAR</code>	Clear screen
<code>curses.KEY_EOS</code>	Clear to end of screen
<code>curses.KEY_EOL</code>	Clear to end of line
<code>curses.KEY_SF</code>	Scroll 1 line forward
<code>curses.KEY_SR</code>	Scroll 1 line backward (reverse)
<code>curses.KEY_NPAGE</code>	Next page
<code>curses.KEY_PPAGE</code>	Previous page
<code>curses.KEY_STAB</code>	Set tab
<code>curses.KEY_CTAB</code>	Clear tab
<code>curses.KEY_CATAB</code>	Clear all tabs
<code>curses.KEY_ENTER</code>	Enter or send (unreliable)
<code>curses.KEY_SRESET</code>	Soft (partial) reset (unreliable)
<code>curses.KEY_RESET</code>	Reset or hard reset (unreliable)

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Key constant	Key
<code>curses.KEY_PRINT</code>	Print
<code>curses.KEY_LL</code>	Home down or bottom (lower left)
<code>curses.KEY_A1</code>	Upper left of keypad
<code>curses.KEY_A3</code>	Upper right of keypad
<code>curses.KEY_B2</code>	Center of keypad
<code>curses.KEY_C1</code>	Lower left of keypad
<code>curses.KEY_C3</code>	Lower right of keypad
<code>curses.KEY_BTAB</code>	Back tab
<code>curses.KEY_BEG</code>	Beg (beginning)
<code>curses.KEY_CANCEL</code>	Cancel
<code>curses.KEY_CLOSE</code>	Close
<code>curses.KEY_COMMAND</code>	Cmd (command)
<code>curses.KEY_COPY</code>	Copy
<code>curses.KEY_CREATE</code>	Create
<code>curses.KEY_END</code>	End
<code>curses.KEY_EXIT</code>	Exit

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Key constant	Key
<code>curses.KEY_FIND</code>	Find
<code>curses.KEY_HELP</code>	Help
<code>curses.KEY_MARK</code>	Mark
<code>curses.KEY_MESSAGE</code>	Message
<code>curses.KEY_MOVE</code>	Move
<code>curses.KEY_NEXT</code>	Next
<code>curses.KEY_OPEN</code>	Open
<code>curses.KEY_OPTIONS</code>	Options
<code>curses.KEY_PREVIOUS</code>	Prev (previous)
<code>curses.KEY_REDO</code>	Redo
<code>curses.KEY_REFERENCE</code>	Ref (reference)
<code>curses.KEY_REFRESH</code>	Refresh
<code>curses.KEY_REPLACE</code>	Replace
<code>curses.KEY_RESTART</code>	Restart
<code>curses.KEY_RESUME</code>	Resume
<code>curses.KEY_SAVE</code>	Save

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Key constant	Key
<code>curses.KEY_SBEG</code>	Shifted Beg (beginning)
<code>curses.KEY_SCANCEL</code>	Shifted Cancel
<code>curses.KEY_SCOMMAND</code>	Shifted Command
<code>curses.KEY_SCOPY</code>	Shifted Copy
<code>curses.KEY_SCREATE</code>	Shifted Create
<code>curses.KEY_SDC</code>	Shifted Delete char
<code>curses.KEY_SDL</code>	Shifted Delete line
<code>curses.KEY_SELECT</code>	Select
<code>curses.KEY_SEND</code>	Shifted End
<code>curses.KEY_SEOL</code>	Shifted Clear line
<code>curses.KEY_SEXIT</code>	Shifted Exit
<code>curses.KEY_SFIND</code>	Shifted Find
<code>curses.KEY_SHELP</code>	Shifted Help
<code>curses.KEY_SHOME</code>	Shifted Home
<code>curses.KEY_SIC</code>	Shifted Input
<code>curses.KEY_SLEFT</code>	Shifted Left arrow

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Key constant	Key
<code>curses.KEY_SMESSAGE</code>	Shifted Message
<code>curses.KEY_SMOVE</code>	Shifted Move
<code>curses.KEY_SNEXT</code>	Shifted Next
<code>curses.KEY_SOPTIONS</code>	Shifted Options
<code>curses.KEY_SPREVIOUS</code>	Shifted Prev
<code>curses.KEY_SPRINT</code>	Shifted Print
<code>curses.KEY_SREDO</code>	Shifted Redo
<code>curses.KEY_SREPLACE</code>	Shifted Replace
<code>curses.KEY_SRIGHT</code>	Shifted Right arrow
<code>curses.KEY_SRSUME</code>	Shifted Resume
<code>curses.KEY_SSAVE</code>	Shifted Save
<code>curses.KEY_SSUSPEND</code>	Shifted Suspend
<code>curses.KEY_SUNDO</code>	Shifted Undo
<code>curses.KEY_SUSPEND</code>	Suspend
<code>curses.KEY_UNDO</code>	Undo
<code>curses.KEY_MOUSE</code>	Mouse event has occurred

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Key constant	Key
<code>curses.KEY_RESIZE</code>	Terminal resize event
<code>curses.KEY_MAX</code>	Maximum key value

On VT100s and their software emulations, such as X terminal emulators, there are normally at least four function keys (`KEY_F1`, `KEY_F2`, `KEY_F3`, `KEY_F4`) available, and the arrow keys mapped to `KEY_UP`, `KEY_DOWN`, `KEY_LEFT` and `KEY_RIGHT` in the obvious way. If your machine has a PC keyboard, it is safe to expect arrow keys and twelve function keys (older PC keyboards may have only ten function keys); also, the following keypad mappings are standard:

Keycap	Constant
Insert	<code>KEY_IC</code>
Delete	<code>KEY_DC</code>
Home	<code>KEY_HOME</code>
End	<code>KEY_END</code>
Page Up	<code>KEY_PPAGE</code>
Page Down	<code>KEY_NPAGE</code>

The following table lists characters from the alternate character set. These are inherited from the VT100 terminal, and will generally be available on software emulations such as X terminals. When there is no graphic available, `curses` falls back on a crude printable ASCII approximation.

備 F: These are available only after `initscr()` has been called.

ACS code	Meaning
<code>curses.ACS_BBSS</code>	alternate name for upper right corner
<code>curses.ACS_BLOCK</code>	solid square block
<code>curses.ACS_BOARD</code>	board of squares
<code>curses.ACS_BSBS</code>	alternate name for horizontal line
<code>curses.ACS_BSSB</code>	alternate name for upper left corner
<code>curses.ACS_BSSS</code>	alternate name for top tee

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ACS code	Meaning
<code>curses.ACS_BTEE</code>	bottom tee
<code>curses.ACS_BULLET</code>	bullet
<code>curses.ACS_CKBOARD</code>	checker board (stipple)
<code>curses.ACS_DARROW</code>	arrow pointing down
<code>curses.ACS_DEGREE</code>	degree symbol
<code>curses.ACS_DIAMOND</code>	diamond
<code>curses.ACS_GEQUAL</code>	greater-than-or-equal-to
<code>curses.ACS_HLINE</code>	horizontal line
<code>curses.ACS_LANTERN</code>	lantern symbol
<code>curses.ACS_LARROW</code>	left arrow
<code>curses.ACS_LEQUAL</code>	less-than-or-equal-to
<code>curses.ACS_LLCORNER</code>	lower left-hand corner
<code>curses.ACS_LRCORNER</code>	lower right-hand corner
<code>curses.ACS_LTEE</code>	left tee
<code>curses.ACS_NEQUAL</code>	not-equal sign
<code>curses.ACS_PI</code>	letter pi

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ACS code	Meaning
<code>curses.ACS_PLMINUS</code>	plus-or-minus sign
<code>curses.ACS_PLUS</code>	big plus sign
<code>curses.ACS_ARROW</code>	right arrow
<code>curses.ACS_RTEE</code>	right tee
<code>curses.ACS_S1</code>	scan line 1
<code>curses.ACS_S3</code>	scan line 3
<code>curses.ACS_S7</code>	scan line 7
<code>curses.ACS_S9</code>	scan line 9
<code>curses.ACS_SBBS</code>	alternate name for lower right corner
<code>curses.ACS_SBSB</code>	alternate name for vertical line
<code>curses.ACS_SBSS</code>	alternate name for right tee
<code>curses.ACS_SSBB</code>	alternate name for lower left corner
<code>curses.ACS_SSBS</code>	alternate name for bottom tee
<code>curses.ACS_SSSB</code>	alternate name for left tee
<code>curses.ACS_SSSS</code>	alternate name for crossover or big plus
<code>curses.ACS_STERLING</code>	pound sterling

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ACS code	Meaning
<code>curses.ACS_TTEE</code>	top tee
<code>curses.ACS_UARROW</code>	up arrow
<code>curses.ACS_ULCORNER</code>	upper left corner
<code>curses.ACS_URCORNER</code>	upper right corner
<code>curses.ACS_VLINE</code>	vertical line

The following table lists mouse button constants used by `getmouse()`:

Mouse button constant	Meaning
<code>curses.BUTTONn_PRESSED</code>	Mouse button <i>n</i> pressed
<code>curses.BUTTONn_RELEASED</code>	Mouse button <i>n</i> released
<code>curses.BUTTONn_CLICKED</code>	Mouse button <i>n</i> clicked
<code>curses.BUTTONn_DOUBLE_CLICKED</code>	Mouse button <i>n</i> double clicked
<code>curses.BUTTONn_TRIPLE_CLICKED</code>	Mouse button <i>n</i> triple clicked
<code>curses.BUTTON_SHIFT</code>	Shift was down during button state change
<code>curses.BUTTON_CTRL</code>	Control was down during button state change
<code>curses.BUTTON_ALT</code>	Control was down during button state change

在 3.10 版的變更: The `BUTTON5_*` constants are now exposed if they are provided by the underlying curses library.

The following table lists the predefined colors:

Constant	色
<code>curses.COLOR_BLACK</code>	黑
<code>curses.COLOR_BLUE</code>	藍
<code>curses.COLOR_CYAN</code>	Cyan (light greenish blue)
<code>curses.COLOR_GREEN</code>	
<code>curses.COLOR_MAGENTA</code>	Magenta (purplish red)
<code>curses.COLOR_RED</code>	紅
<code>curses.COLOR_WHITE</code>	白
<code>curses.COLOR_YELLOW</code>	Yellow

16.11 `curses.textpad` --- Text input widget for curses programs

The `curses.textpad` module provides a `Textbox` class that handles elementary text editing in a curses window, supporting a set of keybindings resembling those of Emacs (thus, also of Netscape Navigator, BBedit 6.x, FrameMaker, and many other programs). The module also provides a rectangle-drawing function useful for framing text boxes or for other purposes.

The module `curses.textpad` defines the following function:

`curses.textpad.rectangle` (*win, uly, ulx, lry, lrx*)

Draw a rectangle. The first argument must be a window object; the remaining arguments are coordinates relative to that window. The second and third arguments are the y and x coordinates of the upper left hand corner of the rectangle to be drawn; the fourth and fifth arguments are the y and x coordinates of the lower right hand corner. The rectangle will be drawn using VT100/IBM PC forms characters on terminals that make this possible (including xterm and most other software terminal emulators). Otherwise it will be drawn with ASCII dashes, vertical bars, and plus signs.

16.11.1 Textbox objects

You can instantiate a `Textbox` object as follows:

class `curses.textpad.Textbox` (*win*)

Return a textbox widget object. The *win* argument should be a curses `window` object in which the textbox is to be contained. The edit cursor of the textbox is initially located at the upper left hand corner of the containing window, with coordinates (0, 0). The instance's `stripspaces` flag is initially on.

`Textbox` objects have the following methods:

edit ([*validator*])

This is the entry point you will normally use. It accepts editing keystrokes until one of the termination keystrokes is entered. If *validator* is supplied, it must be a function. It will be called for each keystroke entered with the keystroke as a parameter; command dispatch is done on the result. This method returns the window contents as a string; whether blanks in the window are included is affected by the *stripspaces* attribute.

do_command (*ch*)

Process a single command keystroke. Here are the supported special keystrokes:

Keystroke	Action
Control-A	Go to left edge of window.
Control-B	Cursor left, wrapping to previous line if appropriate.
Control-D	Delete character under cursor.
Control-E	Go to right edge (stripspaces off) or end of line (stripspaces on).
Control-F	Cursor right, wrapping to next line when appropriate.
Control-G	Terminate, returning the window contents.
Control-H	Delete character backward.
Control-J	Terminate if the window is 1 line, otherwise insert newline.
Control-K	If line is blank, delete it, otherwise clear to end of line.
Control-L	Refresh screen.
Control-N	Cursor down; move down one line.
Control-O	Insert a blank line at cursor location.
Control-P	Cursor up; move up one line.

Move operations do nothing if the cursor is at an edge where the movement is not possible. The following synonyms are supported where possible:

Constant	Keystroke
<i>KEY_LEFT</i>	Control-B
<i>KEY_RIGHT</i>	Control-F
<i>KEY_UP</i>	Control-P
<i>KEY_DOWN</i>	Control-N
<i>KEY_BACKSPACE</i>	Control-h

All other keystrokes are treated as a command to insert the given character and move right (with line wrapping).

gather ()

Return the window contents as a string; whether blanks in the window are included is affected by the *stripspaces* member.

stripspaces

This attribute is a flag which controls the interpretation of blanks in the window. When it is on, trailing blanks on each line are ignored; any cursor motion that would land the cursor on a trailing blank goes to the end of that line instead, and trailing blanks are stripped when the window contents are gathered.

16.12 `curses.ascii` --- ASCII 字元的工具程式

原始碼: [Lib/curses/ascii.py](#)

The `curses.ascii` module supplies name constants for ASCII characters and functions to test membership in various ASCII character classes. The constants supplied are names for control characters as follows:

Name	Meaning
<code>curses.ascii.NUL</code>	
<code>curses.ascii.SOH</code>	Start of heading, console interrupt
<code>curses.ascii.STX</code>	Start of text
<code>curses.ascii.ETX</code>	End of text
<code>curses.ascii.EOT</code>	End of transmission
<code>curses.ascii.ENQ</code>	Enquiry, goes with ACK flow control
<code>curses.ascii.ACK</code>	Acknowledgement
<code>curses.ascii.BEL</code>	Bell
<code>curses.ascii.BS</code>	Backspace
<code>curses.ascii.TAB</code>	Tab
<code>curses.ascii.HT</code>	Alias for TAB : "Horizontal tab"
<code>curses.ascii.LF</code>	Line feed
<code>curses.ascii.NL</code>	Alias for LF : "New line"
<code>curses.ascii.VT</code>	Vertical tab

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Name	Meaning
<code>curses.ascii.FF</code>	Form feed
<code>curses.ascii.CR</code>	Carriage return
<code>curses.ascii.SO</code>	Shift-out, begin alternate character set
<code>curses.ascii.SI</code>	Shift-in, resume default character set
<code>curses.ascii.DLE</code>	Data-link escape
<code>curses.ascii.DC1</code>	XON, for flow control
<code>curses.ascii.DC2</code>	Device control 2, block-mode flow control
<code>curses.ascii.DC3</code>	XOFF, for flow control
<code>curses.ascii.DC4</code>	Device control 4
<code>curses.ascii.NAK</code>	Negative acknowledgement
<code>curses.ascii.SYN</code>	Synchronous idle
<code>curses.ascii.ETB</code>	End transmission block
<code>curses.ascii.CAN</code>	Cancel
<code>curses.ascii.EM</code>	End of medium
<code>curses.ascii.SUB</code>	Substitute
<code>curses.ascii.ESC</code>	Escape

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Name	Meaning
<code>curses.ascii.FS</code>	File separator
<code>curses.ascii.GS</code>	Group separator
<code>curses.ascii.RS</code>	Record separator, block-mode terminator
<code>curses.ascii.US</code>	Unit separator
<code>curses.ascii.SP</code>	Space
<code>curses.ascii.DEL</code>	Delete

Note that many of these have little practical significance in modern usage. The mnemonics derive from teleprinter conventions that predate digital computers.

The module supplies the following functions, patterned on those in the standard C library:

`curses.ascii.isalnum(c)`

Checks for an ASCII alphanumeric character; it is equivalent to `isalpha(c)` or `isdigit(c)`.

`curses.ascii.isalpha(c)`

Checks for an ASCII alphabetic character; it is equivalent to `isupper(c)` or `islower(c)`.

`curses.ascii.isascii(c)`

Checks for a character value that fits in the 7-bit ASCII set.

`curses.ascii.isblank(c)`

Checks for an ASCII whitespace character; space or horizontal tab.

`curses.ascii.iscntrl(c)`

Checks for an ASCII control character (in the range 0x00 to 0x1f or 0x7f).

`curses.ascii.isdigit(c)`

Checks for an ASCII decimal digit, '0' through '9'. This is equivalent to `c in string.digits`.

`curses.ascii.isgraph(c)`

Checks for ASCII any printable character except space.

`curses.ascii.islower(c)`

Checks for an ASCII lower-case character.

`curses.ascii.isprint(c)`

Checks for any ASCII printable character including space.

`curses.ascii.ispunct(c)`

Checks for any printable ASCII character which is not a space or an alphanumeric character.

`curses.ascii.isspace(c)`

Checks for ASCII white-space characters; space, line feed, carriage return, form feed, horizontal tab, vertical tab.

`curses.ascii.isupper(c)`

Checks for an ASCII uppercase letter.

`curses.ascii.isxdigit(c)`

Checks for an ASCII hexadecimal digit. This is equivalent to `c in string.hexdigits`.

`curses.ascii.isctrl(c)`

Checks for an ASCII control character (ordinal values 0 to 31).

`curses.ascii.ismeta(c)`

Checks for a non-ASCII character (ordinal values 0x80 and above).

These functions accept either integers or single-character strings; when the argument is a string, it is first converted using the built-in function `ord()`.

Note that all these functions check ordinal bit values derived from the character of the string you pass in; they do not actually know anything about the host machine's character encoding.

The following two functions take either a single-character string or integer byte value; they return a value of the same type.

`curses.ascii.ascii(c)`

Return the ASCII value corresponding to the low 7 bits of *c*.

`curses.ascii.ctrl(c)`

Return the control character corresponding to the given character (the character bit value is bitwise-anded with 0x1f).

`curses.ascii.alt(c)`

Return the 8-bit character corresponding to the given ASCII character (the character bit value is bitwise-ored with 0x80).

The following function takes either a single-character string or integer value; it returns a string.

`curses.ascii.unctrl(c)`

Return a string representation of the ASCII character *c*. If *c* is printable, this string is the character itself. If the character is a control character (0x00--0x1f) the string consists of a caret ('^') followed by the corresponding uppercase letter. If the character is an ASCII delete (0x7f) the string is '?'. If the character has its meta bit (0x80) set, the meta bit is stripped, the preceding rules applied, and '!' prepended to the result.

`curses.ascii.controlnames`

A 33-element string array that contains the ASCII mnemonics for the thirty-two ASCII control characters from 0 (NUL) to 0x1f (US), in order, plus the mnemonic `SP` for the space character.

16.13 `curses.panel` --- A panel stack extension for `curses`

Panels are windows with the added feature of depth, so they can be stacked on top of each other, and only the visible portions of each window will be displayed. Panels can be added, moved up or down in the stack, and removed.

16.13.1 函式

The module `curses.panel` defines the following functions:

`curses.panel.bottom_panel()`

Returns the bottom panel in the panel stack.

`curses.panel.new_panel(win)`

Returns a panel object, associating it with the given window *win*. Be aware that you need to keep the returned panel object referenced explicitly. If you don't, the panel object is garbage collected and removed from the panel stack.

`curses.panel.top_panel()`

Returns the top panel in the panel stack.

`curses.panel.update_panels()`

Updates the virtual screen after changes in the panel stack. This does not call `curses.doupdate()`, so you'll have to do this yourself.

16.13.2 Panel Objects

Panel objects, as returned by `new_panel()` above, are windows with a stacking order. There's always a window associated with a panel which determines the content, while the panel methods are responsible for the window's depth in the panel stack.

Panel objects have the following methods:

`Panel.above()`

Returns the panel above the current panel.

`Panel.below()`

Returns the panel below the current panel.

`Panel.bottom()`

Push the panel to the bottom of the stack.

`Panel.hidden()`

Returns True if the panel is hidden (not visible), False otherwise.

`Panel.hide()`

Hide the panel. This does not delete the object, it just makes the window on screen invisible.

`Panel.move(y, x)`

Move the panel to the screen coordinates *(y, x)*.

`Panel.replace(win)`

Change the window associated with the panel to the window *win*.

`Panel.set_userptr(obj)`

Set the panel's user pointer to *obj*. This is used to associate an arbitrary piece of data with the panel, and can be any Python object.

`Panel.show()`

Display the panel (which might have been hidden).

`Panel.top()`

Push panel to the top of the stack.

`Panel.userptr()`

Returns the user pointer for the panel. This might be any Python object.

`Panel.window()`

Returns the window object associated with the panel.

16.14 platform --- 獲取底層平台的標識資料

原始碼: [Lib/platform.py](#)

備註: 特定平臺清單按字母順序排列, Linux 包括在 Unix 小節之中。

16.14.1 跨平台

`platform.architecture(executable=sys.executable, bits="", linkage="")`

查詢給定的可執行檔案（預設 Python 直譯器二進位制檔案）來獲取各種架構資訊。

回傳一個 tuple（元組）(bits, linkage)，其中包含可執行檔案所使用的位元架構和連結格式資訊。這兩個值均以字串形式回傳。

無法確定的值將回傳參數所給定之預先設置值。如果給定的位元 `''`，則會使用 `sizeof(pointer)`（或者當 Python 版本 `< 1.5.2` 時 `sizeof(long)`）作所支援指標大小的指示器 (indicator)。

此函式依賴於系統的 `file` 命令來執行實際的操作。這在幾乎所有 Unix 平臺和某些非 Unix 平臺上，只有當可執行檔案指向 Python 直譯器時才可使用。當以上要求不滿足時將會使用合理的預設值。

備註: 在 macOS（也許還有其他平臺）上，可執行檔案可能是包含多種架構的通用檔案。

To get at the "64-bitness" of the current interpreter, it is more reliable to query the `sys.maxsize` attribute:

```
is_64bits = sys.maxsize > 2**32
```

`platform.machine()`

回傳機器種類，例如 `'AMD64'`。如果該值無法確定則會回傳一個空字串。

`platform.node()`

回傳電腦的網路名稱（可能不是完整名稱!）。如果該值無法確定則會回傳一個空字串。

`platform.platform(aliased=0, terse=0)`

會可能附帶有用資訊地回傳一個標識底層平臺的字串。

輸出應人類易讀的 (human readable)，而非機器易剖析的 (machine parseable)。它在不同平臺上看起來可能不一致，這是有意之的。

如果 `aliased` 真值，此函式將使用各種不同於平臺通用名稱的名來回報系統名稱，例如 SunOS 將被回報 Solaris。 `system_alias()` 函式被用於實作此功能。

將 `terse` 設真值將導致此函式只回傳標識平臺所需的最小量資訊。

在 3.8 版的變更: 在 macOS 上，如果 `mac_ver()` 回傳的釋出版字串非空字串，此函式現在會使用它以獲取 macOS 版本而非 darwin 版本。

`platform.processor()`

回傳（真實的）處理器名稱，例如 `'amd64'`。

如果該值無法確定則將回傳空字串。請注意，許多平臺都不提供此資訊或是簡單地回傳與 `machine()` 相同的值。NetBSD 則會提供此資訊。

`platform.python_build()`

回傳一個 tuple (buildno, builddate)，表示字串形式的 Python 建置編號和日期。

`platform.python_compiler()`

回傳一個標識用於編譯 Python 的編譯器的字串。

`platform.python_branch()`

回傳一個標識 Python 實作 SCM 分支的字串。

`platform.python_implementation()`

回傳一個標識 Python 實作的字串。可能的回傳值有：'CPython'、'IronPython'、'Jython'、'PyPy'。

`platform.python_revision()`

回傳一個標識 Python 實作 SCM 修訂版的字串。

`platform.python_version()`

將 Python 版本以字串 'major.minor.patchlevel' 形式回傳。

請注意此回傳值不同於 Python `sys.version`，它總是會包括 patchlevel（預設 '0'）。

`platform.python_version_tuple()`

將 Python 版本以字串 tuple (major, minor, patchlevel) 形式回傳。

請注意此回傳值不同於 Python `sys.version`，它總是會包括 patchlevel（預設 '0'）。

`platform.release()`

回傳系統的釋出版本，例如 '2.2.0' 或 'NT'，如果該值無法確定則將回傳一個空字串。

`platform.system()`

回傳系統/OS 的名稱，例如 'Linux'、'Darwin'、'Java'、'Windows'。如果該值無法確定則回傳一個空字串。

`platform.system_alias(system, release, version)`

回傳做某些系統所使用的常見行銷名稱之名的 (system, release, version)。它還會在可能導致混淆的情下對資訊進行一些重新排序。

`platform.version()`

回傳系統的釋出版本資訊，例如 '#3 on degas'。如果該值無法確定則將回傳一個空字串。

`platform.uname()`

具有高可性 (portable) 的 `uname` 介面。回傳包含六個屬性的 `namedtuple()`：system、node、release、version、machine 和 processor。

請注意此函式新增的第六個屬性 (processor) 不存在於 `os.uname()` 的結果中。且前兩個屬性的屬性名稱也不一致；`os.uname()` 是將它們稱 sysname 和 nodename。

無法確定的條目會被設 ''。

在 3.3 版的變更：將結果從 tuple 改 `namedtuple()`。

16.14.2 Java 平台

`platform.java_ver(release="", vendor="", vminfo="", osinfo="")`

Jython 的版本介面。

回傳一個 tuple (release, vendor, vminfo, osinfo)，其中 `vminfo` 是 tuple (vm_name, vm_release, vm_vendor) 而 `osinfo` 是 tuple (os_name, os_version, os_arch)。無法確定的值將被設由參數所給定的預設值（預設均 ''）。

16.14.3 Windows 平台

`platform.win32_ver (release="", version="", csd="", ptype="")`

從 Windows 登錄檔 (Window Registry) 獲取額外的版本資訊回傳一個 tuple (release, version, csd, ptype)，它代表 OS 發行版、版本號、CSD 級 (service pack) 和 OS 類型 (多個/單個處理器)。

一點提示: `ptype` 在單個處理器的 NT 機器上 'Uniprocessor Free'，而在多個處理器的機器上 'Multiprocessor Free'。'Free' 是指該 OS 版本有除錯程式。它也可能以 'Checked' 表示，代表該 OS 版本使用了除錯程式，即檢查引數、範圍等的程式。

`platform.win32_edition()`

回傳一個代表當前 Windows 版本的字串。可能的值包括但不限於 'Enterprise'、'IoTUAAP'、'ServerStandard' 和 'nanoserver'。

在 3.8 版新加入。

`platform.win32_is_iot()`

如果 `win32_edition()` 回傳的 Windows 版本被識別 IoT 版則回傳 True。

在 3.8 版新加入。

16.14.4 macOS 平台

`platform.mac_ver (release="", versioninfo=("", "", ""), machine="")`

獲取 Mac OS 版本資訊將其回傳 tuple (release, versioninfo, machine)，其中 `versioninfo` 是一個 tuple (version, dev_stage, non_release_version)。

無法確定的條目會被設 ' '。所有 tuple 條目均字串。

16.14.5 Unix 平台

`platform.libc_ver (executable=sys.executable, lib="", version="", chunksize=16384)`

嘗試確認可執行檔案 (預設 Python 直譯器) 所連結到的 libc 版本。回傳一個字串 tuple (lib, version)，當查詢失敗時其預設值將被設給定的參數值。

請注意，此函式對於不同 libc 版本如何可執行檔案新增符號的方式有深層的關聯，可能僅適用於以 gcc 編譯出來的可執行檔案。

檔案會以 `chunksize` 位元組大小的分塊 (chunk) 來讀取和掃描。

16.14.6 Linux 平台

`platform.freedesktop_os_release()`

從 `os-release` 檔案獲取作業系統標識，將其作一個字典回傳。`os-release` 檔案 `freedesktop.org` 標準，在大多數 Linux 發行版上可用。一個重要的例外是 Android 和基於 Android 的發行版。

當 `/etc/os-release` 與 `/usr/lib/os-release` 均無法被讀取時將引發 `OSError` 或其子類。

成功時，該函式將回傳一個字典，其中鍵和值均字串。值當中的特殊字元例如 " 和 \$ 會被移除引號 (unquoted)。欄位 NAME、ID 和 PRETTY_NAME 總會按照標準來定義。所有其他欄位都是可選的。根據不同廠商可能會包括額外的欄位。

請注意 NAME、VERSION 和 VARIANT 等欄位是適用於向使用者展示的字串。程式應當使用 ID、ID_LIKE、VERSION_ID 或 VARIANT_ID 等欄位來標識 Linux 發行版。

範例：

```
def get_like_distro():
    info = platform.freedesktop_os_release()
    ids = [info["ID"]]
    if "ID_LIKE" in info:
        # ids are space separated and ordered by precedence
        ids.extend(info["ID_LIKE"].split())
    return ids
```

在 3.10 版新加入。

16.15 `errno` --- Standard `errno` system symbols

This module makes available standard `errno` system symbols. The value of each symbol is the corresponding integer value. The names and descriptions are borrowed from `linux/include/errno.h`, which should be all-inclusive.

`errno.errorcode`

Dictionary providing a mapping from the `errno` value to the string name in the underlying system. For instance, `errno.errorcode[errno.EPERM]` maps to `'EPERM'`.

To translate a numeric error code to an error message, use `os.strerror()`.

Of the following list, symbols that are not used on the current platform are not defined by the module. The specific list of defined symbols is available as `errno.errorcode.keys()`. Symbols available can include:

`errno.EPERM`

Operation not permitted. This error is mapped to the exception `PermissionError`.

`errno.ENOENT`

No such file or directory. This error is mapped to the exception `FileNotFoundError`.

`errno.ESRCH`

No such process. This error is mapped to the exception `ProcessLookupError`.

`errno.EINTR`

Interrupted system call. This error is mapped to the exception `InterruptedError`.

`errno.EIO`

I/O error

`errno.ENXIO`

No such device or address

`errno.E2BIG`

Arg list too long

`errno.ENOEXEC`

Exec format error

`errno.EBADF`

Bad file number

`errno.ECHILD`

No child processes. This error is mapped to the exception `ChildProcessError`.

`errno.EAGAIN`

Try again. This error is mapped to the exception `BlockingIOError`.

`errno.ENOMEM`

Out of memory

`errno.EACCES`

Permission denied. This error is mapped to the exception *PermissionError*.

`errno.EFAULT`

Bad address

`errno.ENOTBLK`

Block device required

`errno.EBUSY`

Device or resource busy

`errno.EEXIST`

File exists. This error is mapped to the exception *FileExistsError*.

`errno.EXDEV`

Cross-device link

`errno.ENODEV`

No such device

`errno.ENOTDIR`

Not a directory. This error is mapped to the exception *NotADirectoryError*.

`errno.EISDIR`

Is a directory. This error is mapped to the exception *IsADirectoryError*.

`errno.EINVAL`

Invalid argument

`errno.ENFILE`

File table overflow

`errno.EMFILE`

Too many open files

`errno.ENOTTY`

Not a typewriter

`errno.ETXTBSY`

Text file busy

`errno.EFBIG`

File too large

`errno.ENOSPC`

No space left on device

`errno.ESPIPE`

Illegal seek

`errno.EROFS`

Read-only file system

`errno.EMLINK`

Too many links

`errno.EPIPE`

Broken pipe. This error is mapped to the exception *BrokenPipeError*.

`errno.EDOM`

Math argument out of domain of func

`errno.ERANGE`

Math result not representable

`errno.EDEADLK`

Resource deadlock would occur

`errno.ENAMETOOLONG`

File name too long

`errno.ENOLCK`

No record locks available

`errno.ENOSYS`

Function not implemented

`errno.ENOTEMPTY`

Directory not empty

`errno.ELOOP`

Too many symbolic links encountered

`errno.EWOULDBLOCK`

Operation would block. This error is mapped to the exception *BlockingIOError*.

`errno.ENOMSG`

No message of desired type

`errno.EIDRM`

Identifier removed

`errno.ECHRNG`

Channel number out of range

`errno.EL2NSYNC`

Level 2 not synchronized

`errno.EL3HLT`

Level 3 halted

`errno.EL3RST`

Level 3 reset

`errno.ELNRNG`

Link number out of range

`errno.EUNATCH`

Protocol driver not attached

`errno.ENOCSI`

No CSI structure available

`errno.EL2HLT`

Level 2 halted

`errno.EBADE`

Invalid exchange

`errno.EBADR`

Invalid request descriptor

`errno.EXFULL`
Exchange full

`errno.ENOANO`
No anode

`errno.EBADRQC`
Invalid request code

`errno.EBADSLT`
Invalid slot

`errno.EDEADLOCK`
File locking deadlock error

`errno.EBFONT`
Bad font file format

`errno.ENOSTR`
Device not a stream

`errno.ENODATA`
No data available

`errno.ETIME`
Timer expired

`errno.ENOSR`
Out of streams resources

`errno.ENONET`
Machine is not on the network

`errno.ENOPKG`
Package not installed

`errno.EREMOTE`
Object is remote

`errno.ENOLINK`
Link has been severed

`errno.EADV`
Advertise error

`errno.ESRMNT`
Srmount error

`errno.ECOMM`
Communication error on send

`errno.EPROTO`
Protocol error

`errno.EMULTIHOP`
Multihop attempted

`errno.EDOTDOT`
RFS specific error

`errno.EBADMSG`
Not a data message

`errno.EOVERFLOW`
Value too large for defined data type

`errno.ENOTUNIQ`
Name not unique on network

`errno.EBADFD`
File descriptor in bad state

`errno.EREMCHG`
Remote address changed

`errno.ELIBACC`
Can not access a needed shared library

`errno.ELIBBAD`
Accessing a corrupted shared library

`errno.ELIBSCN`
.lib section in a.out corrupted

`errno.ELIBMAX`
Attempting to link in too many shared libraries

`errno.ELIBEXEC`
Cannot exec a shared library directly

`errno.EILSEQ`
Illegal byte sequence

`errno.ERESTART`
Interrupted system call should be restarted

`errno.ESTRPIPE`
Streams pipe error

`errno.EUSERS`
Too many users

`errno.ENOTSOCK`
Socket operation on non-socket

`errno.EDESTADDRREQ`
Destination address required

`errno.EMSGSIZE`
Message too long

`errno.EPROTOTYPE`
Protocol wrong type for socket

`errno.ENOPROTOOPT`
Protocol not available

`errno.EPROTONOSUPPORT`
Protocol not supported

`errno.ESOCKTNOSUPPORT`
Socket type not supported

`errno.EOPNOTSUPP`
Operation not supported on transport endpoint

`errno.ENOTSUP`
Operation not supported
在 3.2 版新加入.

`errno.EPFNOSUPPORT`
Protocol family not supported

`errno.EAFNOSUPPORT`
Address family not supported by protocol

`errno.EADDRINUSE`
Address already in use

`errno.EADDRNOTAVAIL`
Cannot assign requested address

`errno.ENETDOWN`
Network is down

`errno.ENETUNREACH`
Network is unreachable

`errno.ENETRESET`
Network dropped connection because of reset

`errno.ECONNABORTED`
Software caused connection abort. This error is mapped to the exception *ConnectionAbortedError*.

`errno.ECONNRESET`
Connection reset by peer. This error is mapped to the exception *ConnectionResetError*.

`errno.ENOBUFS`
No buffer space available

`errno.EISCONN`
Transport endpoint is already connected

`errno.ENOTCONN`
Transport endpoint is not connected

`errno.ESHUTDOWN`
Cannot send after transport endpoint shutdown. This error is mapped to the exception *BrokenPipeError*.

`errno.ETOOMANYREFS`
Too many references: cannot splice

`errno.ETIMEDOUT`
Connection timed out. This error is mapped to the exception *TimeoutError*.

`errno.ECONNREFUSED`
Connection refused. This error is mapped to the exception *ConnectionRefusedError*.

`errno.EHOSTDOWN`
Host is down

`errno.EHOSTUNREACH`
No route to host

`errno.EALREADY`
Operation already in progress. This error is mapped to the exception *BlockingIOError*.

`errno.EINPROGRESS`

Operation now in progress. This error is mapped to the exception *BlockingIOError*.

`errno.ESTALE`

Stale NFS file handle

`errno.EUCLEAN`

Structure needs cleaning

`errno.ENOTNAM`

Not a XENIX named type file

`errno.ENAVAIL`

No XENIX semaphores available

`errno.EISNAM`

Is a named type file

`errno.EREMOTEIO`

Remote I/O error

`errno.EDQUOT`

Quota exceeded

`errno.EQFULL`

Interface output queue is full

在 3.11 版新加入.

`errno.ENOTCAPABLE`

Capabilities insufficient. This error is mapped to the exception *PermissionError*.

適用: WASI, FreeBSD

在 3.11.1 版新加入.

`errno.ECANCELED`

Operation canceled

在 3.2 版新加入.

`errno.EOWNERDEAD`

Owner died

在 3.2 版新加入.

`errno.ENOTRECOVERABLE`

State not recoverable

在 3.2 版新加入.

16.16 ctypes --- A foreign function library for Python

原始碼: [Lib/ctypes](#)

ctypes is a foreign function library for Python. It provides C compatible data types, and allows calling functions in DLLs or shared libraries. It can be used to wrap these libraries in pure Python.

16.16.1 ctypes tutorial

Note: The code samples in this tutorial use *doctest* to make sure that they actually work. Since some code samples behave differently under Linux, Windows, or macOS, they contain doctest directives in comments.

Note: Some code samples reference the ctypes *c_int* type. On platforms where `sizeof(long) == sizeof(int)` it is an alias to *c_long*. So, you should not be confused if *c_long* is printed if you would expect *c_int* --- they are actually the same type.

Loading dynamic link libraries

ctypes exports the *cdll*, and on Windows *windll* and *oledll* objects, for loading dynamic link libraries.

You load libraries by accessing them as attributes of these objects. *cdll* loads libraries which export functions using the standard *cdecl* calling convention, while *windll* libraries call functions using the *stdcall* calling convention. *oledll* also uses the *stdcall* calling convention, and assumes the functions return a Windows *HRESULT* error code. The error code is used to automatically raise an *OSError* exception when the function call fails.

在 3.3 版的變更: Windows errors used to raise *WindowsError*, which is now an alias of *OSError*.

Here are some examples for Windows. Note that *msvcrt* is the MS standard C library containing most standard C functions, and uses the *cdecl* calling convention:

```
>>> from ctypes import *
>>> print(windll.kernel32)
<WinDLL 'kernel32', handle ... at ...>
>>> print(cdll.msvcrt)
<CDLL 'msvcrt', handle ... at ...>
>>> libc = cdll.msvcrt
>>>
```

Windows appends the usual *.dll* file suffix automatically.

備F: Accessing the standard C library through *cdll.msvcrt* will use an outdated version of the library that may be incompatible with the one being used by Python. Where possible, use native Python functionality, or else import and use the *msvcrt* module.

On Linux, it is required to specify the filename *including* the extension to load a library, so attribute access can not be used to load libraries. Either the *LoadLibrary()* method of the dll loaders should be used, or you should load the library by creating an instance of *CDLL* by calling the constructor:

```
>>> cdll.LoadLibrary("libc.so.6")
<CDLL 'libc.so.6', handle ... at ...>
>>> libc = CDLL("libc.so.6")
>>> libc
<CDLL 'libc.so.6', handle ... at ...>
>>>
```

Accessing functions from loaded dlls

Functions are accessed as attributes of dll objects:

```
>>> libc.printf
<_FuncPtr object at 0x...>
>>> print(windll.kernel32.GetModuleHandleA)
<_FuncPtr object at 0x...>
>>> print(windll.kernel32.MyOwnFunction)
Traceback (most recent call last):
```

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(繼續上一頁)

```
File "<stdin>", line 1, in <module>
File "ctypes.py", line 239, in __getattr__
    func = _StdcallFuncPtr(name, self)
AttributeError: function 'MyOwnFunction' not found
>>>
```

Note that win32 system dlls like kernel32 and user32 often export ANSI as well as UNICODE versions of a function. The UNICODE version is exported with an W appended to the name, while the ANSI version is exported with an A appended to the name. The win32 GetModuleHandle function, which returns a *module handle* for a given module name, has the following C prototype, and a macro is used to expose one of them as GetModuleHandle depending on whether UNICODE is defined or not:

```
/* ANSI version */
HMODULE GetModuleHandleA(LPCSTR lpModuleName);
/* UNICODE version */
HMODULE GetModuleHandleW(LPCWSTR lpModuleName);
```

windll does not try to select one of them by magic, you must access the version you need by specifying GetModuleHandleA or GetModuleHandleW explicitly, and then call it with bytes or string objects respectively.

Sometimes, dlls export functions with names which aren't valid Python identifiers, like "??2@YAPAXI@Z". In this case you have to use `getattr()` to retrieve the function:

```
>>> getattr(cdll.msvcrt, "??2@YAPAXI@Z")
<_FuncPtr object at 0x...>
>>>
```

On Windows, some dlls export functions not by name but by ordinal. These functions can be accessed by indexing the dll object with the ordinal number:

```
>>> cdll.kernel32[1]
<_FuncPtr object at 0x...>
>>> cdll.kernel32[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "ctypes.py", line 310, in __getitem__
    func = _StdcallFuncPtr(name, self)
AttributeError: function ordinal 0 not found
>>>
```

Calling functions

You can call these functions like any other Python callable. This example uses the `time()` function, which returns system time in seconds since the Unix epoch, and the `GetModuleHandleA()` function, which returns a win32 module handle.

This example calls both functions with a NULL pointer (None should be used as the NULL pointer):

```
>>> print(libc.time(None))
1150640792
>>> print(hex(windll.kernel32.GetModuleHandleA(None)))
0x1d000000
>>>
```

ValueError is raised when you call an stdcall function with the `cdecl` calling convention, or vice versa:

```
>>> cdll.kernel32.GetModuleHandleA(None)
Traceback (most recent call last):
```

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```

File "<stdin>", line 1, in <module>
ValueError: Procedure probably called with not enough arguments (4 bytes missing)
>>>

>>> windll.msvcrt.printf(b"spam")
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: Procedure probably called with too many arguments (4 bytes in excess)
>>>

```

To find out the correct calling convention you have to look into the C header file or the documentation for the function you want to call.

On Windows, *ctypes* uses win32 structured exception handling to prevent crashes from general protection faults when functions are called with invalid argument values:

```

>>> windll.kernel32.GetModuleHandleA(32)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
OSError: exception: access violation reading 0x00000020
>>>

```

There are, however, enough ways to crash Python with *ctypes*, so you should be careful anyway. The *faulthandler* module can be helpful in debugging crashes (e.g. from segmentation faults produced by erroneous C library calls).

None, integers, bytes objects and (unicode) strings are the only native Python objects that can directly be used as parameters in these function calls. None is passed as a C NULL pointer, bytes objects and strings are passed as pointer to the memory block that contains their data (*char** or *wchar_t**). Python integers are passed as the platforms default C *int* type, their value is masked to fit into the C type.

Before we move on calling functions with other parameter types, we have to learn more about *ctypes* data types.

Fundamental data types

ctypes defines a number of primitive C compatible data types:

ctypes type	C type	Python type
<code>c_bool</code>	<code>_Bool</code>	<code>bool</code> (1)
<code>c_char</code>	<code>char</code>	1-character bytes object
<code>c_wchar</code>	<code>wchar_t</code>	1-character string
<code>c_byte</code>	<code>char</code>	<code>int</code>
<code>c_ubyte</code>	<code>unsigned char</code>	<code>int</code>
<code>c_short</code>	<code>short</code>	<code>int</code>
<code>c_ushort</code>	<code>unsigned short</code>	<code>int</code>
<code>c_int</code>	<code>int</code>	<code>int</code>
<code>c_uint</code>	<code>unsigned int</code>	<code>int</code>
<code>c_long</code>	<code>long</code>	<code>int</code>
<code>c_ulong</code>	<code>unsigned long</code>	<code>int</code>
<code>c_longlong</code>	<code>__int64</code> 或 <code>long long</code>	<code>int</code>
<code>c_ulonglong</code>	<code>unsigned __int64</code> 或 <code>unsigned long long</code>	<code>int</code>
<code>c_size_t</code>	<code>size_t</code>	<code>int</code>
<code>c_ssize_t</code>	<code>ssize_t</code> or <code>Py_ssize_t</code>	<code>int</code>
<code>c_float</code>	<code>float</code>	<code>float</code>
<code>c_double</code>	<code>double</code>	<code>float</code>
<code>c_longdouble</code>	<code>long double</code>	<code>float</code>
<code>c_char_p</code>	<code>char*</code> (NUL terminated)	bytes object or <code>None</code>
<code>c_wchar_p</code>	<code>wchar_t*</code> (NUL terminated)	字串或 <code>None</code>
<code>c_void_p</code>	<code>void*</code>	<code>int</code> or <code>None</code>

(1) The constructor accepts any object with a truth value.

All these types can be created by calling them with an optional initializer of the correct type and value:

```
>>> c_int()
c_long(0)
>>> c_wchar_p("Hello, World")
c_wchar_p(140018365411392)
>>> c_ushort(-3)
c_ushort(65533)
>>>
```

Since these types are mutable, their value can also be changed afterwards:

```
>>> i = c_int(42)
>>> print(i)
c_long(42)
>>> print(i.value)
42
>>> i.value = -99
>>> print(i.value)
-99
>>>
```

Assigning a new value to instances of the pointer types `c_char_p`, `c_wchar_p`, and `c_void_p` changes the *memory location* they point to, *not the contents* of the memory block (of course not, because Python bytes objects are immutable):

```
>>> s = "Hello, World"
>>> c_s = c_wchar_p(s)
>>> print(c_s)
c_wchar_p(139966785747344)
>>> print(c_s.value)
Hello World
>>> c_s.value = "Hi, there"
>>> print(c_s)           # the memory location has changed
```

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```

c_wchar_p(139966783348904)
>>> print(c_s.value)
Hi, there
>>> print(s)                # first object is unchanged
Hello, World
>>>

```

You should be careful, however, not to pass them to functions expecting pointers to mutable memory. If you need mutable memory blocks, `ctypes` has a `create_string_buffer()` function which creates these in various ways. The current memory block contents can be accessed (or changed) with the `raw` property; if you want to access it as NUL terminated string, use the `value` property:

```

>>> from ctypes import *
>>> p = create_string_buffer(3)                # create a 3 byte buffer, initialized_
↳to NUL bytes
>>> print(sizeof(p), repr(p.raw))
3 b'\x00\x00\x00'
>>> p = create_string_buffer(b"Hello")        # create a buffer containing a NUL_
↳terminated string
>>> print(sizeof(p), repr(p.raw))
6 b'Hello\x00'
>>> print(repr(p.value))
b'Hello'
>>> p = create_string_buffer(b"Hello", 10)    # create a 10 byte buffer
>>> print(sizeof(p), repr(p.raw))
10 b'Hello\x00\x00\x00\x00\x00\x00'
>>> p.value = b"Hi"
>>> print(sizeof(p), repr(p.raw))
10 b'Hi\x00lo\x00\x00\x00\x00\x00'
>>>

```

The `create_string_buffer()` function replaces the old `c_buffer()` function (which is still available as an alias). To create a mutable memory block containing unicode characters of the C type `wchar_t`, use the `create_unicode_buffer()` function.

Calling functions, continued

Note that `printf` prints to the real standard output channel, *not* to `sys.stdout`, so these examples will only work at the console prompt, not from within *IDLE* or *PythonWin*:

```

>>> printf = libc.printf
>>> printf(b"Hello, %s\n", b"World!")
Hello, World!
14
>>> printf(b"Hello, %S\n", "World!")
Hello, World!
14
>>> printf(b"%d bottles of beer\n", 42)
42 bottles of beer
19
>>> printf(b"%f bottles of beer\n", 42.5)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ArgumentError: argument 2: TypeError: Don't know how to convert parameter 2
>>>

```

As has been mentioned before, all Python types except integers, strings, and bytes objects have to be wrapped in their corresponding `ctypes` type, so that they can be converted to the required C data type:

```
>>> printf(b"An int %d, a double %f\n", 1234, c_double(3.14))
An int 1234, a double 3.140000
31
>>>
```

Calling variadic functions

On a lot of platforms calling variadic functions through `ctypes` is exactly the same as calling functions with a fixed number of parameters. On some platforms, and in particular ARM64 for Apple Platforms, the calling convention for variadic functions is different than that for regular functions.

On those platforms it is required to specify the *argtypes* attribute for the regular, non-variadic, function arguments:

```
libc.printf.argtypes = [ctypes.c_char_p]
```

Because specifying the attribute does not inhibit portability it is advised to always specify *argtypes* for all variadic functions.

Calling functions with your own custom data types

You can also customize *ctypes* argument conversion to allow instances of your own classes be used as function arguments. *ctypes* looks for an `_as_parameter_` attribute and uses this as the function argument. The attribute must be an integer, string, bytes, a *ctypes* instance, or an object with an `_as_parameter_` attribute:

```
>>> class Bottles:
...     def __init__(self, number):
...         self._as_parameter_ = number
...
>>> bottles = Bottles(42)
>>> printf(b"%d bottles of beer\n", bottles)
42 bottles of beer
19
>>>
```

If you don't want to store the instance's data in the `_as_parameter_` instance variable, you could define a *property* which makes the attribute available on request.

Specifying the required argument types (function prototypes)

It is possible to specify the required argument types of functions exported from DLLs by setting the *argtypes* attribute.

argtypes must be a sequence of C data types (the `printf` function is probably not a good example here, because it takes a variable number and different types of parameters depending on the format string, on the other hand this is quite handy to experiment with this feature):

```
>>> printf.argtypes = [c_char_p, c_char_p, c_int, c_double]
>>> printf(b"String '%s', Int %d, Double %f\n", b"Hi", 10, 2.2)
String 'Hi', Int 10, Double 2.200000
37
>>>
```

Specifying a format protects against incompatible argument types (just as a prototype for a C function), and tries to convert the arguments to valid types:


```
>>> printf(b"%d %d %d", 1, 2, 3)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ArgumentError: argument 2: TypeError: wrong type
>>> printf(b"%s %d %f\n", b"X", 2, 3)
X 2 3.000000
13
>>>
```

If you have defined your own classes which you pass to function calls, you have to implement a `from_param()` class method for them to be able to use them in the `argtypes` sequence. The `from_param()` class method receives the Python object passed to the function call, it should do a typecheck or whatever is needed to make sure this object is acceptable, and then return the object itself, its `_as_parameter_` attribute, or whatever you want to pass as the C function argument in this case. Again, the result should be an integer, string, bytes, a `ctypes` instance, or an object with an `_as_parameter_` attribute.

Return types

By default functions are assumed to return the C `int` type. Other return types can be specified by setting the `restype` attribute of the function object.

Here is a more advanced example, it uses the `strchr` function, which expects a string pointer and a char, and returns a pointer to a string:

```
>>> strchr = libc.strchr
>>> strchr(b"abcdef", ord("d"))
8059983
>>> strchr.restype = c_char_p      # c_char_p is a pointer to a string
>>> strchr(b"abcdef", ord("d"))
b'def'
>>> print(strchr(b"abcdef", ord("x")))
None
>>>
```

If you want to avoid the `ord("x")` calls above, you can set the `argtypes` attribute, and the second argument will be converted from a single character Python bytes object into a C char:

```
>>> strchr.restype = c_char_p
>>> strchr.argtypes = [c_char_p, c_char]
>>> strchr(b"abcdef", b"d")
'def'
>>> strchr(b"abcdef", b"def")
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ArgumentError: argument 2: TypeError: one character string expected
>>> print(strchr(b"abcdef", b"x"))
None
>>> strchr(b"abcdef", b"d")
'def'
>>>
```

You can also use a callable Python object (a function or a class for example) as the `restype` attribute, if the foreign function returns an integer. The callable will be called with the *integer* the C function returns, and the result of this call will be used as the result of your function call. This is useful to check for error return values and automatically raise an exception:

```
>>> GetModuleHandle = windll.kernel32.GetModuleHandleA
>>> def ValidHandle(value):
...     if value == 0:
...         raise WinError()
```

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```

...     return value
...
>>>
>>> GetModuleHandle.restype = ValidHandle
>>> GetModuleHandle(None)
486539264
>>> GetModuleHandle("something silly")
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "<stdin>", line 3, in ValidHandle
OSError: [Errno 126] The specified module could not be found.
>>>

```

WinError is a function which will call Windows FormatMessage() api to get the string representation of an error code, and returns an exception. WinError takes an optional error code parameter, if no one is used, it calls GetLastError() to retrieve it.

Please note that a much more powerful error checking mechanism is available through the errcheck attribute; see the reference manual for details.

Passing pointers (or: passing parameters by reference)

Sometimes a C api function expects a *pointer* to a data type as parameter, probably to write into the corresponding location, or if the data is too large to be passed by value. This is also known as *passing parameters by reference*.

ctypes exports the byref() function which is used to pass parameters by reference. The same effect can be achieved with the pointer() function, although pointer() does a lot more work since it constructs a real pointer object, so it is faster to use byref() if you don't need the pointer object in Python itself:

```

>>> i = c_int()
>>> f = c_float()
>>> s = create_string_buffer(b'\000' * 32)
>>> print(i.value, f.value, repr(s.value))
0 0.0 b''
>>> libc sscanf(b"1 3.14 Hello", b"%d %f %s",
...             byref(i), byref(f), s)
3
>>> print(i.value, f.value, repr(s.value))
1 3.1400001049 b'Hello'
>>>

```

Structures and unions

Structures and unions must derive from the Structure and Union base classes which are defined in the ctypes module. Each subclass must define a _fields_ attribute. _fields_ must be a list of 2-tuples, containing a *field name* and a *field type*.

The field type must be a ctypes type like c_int, or any other derived ctypes type: structure, union, array, pointer.

Here is a simple example of a POINT structure, which contains two integers named x and y, and also shows how to initialize a structure in the constructor:

```

>>> from ctypes import *
>>> class POINT(Structure):
...     _fields_ = [("x", c_int),
...                 ("y", c_int)]
...
>>> point = POINT(10, 20)

```

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```
>>> print(point.x, point.y)
10 20
>>> point = POINT(y=5)
>>> print(point.x, point.y)
0 5
>>> POINT(1, 2, 3)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: too many initializers
>>>
```

You can, however, build much more complicated structures. A structure can itself contain other structures by using a structure as a field type.

Here is a RECT structure which contains two POINTs named *upperleft* and *lowerright*:

```
>>> class RECT(Structure):
...     _fields_ = [("upperleft", POINT),
...                 ("lowerright", POINT)]
...
>>> rc = RECT(point)
>>> print(rc.upperleft.x, rc.upperleft.y)
0 5
>>> print(rc.lowerright.x, rc.lowerright.y)
0 0
>>>
```

Nested structures can also be initialized in the constructor in several ways:

```
>>> r = RECT(POINT(1, 2), POINT(3, 4))
>>> r = RECT((1, 2), (3, 4))
```

Field *descriptors* can be retrieved from the *class*, they are useful for debugging because they can provide useful information:

```
>>> print(POINT.x)
<Field type=c_long, ofs=0, size=4>
>>> print(POINT.y)
<Field type=c_long, ofs=4, size=4>
>>>
```

警告: *ctypes* does not support passing unions or structures with bit-fields to functions by value. While this may work on 32-bit x86, it's not guaranteed by the library to work in the general case. Unions and structures with bit-fields should always be passed to functions by pointer.

Structure/union alignment and byte order

By default, Structure and Union fields are aligned in the same way the C compiler does it. It is possible to override this behavior by specifying a `_pack_` class attribute in the subclass definition. This must be set to a positive integer and specifies the maximum alignment for the fields. This is what `#pragma pack(n)` also does in MSVC.

ctypes uses the native byte order for Structures and Unions. To build structures with non-native byte order, you can use one of the *BigEndianStructure*, *LittleEndianStructure*, *BigEndianUnion*, and *LittleEndianUnion* base classes. These classes cannot contain pointer fields.

Bit fields in structures and unions

It is possible to create structures and unions containing bit fields. Bit fields are only possible for integer fields, the bit width is specified as the third item in the `_fields_` tuples:

```
>>> class Int(Structure):
...     _fields_ = [("first_16", c_int, 16),
...                 ("second_16", c_int, 16)]
...
>>> print(Int.first_16)
<Field type=c_long, ofs=0:0, bits=16>
>>> print(Int.second_16)
<Field type=c_long, ofs=0:16, bits=16>
>>>
```

Arrays

Arrays are sequences, containing a fixed number of instances of the same type.

The recommended way to create array types is by multiplying a data type with a positive integer:

```
TenPointsArrayType = POINT * 10
```

Here is an example of a somewhat artificial data type, a structure containing 4 POINTs among other stuff:

```
>>> from ctypes import *
>>> class POINT(Structure):
...     _fields_ = ("x", c_int), ("y", c_int)
...
>>> class MyStruct(Structure):
...     _fields_ = [("a", c_int),
...                 ("b", c_float),
...                 ("point_array", POINT * 4)]
...
>>> print(len(MyStruct().point_array))
4
>>>
```

Instances are created in the usual way, by calling the class:

```
arr = TenPointsArrayType()
for pt in arr:
    print(pt.x, pt.y)
```

The above code print a series of 0 0 lines, because the array contents is initialized to zeros.

Initializers of the correct type can also be specified:

```
>>> from ctypes import *
>>> TenIntegers = c_int * 10
>>> ii = TenIntegers(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
>>> print(ii)
<c_long_Array_10 object at 0x...>
>>> for i in ii: print(i, end=" ")
...
1 2 3 4 5 6 7 8 9 10
>>>
```

Pointers

Pointer instances are created by calling the `pointer()` function on a `ctypes` type:

```
>>> from ctypes import *
>>> i = c_int(42)
>>> pi = pointer(i)
>>>
```

Pointer instances have a `contents` attribute which returns the object to which the pointer points, the `i` object above:

```
>>> pi.contents
c_long(42)
>>>
```

Note that `ctypes` does not have OOR (original object return), it constructs a new, equivalent object each time you retrieve an attribute:

```
>>> pi.contents is i
False
>>> pi.contents is pi.contents
False
>>>
```

Assigning another `c_int` instance to the pointer's `contents` attribute would cause the pointer to point to the memory location where this is stored:

```
>>> i = c_int(99)
>>> pi.contents = i
>>> pi.contents
c_long(99)
>>>
```

Pointer instances can also be indexed with integers:

```
>>> pi[0]
99
>>>
```

Assigning to an integer index changes the pointed to value:

```
>>> print(i)
c_long(99)
>>> pi[0] = 22
>>> print(i)
c_long(22)
>>>
```

It is also possible to use indexes different from 0, but you must know what you're doing, just as in C: You can access or change arbitrary memory locations. Generally you only use this feature if you receive a pointer from a C function, and you *know* that the pointer actually points to an array instead of a single item.

Behind the scenes, the `pointer()` function does more than simply create pointer instances, it has to create pointer *types* first. This is done with the `POINTER()` function, which accepts any `ctypes` type, and returns a new type:

```
>>> PI = POINTER(c_int)
>>> PI
<class 'ctypes.LP_c_long'>
>>> PI(42)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: expected c_long instead of int
```

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```
>>> PI(c_int(42))
<ctypes.LP_c_long object at 0x...>
>>>
```

Calling the pointer type without an argument creates a NULL pointer. NULL pointers have a False boolean value:

```
>>> null_ptr = POINTER(c_int)()
>>> print(bool(null_ptr))
False
>>>
```

`ctypes` checks for NULL when dereferencing pointers (but dereferencing invalid non-NULL pointers would crash Python):

```
>>> null_ptr[0]
Traceback (most recent call last):
....
ValueError: NULL pointer access
>>>

>>> null_ptr[0] = 1234
Traceback (most recent call last):
....
ValueError: NULL pointer access
>>>
```

Type conversions

Usually, `ctypes` does strict type checking. This means, if you have `POINTER(c_int)` in the `argtypes` list of a function or as the type of a member field in a structure definition, only instances of exactly the same type are accepted. There are some exceptions to this rule, where `ctypes` accepts other objects. For example, you can pass compatible array instances instead of pointer types. So, for `POINTER(c_int)`, `ctypes` accepts an array of `c_int`:

```
>>> class Bar(Structure):
...     _fields_ = [("count", c_int), ("values", POINTER(c_int))]
...
>>> bar = Bar()
>>> bar.values = (c_int * 3)(1, 2, 3)
>>> bar.count = 3
>>> for i in range(bar.count):
...     print(bar.values[i])
...
1
2
3
>>>
```

In addition, if a function argument is explicitly declared to be a pointer type (such as `POINTER(c_int)`) in `argtypes`, an object of the pointed type (`c_int` in this case) can be passed to the function. `ctypes` will apply the required `byref()` conversion in this case automatically.

To set a `POINTER` type field to NULL, you can assign `None`:

```
>>> bar.values = None
>>>
```

Sometimes you have instances of incompatible types. In C, you can cast one type into another type. `ctypes` provides a `cast()` function which can be used in the same way. The `Bar` structure defined above accepts `POINTER(c_int)` pointers or `c_int` arrays for its `values` field, but not instances of other types:

```
>>> bar.values = (c_byte * 4)()
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: incompatible types, c_byte_Array_4 instance instead of LP_c_long_
↳instance
>>>
```

For these cases, the `cast()` function is handy.

The `cast()` function can be used to cast a ctypes instance into a pointer to a different ctypes data type. `cast()` takes two parameters, a ctypes object that is or can be converted to a pointer of some kind, and a ctypes pointer type. It returns an instance of the second argument, which references the same memory block as the first argument:

```
>>> a = (c_byte * 4)()
>>> cast(a, POINTER(c_int))
<ctypes.LP_c_long object at ...>
>>>
```

So, `cast()` can be used to assign to the `values` field of `Bar` the structure:

```
>>> bar = Bar()
>>> bar.values = cast((c_byte * 4)(), POINTER(c_int))
>>> print(bar.values[0])
0
>>>
```

Incomplete Types

Incomplete Types are structures, unions or arrays whose members are not yet specified. In C, they are specified by forward declarations, which are defined later:

```
struct cell; /* forward declaration */

struct cell {
    char *name;
    struct cell *next;
};
```

The straightforward translation into ctypes code would be this, but it does not work:

```
>>> class cell(Structure):
...     _fields_ = [("name", c_char_p),
...                 ("next", POINTER(cell))]
...
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "<stdin>", line 2, in cell
NameError: name 'cell' is not defined
>>>
```

because the new class `cell` is not available in the class statement itself. In *ctypes*, we can define the `cell` class and set the `_fields_` attribute later, after the class statement:

```
>>> from ctypes import *
>>> class cell(Structure):
...     pass
...
>>> cell._fields_ = [("name", c_char_p),
...                  ("next", POINTER(cell))]
>>>
```

Let's try it. We create two instances of `cell`, and let them point to each other, and finally follow the pointer chain a few times:

```
>>> c1 = cell()
>>> c1.name = b"foo"
>>> c2 = cell()
>>> c2.name = b"bar"
>>> c1.next = pointer(c2)
>>> c2.next = pointer(c1)
>>> p = c1
>>> for i in range(8):
...     print(p.name, end=" ")
...     p = p.next[0]
...
foo bar foo bar foo bar foo bar
>>>
```

Callback functions

`ctypes` allows creating C callable function pointers from Python callables. These are sometimes called *callback functions*.

First, you must create a class for the callback function. The class knows the calling convention, the return type, and the number and types of arguments this function will receive.

The `CFUNCTYPE()` factory function creates types for callback functions using the `cdecl` calling convention. On Windows, the `WINFUNCTYPE()` factory function creates types for callback functions using the `stdcall` calling convention.

Both of these factory functions are called with the result type as first argument, and the callback functions expected argument types as the remaining arguments.

I will present an example here which uses the standard C library's `qsort()` function, that is used to sort items with the help of a callback function. `qsort()` will be used to sort an array of integers:

```
>>> IntArray5 = c_int * 5
>>> ia = IntArray5(5, 1, 7, 33, 99)
>>> qsort = libc.qsort
>>> qsort.restype = None
>>>
```

`qsort()` must be called with a pointer to the data to sort, the number of items in the data array, the size of one item, and a pointer to the comparison function, the callback. The callback will then be called with two pointers to items, and it must return a negative integer if the first item is smaller than the second, a zero if they are equal, and a positive integer otherwise.

So our callback function receives pointers to integers, and must return an integer. First we create the `type` for the callback function:

```
>>> CMPFUNC = CFUNCTYPE(c_int, POINTER(c_int), POINTER(c_int))
>>>
```

To get started, here is a simple callback that shows the values it gets passed:

```
>>> def py_cmp_func(a, b):
...     print("py_cmp_func", a[0], b[0])
...     return 0
...
>>> cmp_func = CMPFUNC(py_cmp_func)
>>>
```

The result:


```
>>> qsort(ia, len(ia), sizeof(c_int), cmp_func)
py_cmp_func 5 1
py_cmp_func 33 99
py_cmp_func 7 33
py_cmp_func 5 7
py_cmp_func 1 7
>>>
```

Now we can actually compare the two items and return a useful result:

```
>>> def py_cmp_func(a, b):
...     print("py_cmp_func", a[0], b[0])
...     return a[0] - b[0]
...
>>>
>>> qsort(ia, len(ia), sizeof(c_int), CMPFUNC(py_cmp_func))
py_cmp_func 5 1
py_cmp_func 33 99
py_cmp_func 7 33
py_cmp_func 1 7
py_cmp_func 5 7
>>>
```

As we can easily check, our array is sorted now:

```
>>> for i in ia: print(i, end=" ")
...
1 5 7 33 99
>>>
```

The function factories can be used as decorator factories, so we may as well write:

```
>>> @CFUNCTYPE(c_int, POINTER(c_int), POINTER(c_int))
... def py_cmp_func(a, b):
...     print("py_cmp_func", a[0], b[0])
...     return a[0] - b[0]
...
>>> qsort(ia, len(ia), sizeof(c_int), py_cmp_func)
py_cmp_func 5 1
py_cmp_func 33 99
py_cmp_func 7 33
py_cmp_func 1 7
py_cmp_func 5 7
>>>
```

備註: Make sure you keep references to `CFUNCTYPE()` objects as long as they are used from C code. `ctypes` doesn't, and if you don't, they may be garbage collected, crashing your program when a callback is made.

Also, note that if the callback function is called in a thread created outside of Python's control (e.g. by the foreign code that calls the callback), `ctypes` creates a new dummy Python thread on every invocation. This behavior is correct for most purposes, but it means that values stored with `threading.local` will *not* survive across different callbacks, even when those calls are made from the same C thread.

Accessing values exported from dlls

Some shared libraries not only export functions, they also export variables. An example in the Python library itself is the `Py_OptimizeFlag`, an integer set to 0, 1, or 2, depending on the `-O` or `-OO` flag given on startup.

`ctypes` can access values like this with the `in_dll()` class methods of the type. `pythonapi` is a predefined symbol giving access to the Python C api:

```
>>> opt_flag = c_int.in_dll(pythonapi, "Py_OptimizeFlag")
>>> print(opt_flag)
c_long(0)
>>>
```

If the interpreter would have been started with `-O`, the sample would have printed `c_long(1)`, or `c_long(2)` if `-OO` would have been specified.

An extended example which also demonstrates the use of pointers accesses the `PyImport_FrozenModules` pointer exported by Python.

Quoting the docs for that value:

This pointer is initialized to point to an array of `_frozen` records, terminated by one whose members are all NULL or zero. When a frozen module is imported, it is searched in this table. Third-party code could play tricks with this to provide a dynamically created collection of frozen modules.

So manipulating this pointer could even prove useful. To restrict the example size, we show only how this table can be read with `ctypes`:

```
>>> from ctypes import *
>>>
>>> class struct_frozen(Structure):
...     _fields_ = [("name", c_char_p),
...                 ("code", POINTER(c_ubyte)),
...                 ("size", c_int),
...                 ("get_code", POINTER(c_ubyte)), # Function pointer
...                 ]
...
>>>
```

We have defined the `_frozen` data type, so we can get the pointer to the table:

```
>>> FrozenTable = POINTER(struct_frozen)
>>> table = FrozenTable.in_dll(pythonapi, "_PyImport_FrozenBootstrap")
>>>
```

Since `table` is a pointer to the array of `struct_frozen` records, we can iterate over it, but we just have to make sure that our loop terminates, because pointers have no size. Sooner or later it would probably crash with an access violation or whatever, so it's better to break out of the loop when we hit the `NULL` entry:

```
>>> for item in table:
...     if item.name is None:
...         break
...     print(item.name.decode("ascii"), item.size)
...
_frozen_importlib 31764
_frozen_importlib_external 41499
zipimport 12345
>>>
```

The fact that standard Python has a frozen module and a frozen package (indicated by the negative `size` member) is not well known, it is only used for testing. Try it out with `import __hello__` for example.

Surprises

There are some edges in *ctypes* where you might expect something other than what actually happens.

Consider the following example:

```
>>> from ctypes import *
>>> class POINT(Structure):
...     _fields_ = ("x", c_int), ("y", c_int)
...
>>> class RECT(Structure):
...     _fields_ = ("a", POINT), ("b", POINT)
...
>>> p1 = POINT(1, 2)
>>> p2 = POINT(3, 4)
>>> rc = RECT(p1, p2)
>>> print(rc.a.x, rc.a.y, rc.b.x, rc.b.y)
1 2 3 4
>>> # now swap the two points
>>> rc.a, rc.b = rc.b, rc.a
>>> print(rc.a.x, rc.a.y, rc.b.x, rc.b.y)
3 4 3 4
>>>
```

Hm. We certainly expected the last statement to print 3 4 1 2. What happened? Here are the steps of the `rc.a, rc.b = rc.b, rc.a` line above:

```
>>> temp0, temp1 = rc.b, rc.a
>>> rc.a = temp0
>>> rc.b = temp1
>>>
```

Note that `temp0` and `temp1` are objects still using the internal buffer of the `rc` object above. So executing `rc.a = temp0` copies the buffer contents of `temp0` into `rc`'s buffer. This, in turn, changes the contents of `temp1`. So, the last assignment `rc.b = temp1`, doesn't have the expected effect.

Keep in mind that retrieving sub-objects from Structure, Unions, and Arrays doesn't *copy* the sub-object, instead it retrieves a wrapper object accessing the root-object's underlying buffer.

Another example that may behave differently from what one would expect is this:

```
>>> s = c_char_p()
>>> s.value = b"abc def ghi"
>>> s.value
b'abc def ghi'
>>> s.value is s.value
False
>>>
```

備F: Objects instantiated from `c_char_p` can only have their value set to bytes or integers.

Why is it printing `False`? *ctypes* instances are objects containing a memory block plus some *descriptors* accessing the contents of the memory. Storing a Python object in the memory block does not store the object itself, instead the contents of the object is stored. Accessing the contents again constructs a new Python object each time!

Variable-sized data types

`ctypes` provides some support for variable-sized arrays and structures.

The `resize()` function can be used to resize the memory buffer of an existing `ctypes` object. The function takes the object as first argument, and the requested size in bytes as the second argument. The memory block cannot be made smaller than the natural memory block specified by the object's type, a `ValueError` is raised if this is tried:

```
>>> short_array = (c_short * 4)()
>>> print(sizeof(short_array))
8
>>> resize(short_array, 4)
Traceback (most recent call last):
...
ValueError: minimum size is 8
>>> resize(short_array, 32)
>>> sizeof(short_array)
32
>>> sizeof(type(short_array))
8
>>>
```

This is nice and fine, but how would one access the additional elements contained in this array? Since the type still only knows about 4 elements, we get errors accessing other elements:

```
>>> short_array[:]
[0, 0, 0, 0]
>>> short_array[7]
Traceback (most recent call last):
...
IndexError: invalid index
>>>
```

Another way to use variable-sized data types with `ctypes` is to use the dynamic nature of Python, and (re-)define the data type after the required size is already known, on a case by case basis.

16.16.2 ctypes reference

Finding shared libraries

When programming in a compiled language, shared libraries are accessed when compiling/linking a program, and when the program is run.

The purpose of the `find_library()` function is to locate a library in a way similar to what the compiler or runtime loader does (on platforms with several versions of a shared library the most recent should be loaded), while the `ctypes` library loaders act like when a program is run, and call the runtime loader directly.

The `ctypes.util` module provides a function which can help to determine the library to load.

`ctypes.util.find_library(name)`

Try to find a library and return a pathname. *name* is the library name without any prefix like *lib*, suffix like *.so*, *.dylib* or version number (this is the form used for the posix linker option *-l*). If no library can be found, returns `None`.

The exact functionality is system dependent.

On Linux, `find_library()` tries to run external programs (`/sbin/ldconfig`, `gcc`, `objdump` and `ld`) to find the library file. It returns the filename of the library file.

在 3.6 版的變更: On Linux, the value of the environment variable `LD_LIBRARY_PATH` is used when searching for libraries, if a library cannot be found by any other means.

以下是一些範例:

```
>>> from ctypes.util import find_library
>>> find_library("m")
'libm.so.6'
>>> find_library("c")
'libc.so.6'
>>> find_library("bz2")
'libbz2.so.1.0'
>>>
```

On macOS, `find_library()` tries several predefined naming schemes and paths to locate the library, and returns a full pathname if successful:

```
>>> from ctypes.util import find_library
>>> find_library("c")
'/usr/lib/libc.dylib'
>>> find_library("m")
'/usr/lib/libm.dylib'
>>> find_library("bz2")
'/usr/lib/libbz2.dylib'
>>> find_library("AGL")
'/System/Library/Frameworks/AGL.framework/AGL'
>>>
```

On Windows, `find_library()` searches along the system search path, and returns the full pathname, but since there is no predefined naming scheme a call like `find_library("c")` will fail and return `None`.

If wrapping a shared library with `ctypes`, it *may* be better to determine the shared library name at development time, and hardcode that into the wrapper module instead of using `find_library()` to locate the library at runtime.

Loading shared libraries

There are several ways to load shared libraries into the Python process. One way is to instantiate one of the following classes:

```
class ctypes.CDLL(name, mode=DEFAULT_MODE, handle=None, use_errno=False, use_last_error=False,
                  winmode=None)
```

Instances of this class represent loaded shared libraries. Functions in these libraries use the standard C calling convention, and are assumed to return `int`.

On Windows creating a `CDLL` instance may fail even if the DLL name exists. When a dependent DLL of the loaded DLL is not found, a `OSError` error is raised with the message "[WinError 126] The specified module could not be found". This error message does not contain the name of the missing DLL because the Windows API does not return this information making this error hard to diagnose. To resolve this error and determine which DLL is not found, you need to find the list of dependent DLLs and determine which one is not found using Windows debugging and tracing tools.

也參考:

Microsoft `DUMPBIN` tool -- A tool to find DLL dependents.

```
class ctypes.OleDLL(name, mode=DEFAULT_MODE, handle=None, use_errno=False,
                   use_last_error=False, winmode=None)
```

Windows only: Instances of this class represent loaded shared libraries, functions in these libraries use the `stdcall` calling convention, and are assumed to return the windows specific `HRESULT` code. `HRESULT` values contain information specifying whether the function call failed or succeeded, together with additional error code. If the return value signals a failure, an `OSError` is automatically raised.

在 3.3 版的變更: `WindowsError` used to be raised, which is now an alias of `OSError`.

```
class ctypes.WinDLL(name, mode=DEFAULT_MODE, handle=None, use_errno=False,
                   use_last_error=False, winmode=None)
```

Windows only: Instances of this class represent loaded shared libraries, functions in these libraries use the `stdcall` calling convention, and are assumed to return `int` by default.

The Python *global interpreter lock* is released before calling any function exported by these libraries, and reacquired afterwards.

class `ctypes.PyDLL` (*name*, *mode*=`DEFAULT_MODE`, *handle*=`None`)

Instances of this class behave like `CDLL` instances, except that the Python GIL is *not* released during the function call, and after the function execution the Python error flag is checked. If the error flag is set, a Python exception is raised.

Thus, this is only useful to call Python C api functions directly.

All these classes can be instantiated by calling them with at least one argument, the pathname of the shared library. If you have an existing handle to an already loaded shared library, it can be passed as the `handle` named parameter, otherwise the underlying platforms `dlopen` or `LoadLibrary` function is used to load the library into the process, and to get a handle to it.

The *mode* parameter can be used to specify how the library is loaded. For details, consult the `dlopen(3)` manpage. On Windows, *mode* is ignored. On posix systems, `RTLD_NOW` is always added, and is not configurable.

The *use_errno* parameter, when set to true, enables a ctypes mechanism that allows accessing the system *errno* error number in a safe way. ctypes maintains a thread-local copy of the systems *errno* variable; if you call foreign functions created with `use_errno=True` then the *errno* value before the function call is swapped with the ctypes private copy, the same happens immediately after the function call.

The function `ctypes.get_errno()` returns the value of the ctypes private copy, and the function `ctypes.set_errno()` changes the ctypes private copy to a new value and returns the former value.

The *use_last_error* parameter, when set to true, enables the same mechanism for the Windows error code which is managed by the `GetLastError()` and `SetLastError()` Windows API functions; `ctypes.get_last_error()` and `ctypes.set_last_error()` are used to request and change the ctypes private copy of the windows error code.

The *winmode* parameter is used on Windows to specify how the library is loaded (since *mode* is ignored). It takes any value that is valid for the Win32 API `LoadLibraryEx` flags parameter. When omitted, the default is to use the flags that result in the most secure DLL load to avoiding issues such as DLL hijacking. Passing the full path to the DLL is the safest way to ensure the correct library and dependencies are loaded.

在 3.8 版的變更: 新增 *winmode* 參數。

`ctypes.RTLD_GLOBAL`

Flag to use as *mode* parameter. On platforms where this flag is not available, it is defined as the integer zero.

`ctypes.RTLD_LOCAL`

Flag to use as *mode* parameter. On platforms where this is not available, it is the same as `RTLD_GLOBAL`.

`ctypes.DEFAULT_MODE`

The default mode which is used to load shared libraries. On OSX 10.3, this is `RTLD_GLOBAL`, otherwise it is the same as `RTLD_LOCAL`.

Instances of these classes have no public methods. Functions exported by the shared library can be accessed as attributes or by index. Please note that accessing the function through an attribute caches the result and therefore accessing it repeatedly returns the same object each time. On the other hand, accessing it through an index returns a new object each time:

```
>>> from ctypes import CDLL
>>> libc = CDLL("libc.so.6") # On Linux
>>> libc.time == libc.time
True
>>> libc['time'] == libc['time']
False
```

The following public attributes are available, their name starts with an underscore to not clash with exported function names:

`PyDLL._handle`

The system handle used to access the library.

`PyDLL._name`

The name of the library passed in the constructor.

Shared libraries can also be loaded by using one of the prefabricated objects, which are instances of the `LibraryLoader` class, either by calling the `LoadLibrary()` method, or by retrieving the library as attribute of the loader instance.

class `ctypes.LibraryLoader` (*dlltype*)

Class which loads shared libraries. *dlltype* should be one of the `CDLL`, `PyDLL`, `WinDLL`, or `OleDLL` types.

`__getattr__()` has special behavior: It allows loading a shared library by accessing it as attribute of a library loader instance. The result is cached, so repeated attribute accesses return the same library each time.

LoadLibrary (*name*)

Load a shared library into the process and return it. This method always returns a new instance of the library.

These prefabricated library loaders are available:

`ctypes.cdll`

Creates `CDLL` instances.

`ctypes.windll`

Windows only: Creates `WinDLL` instances.

`ctypes.oledll`

Windows only: Creates `OleDLL` instances.

`ctypes.pydll`

Creates `PyDLL` instances.

For accessing the C Python api directly, a ready-to-use Python shared library object is available:

`ctypes.pythonapi`

An instance of `PyDLL` that exposes Python C API functions as attributes. Note that all these functions are assumed to return C `int`, which is of course not always the truth, so you have to assign the correct `restype` attribute to use these functions.

引發一個附帶引數 *name* 的稽核事件 `ctypes.dlopen`。

Accessing a function on a loaded library raises an auditing event `ctypes.dlsym` with arguments `library` (the library object) and `name` (the symbol's name as a string or integer).

In cases when only the library handle is available rather than the object, accessing a function raises an auditing event `ctypes.dlsym/handle` with arguments `handle` (the raw library handle) and `name`.

Foreign functions

As explained in the previous section, foreign functions can be accessed as attributes of loaded shared libraries. The function objects created in this way by default accept any number of arguments, accept any ctypes data instances as arguments, and return the default result type specified by the library loader. They are instances of a private class:

class `ctypes._FuncPtr`

Base class for C callable foreign functions.

Instances of foreign functions are also C compatible data types; they represent C function pointers.

This behavior can be customized by assigning to special attributes of the foreign function object.

restype

Assign a ctypes type to specify the result type of the foreign function. Use `None` for `void`, a function not returning anything.

It is possible to assign a callable Python object that is not a ctypes type, in this case the function is assumed to return a C `int`, and the callable will be called with this integer, allowing further processing or error checking. Using this is deprecated, for more flexible post processing or error checking use a ctypes data type as `restype` and assign a callable to the `errcheck` attribute.

argtypes

Assign a tuple of ctypes types to specify the argument types that the function accepts. Functions using the `stdcall` calling convention can only be called with the same number of arguments as the length of this tuple; functions using the C calling convention accept additional, unspecified arguments as well.

When a foreign function is called, each actual argument is passed to the `from_param()` class method of the items in the `argtypes` tuple, this method allows adapting the actual argument to an object that the foreign function accepts. For example, a `c_char_p` item in the `argtypes` tuple will convert a string passed as argument into a bytes object using ctypes conversion rules.

New: It is now possible to put items in `argtypes` which are not ctypes types, but each item must have a `from_param()` method which returns a value usable as argument (integer, string, ctypes instance). This allows defining adapters that can adapt custom objects as function parameters.

errcheck

Assign a Python function or another callable to this attribute. The callable will be called with three or more arguments:

callable (*result, func, arguments*)

result is what the foreign function returns, as specified by the `restype` attribute.

func is the foreign function object itself, this allows reusing the same callable object to check or post process the results of several functions.

arguments is a tuple containing the parameters originally passed to the function call, this allows specializing the behavior on the arguments used.

The object that this function returns will be returned from the foreign function call, but it can also check the result value and raise an exception if the foreign function call failed.

exception `ctypes.ArgumentError`

This exception is raised when a foreign function call cannot convert one of the passed arguments.

On Windows, when a foreign function call raises a system exception (for example, due to an access violation), it will be captured and replaced with a suitable Python exception. Further, an auditing event `ctypes.seh_exception` with argument `code` will be raised, allowing an audit hook to replace the exception with its own.

Some ways to invoke foreign function calls may raise an auditing event `ctypes.call_function` with arguments `function pointer` and `arguments`.

Function prototypes

Foreign functions can also be created by instantiating function prototypes. Function prototypes are similar to function prototypes in C; they describe a function (return type, argument types, calling convention) without defining an implementation. The factory functions must be called with the desired result type and the argument types of the function, and can be used as decorator factories, and as such, be applied to functions through the `@wrapper` syntax. See *Callback functions* for examples.

`ctypes.CFUNCTYPE` (*restype*, **argtypes*, *use_errno*=False, *use_last_error*=False)

The returned function prototype creates functions that use the standard C calling convention. The function will release the GIL during the call. If *use_errno* is set to true, the ctypes private copy of the system `errno` variable is exchanged with the real `errno` value before and after the call; *use_last_error* does the same for the Windows error code.

`ctypes.WINFUNCTYPE` (*restype*, **argtypes*, *use_errno*=False, *use_last_error*=False)

Windows only: The returned function prototype creates functions that use the `stdcall` calling convention. The function will release the GIL during the call. *use_errno* and *use_last_error* have the same meaning as above.

`ctypes.PYFUNCTYPE` (*restype*, **argtypes*)

The returned function prototype creates functions that use the Python calling convention. The function will *not* release the GIL during the call.

Function prototypes created by these factory functions can be instantiated in different ways, depending on the type and number of the parameters in the call:

prototype (*address*)

Returns a foreign function at the specified address which must be an integer.

prototype (*callable*)

Create a C callable function (a callback function) from a Python *callable*.

prototype (*func_spec* [, *paramflags*])

Returns a foreign function exported by a shared library. *func_spec* must be a 2-tuple (*name_or_ordinal*, *library*). The first item is the name of the exported function as string, or the ordinal of the exported function as small integer. The second item is the shared library instance.

prototype (*vtbl_index*, *name* [, *paramflags* [, *iid*]])

Returns a foreign function that will call a COM method. *vtbl_index* is the index into the virtual function table, a small non-negative integer. *name* is name of the COM method. *iid* is an optional pointer to the interface identifier which is used in extended error reporting.

COM methods use a special calling convention: They require a pointer to the COM interface as first argument, in addition to those parameters that are specified in the *argtypes* tuple.

The optional *paramflags* parameter creates foreign function wrappers with much more functionality than the features described above.

paramflags must be a tuple of the same length as *argtypes*.

Each item in this tuple contains further information about a parameter, it must be a tuple containing one, two, or three items.

The first item is an integer containing a combination of direction flags for the parameter:

- 1 Specifies an input parameter to the function.
- 2 Output parameter. The foreign function fills in a value.
- 4 Input parameter which defaults to the integer zero.

The optional second item is the parameter name as string. If this is specified, the foreign function can be called with named parameters.

The optional third item is the default value for this parameter.

The following example demonstrates how to wrap the Windows `MessageBoxW` function so that it supports default parameters and named arguments. The C declaration from the windows header file is this:

```
WINUSERAPI int WINAPI
MessageBoxW(
    HWND hWnd,
    LPCWSTR lpText,
    LPCWSTR lpCaption,
    UINT uType);
```

Here is the wrapping with `ctypes`:

```
>>> from ctypes import c_int, WINFUNCTYPE, windll
>>> from ctypes.wintypes import HWND, LPCWSTR, UINT
>>> prototype = WINFUNCTYPE(c_int, HWND, LPCWSTR, LPCWSTR, UINT)
>>> paramflags = (1, "hwnd", 0), (1, "text", "Hi"), (1, "caption", "Hello from_
↳ctypes"), (1, "flags", 0)
>>> MessageBox = prototype(("MessageBoxW", windll.user32), paramflags)
```

The `MessageBox` foreign function can now be called in these ways:

```
>>> MessageBox()
>>> MessageBox(text="Spam, spam, spam")
>>> MessageBox(flags=2, text="foo bar")
```

A second example demonstrates output parameters. The win32 `GetWindowRect` function retrieves the dimensions of a specified window by copying them into `RECT` structure that the caller has to supply. Here is the C declaration:

```
WINUSERAPI BOOL WINAPI
GetWindowRect(
    HWND hWnd,
    LPRECT lpRect);
```

Here is the wrapping with `ctypes`:

```
>>> from ctypes import POINTER, WINFUNCTYPE, windll, WinError
>>> from ctypes.wintypes import BOOL, HWND, RECT
>>> prototype = WINFUNCTYPE(BOOL, HWND, POINTER(RECT))
>>> paramflags = (1, "hwnd"), (2, "lprect")
>>> GetWindowRect = prototype(("GetWindowRect", windll.user32), paramflags)
>>>
```

Functions with output parameters will automatically return the output parameter value if there is a single one, or a tuple containing the output parameter values when there are more than one, so the `GetWindowRect` function now returns a `RECT` instance, when called.

Output parameters can be combined with the `errcheck` protocol to do further output processing and error checking. The win32 `GetWindowRect` api function returns a `BOOL` to signal success or failure, so this function could do the error checking, and raises an exception when the api call failed:

```
>>> def errcheck(result, func, args):
...     if not result:
...         raise WinError()
...     return args
...
>>> GetWindowRect.errcheck = errcheck
>>>
```

If the `errcheck` function returns the argument tuple it receives unchanged, `ctypes` continues the normal processing it does on the output parameters. If you want to return a tuple of window coordinates instead of a `RECT` instance, you can retrieve the fields in the function and return them instead, the normal processing will no longer take place:

```
>>> def errcheck(result, func, args):
...     if not result:
...         raise WinError()
...     rc = args[1]
...     return rc.left, rc.top, rc.bottom, rc.right
...
>>> GetWindowRect.errcheck = errcheck
>>>
```

Utility functions

`ctypes.addressof(obj)`

Returns the address of the memory buffer as integer. *obj* must be an instance of a `ctypes` type.

引發一個附帶引數 *obj* 的稽核事件 `ctypes.addressof`。

`ctypes.alignment(obj_or_type)`

Returns the alignment requirements of a `ctypes` type. *obj_or_type* must be a `ctypes` type or instance.

`ctypes.byref(obj[, offset])`

Returns a light-weight pointer to *obj*, which must be an instance of a `ctypes` type. *offset* defaults to zero, and must be an integer that will be added to the internal pointer value.

`byref(obj, offset)` corresponds to this C code:

```
((char *)&obj) + offset)
```

The returned object can only be used as a foreign function call parameter. It behaves similar to `pointer(obj)`, but the construction is a lot faster.

`ctypes.cast(obj, type)`

This function is similar to the cast operator in C. It returns a new instance of *type* which points to the same memory block as *obj*. *type* must be a pointer type, and *obj* must be an object that can be interpreted as a pointer.

`ctypes.create_string_buffer(init_or_size, size=None)`

This function creates a mutable character buffer. The returned object is a `ctypes` array of `c_char`.

init_or_size must be an integer which specifies the size of the array, or a bytes object which will be used to initialize the array items.

If a bytes object is specified as first argument, the buffer is made one item larger than its length so that the last element in the array is a NUL termination character. An integer can be passed as second argument which allows specifying the size of the array if the length of the bytes should not be used.

引發一個附帶引數 *init* 與 *size* 的稽核事件 `ctypes.create_string_buffer`。

`ctypes.create_unicode_buffer(init_or_size, size=None)`

This function creates a mutable unicode character buffer. The returned object is a `ctypes` array of `c_wchar`.

init_or_size must be an integer which specifies the size of the array, or a string which will be used to initialize the array items.

If a string is specified as first argument, the buffer is made one item larger than the length of the string so that the last element in the array is a NUL termination character. An integer can be passed as second argument which allows specifying the size of the array if the length of the string should not be used.

引發一個附帶引數 *init* 與 *size* 的稽核事件 `ctypes.create_unicode_buffer`。

`ctypes.DllCanUnloadNow()`

Windows only: This function is a hook which allows implementing in-process COM servers with ctypes. It is called from the `DllCanUnloadNow` function that the `_ctypes` extension dll exports.

`ctypes.DllGetClassObject()`

Windows only: This function is a hook which allows implementing in-process COM servers with ctypes. It is called from the `DllGetClassObject` function that the `_ctypes` extension dll exports.

`ctypes.util.find_library(name)`

Try to find a library and return a pathname. *name* is the library name without any prefix like `lib`, suffix like `.so`, `.dylib` or version number (this is the form used for the posix linker option `-l`). If no library can be found, returns `None`.

The exact functionality is system dependent.

`ctypes.util.find_msvcr()`

Windows only: return the filename of the VC runtime library used by Python, and by the extension modules. If the name of the library cannot be determined, `None` is returned.

If you need to free memory, for example, allocated by an extension module with a call to the `free(void*)`, it is important that you use the function in the same library that allocated the memory.

`ctypes.FormatError([code])`

Windows only: Returns a textual description of the error code *code*. If no error code is specified, the last error code is used by calling the Windows api function `GetLastError`.

`ctypes.GetLastError()`

Windows only: Returns the last error code set by Windows in the calling thread. This function calls the Windows `GetLastError()` function directly, it does not return the ctypes-private copy of the error code.

`ctypes.get_errno()`

Returns the current value of the ctypes-private copy of the system *errno* variable in the calling thread.

引發一個不附帶引數的稽核事件 `ctypes.get_errno`。

`ctypes.get_last_error()`

Windows only: returns the current value of the ctypes-private copy of the system `LastError` variable in the calling thread.

引發一個不附帶引數的稽核事件 `ctypes.get_last_error`。

`ctypes.memmove(dst, src, count)`

Same as the standard C `memmove` library function: copies *count* bytes from *src* to *dst*. *dst* and *src* must be integers or ctypes instances that can be converted to pointers.

`ctypes.memset(dst, c, count)`

Same as the standard C `memset` library function: fills the memory block at address *dst* with *count* bytes of value *c*. *dst* must be an integer specifying an address, or a ctypes instance.

`ctypes.POINTER(type, /)`

Create and return a new ctypes pointer type. Pointer types are cached and reused internally, so calling this function repeatedly is cheap. *type* must be a ctypes type.

`ctypes.pointer(obj, /)`

Create a new pointer instance, pointing to *obj*. The returned object is of the type `POINTER(type(obj))`.

Note: If you just want to pass a pointer to an object to a foreign function call, you should use `byref(obj)` which is much faster.

`ctypes.resize(obj, size)`

This function resizes the internal memory buffer of *obj*, which must be an instance of a ctypes type. It is not possible to make the buffer smaller than the native size of the objects type, as given by `sizeof(type(obj))`, but it is possible to enlarge the buffer.

`ctypes.set_errno(value)`

Set the current value of the ctypes-private copy of the system `errno` variable in the calling thread to *value* and return the previous value.

引發一個附帶引數 `errno` 的稽核事件 `ctypes.set_errno`。

`ctypes.set_last_error(value)`

Windows only: set the current value of the ctypes-private copy of the system `LastError` variable in the calling thread to *value* and return the previous value.

引發一個附帶引數 `error` 的稽核事件 `ctypes.get_last_error`。

`ctypes.sizeof(obj_or_type)`

Returns the size in bytes of a ctypes type or instance memory buffer. Does the same as the C `sizeof` operator.

`ctypes.string_at(address, size=-1)`

This function returns the C string starting at memory address *address* as a bytes object. If *size* is specified, it is used as size, otherwise the string is assumed to be zero-terminated.

引發一個附帶引數 `error`、`size` 的稽核事件 `ctypes.string_at`。

`ctypes.WinError(code=None, descr=None)`

Windows only: this function is probably the worst-named thing in ctypes. It creates an instance of `OSError`. If *code* is not specified, `GetLastError` is called to determine the error code. If *descr* is not specified, `FormatError()` is called to get a textual description of the error.

在 3.3 版的變更: An instance of `WindowsError` used to be created, which is now an alias of `OSError`.

`ctypes.wstring_at(address, size=-1)`

This function returns the wide character string starting at memory address *address* as a string. If *size* is specified, it is used as the number of characters of the string, otherwise the string is assumed to be zero-terminated.

引發一個附帶引數 `address`、`size` 的稽核事件 `ctypes.wstring_at`。

Data types

class `ctypes._CData`

This non-public class is the common base class of all ctypes data types. Among other things, all ctypes type instances contain a memory block that hold C compatible data; the address of the memory block is returned by the `addressof()` helper function. Another instance variable is exposed as `_objects`; this contains other Python objects that need to be kept alive in case the memory block contains pointers.

Common methods of ctypes data types, these are all class methods (to be exact, they are methods of the *metaclass*):

from_buffer (*source*[, *offset*])

This method returns a ctypes instance that shares the buffer of the *source* object. The *source* object must support the writeable buffer interface. The optional *offset* parameter specifies an offset into the source buffer in bytes; the default is zero. If the source buffer is not large enough a `ValueError` is raised.

引發一個附帶引數 `pointer`、`size`、`offset` 的稽核事件 `ctypes.cdata/buffer`。

from_buffer_copy (*source*[, *offset*])

This method creates a ctypes instance, copying the buffer from the *source* object buffer which must be readable. The optional *offset* parameter specifies an offset into the source buffer in bytes; the default is zero. If the source buffer is not large enough a `ValueError` is raised.

引發一個附帶引數 `pointer`、`size`、`offset` 的稽核事件 `ctypes.cdata/buffer`。

from_address (*address*)

This method returns a ctypes type instance using the memory specified by *address* which must be an integer.

引發一個附帶引數 `address` 的稽核事件 `ctypes.cdata`。

from_param (*obj*)

This method adapts *obj* to a ctypes type. It is called with the actual object used in a foreign function call when the type is present in the foreign function's `argtypes` tuple; it must return an object that can be used as a function call parameter.

All ctypes data types have a default implementation of this classmethod that normally returns *obj* if that is an instance of the type. Some types accept other objects as well.

in_dll (*library*, *name*)

This method returns a ctypes type instance exported by a shared library. *name* is the name of the symbol that exports the data, *library* is the loaded shared library.

Common instance variables of ctypes data types:

_b_base_

Sometimes ctypes data instances do not own the memory block they contain, instead they share part of the memory block of a base object. The `_b_base_` read-only member is the root ctypes object that owns the memory block.

_b_needsfree_

This read-only variable is true when the ctypes data instance has allocated the memory block itself, false otherwise.

_objects

This member is either `None` or a dictionary containing Python objects that need to be kept alive so that the memory block contents is kept valid. This object is only exposed for debugging; never modify the contents of this dictionary.

Fundamental data types

class ctypes._SimpleCData

This non-public class is the base class of all fundamental ctypes data types. It is mentioned here because it contains the common attributes of the fundamental ctypes data types. `_SimpleCData` is a subclass of `_CData`, so it inherits their methods and attributes. ctypes data types that are not and do not contain pointers can now be pickled.

Instances have a single attribute:

value

This attribute contains the actual value of the instance. For integer and pointer types, it is an integer, for character types, it is a single character bytes object or string, for character pointer types it is a Python bytes object or string.

When the `value` attribute is retrieved from a ctypes instance, usually a new object is returned each time. `ctypes` does *not* implement original object return, always a new object is constructed. The same is true for all other ctypes object instances.

Fundamental data types, when returned as foreign function call results, or, for example, by retrieving structure field members or array items, are transparently converted to native Python types. In other words, if a foreign function has a `restype` of `c_char_p`, you will always receive a Python bytes object, *not* a `c_char_p` instance.

Subclasses of fundamental data types do *not* inherit this behavior. So, if a foreign functions `restype` is a subclass of `c_void_p`, you will receive an instance of this subclass from the function call. Of course, you can get the value of the pointer by accessing the `value` attribute.

These are the fundamental ctypes data types:

class ctypes.c_byte

Represents the C `signed char` datatype, and interprets the value as small integer. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_char`

Represents the C `char` datatype, and interprets the value as a single character. The constructor accepts an optional string initializer, the length of the string must be exactly one character.

class `ctypes.c_char_p`

Represents the C `char*` datatype when it points to a zero-terminated string. For a general character pointer that may also point to binary data, `POINTER(c_char)` must be used. The constructor accepts an integer address, or a bytes object.

class `ctypes.c_double`

Represents the C `double` datatype. The constructor accepts an optional float initializer.

class `ctypes.c_longdouble`

Represents the C `long double` datatype. The constructor accepts an optional float initializer. On platforms where `sizeof(long double) == sizeof(double)` it is an alias to `c_double`.

class `ctypes.c_float`

Represents the C `float` datatype. The constructor accepts an optional float initializer.

class `ctypes.c_int`

Represents the C `signed int` datatype. The constructor accepts an optional integer initializer; no overflow checking is done. On platforms where `sizeof(int) == sizeof(long)` it is an alias to `c_long`.

class `ctypes.c_int8`

Represents the C 8-bit `signed int` datatype. Usually an alias for `c_byte`.

class `ctypes.c_int16`

Represents the C 16-bit `signed int` datatype. Usually an alias for `c_short`.

class `ctypes.c_int32`

Represents the C 32-bit `signed int` datatype. Usually an alias for `c_int`.

class `ctypes.c_int64`

Represents the C 64-bit `signed int` datatype. Usually an alias for `c_longlong`.

class `ctypes.c_long`

Represents the C `signed long` datatype. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_longlong`

Represents the C `signed long long` datatype. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_short`

Represents the C `signed short` datatype. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_size_t`

Represents the C `size_t` datatype.

class `ctypes.c_ssize_t`

Represents the C `ssize_t` datatype.

在 3.2 版新加入。

class `ctypes.c_ubyte`

Represents the C `unsigned char` datatype, it interprets the value as small integer. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_uint`

Represents the C `unsigned int` datatype. The constructor accepts an optional integer initializer; no overflow checking is done. On platforms where `sizeof(int) == sizeof(long)` it is an alias for `c_ulong`.

class `ctypes.c_uint8`

Represents the C 8-bit unsigned int datatype. Usually an alias for `c_ubyte`.

class `ctypes.c_uint16`

Represents the C 16-bit unsigned int datatype. Usually an alias for `c_ushort`.

class `ctypes.c_uint32`

Represents the C 32-bit unsigned int datatype. Usually an alias for `c_uint`.

class `ctypes.c_uint64`

Represents the C 64-bit unsigned int datatype. Usually an alias for `c_ulonglong`.

class `ctypes.c_ulong`

Represents the C unsigned long datatype. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_ulonglong`

Represents the C unsigned long long datatype. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_ushort`

Represents the C unsigned short datatype. The constructor accepts an optional integer initializer; no overflow checking is done.

class `ctypes.c_void_p`

Represents the C void* type. The value is represented as integer. The constructor accepts an optional integer initializer.

class `ctypes.c_wchar`

Represents the C wchar_t datatype, and interprets the value as a single character unicode string. The constructor accepts an optional string initializer, the length of the string must be exactly one character.

class `ctypes.c_wchar_p`

Represents the C wchar_t* datatype, which must be a pointer to a zero-terminated wide character string. The constructor accepts an integer address, or a string.

class `ctypes.c_bool`

Represent the C bool datatype (more accurately, _Bool from C99). Its value can be True or False, and the constructor accepts any object that has a truth value.

class `ctypes.HRESULT`

Windows only: Represents a HRESULT value, which contains success or error information for a function or method call.

class `ctypes.py_object`

Represents the C PyObject* datatype. Calling this without an argument creates a NULL PyObject* pointer.

The `ctypes.wintypes` module provides quite some other Windows specific data types, for example HWND, WPARAM, or DWORD. Some useful structures like MSG or RECT are also defined.

Structured data types

class `ctypes.Union` (*args, **kw)

Abstract base class for unions in native byte order.

class `ctypes.BigEndianUnion` (*args, **kw)

Abstract base class for unions in *big endian* byte order.

在 3.11 版新加入.

class `ctypes.LittleEndianUnion` (*args, **kw)

Abstract base class for unions in *little endian* byte order.

在 3.11 版新加入.

class `ctypes.BigEndianStructure` (*args, **kw)

Abstract base class for structures in *big endian* byte order.

class `ctypes.LittleEndianStructure` (*args, **kw)

Abstract base class for structures in *little endian* byte order.

Structures and unions with non-native byte order cannot contain pointer type fields, or any other data types containing pointer type fields.

class `ctypes.Structure` (*args, **kw)

Abstract base class for structures in *native* byte order.

Concrete structure and union types must be created by subclassing one of these types, and at least define a `__fields__` class variable. `ctypes` will create *descriptors* which allow reading and writing the fields by direct attribute accesses. These are the

`__fields__`

A sequence defining the structure fields. The items must be 2-tuples or 3-tuples. The first item is the name of the field, the second item specifies the type of the field; it can be any ctypes data type.

For integer type fields like `c_int`, a third optional item can be given. It must be a small positive integer defining the bit width of the field.

Field names must be unique within one structure or union. This is not checked, only one field can be accessed when names are repeated.

It is possible to define the `__fields__` class variable *after* the class statement that defines the Structure subclass, this allows creating data types that directly or indirectly reference themselves:

```
class List(Structure):
    pass
List.__fields__ = [("pNext", POINTER(List)),
                  ...
                  ]
```

The `__fields__` class variable must, however, be defined before the type is first used (an instance is created, `sizeof()` is called on it, and so on). Later assignments to the `__fields__` class variable will raise an `AttributeError`.

It is possible to define sub-subclasses of structure types, they inherit the fields of the base class plus the `__fields__` defined in the sub-subclass, if any.

`__pack__`

An optional small integer that allows overriding the alignment of structure fields in the instance. `__pack__` must already be defined when `__fields__` is assigned, otherwise it will have no effect.

`__anonymous__`

An optional sequence that lists the names of unnamed (anonymous) fields. `__anonymous__` must be already defined when `__fields__` is assigned, otherwise it will have no effect.

The fields listed in this variable must be structure or union type fields. `ctypes` will create descriptors in the structure type that allows accessing the nested fields directly, without the need to create the structure or union field.

Here is an example type (Windows):

```
class _U(Union):
    _fields_ = [ ("lptdesc", POINTER(TYPEDESC)),
                 ("lpadesc", POINTER(ARRAYDESC)),
                 ("hreftype", HREFTYPE) ]

class TYPEDESC(Structure):
    _anonymous_ = ("u",)
    _fields_ = [ ("u", _U),
                 ("vt", VARTYPE) ]
```

The TYPEDESC structure describes a COM data type, the `vt` field specifies which one of the union fields is valid. Since the `u` field is defined as anonymous field, it is now possible to access the members directly off the TYPEDESC instance. `td.lptdesc` and `td.u.lptdesc` are equivalent, but the former is faster since it does not need to create a temporary union instance:

```
td = TYPEDESC()
td.vt = VT_PTR
td.lptdesc = POINTER(some_type)
td.u.lptdesc = POINTER(some_type)
```

It is possible to define sub-subclasses of structures, they inherit the fields of the base class. If the subclass definition has a separate `_fields_` variable, the fields specified in this are appended to the fields of the base class.

Structure and union constructors accept both positional and keyword arguments. Positional arguments are used to initialize member fields in the same order as they appear in `_fields_`. Keyword arguments in the constructor are interpreted as attribute assignments, so they will initialize `_fields_` with the same name, or create new attributes for names not present in `_fields_`.

Arrays and pointers

class `ctypes.Array(*args)`

Abstract base class for arrays.

The recommended way to create concrete array types is by multiplying any `ctypes` data type with a non-negative integer. Alternatively, you can subclass this type and define `_length_` and `_type_` class variables. Array elements can be read and written using standard subscript and slice accesses; for slice reads, the resulting object is *not* itself an `Array`.

length

A positive integer specifying the number of elements in the array. Out-of-range subscripts result in an `IndexError`. Will be returned by `len()`.

type

Specifies the type of each element in the array.

Array subclass constructors accept positional arguments, used to initialize the elements in order.

class `ctypes._Pointer`

Private, abstract base class for pointers.

Concrete pointer types are created by calling `POINTER()` with the type that will be pointed to; this is done automatically by `pointer()`.

If a pointer points to an array, its elements can be read and written using standard subscript and slice accesses. Pointer objects have no size, so `len()` will raise `TypeError`. Negative subscripts will read from the memory

before the pointer (as in C), and out-of-range subscripts will probably crash with an access violation (if you're lucky).

type

Specifies the type pointed to.

contents

Returns the object to which the pointer points. Assigning to this attribute changes the pointer to point to the assigned object.

☐行執行 (Concurrent Execution)

本章節描述的模組在程式的☐行執行上提供支援。選擇要使用哪一個工具則取☐於是執行什☐樣的任務 (CPU 密集或 IO 密集) 與偏好的開發風格 (事件驅動協作式多工處理或搶占式多工處理)。以下☐此章節總覽：

17.1 threading --- Thread-based parallelism

原始碼： [Lib/threading.py](#)

This module constructs higher-level threading interfaces on top of the lower level `_thread` module.

在 3.7 版的變更： This module used to be optional, it is now always available.

也參考：

`concurrent.futures.ThreadPoolExecutor` offers a higher level interface to push tasks to a background thread without blocking execution of the calling thread, while still being able to retrieve their results when needed.

`queue` provides a thread-safe interface for exchanging data between running threads.

`asyncio` offers an alternative approach to achieving task level concurrency without requiring the use of multiple operating system threads.

備☐： In the Python 2.x series, this module contained `camelCase` names for some methods and functions. These are deprecated as of Python 3.10, but they are still supported for compatibility with Python 2.5 and lower.

CPython 實作細節： In CPython, due to the *Global Interpreter Lock*, only one thread can execute Python code at once (even though certain performance-oriented libraries might overcome this limitation). If you want your application to make better use of the computational resources of multi-core machines, you are advised to use `multiprocessing` or `concurrent.futures.ProcessPoolExecutor`. However, threading is still an appropriate model if you want to run multiple I/O-bound tasks simultaneously.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See *WebAssembly 平台* for more information.

This module defines the following functions:

`threading.active_count()`

Return the number of *Thread* objects currently alive. The returned count is equal to the length of the list returned by *enumerate()*.

The function `activeCount` is a deprecated alias for this function.

`threading.current_thread()`

Return the current *Thread* object, corresponding to the caller's thread of control. If the caller's thread of control was not created through the *threading* module, a dummy thread object with limited functionality is returned.

The function `currentThread` is a deprecated alias for this function.

`threading.excepthook(args, /)`

Handle uncaught exception raised by *Thread.run()*.

The *args* argument has the following attributes:

- *exc_type*: Exception type.
- *exc_value*: Exception value, can be `None`.
- *exc_traceback*: Exception traceback, can be `None`.
- *thread*: Thread which raised the exception, can be `None`.

If *exc_type* is *SystemExit*, the exception is silently ignored. Otherwise, the exception is printed out on *sys.stderr*.

If this function raises an exception, *sys.excepthook()* is called to handle it.

threading.excepthook() can be overridden to control how uncaught exceptions raised by *Thread.run()* are handled.

Storing *exc_value* using a custom hook can create a reference cycle. It should be cleared explicitly to break the reference cycle when the exception is no longer needed.

Storing *thread* using a custom hook can resurrect it if it is set to an object which is being finalized. Avoid storing *thread* after the custom hook completes to avoid resurrecting objects.

也参考:

sys.excepthook() handles uncaught exceptions.

在 3.8 版新加入.

`threading.__excepthook__`

Holds the original value of *threading.excepthook()*. It is saved so that the original value can be restored in case they happen to get replaced with broken or alternative objects.

在 3.10 版新加入.

`threading.get_ident()`

Return the 'thread identifier' of the current thread. This is a nonzero integer. Its value has no direct meaning; it is intended as a magic cookie to be used e.g. to index a dictionary of thread-specific data. Thread identifiers may be recycled when a thread exits and another thread is created.

在 3.3 版新加入.

`threading.get_native_id()`

Return the native integral Thread ID of the current thread assigned by the kernel. This is a non-negative integer. Its value may be used to uniquely identify this particular thread system-wide (until the thread terminates, after which the value may be recycled by the OS).

Availability: Windows, FreeBSD, Linux, macOS, OpenBSD, NetBSD, AIX.

在 3.8 版新加入.

`threading.enumerate()`

Return a list of all *Thread* objects currently active. The list includes daemon threads and dummy thread objects created by *current_thread()*. It excludes terminated threads and threads that have not yet been started. However, the main thread is always part of the result, even when terminated.

`threading.main_thread()`

Return the main *Thread* object. In normal conditions, the main thread is the thread from which the Python interpreter was started.

在 3.4 版新加入。

`threading.settrace(func)`

Set a trace function for all threads started from the *threading* module. The *func* will be passed to *sys.settrace()* for each thread, before its *run()* method is called.

`threading.gettrace()`

Get the trace function as set by *settrace()*.

在 3.10 版新加入。

`threading.setprofile(func)`

Set a profile function for all threads started from the *threading* module. The *func* will be passed to *sys.setprofile()* for each thread, before its *run()* method is called.

`threading.getprofile()`

Get the profiler function as set by *setprofile()*.

在 3.10 版新加入。

`threading.stack_size([size])`

Return the thread stack size used when creating new threads. The optional *size* argument specifies the stack size to be used for subsequently created threads, and must be 0 (use platform or configured default) or a positive integer value of at least 32,768 (32 KiB). If *size* is not specified, 0 is used. If changing the thread stack size is unsupported, a *RuntimeError* is raised. If the specified stack size is invalid, a *ValueError* is raised and the stack size is unmodified. 32 KiB is currently the minimum supported stack size value to guarantee sufficient stack space for the interpreter itself. Note that some platforms may have particular restrictions on values for the stack size, such as requiring a minimum stack size > 32 KiB or requiring allocation in multiples of the system memory page size - platform documentation should be referred to for more information (4 KiB pages are common; using multiples of 4096 for the stack size is the suggested approach in the absence of more specific information).

適用：Windows, pthreads。

Unix platforms with POSIX threads support.

This module also defines the following constant:

`threading.TIMEOUT_MAX`

The maximum value allowed for the *timeout* parameter of blocking functions (*Lock.acquire()*, *RLock.acquire()*, *Condition.wait()*, etc.). Specifying a timeout greater than this value will raise an *OverflowError*.

在 3.2 版新加入。

This module defines a number of classes, which are detailed in the sections below.

The design of this module is loosely based on Java's threading model. However, where Java makes locks and condition variables basic behavior of every object, they are separate objects in Python. Python's *Thread* class supports a subset of the behavior of Java's Thread class; currently, there are no priorities, no thread groups, and threads cannot be destroyed, stopped, suspended, resumed, or interrupted. The static methods of Java's Thread class, when implemented, are mapped to module-level functions.

All of the methods described below are executed atomically.

17.1.1 Thread-Local Data

Thread-local data is data whose values are thread specific. To manage thread-local data, just create an instance of `local` (or a subclass) and store attributes on it:

```
mydata = threading.local()
mydata.x = 1
```

The instance's values will be different for separate threads.

class `threading.local`

A class that represents thread-local data.

For more details and extensive examples, see the documentation string of the `_threading_local` module: [Lib/_threading_local.py](#).

17.1.2 Thread Objects

The `Thread` class represents an activity that is run in a separate thread of control. There are two ways to specify the activity: by passing a callable object to the constructor, or by overriding the `run()` method in a subclass. No other methods (except for the constructor) should be overridden in a subclass. In other words, *only* override the `__init__()` and `run()` methods of this class.

Once a thread object is created, its activity must be started by calling the thread's `start()` method. This invokes the `run()` method in a separate thread of control.

Once the thread's activity is started, the thread is considered 'alive'. It stops being alive when its `run()` method terminates -- either normally, or by raising an unhandled exception. The `is_alive()` method tests whether the thread is alive.

Other threads can call a thread's `join()` method. This blocks the calling thread until the thread whose `join()` method is called is terminated.

A thread has a name. The name can be passed to the constructor, and read or changed through the `name` attribute.

If the `run()` method raises an exception, `threading.excepthook()` is called to handle it. By default, `threading.excepthook()` ignores silently `SystemExit`.

A thread can be flagged as a "daemon thread". The significance of this flag is that the entire Python program exits when only daemon threads are left. The initial value is inherited from the creating thread. The flag can be set through the `daemon` property or the `daemon` constructor argument.

備F: Daemon threads are abruptly stopped at shutdown. Their resources (such as open files, database transactions, etc.) may not be released properly. If you want your threads to stop gracefully, make them non-daemonic and use a suitable signalling mechanism such as an `Event`.

There is a "main thread" object; this corresponds to the initial thread of control in the Python program. It is not a daemon thread.

There is the possibility that "dummy thread objects" are created. These are thread objects corresponding to "alien threads", which are threads of control started outside the threading module, such as directly from C code. Dummy thread objects have limited functionality; they are always considered alive and daemonic, and cannot be *joined*. They are never deleted, since it is impossible to detect the termination of alien threads.

class `threading.Thread` (*group=None, target=None, name=None, args=(), kwargs={}, *, daemon=None*)

This constructor should always be called with keyword arguments. Arguments are:

group should be `None`; reserved for future extension when a `ThreadGroup` class is implemented.

target is the callable object to be invoked by the `run()` method. Defaults to `None`, meaning nothing is called.

name is the thread name. By default, a unique name is constructed of the form "Thread-*N*" where *N* is a small decimal number, or "Thread-*N* (target)" where "target" is `target.__name__` if the *target* argument is specified.

args is a list or tuple of arguments for the target invocation. Defaults to `()`.

kwargs is a dictionary of keyword arguments for the target invocation. Defaults to `{}`.

If not `None`, *daemon* explicitly sets whether the thread is daemon. If `None` (the default), the daemon property is inherited from the current thread.

If the subclass overrides the constructor, it must make sure to invoke the base class constructor (`Thread.__init__()`) before doing anything else to the thread.

在 3.3 版的變更: Added the *daemon* parameter.

在 3.10 版的變更: Use the *target* name if *name* argument is omitted.

start()

Start the thread's activity.

It must be called at most once per thread object. It arranges for the object's `run()` method to be invoked in a separate thread of control.

This method will raise a `RuntimeError` if called more than once on the same thread object.

run()

Method representing the thread's activity.

You may override this method in a subclass. The standard `run()` method invokes the callable object passed to the object's constructor as the *target* argument, if any, with positional and keyword arguments taken from the *args* and *kwargs* arguments, respectively.

Using list or tuple as the *args* argument which passed to the `Thread` could achieve the same effect.

舉例來:

```
>>> from threading import Thread
>>> t = Thread(target=print, args=[1])
>>> t.run()
1
>>> t = Thread(target=print, args=(1,))
>>> t.run()
1
```

join(timeout=None)

Wait until the thread terminates. This blocks the calling thread until the thread whose `join()` method is called terminates -- either normally or through an unhandled exception -- or until the optional timeout occurs.

When the *timeout* argument is present and not `None`, it should be a floating point number specifying a timeout for the operation in seconds (or fractions thereof). As `join()` always returns `None`, you must call `is_alive()` after `join()` to decide whether a timeout happened -- if the thread is still alive, the `join()` call timed out.

When the *timeout* argument is not present or `None`, the operation will block until the thread terminates.

A thread can be joined many times.

`join()` raises a `RuntimeError` if an attempt is made to join the current thread as that would cause a deadlock. It is also an error to `join()` a thread before it has been started and attempts to do so raise the same exception.

name

A string used for identification purposes only. It has no semantics. Multiple threads may be given the same name. The initial name is set by the constructor.

getName()

setName()

Deprecated getter/setter API for *name*; use it directly as a property instead.

在 3.10 版之後被 用。

ident

The 'thread identifier' of this thread or `None` if the thread has not been started. This is a nonzero integer. See the `get_ident()` function. Thread identifiers may be recycled when a thread exits and another thread is created. The identifier is available even after the thread has exited.

native_id

The Thread ID (TID) of this thread, as assigned by the OS (kernel). This is a non-negative integer, or `None` if the thread has not been started. See the `get_native_id()` function. This value may be used to uniquely identify this particular thread system-wide (until the thread terminates, after which the value may be recycled by the OS).

備： Similar to Process IDs, Thread IDs are only valid (guaranteed unique system-wide) from the time the thread is created until the thread has been terminated.

Availability: Windows, FreeBSD, Linux, macOS, OpenBSD, NetBSD, AIX, DragonFlyBSD.

在 3.8 版新加入。

is_alive()

Return whether the thread is alive.

This method returns `True` just before the `run()` method starts until just after the `run()` method terminates. The module function `enumerate()` returns a list of all alive threads.

daemon

A boolean value indicating whether this thread is a daemon thread (`True`) or not (`False`). This must be set before `start()` is called, otherwise `RuntimeError` is raised. Its initial value is inherited from the creating thread; the main thread is not a daemon thread and therefore all threads created in the main thread default to `daemon = False`.

The entire Python program exits when no alive non-daemon threads are left.

isDaemon()

setDaemon()

Deprecated getter/setter API for *daemon*; use it directly as a property instead.

在 3.10 版之後被 用。

17.1.3 Lock Objects

A primitive lock is a synchronization primitive that is not owned by a particular thread when locked. In Python, it is currently the lowest level synchronization primitive available, implemented directly by the `_thread` extension module.

A primitive lock is in one of two states, "locked" or "unlocked". It is created in the unlocked state. It has two basic methods, `acquire()` and `release()`. When the state is unlocked, `acquire()` changes the state to locked and returns immediately. When the state is locked, `acquire()` blocks until a call to `release()` in another thread changes it to unlocked, then the `acquire()` call resets it to locked and returns. The `release()` method should only be called in the locked state; it changes the state to unlocked and returns immediately. If an attempt is made to release an unlocked lock, a `RuntimeError` will be raised.

Locks also support the *context management protocol*.

When more than one thread is blocked in `acquire()` waiting for the state to turn to unlocked, only one thread proceeds when a `release()` call resets the state to unlocked; which one of the waiting threads proceeds is not defined, and may vary across implementations.

All methods are executed atomically.

class `threading.Lock`

The class implementing primitive lock objects. Once a thread has acquired a lock, subsequent attempts to acquire it block, until it is released; any thread may release it.

Note that `Lock` is actually a factory function which returns an instance of the most efficient version of the concrete `Lock` class that is supported by the platform.

acquire (*blocking=True, timeout=-1*)

Acquire a lock, blocking or non-blocking.

When invoked with the *blocking* argument set to `True` (the default), block until the lock is unlocked, then set it to locked and return `True`.

When invoked with the *blocking* argument set to `False`, do not block. If a call with *blocking* set to `True` would block, return `False` immediately; otherwise, set the lock to locked and return `True`.

When invoked with the floating-point *timeout* argument set to a positive value, block for at most the number of seconds specified by *timeout* and as long as the lock cannot be acquired. A *timeout* argument of `-1` specifies an unbounded wait. It is forbidden to specify a *timeout* when *blocking* is `False`.

The return value is `True` if the lock is acquired successfully, `False` if not (for example if the *timeout* expired).

在 3.2 版的變更: The *timeout* parameter is new.

在 3.2 版的變更: Lock acquisition can now be interrupted by signals on POSIX if the underlying threading implementation supports it.

release ()

Release a lock. This can be called from any thread, not only the thread which has acquired the lock.

When the lock is locked, reset it to unlocked, and return. If any other threads are blocked waiting for the lock to become unlocked, allow exactly one of them to proceed.

When invoked on an unlocked lock, a `RuntimeError` is raised.

There is no return value.

locked ()

Return `True` if the lock is acquired.

17.1.4 RLock 物件

A reentrant lock is a synchronization primitive that may be acquired multiple times by the same thread. Internally, it uses the concepts of "owning thread" and "recursion level" in addition to the locked/unlocked state used by primitive locks. In the locked state, some thread owns the lock; in the unlocked state, no thread owns it.

To lock the lock, a thread calls its `acquire()` method; this returns once the thread owns the lock. To unlock the lock, a thread calls its `release()` method. `acquire()/release()` call pairs may be nested; only the final `release()` (the `release()` of the outermost pair) resets the lock to unlocked and allows another thread blocked in `acquire()` to proceed.

Reentrant locks also support the *context management protocol*.

class `threading.RLock`

This class implements reentrant lock objects. A reentrant lock must be released by the thread that acquired it. Once a thread has acquired a reentrant lock, the same thread may acquire it again without blocking; the thread must release it once for each time it has acquired it.

Note that `Rlock` is actually a factory function which returns an instance of the most efficient version of the concrete `Rlock` class that is supported by the platform.

acquire (*blocking=True, timeout=-1*)

Acquire a lock, blocking or non-blocking.

When invoked without arguments: if this thread already owns the lock, increment the recursion level by one, and return immediately. Otherwise, if another thread owns the lock, block until the lock is unlocked. Once the lock is unlocked (not owned by any thread), then grab ownership, set the recursion level to one, and return. If more than one thread is blocked waiting until the lock is unlocked, only one at a time will be able to grab ownership of the lock. There is no return value in this case.

When invoked with the *blocking* argument set to `True`, do the same thing as when called without arguments, and return `True`.

When invoked with the *blocking* argument set to `False`, do not block. If a call without an argument would block, return `False` immediately; otherwise, do the same thing as when called without arguments, and return `True`.

When invoked with the floating-point *timeout* argument set to a positive value, block for at most the number of seconds specified by *timeout* and as long as the lock cannot be acquired. Return `True` if the lock has been acquired, `False` if the timeout has elapsed.

在 3.2 版的變更: The *timeout* parameter is new.

release ()

Release a lock, decrementing the recursion level. If after the decrement it is zero, reset the lock to unlocked (not owned by any thread), and if any other threads are blocked waiting for the lock to become unlocked, allow exactly one of them to proceed. If after the decrement the recursion level is still nonzero, the lock remains locked and owned by the calling thread.

Only call this method when the calling thread owns the lock. A `RuntimeError` is raised if this method is called when the lock is unlocked.

There is no return value.

17.1.5 Condition Objects

A condition variable is always associated with some kind of lock; this can be passed in or one will be created by default. Passing one in is useful when several condition variables must share the same lock. The lock is part of the condition object: you don't have to track it separately.

A condition variable obeys the *context management protocol*: using the `with` statement acquires the associated lock for the duration of the enclosed block. The `acquire()` and `release()` methods also call the corresponding methods of the associated lock.

Other methods must be called with the associated lock held. The `wait()` method releases the lock, and then blocks until another thread awakens it by calling `notify()` or `notify_all()`. Once awakened, `wait()` re-acquires the lock and returns. It is also possible to specify a timeout.

The `notify()` method wakes up one of the threads waiting for the condition variable, if any are waiting. The `notify_all()` method wakes up all threads waiting for the condition variable.

Note: the `notify()` and `notify_all()` methods don't release the lock; this means that the thread or threads awakened will not return from their `wait()` call immediately, but only when the thread that called `notify()` or `notify_all()` finally relinquishes ownership of the lock.

The typical programming style using condition variables uses the lock to synchronize access to some shared state; threads that are interested in a particular change of state call `wait()` repeatedly until they see the desired state, while threads that modify the state call `notify()` or `notify_all()` when they change the state in such a way that it could possibly be a desired state for one of the waiters. For example, the following code is a generic producer-consumer situation with unlimited buffer capacity:

```
# Consume one item
with cv:
    while not an_item_is_available():
        cv.wait()
    get_an_available_item()

# Produce one item
with cv:
    make_an_item_available()
    cv.notify()
```

The `while` loop checking for the application's condition is necessary because `wait()` can return after an arbitrary long time, and the condition which prompted the `notify()` call may no longer hold true. This is inherent to multi-threaded programming. The `wait_for()` method can be used to automate the condition checking, and eases the computation of timeouts:

```
# Consume an item
with cv:
    cv.wait_for(an_item_is_available)
    get_an_available_item()
```

To choose between `notify()` and `notify_all()`, consider whether one state change can be interesting for only one or several waiting threads. E.g. in a typical producer-consumer situation, adding one item to the buffer only needs to wake up one consumer thread.

class `threading.Condition` (*lock=None*)

This class implements condition variable objects. A condition variable allows one or more threads to wait until they are notified by another thread.

If the *lock* argument is given and not `None`, it must be a `Lock` or `RLock` object, and it is used as the underlying lock. Otherwise, a new `RLock` object is created and used as the underlying lock.

在 3.3 版的變更: changed from a factory function to a class.

acquire (*args)

Acquire the underlying lock. This method calls the corresponding method on the underlying lock; the return value is whatever that method returns.

release ()

Release the underlying lock. This method calls the corresponding method on the underlying lock; there is no return value.

wait (*timeout=None*)

Wait until notified or until a timeout occurs. If the calling thread has not acquired the lock when this method is called, a `RuntimeError` is raised.

This method releases the underlying lock, and then blocks until it is awakened by a `notify()` or `notify_all()` call for the same condition variable in another thread, or until the optional timeout occurs. Once awakened or timed out, it re-acquires the lock and returns.

When the *timeout* argument is present and not `None`, it should be a floating point number specifying a timeout for the operation in seconds (or fractions thereof).

When the underlying lock is an `RLock`, it is not released using its `release()` method, since this may not actually unlock the lock when it was acquired multiple times recursively. Instead, an internal interface of the `RLock` class is used, which really unlocks it even when it has been recursively acquired several times. Another internal interface is then used to restore the recursion level when the lock is reacquired.

The return value is `True` unless a given *timeout* expired, in which case it is `False`.

在 3.2 版的變更: Previously, the method always returned `None`.

wait_for (*predicate*, *timeout=None*)

Wait until a condition evaluates to true. *predicate* should be a callable which result will be interpreted as a boolean value. A *timeout* may be provided giving the maximum time to wait.

This utility method may call `wait()` repeatedly until the predicate is satisfied, or until a timeout occurs. The return value is the last return value of the predicate and will evaluate to `False` if the method timed out.

Ignoring the timeout feature, calling this method is roughly equivalent to writing:

```
while not predicate():
    cv.wait()
```

Therefore, the same rules apply as with `wait()`: The lock must be held when called and is re-acquired on return. The predicate is evaluated with the lock held.

在 3.2 版新加入。

notify (*n=1*)

By default, wake up one thread waiting on this condition, if any. If the calling thread has not acquired the lock when this method is called, a `RuntimeError` is raised.

This method wakes up at most *n* of the threads waiting for the condition variable; it is a no-op if no threads are waiting.

The current implementation wakes up exactly *n* threads, if at least *n* threads are waiting. However, it's not safe to rely on this behavior. A future, optimized implementation may occasionally wake up more than *n* threads.

Note: an awakened thread does not actually return from its `wait()` call until it can reacquire the lock. Since `notify()` does not release the lock, its caller should.

notify_all ()

Wake up all threads waiting on this condition. This method acts like `notify()`, but wakes up all waiting threads instead of one. If the calling thread has not acquired the lock when this method is called, a `RuntimeError` is raised.

The method `notifyAll` is a deprecated alias for this method.

17.1.6 Semaphore Objects

This is one of the oldest synchronization primitives in the history of computer science, invented by the early Dutch computer scientist Edsger W. Dijkstra (he used the names `P()` and `V()` instead of `acquire()` and `release()`).

A semaphore manages an internal counter which is decremented by each `acquire()` call and incremented by each `release()` call. The counter can never go below zero; when `acquire()` finds that it is zero, it blocks, waiting until some other thread calls `release()`.

Semaphores also support the *context management protocol*.

class `threading.Semaphore` (*value=1*)

This class implements semaphore objects. A semaphore manages an atomic counter representing the number of `release()` calls minus the number of `acquire()` calls, plus an initial value. The `acquire()` method blocks if necessary until it can return without making the counter negative. If not given, *value* defaults to 1.

The optional argument gives the initial *value* for the internal counter; it defaults to 1. If the *value* given is less than 0, `ValueError` is raised.

在 3.3 版的變更: changed from a factory function to a class.

acquire (*blocking=True*, *timeout=None*)

Acquire a semaphore.

When invoked without arguments:

- If the internal counter is larger than zero on entry, decrement it by one and return `True` immediately.
- If the internal counter is zero on entry, block until awoken by a call to `release()`. Once awoken (and the counter is greater than 0), decrement the counter by 1 and return `True`. Exactly one thread will be awoken by each call to `release()`. The order in which threads are awoken should not be relied on.

When invoked with *blocking* set to `False`, do not block. If a call without an argument would block, return `False` immediately; otherwise, do the same thing as when called without arguments, and return `True`.

When invoked with a *timeout* other than `None`, it will block for at most *timeout* seconds. If acquire does not complete successfully in that interval, return `False`. Return `True` otherwise.

在 3.2 版的變更: The *timeout* parameter is new.

release (*n=1*)

Release a semaphore, incrementing the internal counter by *n*. When it was zero on entry and other threads are waiting for it to become larger than zero again, wake up *n* of those threads.

在 3.9 版的變更: Added the *n* parameter to release multiple waiting threads at once.

class `threading.BoundedSemaphore` (*value=1*)

Class implementing bounded semaphore objects. A bounded semaphore checks to make sure its current value doesn't exceed its initial value. If it does, `ValueError` is raised. In most situations semaphores are used to guard resources with limited capacity. If the semaphore is released too many times it's a sign of a bug. If not given, *value* defaults to 1.

在 3.3 版的變更: changed from a factory function to a class.

Semaphore 范例

Semaphores are often used to guard resources with limited capacity, for example, a database server. In any situation where the size of the resource is fixed, you should use a bounded semaphore. Before spawning any worker threads, your main thread would initialize the semaphore:

```
maxconnections = 5
# ...
pool_sema = BoundedSemaphore(value=maxconnections)
```

Once spawned, worker threads call the semaphore's `acquire` and `release` methods when they need to connect to the server:

```
with pool_sema:
    conn = connectdb()
    try:
        # ... use connection ...
    finally:
        conn.close()
```

The use of a bounded semaphore reduces the chance that a programming error which causes the semaphore to be released more than it's acquired will go undetected.

17.1.7 Event Objects

This is one of the simplest mechanisms for communication between threads: one thread signals an event and other threads wait for it.

An event object manages an internal flag that can be set to true with the `set()` method and reset to false with the `clear()` method. The `wait()` method blocks until the flag is true.

class `threading.Event`

Class implementing event objects. An event manages a flag that can be set to true with the `set()` method and reset to false with the `clear()` method. The `wait()` method blocks until the flag is true. The flag is initially false.

在 3.3 版的變更: changed from a factory function to a class.

is_set()

Return `True` if and only if the internal flag is true.

The method `isSet` is a deprecated alias for this method.

set()

Set the internal flag to true. All threads waiting for it to become true are awakened. Threads that call `wait()` once the flag is true will not block at all.

clear()

Reset the internal flag to false. Subsequently, threads calling `wait()` will block until `set()` is called to set the internal flag to true again.

wait (*timeout=None*)

Block as long as the internal flag is false and the timeout, if given, has not expired. The return value represents the reason that this blocking method returned; `True` if returning because the internal flag is set to true, or `False` if a timeout is given and the internal flag did not become true within the given wait time.

When the timeout argument is present and not `None`, it should be a floating point number specifying a timeout for the operation in seconds, or fractions thereof.

在 3.1 版的變更: Previously, the method always returned `None`.

17.1.8 Timer Objects

This class represents an action that should be run only after a certain amount of time has passed --- a timer. `Timer` is a subclass of `Thread` and as such also functions as an example of creating custom threads.

Timers are started, as with threads, by calling their `Timer.start` method. The timer can be stopped (before its action has begun) by calling the `cancel()` method. The interval the timer will wait before executing its action may not be exactly the same as the interval specified by the user.

舉例來 F:

```
def hello():
    print("hello, world")

t = Timer(30.0, hello)
t.start()  # after 30 seconds, "hello, world" will be printed
```

class `threading.Timer` (*interval, function, args=None, kwargs=None*)

Create a timer that will run *function* with arguments *args* and keyword arguments *kwargs*, after *interval* seconds have passed. If *args* is `None` (the default) then an empty list will be used. If *kwargs* is `None` (the default) then an empty dict will be used.

在 3.3 版的變更: changed from a factory function to a class.

cancel()

Stop the timer, and cancel the execution of the timer's action. This will only work if the timer is still in its waiting stage.

17.1.9 Barrier Objects

在 3.2 版新加入。

This class provides a simple synchronization primitive for use by a fixed number of threads that need to wait for each other. Each of the threads tries to pass the barrier by calling the `wait()` method and will block until all of the threads have made their `wait()` calls. At this point, the threads are released simultaneously.

The barrier can be reused any number of times for the same number of threads.

As an example, here is a simple way to synchronize a client and server thread:

```
b = Barrier(2, timeout=5)

def server():
    start_server()
    b.wait()
    while True:
        connection = accept_connection()
        process_server_connection(connection)

def client():
    b.wait()
    while True:
        connection = make_connection()
        process_client_connection(connection)
```

class `threading.Barrier` (*parties*, *action=None*, *timeout=None*)

Create a barrier object for *parties* number of threads. An *action*, when provided, is a callable to be called by one of the threads when they are released. *timeout* is the default timeout value if none is specified for the `wait()` method.

wait (*timeout=None*)

Pass the barrier. When all the threads party to the barrier have called this function, they are all released simultaneously. If a *timeout* is provided, it is used in preference to any that was supplied to the class constructor.

The return value is an integer in the range 0 to *parties* -- 1, different for each thread. This can be used to select a thread to do some special housekeeping, e.g.:

```
i = barrier.wait()
if i == 0:
    # Only one thread needs to print this
    print("passed the barrier")
```

If an *action* was provided to the constructor, one of the threads will have called it prior to being released. Should this call raise an error, the barrier is put into the broken state.

If the call times out, the barrier is put into the broken state.

This method may raise a `BrokenBarrierError` exception if the barrier is broken or reset while a thread is waiting.

reset ()

Return the barrier to the default, empty state. Any threads waiting on it will receive the `BrokenBarrierError` exception.

Note that using this function may require some external synchronization if there are other threads whose state is unknown. If a barrier is broken it may be better to just leave it and create a new one.

abort()

Put the barrier into a broken state. This causes any active or future calls to `wait()` to fail with the `BrokenBarrierError`. Use this for example if one of the threads needs to abort, to avoid dead-locking the application.

It may be preferable to simply create the barrier with a sensible *timeout* value to automatically guard against one of the threads going awry.

parties

The number of threads required to pass the barrier.

n_waiting

The number of threads currently waiting in the barrier.

broken

A boolean that is `True` if the barrier is in the broken state.

exception `threading.BrokenBarrierError`

This exception, a subclass of `RuntimeError`, is raised when the `Barrier` object is reset or broken.

17.1.10 Using locks, conditions, and semaphores in the `with` statement

All of the objects provided by this module that have `acquire` and `release` methods can be used as context managers for a `with` statement. The `acquire` method will be called when the block is entered, and `release` will be called when the block is exited. Hence, the following snippet:

```
with some_lock:
    # do something...
```

is equivalent to:

```
some_lock.acquire()
try:
    # do something...
finally:
    some_lock.release()
```

Currently, `Lock`, `RLock`, `Condition`, `Semaphore`, and `BoundedSemaphore` objects may be used as `with` statement context managers.

17.2 multiprocessing --- Process-based parallelism

原始碼: [Lib/multiprocessing/](#)

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

17.2.1 簡介

multiprocessing is a package that supports spawning processes using an API similar to the *threading* module. The *multiprocessing* package offers both local and remote concurrency, effectively side-stepping the *Global Interpreter Lock* by using subprocesses instead of threads. Due to this, the *multiprocessing* module allows the programmer to fully leverage multiple processors on a given machine. It runs on both Unix and Windows.

The *multiprocessing* module also introduces APIs which do not have analogs in the *threading* module. A prime example of this is the *Pool* object which offers a convenient means of parallelizing the execution of a function across multiple input values, distributing the input data across processes (data parallelism). The following example demonstrates the common practice of defining such functions in a module so that child processes can successfully import that module. This basic example of data parallelism using *Pool*,

```
from multiprocessing import Pool

def f(x):
    return x*x

if __name__ == '__main__':
    with Pool(5) as p:
        print(p.map(f, [1, 2, 3]))
```

will print to standard output

```
[1, 4, 9]
```

也參考:

concurrent.futures.ProcessPoolExecutor offers a higher level interface to push tasks to a background process without blocking execution of the calling process. Compared to using the *Pool* interface directly, the *concurrent.futures* API more readily allows the submission of work to the underlying process pool to be separated from waiting for the results.

The Process class

In *multiprocessing*, processes are spawned by creating a *Process* object and then calling its *start()* method. *Process* follows the API of *threading.Thread*. A trivial example of a multiprocess program is

```
from multiprocessing import Process

def f(name):
    print('hello', name)

if __name__ == '__main__':
    p = Process(target=f, args=('bob',))
    p.start()
    p.join()
```

To show the individual process IDs involved, here is an expanded example:

```
from multiprocessing import Process
import os

def info(title):
    print(title)
    print('module name:', __name__)
    print('parent process:', os.getppid())
    print('process id:', os.getpid())

def f(name):
    info('function f')
```

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```

print('hello', name)

if __name__ == '__main__':
    info('main line')
    p = Process(target=f, args=('bob',))
    p.start()
    p.join()

```

For an explanation of why the `if __name__ == '__main__':` part is necessary, see [Programming guidelines](#).

Contexts and start methods

Depending on the platform, *multiprocessing* supports three ways to start a process. These *start methods* are

spawn

The parent process starts a fresh Python interpreter process. The child process will only inherit those resources necessary to run the process object's `run()` method. In particular, unnecessary file descriptors and handles from the parent process will not be inherited. Starting a process using this method is rather slow compared to using *fork* or *forkserver*.

Available on Unix and Windows. The default on Windows and macOS.

fork

The parent process uses `os.fork()` to fork the Python interpreter. The child process, when it begins, is effectively identical to the parent process. All resources of the parent are inherited by the child process. Note that safely forking a multithreaded process is problematic.

Available on Unix only. The default on Unix.

forkserver

When the program starts and selects the *forkserver* start method, a server process is started. From then on, whenever a new process is needed, the parent process connects to the server and requests that it fork a new process. The fork server process is single threaded so it is safe for it to use `os.fork()`. No unnecessary resources are inherited.

Available on Unix platforms which support passing file descriptors over Unix pipes.

在 3.4 版的變更: *spawn* added on all Unix platforms, and *forkserver* added for some Unix platforms. Child processes no longer inherit all of the parents inheritable handles on Windows.

在 3.8 版的變更: On macOS, the *spawn* start method is now the default. The *fork* start method should be considered unsafe as it can lead to crashes of the subprocess as macOS system libraries may start threads. See [bpo-33725](#).

On POSIX using the *spawn* or *forkserver* start methods will also start a *resource tracker* process which tracks the unlinked named system resources (such as named semaphores or *SharedMemory* objects) created by processes of the program. When all processes have exited the resource tracker unlinks any remaining tracked object. Usually there should be none, but if a process was killed by a signal there may be some "leaked" resources. (Neither leaked semaphores nor shared memory segments will be automatically unlinked until the next reboot. This is problematic for both objects because the system allows only a limited number of named semaphores, and shared memory segments occupy some space in the main memory.)

To select a start method you use the `set_start_method()` in the `if __name__ == '__main__':` clause of the main module. For example:

```

import multiprocessing as mp

def foo(q):
    q.put('hello')

if __name__ == '__main__':
    mp.set_start_method('spawn')
    q = mp.Queue()

```

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```
p = mp.Process(target=foo, args=(q,))
p.start()
print(q.get())
p.join()
```

`set_start_method()` should not be used more than once in the program.

Alternatively, you can use `get_context()` to obtain a context object. Context objects have the same API as the multiprocessing module, and allow one to use multiple start methods in the same program.

```
import multiprocessing as mp

def foo(q):
    q.put('hello')

if __name__ == '__main__':
    ctx = mp.get_context('spawn')
    q = ctx.Queue()
    p = ctx.Process(target=foo, args=(q,))
    p.start()
    print(q.get())
    p.join()
```

Note that objects related to one context may not be compatible with processes for a different context. In particular, locks created using the *fork* context cannot be passed to processes started using the *spawn* or *forkserver* start methods.

A library which wants to use a particular start method should probably use `get_context()` to avoid interfering with the choice of the library user.

警告: The 'spawn' and 'forkserver' start methods cannot currently be used with "frozen" executables (i.e., binaries produced by packages like **PyInstaller** and **cx_Freeze**) on Unix. The 'fork' start method does work.

Exchanging objects between processes

`multiprocessing` supports two types of communication channel between processes:

Queues

The `Queue` class is a near clone of `queue.Queue`. For example:

```
from multiprocessing import Process, Queue

def f(q):
    q.put([42, None, 'hello'])

if __name__ == '__main__':
    q = Queue()
    p = Process(target=f, args=(q,))
    p.start()
    print(q.get())    # prints "[42, None, 'hello']"
    p.join()
```

Queues are thread and process safe.

Pipes

The `Pipe()` function returns a pair of connection objects connected by a pipe which by default is duplex (two-way). For example:

```

from multiprocessing import Process, Pipe

def f(conn):
    conn.send([42, None, 'hello'])
    conn.close()

if __name__ == '__main__':
    parent_conn, child_conn = Pipe()
    p = Process(target=f, args=(child_conn,))
    p.start()
    print(parent_conn.recv()) # prints "[42, None, 'hello']"
    p.join()

```

The two connection objects returned by `Pipe()` represent the two ends of the pipe. Each connection object has `send()` and `recv()` methods (among others). Note that data in a pipe may become corrupted if two processes (or threads) try to read from or write to the *same* end of the pipe at the same time. Of course there is no risk of corruption from processes using different ends of the pipe at the same time.

Synchronization between processes

`multiprocessing` contains equivalents of all the synchronization primitives from `threading`. For instance one can use a lock to ensure that only one process prints to standard output at a time:

```

from multiprocessing import Process, Lock

def f(l, i):
    l.acquire()
    try:
        print('hello world', i)
    finally:
        l.release()

if __name__ == '__main__':
    lock = Lock()

    for num in range(10):
        Process(target=f, args=(lock, num)).start()

```

Without using the lock output from the different processes is liable to get all mixed up.

Sharing state between processes

As mentioned above, when doing concurrent programming it is usually best to avoid using shared state as far as possible. This is particularly true when using multiple processes.

However, if you really do need to use some shared data then `multiprocessing` provides a couple of ways of doing so.

Shared memory

Data can be stored in a shared memory map using `Value` or `Array`. For example, the following code

```

from multiprocessing import Process, Value, Array

def f(n, a):
    n.value = 3.1415927
    for i in range(len(a)):
        a[i] = -a[i]

```

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```

if __name__ == '__main__':
    num = Value('d', 0.0)
    arr = Array('i', range(10))

    p = Process(target=f, args=(num, arr))
    p.start()
    p.join()

    print(num.value)
    print(arr[:])

```

will print

```

3.1415927
[0, -1, -2, -3, -4, -5, -6, -7, -8, -9]

```

The 'd' and 'i' arguments used when creating `num` and `arr` are typecodes of the kind used by the `array` module: 'd' indicates a double precision float and 'i' indicates a signed integer. These shared objects will be process and thread-safe.

For more flexibility in using shared memory one can use the `multiprocessing.sharedctypes` module which supports the creation of arbitrary ctypes objects allocated from shared memory.

Server process

A manager object returned by `Manager()` controls a server process which holds Python objects and allows other processes to manipulate them using proxies.

A manager returned by `Manager()` will support types `list`, `dict`, `Namespace`, `Lock`, `RLock`, `Semaphore`, `BoundedSemaphore`, `Condition`, `Event`, `Barrier`, `Queue`, `Value` and `Array`. For example,

```

from multiprocessing import Process, Manager

def f(d, l):
    d[1] = '1'
    d['2'] = 2
    d[0.25] = None
    l.reverse()

if __name__ == '__main__':
    with Manager() as manager:
        d = manager.dict()
        l = manager.list(range(10))

        p = Process(target=f, args=(d, l))
        p.start()
        p.join()

        print(d)
        print(l)

```

will print

```

{0.25: None, 1: '1', '2': 2}
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]

```

Server process managers are more flexible than using shared memory objects because they can be made to support arbitrary object types. Also, a single manager can be shared by processes on different computers over a network. They are, however, slower than using shared memory.

Using a pool of workers

The `Pool` class represents a pool of worker processes. It has methods which allows tasks to be offloaded to the worker processes in a few different ways.

舉例來F:

```
from multiprocessing import Pool, TimeoutError
import time
import os

def f(x):
    return x*x

if __name__ == '__main__':
    # start 4 worker processes
    with Pool(processes=4) as pool:

        # print "[0, 1, 4, ..., 81]"
        print(pool.map(f, range(10)))

        # print same numbers in arbitrary order
        for i in pool.imap_unordered(f, range(10)):
            print(i)

        # evaluate "f(20)" asynchronously
        res = pool.apply_async(f, (20,))    # runs in *only* one process
        print(res.get(timeout=1))           # prints "400"

        # evaluate "os.getpid()" asynchronously
        res = pool.apply_async(os.getpid, ()) # runs in *only* one process
        print(res.get(timeout=1))             # prints the PID of that process

        # launching multiple evaluations asynchronously *may* use more processes
        multiple_results = [pool.apply_async(os.getpid, ()) for i in range(4)]
        print([res.get(timeout=1) for res in multiple_results])

        # make a single worker sleep for 10 seconds
        res = pool.apply_async(time.sleep, (10,))
        try:
            print(res.get(timeout=1))
        except TimeoutError:
            print("We lacked patience and got a multiprocessing.TimeoutError")

        print("For the moment, the pool remains available for more work")

    # exiting the 'with'-block has stopped the pool
    print("Now the pool is closed and no longer available")
```

Note that the methods of a pool should only ever be used by the process which created it.

備F: Functionality within this package requires that the `__main__` module be importable by the children. This is covered in *Programming guidelines* however it is worth pointing out here. This means that some examples, such as the `multiprocessing.pool.Pool` examples will not work in the interactive interpreter. For example:

```
>>> from multiprocessing import Pool
>>> p = Pool(5)
>>> def f(x):
...     return x*x
...
>>> with p:
...     p.map(f, [1,2,3])
```

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```

Process PoolWorker-1:
Process PoolWorker-2:
Process PoolWorker-3:
Traceback (most recent call last):
Traceback (most recent call last):
Traceback (most recent call last):
AttributeError: Can't get attribute 'f' on <module '__main__' (built-in)>
AttributeError: Can't get attribute 'f' on <module '__main__' (built-in)>
AttributeError: Can't get attribute 'f' on <module '__main__' (built-in)>

```

(If you try this it will actually output three full tracebacks interleaved in a semi-random fashion, and then you may have to stop the parent process somehow.)

17.2.2 Reference

The *multiprocessing* package mostly replicates the API of the *threading* module.

Process 與例外

```
class multiprocessing.Process (group=None, target=None, name=None, args=(), kwargs={}, *,
                                daemon=None)
```

Process objects represent activity that is run in a separate process. The *Process* class has equivalents of all the methods of *threading.Thread*.

The constructor should always be called with keyword arguments. *group* should always be *None*; it exists solely for compatibility with *threading.Thread*. *target* is the callable object to be invoked by the *run()* method. It defaults to *None*, meaning nothing is called. *name* is the process name (see *name* for more details). *args* is the argument tuple for the target invocation. *kwargs* is a dictionary of keyword arguments for the target invocation. If provided, the keyword-only *daemon* argument sets the process *daemon* flag to *True* or *False*. If *None* (the default), this flag will be inherited from the creating process.

By default, no arguments are passed to *target*. The *args* argument, which defaults to *()*, can be used to specify a list or tuple of the arguments to pass to *target*.

If a subclass overrides the constructor, it must make sure it invokes the base class constructor (*Process.__init__()*) before doing anything else to the process.

在 3.3 版的變更: Added the *daemon* parameter.

run()

Method representing the process's activity.

You may override this method in a subclass. The standard *run()* method invokes the callable object passed to the object's constructor as the target argument, if any, with sequential and keyword arguments taken from the *args* and *kwargs* arguments, respectively.

Using a list or tuple as the *args* argument passed to *Process* achieves the same effect.

範例:

```

>>> from multiprocessing import Process
>>> p = Process(target=print, args=[1])
>>> p.run()
1
>>> p = Process(target=print, args=(1,))
>>> p.run()
1

```

start()

Start the process's activity.

This must be called at most once per process object. It arranges for the object's `run()` method to be invoked in a separate process.

join([*timeout*])

If the optional argument *timeout* is `None` (the default), the method blocks until the process whose `join()` method is called terminates. If *timeout* is a positive number, it blocks at most *timeout* seconds. Note that the method returns `None` if its process terminates or if the method times out. Check the process's `exitcode` to determine if it terminated.

A process can be joined many times.

A process cannot join itself because this would cause a deadlock. It is an error to attempt to join a process before it has been started.

name

The process's name. The name is a string used for identification purposes only. It has no semantics. Multiple processes may be given the same name.

The initial name is set by the constructor. If no explicit name is provided to the constructor, a name of the form 'Process-N₁:N₂:...:N_k' is constructed, where each N_k is the N-th child of its parent.

is_alive()

Return whether the process is alive.

Roughly, a process object is alive from the moment the `start()` method returns until the child process terminates.

daemon

The process's daemon flag, a Boolean value. This must be set before `start()` is called.

The initial value is inherited from the creating process.

When a process exits, it attempts to terminate all of its daemon child processes.

Note that a daemon process is not allowed to create child processes. Otherwise a daemon process would leave its children orphaned if it gets terminated when its parent process exits. Additionally, these are **not** Unix daemons or services, they are normal processes that will be terminated (and not joined) if non-daemon processes have exited.

In addition to the `threading.Thread` API, `Process` objects also support the following attributes and methods:

pid

Return the process ID. Before the process is spawned, this will be `None`.

exitcode

The child's exit code. This will be `None` if the process has not yet terminated.

If the child's `run()` method returned normally, the exit code will be 0. If it terminated via `sys.exit()` with an integer argument *N*, the exit code will be *N*.

If the child terminated due to an exception not caught within `run()`, the exit code will be 1. If it was terminated by signal *N*, the exit code will be the negative value *-N*.

authkey

The process's authentication key (a byte string).

When `multiprocessing` is initialized the main process is assigned a random string using `os.urandom()`.

When a `Process` object is created, it will inherit the authentication key of its parent process, although this may be changed by setting `authkey` to another byte string.

参F Authentication keys。

sentinel

A numeric handle of a system object which will become "ready" when the process ends.

You can use this value if you want to wait on several events at once using `multiprocessing.connection.wait()`. Otherwise calling `join()` is simpler.

On Windows, this is an OS handle usable with the `WaitForSingleObject` and `WaitForMultipleObjects` family of API calls. On Unix, this is a file descriptor usable with primitives from the `select` module.

在 3.3 版新加入.

terminate()

Terminate the process. On POSIX this is done using the `SIGTERM` signal; on Windows `TerminateProcess()` is used. Note that exit handlers and finally clauses, etc., will not be executed.

Note that descendant processes of the process will *not* be terminated -- they will simply become orphaned.

警告: If this method is used when the associated process is using a pipe or queue then the pipe or queue is liable to become corrupted and may become unusable by other process. Similarly, if the process has acquired a lock or semaphore etc. then terminating it is liable to cause other processes to deadlock.

kill()

Same as `terminate()` but using the `SIGKILL` signal on Unix.

在 3.7 版新加入.

close()

Close the `Process` object, releasing all resources associated with it. `ValueError` is raised if the underlying process is still running. Once `close()` returns successfully, most other methods and attributes of the `Process` object will raise `ValueError`.

在 3.7 版新加入.

Note that the `start()`, `join()`, `is_alive()`, `terminate()` and `exitcode` methods should only be called by the process that created the process object.

Example usage of some of the methods of `Process`:

```
>>> import multiprocessing, time, signal
>>> p = multiprocessing.Process(target=time.sleep, args=(1000,))
>>> print(p, p.is_alive())
<Process ... initial> False
>>> p.start()
>>> print(p, p.is_alive())
<Process ... started> True
>>> p.terminate()
>>> time.sleep(0.1)
>>> print(p, p.is_alive())
<Process ... stopped exitcode=-SIGTERM> False
>>> p.exitcode == -signal.SIGTERM
True
```

exception multiprocessing.ProcessError

The base class of all `multiprocessing` exceptions.

exception multiprocessing.BufferTooShort

Exception raised by `Connection.recv_bytes_into()` when the supplied buffer object is too small for the message read.

If `e` is an instance of `BufferTooShort` then `e.args[0]` will give the message as a byte string.

exception `multiprocessing.AuthenticationError`

Raised when there is an authentication error.

exception `multiprocessing.TimeoutError`

Raised by methods with a timeout when the timeout expires.

Pipes and Queues

When using multiple processes, one generally uses message passing for communication between processes and avoids having to use any synchronization primitives like locks.

For passing messages one can use `Pipe()` (for a connection between two processes) or a queue (which allows multiple producers and consumers).

The `Queue`, `SimpleQueue` and `JoinableQueue` types are multi-producer, multi-consumer FIFO queues modelled on the `queue.Queue` class in the standard library. They differ in that `Queue` lacks the `task_done()` and `join()` methods introduced into Python 2.5's `queue.Queue` class.

If you use `JoinableQueue` then you **must** call `JoinableQueue.task_done()` for each task removed from the queue or else the semaphore used to count the number of unfinished tasks may eventually overflow, raising an exception.

Note that one can also create a shared queue by using a manager object -- see *Managers*.

備 F: `multiprocessing` uses the usual `queue.Empty` and `queue.Full` exceptions to signal a timeout. They are not available in the `multiprocessing` namespace so you need to import them from `queue`.

備 F: When an object is put on a queue, the object is pickled and a background thread later flushes the pickled data to an underlying pipe. This has some consequences which are a little surprising, but should not cause any practical difficulties -- if they really bother you then you can instead use a queue created with a *manager*.

- (1) After putting an object on an empty queue there may be an infinitesimal delay before the queue's `empty()` method returns `False` and `get_nowait()` can return without raising `queue.Empty`.
 - (2) If multiple processes are enqueueing objects, it is possible for the objects to be received at the other end out-of-order. However, objects enqueued by the same process will always be in the expected order with respect to each other.
-

警告: If a process is killed using `Process.terminate()` or `os.kill()` while it is trying to use a `Queue`, then the data in the queue is likely to become corrupted. This may cause any other process to get an exception when it tries to use the queue later on.

警告: As mentioned above, if a child process has put items on a queue (and it has not used `JoinableQueue.cancel_join_thread`), then that process will not terminate until all buffered items have been flushed to the pipe.

This means that if you try joining that process you may get a deadlock unless you are sure that all items which have been put on the queue have been consumed. Similarly, if the child process is non-daemonic then the parent process may hang on exit when it tries to join all its non-daemonic children.

Note that a queue created using a manager does not have this issue. See *Programming guidelines*.

For an example of the usage of queues for interprocess communication see 範例.

`multiprocessing.Pipe([duplex])`

Returns a pair (`conn1`, `conn2`) of [Connection](#) objects representing the ends of a pipe.

If `duplex` is `True` (the default) then the pipe is bidirectional. If `duplex` is `False` then the pipe is unidirectional: `conn1` can only be used for receiving messages and `conn2` can only be used for sending messages.

class `multiprocessing.Queue([maxsize])`

Returns a process shared queue implemented using a pipe and a few locks/semaphores. When a process first puts an item on the queue a feeder thread is started which transfers objects from a buffer into the pipe.

The usual [queue.Empty](#) and [queue.Full](#) exceptions from the standard library's [queue](#) module are raised to signal timeouts.

[Queue](#) implements all the methods of [queue.Queue](#) except for [task_done\(\)](#) and [join\(\)](#).

qsize()

Return the approximate size of the queue. Because of multithreading/multiprocessing semantics, this number is not reliable.

Note that this may raise [NotImplementedError](#) on Unix platforms like macOS where [sem_getvalue\(\)](#) is not implemented.

empty()

Return `True` if the queue is empty, `False` otherwise. Because of multithreading/multiprocessing semantics, this is not reliable.

full()

Return `True` if the queue is full, `False` otherwise. Because of multithreading/multiprocessing semantics, this is not reliable.

put(obj[, block[, timeout]])

Put `obj` into the queue. If the optional argument `block` is `True` (the default) and `timeout` is `None` (the default), block if necessary until a free slot is available. If `timeout` is a positive number, it blocks at most `timeout` seconds and raises the [queue.Full](#) exception if no free slot was available within that time. Otherwise (`block` is `False`), put an item on the queue if a free slot is immediately available, else raise the [queue.Full](#) exception (`timeout` is ignored in that case).

在 3.8 版的變更: If the queue is closed, [ValueError](#) is raised instead of [AssertionError](#).

put_nowait(obj)

Equivalent to `put(obj, False)`.

get([block[, timeout]])

Remove and return an item from the queue. If optional args `block` is `True` (the default) and `timeout` is `None` (the default), block if necessary until an item is available. If `timeout` is a positive number, it blocks at most `timeout` seconds and raises the [queue.Empty](#) exception if no item was available within that time. Otherwise (`block` is `False`), return an item if one is immediately available, else raise the [queue.Empty](#) exception (`timeout` is ignored in that case).

在 3.8 版的變更: If the queue is closed, [ValueError](#) is raised instead of [OSError](#).

get_nowait()

Equivalent to `get(False)`.

[multiprocessing.Queue](#) has a few additional methods not found in [queue.Queue](#). These methods are usually unnecessary for most code:

close()

Indicate that no more data will be put on this queue by the current process. The background thread will quit once it has flushed all buffered data to the pipe. This is called automatically when the queue is garbage collected.

join_thread()

Join the background thread. This can only be used after `close()` has been called. It blocks until the background thread exits, ensuring that all data in the buffer has been flushed to the pipe.

By default if a process is not the creator of the queue then on exit it will attempt to join the queue's background thread. The process can call `cancel_join_thread()` to make `join_thread()` do nothing.

cancel_join_thread()

Prevent `join_thread()` from blocking. In particular, this prevents the background thread from being joined automatically when the process exits -- see `join_thread()`.

A better name for this method might be `allow_exit_without_flush()`. It is likely to cause enqueued data to be lost, and you almost certainly will not need to use it. It is really only there if you need the current process to exit immediately without waiting to flush enqueued data to the underlying pipe, and you don't care about lost data.

備 F: This class's functionality requires a functioning shared semaphore implementation on the host operating system. Without one, the functionality in this class will be disabled, and attempts to instantiate a `Queue` will result in an `ImportError`. See [bpo-3770](#) for additional information. The same holds true for any of the specialized queue types listed below.

class multiprocessing.SimpleQueue

It is a simplified `Queue` type, very close to a locked `Pipe`.

close()

Close the queue: release internal resources.

A queue must not be used anymore after it is closed. For example, `get()`, `put()` and `empty()` methods must no longer be called.

在 3.9 版新加入.

empty()

Return `True` if the queue is empty, `False` otherwise.

get()

Remove and return an item from the queue.

put(item)

Put `item` into the queue.

class multiprocessing.JoinableQueue([maxsize])

`JoinableQueue`, a `Queue` subclass, is a queue which additionally has `task_done()` and `join()` methods.

task_done()

Indicate that a formerly enqueued task is complete. Used by queue consumers. For each `get()` used to fetch a task, a subsequent call to `task_done()` tells the queue that the processing on the task is complete.

If a `join()` is currently blocking, it will resume when all items have been processed (meaning that a `task_done()` call was received for every item that had been `put()` into the queue).

Raises a `ValueError` if called more times than there were items placed in the queue.

join()

Block until all items in the queue have been gotten and processed.

The count of unfinished tasks goes up whenever an item is added to the queue. The count goes down whenever a consumer calls `task_done()` to indicate that the item was retrieved and all work on it is complete. When the count of unfinished tasks drops to zero, `join()` unblocks.

Miscellaneous

`multiprocessing.active_children()`

Return list of all live children of the current process.

Calling this has the side effect of "joining" any processes which have already finished.

`multiprocessing.cpu_count()`

Return the number of CPUs in the system.

This number is not equivalent to the number of CPUs the current process can use. The number of usable CPUs can be obtained with `len(os.sched_getaffinity(0))`

When the number of CPUs cannot be determined a `NotImplementedError` is raised.

也参考:

`os.cpu_count()`

`multiprocessing.current_process()`

Return the `Process` object corresponding to the current process.

An analogue of `threading.current_thread()`.

`multiprocessing.parent_process()`

Return the `Process` object corresponding to the parent process of the `current_process()`. For the main process, `parent_process` will be `None`.

在 3.8 版新加入.

`multiprocessing.freeze_support()`

Add support for when a program which uses `multiprocessing` has been frozen to produce a Windows executable. (Has been tested with `py2exe`, `PyInstaller` and `cx_Freeze`.)

One needs to call this function straight after the `if __name__ == '__main__':` line of the main module. For example:

```
from multiprocessing import Process, freeze_support

def f():
    print('hello world!')

if __name__ == '__main__':
    freeze_support()
    Process(target=f).start()
```

If the `freeze_support()` line is omitted then trying to run the frozen executable will raise `RuntimeError`.

Calling `freeze_support()` has no effect when invoked on any operating system other than Windows. In addition, if the module is being run normally by the Python interpreter on Windows (the program has not been frozen), then `freeze_support()` has no effect.

`multiprocessing.get_all_start_methods()`

Returns a list of the supported start methods, the first of which is the default. The possible start methods are 'fork', 'spawn' and 'forkserver'. On Windows only 'spawn' is available. On Unix 'fork' and 'spawn' are always supported, with 'fork' being the default.

在 3.4 版新加入.

`multiprocessing.get_context(method=None)`

Return a context object which has the same attributes as the `multiprocessing` module.

If `method` is `None` then the default context is returned. Otherwise `method` should be 'fork', 'spawn', 'forkserver'. `ValueError` is raised if the specified start method is not available.

在 3.4 版新加入.

`multiprocessing.get_start_method(allow_none=False)`

Return the name of start method used for starting processes.

If the start method has not been fixed and `allow_none` is false, then the start method is fixed to the default and the name is returned. If the start method has not been fixed and `allow_none` is true then `None` is returned.

The return value can be 'fork', 'spawn', 'forkserver' or `None`. 'fork' is the default on Unix, while 'spawn' is the default on Windows and macOS.

在 3.4 版新加入.

在 3.8 版的變更: On macOS, the `spawn` start method is now the default. The `fork` start method should be considered unsafe as it can lead to crashes of the subprocess. See [bpo-33725](#).

`multiprocessing.set_executable(executable)`

Set the path of the Python interpreter to use when starting a child process. (By default `sys.executable` is used). Embedders will probably need to do some thing like

```
set_executable(os.path.join(sys.exec_prefix, 'pythonw.exe'))
```

before they can create child processes.

在 3.4 版的變更: Now supported on Unix when the 'spawn' start method is used.

在 3.11 版的變更: Accepts a *path-like object*.

`multiprocessing.set_start_method(method, force=False)`

Set the method which should be used to start child processes. The `method` argument can be 'fork', 'spawn' or 'forkserver'. Raises `RuntimeError` if the start method has already been set and `force` is not `True`. If `method` is `None` and `force` is `True` then the start method is set to `None`. If `method` is `None` and `force` is `False` then the context is set to the default context.

Note that this should be called at most once, and it should be protected inside the `if __name__ == '__main__':` clause of the main module.

在 3.4 版新加入.

備 F: `multiprocessing` contains no analogues of `threading.active_count()`, `threading.enumerate()`, `threading.settrace()`, `threading.setprofile()`, `threading.Timer`, or `threading.local`.

Connection Objects

Connection objects allow the sending and receiving of picklable objects or strings. They can be thought of as message oriented connected sockets.

Connection objects are usually created using *Pipe* -- see also *Listeners and Clients*.

class `multiprocessing.connection.Connection`

send(*obj*)

Send an object to the other end of the connection which should be read using `recv()`.

The object must be picklable. Very large pickles (approximately 32 MiB+, though it depends on the OS) may raise a `ValueError` exception.

recv()

Return an object sent from the other end of the connection using `send()`. Blocks until there is something to receive. Raises `EOFError` if there is nothing left to receive and the other end was closed.

fileno()

Return the file descriptor or handle used by the connection.

close()

Close the connection.

This is called automatically when the connection is garbage collected.

poll([timeout])

Return whether there is any data available to be read.

If *timeout* is not specified then it will return immediately. If *timeout* is a number then this specifies the maximum time in seconds to block. If *timeout* is `None` then an infinite timeout is used.

Note that multiple connection objects may be polled at once by using `multiprocessing.connection.wait()`.

send_bytes(buffer[, offset[, size]])

Send byte data from a *bytes-like object* as a complete message.

If *offset* is given then data is read from that position in *buffer*. If *size* is given then that many bytes will be read from *buffer*. Very large buffers (approximately 32 MiB+, though it depends on the OS) may raise a `ValueError` exception

recv_bytes([maxlength])

Return a complete message of byte data sent from the other end of the connection as a string. Blocks until there is something to receive. Raises `EOFError` if there is nothing left to receive and the other end has closed.

If *maxlength* is specified and the message is longer than *maxlength* then `OSError` is raised and the connection will no longer be readable.

在 3.3 版的變更: This function used to raise `IOError`, which is now an alias of `OSError`.

recv_bytes_into(buffer[, offset])

Read into *buffer* a complete message of byte data sent from the other end of the connection and return the number of bytes in the message. Blocks until there is something to receive. Raises `EOFError` if there is nothing left to receive and the other end was closed.

buffer must be a writable *bytes-like object*. If *offset* is given then the message will be written into the buffer from that position. Offset must be a non-negative integer less than the length of *buffer* (in bytes).

If the buffer is too short then a `BufferTooShort` exception is raised and the complete message is available as `e.args[0]` where `e` is the exception instance.

在 3.3 版的變更: Connection objects themselves can now be transferred between processes using `Connection.send()` and `Connection.recv()`.

Connection objects also now support the context management protocol -- see *Context Manager Types*. `__enter__()` returns the connection object, and `__exit__()` calls `close()`.

For example:

```
>>> from multiprocessing import Pipe
>>> a, b = Pipe()
>>> a.send([1, 'hello', None])
>>> b.recv()
[1, 'hello', None]
>>> b.send_bytes(b'thank you')
>>> a.recv_bytes()
b'thank you'
>>> import array
>>> arr1 = array.array('i', range(5))
>>> arr2 = array.array('i', [0] * 10)
>>> a.send_bytes(arr1)
>>> count = b.recv_bytes_into(arr2)
>>> assert count == len(arr1) * arr1.itemsize
>>> arr2
array('i', [0, 1, 2, 3, 4, 0, 0, 0, 0, 0])
```

警告: The `Connection.recv()` method automatically unpickles the data it receives, which can be a security risk unless you can trust the process which sent the message.

Therefore, unless the connection object was produced using `Pipe()` you should only use the `recv()` and `send()` methods after performing some sort of authentication. See [Authentication keys](#).

警告: If a process is killed while it is trying to read or write to a pipe then the data in the pipe is likely to become corrupted, because it may become impossible to be sure where the message boundaries lie.

Synchronization primitives

Generally synchronization primitives are not as necessary in a multiprocess program as they are in a multithreaded program. See the documentation for [threading](#) module.

Note that one can also create synchronization primitives by using a manager object -- see [Managers](#).

class `multiprocessing.Barrier` (`parties`[, `action`[, `timeout`]])

A barrier object: a clone of [threading.Barrier](#).

在 3.3 版新加入.

class `multiprocessing.BoundedSemaphore` ([`value`])

A bounded semaphore object: a close analog of [threading.BoundedSemaphore](#).

A solitary difference from its close analog exists: its `acquire` method's first argument is named `block`, as is consistent with [Lock.acquire\(\)](#).

備 F: On macOS, this is indistinguishable from [Semaphore](#) because `sem_getvalue()` is not implemented on that platform.

class `multiprocessing.Condition` ([`lock`])

A condition variable: an alias for [threading.Condition](#).

If `lock` is specified then it should be a [Lock](#) or [RLock](#) object from [multiprocessing](#).

在 3.3 版的變更: The `wait_for()` method was added.

class `multiprocessing.Event`

A clone of [threading.Event](#).

class `multiprocessing.Lock`

A non-recursive lock object: a close analog of [threading.Lock](#). Once a process or thread has acquired a lock, subsequent attempts to acquire it from any process or thread will block until it is released; any process or thread may release it. The concepts and behaviors of [threading.Lock](#) as it applies to threads are replicated here in [multiprocessing.Lock](#) as it applies to either processes or threads, except as noted.

Note that `Lock` is actually a factory function which returns an instance of `multiprocessing.synchronize.Lock` initialized with a default context.

`Lock` supports the [context manager](#) protocol and thus may be used in `with` statements.

acquire (`block=True`, `timeout=None`)

Acquire a lock, blocking or non-blocking.

With the `block` argument set to `True` (the default), the method call will block until the lock is in an unlocked state, then set it to locked and return `True`. Note that the name of this first argument differs from that in [threading.Lock.acquire\(\)](#).

With the *block* argument set to `False`, the method call does not block. If the lock is currently in a locked state, return `False`; otherwise set the lock to a locked state and return `True`.

When invoked with a positive, floating-point value for *timeout*, block for at most the number of seconds specified by *timeout* as long as the lock can not be acquired. Invocations with a negative value for *timeout* are equivalent to a *timeout* of zero. Invocations with a *timeout* value of `None` (the default) set the timeout period to infinite. Note that the treatment of negative or `None` values for *timeout* differs from the implemented behavior in `threading.Lock.acquire()`. The *timeout* argument has no practical implications if the *block* argument is set to `False` and is thus ignored. Returns `True` if the lock has been acquired or `False` if the timeout period has elapsed.

release()

Release a lock. This can be called from any process or thread, not only the process or thread which originally acquired the lock.

Behavior is the same as in `threading.Lock.release()` except that when invoked on an unlocked lock, a `ValueError` is raised.

class multiprocessing.RLock

A recursive lock object: a close analog of `threading.RLock`. A recursive lock must be released by the process or thread that acquired it. Once a process or thread has acquired a recursive lock, the same process or thread may acquire it again without blocking; that process or thread must release it once for each time it has been acquired.

Note that `RLock` is actually a factory function which returns an instance of `multiprocessing.synchronize.RLock` initialized with a default context.

`RLock` supports the *context manager* protocol and thus may be used in `with` statements.

acquire(block=True, timeout=None)

Acquire a lock, blocking or non-blocking.

When invoked with the *block* argument set to `True`, block until the lock is in an unlocked state (not owned by any process or thread) unless the lock is already owned by the current process or thread. The current process or thread then takes ownership of the lock (if it does not already have ownership) and the recursion level inside the lock increments by one, resulting in a return value of `True`. Note that there are several differences in this first argument's behavior compared to the implementation of `threading.RLock.acquire()`, starting with the name of the argument itself.

When invoked with the *block* argument set to `False`, do not block. If the lock has already been acquired (and thus is owned) by another process or thread, the current process or thread does not take ownership and the recursion level within the lock is not changed, resulting in a return value of `False`. If the lock is in an unlocked state, the current process or thread takes ownership and the recursion level is incremented, resulting in a return value of `True`.

Use and behaviors of the *timeout* argument are the same as in `Lock.acquire()`. Note that some of these behaviors of *timeout* differ from the implemented behaviors in `threading.RLock.acquire()`.

release()

Release a lock, decrementing the recursion level. If after the decrement the recursion level is zero, reset the lock to unlocked (not owned by any process or thread) and if any other processes or threads are blocked waiting for the lock to become unlocked, allow exactly one of them to proceed. If after the decrement the recursion level is still nonzero, the lock remains locked and owned by the calling process or thread.

Only call this method when the calling process or thread owns the lock. An `AssertionError` is raised if this method is called by a process or thread other than the owner or if the lock is in an unlocked (unowned) state. Note that the type of exception raised in this situation differs from the implemented behavior in `threading.RLock.release()`.

class multiprocessing.Semaphore([value])

A semaphore object: a close analog of `threading.Semaphore`.

A solitary difference from its close analog exists: its `acquire` method's first argument is named *block*, as is consistent with `Lock.acquire()`.

備 F: On macOS, `sem_timedwait` is unsupported, so calling `acquire()` with a timeout will emulate that function's behavior using a sleeping loop.

備 F: If the SIGINT signal generated by Ctrl-C arrives while the main thread is blocked by a call to `BoundedSemaphore.acquire()`, `Lock.acquire()`, `RLock.acquire()`, `Semaphore.acquire()`, `Condition.acquire()` or `Condition.wait()` then the call will be immediately interrupted and `KeyboardInterrupt` will be raised.

This differs from the behaviour of `threading` where SIGINT will be ignored while the equivalent blocking calls are in progress.

備 F: Some of this package's functionality requires a functioning shared semaphore implementation on the host operating system. Without one, the `multiprocessing.synchronize` module will be disabled, and attempts to import it will result in an `ImportError`. See [bpo-3770](#) for additional information.

Shared ctypes Objects

It is possible to create shared objects using shared memory which can be inherited by child processes.

`multiprocessing.Value` (*typecode_or_type*, **args*, *lock=True*)

Return a `ctypes` object allocated from shared memory. By default the return value is actually a synchronized wrapper for the object. The object itself can be accessed via the *value* attribute of a `Value`.

typecode_or_type determines the type of the returned object: it is either a `ctypes` type or a one character typecode of the kind used by the `array` module. **args* is passed on to the constructor for the type.

If *lock* is `True` (the default) then a new recursive lock object is created to synchronize access to the value. If *lock* is a `Lock` or `RLock` object then that will be used to synchronize access to the value. If *lock* is `False` then access to the returned object will not be automatically protected by a lock, so it will not necessarily be "process-safe".

Operations like `+=` which involve a read and write are not atomic. So if, for instance, you want to atomically increment a shared value it is insufficient to just do

```
counter.value += 1
```

Assuming the associated lock is recursive (which it is by default) you can instead do

```
with counter.get_lock():
    counter.value += 1
```

Note that *lock* is a keyword-only argument.

`multiprocessing.Array` (*typecode_or_type*, *size_or_initializer*, *, *lock=True*)

Return a `ctypes` array allocated from shared memory. By default the return value is actually a synchronized wrapper for the array.

typecode_or_type determines the type of the elements of the returned array: it is either a `ctypes` type or a one character typecode of the kind used by the `array` module. If *size_or_initializer* is an integer, then it determines the length of the array, and the array will be initially zeroed. Otherwise, *size_or_initializer* is a sequence which is used to initialize the array and whose length determines the length of the array.

If *lock* is `True` (the default) then a new lock object is created to synchronize access to the value. If *lock* is a `Lock` or `RLock` object then that will be used to synchronize access to the value. If *lock* is `False` then access to the returned object will not be automatically protected by a lock, so it will not necessarily be "process-safe".

Note that *lock* is a keyword only argument.

Note that an array of `ctypes.c_char` has *value* and *raw* attributes which allow one to use it to store and retrieve strings.

The `multiprocessing.sharedctypes` module

The `multiprocessing.sharedctypes` module provides functions for allocating `ctypes` objects from shared memory which can be inherited by child processes.

備註: Although it is possible to store a pointer in shared memory remember that this will refer to a location in the address space of a specific process. However, the pointer is quite likely to be invalid in the context of a second process and trying to dereference the pointer from the second process may cause a crash.

`multiprocessing.sharedctypes.RawArray` (*typecode_or_type*, *size_or_initializer*)

Return a `ctypes` array allocated from shared memory.

typecode_or_type determines the type of the elements of the returned array: it is either a `ctypes` type or a one character typecode of the kind used by the `array` module. If *size_or_initializer* is an integer then it determines the length of the array, and the array will be initially zeroed. Otherwise *size_or_initializer* is a sequence which is used to initialize the array and whose length determines the length of the array.

Note that setting and getting an element is potentially non-atomic -- use `Array()` instead to make sure that access is automatically synchronized using a lock.

`multiprocessing.sharedctypes.RawValue` (*typecode_or_type*, **args*)

Return a `ctypes` object allocated from shared memory.

typecode_or_type determines the type of the returned object: it is either a `ctypes` type or a one character typecode of the kind used by the `array` module. **args* is passed on to the constructor for the type.

Note that setting and getting the value is potentially non-atomic -- use `Value()` instead to make sure that access is automatically synchronized using a lock.

Note that an array of `ctypes.c_char` has *value* and *raw* attributes which allow one to use it to store and retrieve strings -- see documentation for `ctypes`.

`multiprocessing.sharedctypes.Array` (*typecode_or_type*, *size_or_initializer*, *, *lock=True*)

The same as `RawArray()` except that depending on the value of *lock* a process-safe synchronization wrapper may be returned instead of a raw `ctypes` array.

If *lock* is `True` (the default) then a new lock object is created to synchronize access to the value. If *lock* is a `Lock` or `RLock` object then that will be used to synchronize access to the value. If *lock* is `False` then access to the returned object will not be automatically protected by a lock, so it will not necessarily be "process-safe".

Note that *lock* is a keyword-only argument.

`multiprocessing.sharedctypes.Value` (*typecode_or_type*, **args*, *lock=True*)

The same as `RawValue()` except that depending on the value of *lock* a process-safe synchronization wrapper may be returned instead of a raw `ctypes` object.

If *lock* is `True` (the default) then a new lock object is created to synchronize access to the value. If *lock* is a `Lock` or `RLock` object then that will be used to synchronize access to the value. If *lock* is `False` then access to the returned object will not be automatically protected by a lock, so it will not necessarily be "process-safe".

Note that *lock* is a keyword-only argument.

`multiprocessing.sharedctypes.copy(obj)`

Return a ctypes object allocated from shared memory which is a copy of the ctypes object *obj*.

`multiprocessing.sharedctypes.synchronized(obj[, lock])`

Return a process-safe wrapper object for a ctypes object which uses *lock* to synchronize access. If *lock* is None (the default) then a `multiprocessing.RLock` object is created automatically.

A synchronized wrapper will have two methods in addition to those of the object it wraps: `get_obj()` returns the wrapped object and `get_lock()` returns the lock object used for synchronization.

Note that accessing the ctypes object through the wrapper can be a lot slower than accessing the raw ctypes object.

在 3.5 版的變更: Synchronized objects support the *context manager* protocol.

The table below compares the syntax for creating shared ctypes objects from shared memory with the normal ctypes syntax. (In the table `MyStruct` is some subclass of `ctypes.Structure`.)

ctypes	sharedctypes using type	sharedctypes using typecode
<code>c_double(2.4)</code>	<code>RawValue(c_double, 2.4)</code>	<code>RawValue('d', 2.4)</code>
<code>MyStruct(4, 6)</code>	<code>RawValue(MyStruct, 4, 6)</code>	
<code>(c_short * 7)()</code>	<code>RawArray(c_short, 7)</code>	<code>RawArray('h', 7)</code>
<code>(c_int * 3)(9, 2, 8)</code>	<code>RawArray(c_int, (9, 2, 8))</code>	<code>RawArray('i', (9, 2, 8))</code>

Below is an example where a number of ctypes objects are modified by a child process:

```
from multiprocessing import Process, Lock
from multiprocessing.sharedctypes import Value, Array
from ctypes import Structure, c_double

class Point(Structure):
    _fields_ = [('x', c_double), ('y', c_double)]

def modify(n, x, s, A):
    n.value **= 2
    x.value **= 2
    s.value = s.value.upper()
    for a in A:
        a.x **= 2
        a.y **= 2

if __name__ == '__main__':
    lock = Lock()

    n = Value('i', 7)
    x = Value(c_double, 1.0/3.0, lock=False)
    s = Array('c', b'hello world', lock=lock)
    A = Array(Point, [(1.875, -6.25), (-5.75, 2.0), (2.375, 9.5)], lock=lock)

    p = Process(target=modify, args=(n, x, s, A))
    p.start()
    p.join()

    print(n.value)
    print(x.value)
    print(s.value)
    print([(a.x, a.y) for a in A])
```

The results printed are

```

49
0.1111111111111111
HELLO WORLD
[(3.515625, 39.0625), (33.0625, 4.0), (5.640625, 90.25)]

```

Managers

Managers provide a way to create data which can be shared between different processes, including sharing over a network between processes running on different machines. A manager object controls a server process which manages *shared objects*. Other processes can access the shared objects by using proxies.

`multiprocessing.Manager()`

Returns a started *SyncManager* object which can be used for sharing objects between processes. The returned manager object corresponds to a spawned child process and has methods which will create shared objects and return corresponding proxies.

Manager processes will be shutdown as soon as they are garbage collected or their parent process exits. The manager classes are defined in the `multiprocessing.managers` module:

```
class multiprocessing.managers.BaseManager (address=None, authkey=None, serializer='pickle',
                                           ctx=None, *, shutdown_timeout=1.0)
```

Create a BaseManager object.

Once created one should call `start()` or `get_server().serve_forever()` to ensure that the manager object refers to a started manager process.

address is the address on which the manager process listens for new connections. If *address* is `None` then an arbitrary one is chosen.

authkey is the authentication key which will be used to check the validity of incoming connections to the server process. If *authkey* is `None` then `current_process().authkey` is used. Otherwise *authkey* is used and it must be a byte string.

serializer must be 'pickle' (use *pickle* serialization) or 'xmlrpclib' (use *xmlrpc.client* serialization).

ctx is a context object, or `None` (use the current context). See the `get_context()` function.

shutdown_timeout is a timeout in seconds used to wait until the process used by the manager completes in the `shutdown()` method. If the shutdown times out, the process is terminated. If terminating the process also times out, the process is killed.

在 3.11 版的變更: 新增 *shutdown_timeout* 參數。

`start([initializer[, initargs]])`

Start a subprocess to start the manager. If *initializer* is not `None` then the subprocess will call `initializer(*initargs)` when it starts.

`get_server()`

Returns a *Server* object which represents the actual server under the control of the Manager. The *Server* object supports the `serve_forever()` method:

```

>>> from multiprocessing.managers import BaseManager
>>> manager = BaseManager(address=('', 50000), authkey=b'abc')
>>> server = manager.get_server()
>>> server.serve_forever()

```

Server additionally has an *address* attribute.

`connect()`

Connect a local manager object to a remote manager process:


```
>>> from multiprocessing.managers import BaseManager
>>> m = BaseManager(address=('127.0.0.1', 50000), authkey=b'abc')
>>> m.connect()
```

shutdown()

Stop the process used by the manager. This is only available if `start()` has been used to start the server process.

This can be called multiple times.

register(*typeid*[, *callable*[, *proxytype*[, *exposed*[, *method_to_typeid*[, *create_method*]]]]])

A classmethod which can be used for registering a type or callable with the manager class.

typeid is a "type identifier" which is used to identify a particular type of shared object. This must be a string.

callable is a callable used for creating objects for this type identifier. If a manager instance will be connected to the server using the `connect()` method, or if the *create_method* argument is `False` then this can be left as `None`.

proxytype is a subclass of `BaseProxy` which is used to create proxies for shared objects with this *typeid*. If `None` then a proxy class is created automatically.

exposed is used to specify a sequence of method names which proxies for this *typeid* should be allowed to access using `BaseProxy._callmethod()`. (If *exposed* is `None` then `proxytype._exposed` is used instead if it exists.) In the case where no exposed list is specified, all "public methods" of the shared object will be accessible. (Here a "public method" means any attribute which has a `__call__()` method and whose name does not begin with `'_'`.)

method_to_typeid is a mapping used to specify the return type of those exposed methods which should return a proxy. It maps method names to *typeid* strings. (If *method_to_typeid* is `None` then `proxytype._method_to_typeid` is used instead if it exists.) If a method's name is not a key of this mapping or if the mapping is `None` then the object returned by the method will be copied by value.

create_method determines whether a method should be created with name *typeid* which can be used to tell the server process to create a new shared object and return a proxy for it. By default it is `True`.

`BaseManager` instances also have one read-only property:

address

The address used by the manager.

在 3.3 版的變更: Manager objects support the context management protocol -- see *Context Manager Types*. `__enter__()` starts the server process (if it has not already started) and then returns the manager object. `__exit__()` calls `shutdown()`.

In previous versions `__enter__()` did not start the manager's server process if it was not already started.

class multiprocessing.managers.SyncManager

A subclass of `BaseManager` which can be used for the synchronization of processes. Objects of this type are returned by `multiprocessing.Manager()`.

Its methods create and return *Proxy Objects* for a number of commonly used data types to be synchronized across processes. This notably includes shared lists and dictionaries.

Barrier(*parties*[, *action*[, *timeout*]])

Create a shared `threading.Barrier` object and return a proxy for it.

在 3.3 版新加入.

BoundedSemaphore(*value*)

Create a shared `threading.BoundedSemaphore` object and return a proxy for it.

Condition ([*lock*])

Create a shared `threading.Condition` object and return a proxy for it.

If *lock* is supplied then it should be a proxy for a `threading.Lock` or `threading.RLock` object.

在 3.3 版的變更: The `wait_for()` method was added.

Event ()

Create a shared `threading.Event` object and return a proxy for it.

Lock ()

Create a shared `threading.Lock` object and return a proxy for it.

Namespace ()

Create a shared `Namespace` object and return a proxy for it.

Queue ([*maxsize*])

Create a shared `queue.Queue` object and return a proxy for it.

RLock ()

Create a shared `threading.RLock` object and return a proxy for it.

Semaphore ([*value*])

Create a shared `threading.Semaphore` object and return a proxy for it.

Array (*typecode*, *sequence*)

Create an array and return a proxy for it.

Value (*typecode*, *value*)

Create an object with a writable `value` attribute and return a proxy for it.

dict ()**dict** (*mapping*)**dict** (*sequence*)

Create a shared `dict` object and return a proxy for it.

list ()**list** (*sequence*)

Create a shared `list` object and return a proxy for it.

在 3.6 版的變更: Shared objects are capable of being nested. For example, a shared container object such as a shared list can contain other shared objects which will all be managed and synchronized by the `SyncManager`.

class `multiprocessing.managers.Namespace`

A type that can register with `SyncManager`.

A namespace object has no public methods, but does have writable attributes. Its representation shows the values of its attributes.

However, when using a proxy for a namespace object, an attribute beginning with `'_'` will be an attribute of the proxy and not an attribute of the referent:

```
>>> manager = multiprocessing.Manager()
>>> Global = manager.Namespace()
>>> Global.x = 10
>>> Global.y = 'hello'
>>> Global._z = 12.3      # this is an attribute of the proxy
>>> print(Global)
Namespace(x=10, y='hello')
```

Customized managers

To create one's own manager, one creates a subclass of `BaseManager` and uses the `register()` classmethod to register new types or callables with the manager class. For example:

```
from multiprocessing.managers import BaseManager

class MathsClass:
    def add(self, x, y):
        return x + y
    def mul(self, x, y):
        return x * y

class MyManager(BaseManager):
    pass

MyManager.register('Maths', MathsClass)

if __name__ == '__main__':
    with MyManager() as manager:
        maths = manager.Maths()
        print(maths.add(4, 3))          # prints 7
        print(maths.mul(7, 8))         # prints 56
```

Using a remote manager

It is possible to run a manager server on one machine and have clients use it from other machines (assuming that the firewalls involved allow it).

Running the following commands creates a server for a single shared queue which remote clients can access:

```
>>> from multiprocessing.managers import BaseManager
>>> from queue import Queue
>>> queue = Queue()
>>> class QueueManager(BaseManager): pass
>>> QueueManager.register('get_queue', callable=lambda: queue)
>>> m = QueueManager(address=('', 50000), authkey=b'abracadabra')
>>> s = m.get_server()
>>> s.serve_forever()
```

One client can access the server as follows:

```
>>> from multiprocessing.managers import BaseManager
>>> class QueueManager(BaseManager): pass
>>> QueueManager.register('get_queue')
>>> m = QueueManager(address=('foo.bar.org', 50000), authkey=b'abracadabra')
>>> m.connect()
>>> queue = m.get_queue()
>>> queue.put('hello')
```

Another client can also use it:

```
>>> from multiprocessing.managers import BaseManager
>>> class QueueManager(BaseManager): pass
>>> QueueManager.register('get_queue')
>>> m = QueueManager(address=('foo.bar.org', 50000), authkey=b'abracadabra')
>>> m.connect()
>>> queue = m.get_queue()
>>> queue.get()
'hello'
```

Local processes can also access that queue, using the code from above on the client to access it remotely:

```
>>> from multiprocessing import Process, Queue
>>> from multiprocessing.managers import BaseManager
>>> class Worker(Process):
...     def __init__(self, q):
...         self.q = q
...         super().__init__()
...     def run(self):
...         self.q.put('local hello')
...
>>> queue = Queue()
>>> w = Worker(queue)
>>> w.start()
>>> class QueueManager(BaseManager): pass
...
>>> QueueManager.register('get_queue', callable=lambda: queue)
>>> m = QueueManager(address=('', 50000), authkey=b'abracadabra')
>>> s = m.get_server()
>>> s.serve_forever()
```

Proxy Objects

A proxy is an object which *refers* to a shared object which lives (presumably) in a different process. The shared object is said to be the *referent* of the proxy. Multiple proxy objects may have the same referent.

A proxy object has methods which invoke corresponding methods of its referent (although not every method of the referent will necessarily be available through the proxy). In this way, a proxy can be used just like its referent can:

```
>>> from multiprocessing import Manager
>>> manager = Manager()
>>> l = manager.list([i*i for i in range(10)])
>>> print(l)
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
>>> print(repr(l))
<ListProxy object, typeid 'list' at 0x...>
>>> l[4]
16
>>> l[2:5]
[4, 9, 16]
```

Notice that applying `str()` to a proxy will return the representation of the referent, whereas applying `repr()` will return the representation of the proxy.

An important feature of proxy objects is that they are picklable so they can be passed between processes. As such, a referent can contain *Proxy Objects*. This permits nesting of these managed lists, dicts, and other *Proxy Objects*:

```
>>> a = manager.list()
>>> b = manager.list()
>>> a.append(b)           # referent of a now contains referent of b
>>> print(a, b)
[<ListProxy object, typeid 'list' at ...>] []
>>> b.append('hello')
>>> print(a[0], b)
['hello'] ['hello']
```

Similarly, dict and list proxies may be nested inside one another:

```
>>> l_outer = manager.list([ manager.dict() for i in range(2) ])
>>> d_first_inner = l_outer[0]
>>> d_first_inner['a'] = 1
```

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```
>>> d_first_inner['b'] = 2
>>> l_outer[1]['c'] = 3
>>> l_outer[1]['z'] = 26
>>> print(l_outer[0])
{'a': 1, 'b': 2}
>>> print(l_outer[1])
{'c': 3, 'z': 26}
```

If standard (non-proxy) *list* or *dict* objects are contained in a referent, modifications to those mutable values will not be propagated through the manager because the proxy has no way of knowing when the values contained within are modified. However, storing a value in a container proxy (which triggers a `__setitem__` on the proxy object) does propagate through the manager and so to effectively modify such an item, one could re-assign the modified value to the container proxy:

```
# create a list proxy and append a mutable object (a dictionary)
lproxy = manager.list()
lproxy.append({})
# now mutate the dictionary
d = lproxy[0]
d['a'] = 1
d['b'] = 2
# at this point, the changes to d are not yet synced, but by
# updating the dictionary, the proxy is notified of the change
lproxy[0] = d
```

This approach is perhaps less convenient than employing nested *Proxy Objects* for most use cases but also demonstrates a level of control over the synchronization.

備 F: The proxy types in *multiprocessing* do nothing to support comparisons by value. So, for instance, we have:

```
>>> manager.list([1,2,3]) == [1,2,3]
False
```

One should just use a copy of the referent instead when making comparisons.

class multiprocessing.managers.**BaseProxy**

Proxy objects are instances of subclasses of *BaseProxy*.

__callmethod(*methodname*[, *args*[, *kws*]])

Call and return the result of a method of the proxy's referent.

If *proxy* is a proxy whose referent is *obj* then the expression

```
proxy._callmethod(methodname, args, kws)
```

will evaluate the expression

```
getattr(obj, methodname)(*args, **kws)
```

in the manager's process.

The returned value will be a copy of the result of the call or a proxy to a new shared object -- see documentation for the *method_to_typeid* argument of *BaseManager.register()*.

If an exception is raised by the call, then is re-raised by *__callmethod()*. If some other exception is raised in the manager's process then this is converted into a *RemoteError* exception and is raised by *__callmethod()*.

Note in particular that an exception will be raised if *methodname* has not been *exposed*.

An example of the usage of `_callmethod()`:

```
>>> l = manager.list(range(10))
>>> l._callmethod('__len__')
10
>>> l._callmethod('__getitem__', (slice(2, 7),)) # equivalent to l[2:7]
[2, 3, 4, 5, 6]
>>> l._callmethod('__getitem__', (20,))          # equivalent to l[20]
Traceback (most recent call last):
...
IndexError: list index out of range
```

`_getvalue()`

Return a copy of the referent.

If the referent is unpicklable then this will raise an exception.

`__repr__()`

Return a representation of the proxy object.

`__str__()`

Return the representation of the referent.

Cleanup

A proxy object uses a weakref callback so that when it gets garbage collected it deregisters itself from the manager which owns its referent.

A shared object gets deleted from the manager process when there are no longer any proxies referring to it.

Process Pools

One can create a pool of processes which will carry out tasks submitted to it with the `Pool` class.

```
class multiprocessing.pool.Pool([processes[, initializer[, initargs[, maxtasksperchild[, context]]]])
```

A process pool object which controls a pool of worker processes to which jobs can be submitted. It supports asynchronous results with timeouts and callbacks and has a parallel map implementation.

`processes` is the number of worker processes to use. If `processes` is `None` then the number returned by `os.cpu_count()` is used.

If `initializer` is not `None` then each worker process will call `initializer(*initargs)` when it starts.

`maxtasksperchild` is the number of tasks a worker process can complete before it will exit and be replaced with a fresh worker process, to enable unused resources to be freed. The default `maxtasksperchild` is `None`, which means worker processes will live as long as the pool.

`context` can be used to specify the context used for starting the worker processes. Usually a pool is created using the function `multiprocessing.Pool()` or the `Pool()` method of a context object. In both cases `context` is set appropriately.

Note that the methods of the pool object should only be called by the process which created the pool.

警告: `multiprocessing.pool` objects have internal resources that need to be properly managed (like any other resource) by using the pool as a context manager or by calling `close()` and `terminate()` manually. Failure to do this can lead to the process hanging on finalization.

Note that it is **not correct** to rely on the garbage collector to destroy the pool as CPython does not assure that the finalizer of the pool will be called (see `object.__del__()` for more information).

在 3.2 版的變更: Added the *maxtasksperchild* parameter.

在 3.4 版的變更: Added the *context* parameter.

備 F: Worker processes within a *Pool* typically live for the complete duration of the Pool's work queue. A frequent pattern found in other systems (such as Apache, *mod_wsgi*, etc) to free resources held by workers is to allow a worker within a pool to complete only a set amount of work before being exiting, being cleaned up and a new process spawned to replace the old one. The *maxtasksperchild* argument to the *Pool* exposes this ability to the end user.

apply (*func*[, *args*[, *kwargs*]])

Call *func* with arguments *args* and keyword arguments *kwargs*. It blocks until the result is ready. Given this blocks, *apply_async()* is better suited for performing work in parallel. Additionally, *func* is only executed in one of the workers of the pool.

apply_async (*func*[, *args*[, *kwargs*[, *callback*[, *error_callback*]]]])

A variant of the *apply()* method which returns a *AsyncResult* object.

If *callback* is specified then it should be a callable which accepts a single argument. When the result becomes ready *callback* is applied to it, that is unless the call failed, in which case the *error_callback* is applied instead.

If *error_callback* is specified then it should be a callable which accepts a single argument. If the target function fails, then the *error_callback* is called with the exception instance.

Callbacks should complete immediately since otherwise the thread which handles the results will get blocked.

map (*func*, *iterable*[, *chunksize*])

A parallel equivalent of the *map()* built-in function (it supports only one *iterable* argument though, for multiple iterables see *starmap()*). It blocks until the result is ready.

This method chops the iterable into a number of chunks which it submits to the process pool as separate tasks. The (approximate) size of these chunks can be specified by setting *chunksize* to a positive integer.

Note that it may cause high memory usage for very long iterables. Consider using *imap()* or *imap_unordered()* with explicit *chunksize* option for better efficiency.

map_async (*func*, *iterable*[, *chunksize*[, *callback*[, *error_callback*]]])

A variant of the *map()* method which returns a *AsyncResult* object.

If *callback* is specified then it should be a callable which accepts a single argument. When the result becomes ready *callback* is applied to it, that is unless the call failed, in which case the *error_callback* is applied instead.

If *error_callback* is specified then it should be a callable which accepts a single argument. If the target function fails, then the *error_callback* is called with the exception instance.

Callbacks should complete immediately since otherwise the thread which handles the results will get blocked.

imap (*func*, *iterable*[, *chunksize*])

A lazier version of *map()*.

The *chunksize* argument is the same as the one used by the *map()* method. For very long iterables using a large value for *chunksize* can make the job complete **much** faster than using the default value of 1.

Also if *chunksize* is 1 then the *next()* method of the iterator returned by the *imap()* method has an optional *timeout* parameter: *next(timeout)* will raise *multiprocessing.TimeoutError* if the result cannot be returned within *timeout* seconds.

imap_unordered (*func*, *iterable*[, *chunksize*])

The same as *imap()* except that the ordering of the results from the returned iterator should be considered arbitrary. (Only when there is only one worker process is the order guaranteed to be "correct".)

starmap (*func*, *iterable*_[, *chunksize*])

Like *map()* except that the elements of the *iterable* are expected to be iterables that are unpacked as arguments.

Hence an *iterable* of [(1, 2), (3, 4)] results in [func(1, 2), func(3, 4)].

在 3.3 版新加入.

starmap_async (*func*, *iterable*_[, *chunksize*]_{[, *callback*_[, *error_callback*]]])}

A combination of *starmap()* and *map_async()* that iterates over *iterable* of iterables and calls *func* with the iterables unpacked. Returns a result object.

在 3.3 版新加入.

close ()

Prevents any more tasks from being submitted to the pool. Once all the tasks have been completed the worker processes will exit.

terminate ()

Stops the worker processes immediately without completing outstanding work. When the pool object is garbage collected *terminate()* will be called immediately.

join ()

Wait for the worker processes to exit. One must call *close()* or *terminate()* before using *join()*.

在 3.3 版的變更: Pool objects now support the context management protocol -- see *Context Manager Types*. *__enter__()* returns the pool object, and *__exit__()* calls *terminate()*.

class multiprocessing.pool.**AsyncResult**

The class of the result returned by *Pool.apply_async()* and *Pool.map_async()*.

get ([*timeout*])

Return the result when it arrives. If *timeout* is not None and the result does not arrive within *timeout* seconds then *multiprocessing.TimeoutError* is raised. If the remote call raised an exception then that exception will be reraised by *get()*.

wait ([*timeout*])

Wait until the result is available or until *timeout* seconds pass.

ready ()

Return whether the call has completed.

successful ()

Return whether the call completed without raising an exception. Will raise *ValueError* if the result is not ready.

在 3.7 版的變更: If the result is not ready, *ValueError* is raised instead of *AssertionError*.

The following example demonstrates the use of a pool:

```
from multiprocessing import Pool
import time

def f(x):
    return x*x

if __name__ == '__main__':
    with Pool(processes=4) as pool:          # start 4 worker processes
        result = pool.apply_async(f, (10,)) # evaluate "f(10)" asynchronously in a
        ↪ single process
        print(result.get(timeout=1))        # prints "100" unless your computer is
        ↪ *very* slow
```

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```

print(pool.map(f, range(10)))          # prints "[0, 1, 4,..., 81]"

it = pool.imap(f, range(10))
print(next(it))                        # prints "0"
print(next(it))                        # prints "1"
print(it.next(timeout=1))              # prints "4" unless your computer is
↳ *very* slow

result = pool.apply_async(time.sleep, (10,))
print(result.get(timeout=1))           # raises multiprocessing.TimeoutError

```

Listeners and Clients

Usually message passing between processes is done using queues or by using *Connection* objects returned by *Pipe()*.

However, the *multiprocessing.connection* module allows some extra flexibility. It basically gives a high level message oriented API for dealing with sockets or Windows named pipes. It also has support for *digest authentication* using the *hmac* module, and for polling multiple connections at the same time.

multiprocessing.connection.deliver_challenge (*connection*, *authkey*)

Send a randomly generated message to the other end of the connection and wait for a reply.

If the reply matches the digest of the message using *authkey* as the key then a welcome message is sent to the other end of the connection. Otherwise *AuthenticationError* is raised.

multiprocessing.connection.answer_challenge (*connection*, *authkey*)

Receive a message, calculate the digest of the message using *authkey* as the key, and then send the digest back.

If a welcome message is not received, then *AuthenticationError* is raised.

multiprocessing.connection.Client (*address*[, *family*[, *authkey*]])

Attempt to set up a connection to the listener which is using address *address*, returning a *Connection*.

The type of the connection is determined by *family* argument, but this can generally be omitted since it can usually be inferred from the format of *address*. (See *Address Formats*)

If *authkey* is given and not None, it should be a byte string and will be used as the secret key for an HMAC-based authentication challenge. No authentication is done if *authkey* is None. *AuthenticationError* is raised if authentication fails. See *Authentication keys*.

class *multiprocessing.connection.Listener* ([*address*[, *family*[, *backlog*[, *authkey*]]]])

A wrapper for a bound socket or Windows named pipe which is 'listening' for connections.

address is the address to be used by the bound socket or named pipe of the listener object.

備註: If an address of '0.0.0.0' is used, the address will not be a connectable end point on Windows. If you require a connectable end-point, you should use '127.0.0.1'.

family is the type of socket (or named pipe) to use. This can be one of the strings 'AF_INET' (for a TCP socket), 'AF_UNIX' (for a Unix domain socket) or 'AF_PIPE' (for a Windows named pipe). Of these only the first is guaranteed to be available. If *family* is None then the family is inferred from the format of *address*. If *address* is also None then a default is chosen. This default is the family which is assumed to be the fastest available. See *Address Formats*. Note that if *family* is 'AF_UNIX' and *address* is None then the socket will be created in a private temporary directory created using *tempfile.mkstemp()*.

If the listener object uses a socket then *backlog* (1 by default) is passed to the *listen()* method of the socket once it has been bound.

If *authkey* is given and not *None*, it should be a byte string and will be used as the secret key for an HMAC-based authentication challenge. No authentication is done if *authkey* is *None*. *AuthenticationError* is raised if authentication fails. See *Authentication keys*.

accept()

Accept a connection on the bound socket or named pipe of the listener object and return a *Connection* object. If authentication is attempted and fails, then *AuthenticationError* is raised.

close()

Close the bound socket or named pipe of the listener object. This is called automatically when the listener is garbage collected. However it is advisable to call it explicitly.

Listener objects have the following read-only properties:

address

The address which is being used by the Listener object.

last_accepted

The address from which the last accepted connection came. If this is unavailable then it is *None*.

在 3.3 版的變更: Listener objects now support the context management protocol -- see *Context Manager Types*. *__enter__()* returns the listener object, and *__exit__()* calls *close()*.

`multiprocessing.connection.wait(object_list, timeout=None)`

Wait till an object in *object_list* is ready. Returns the list of those objects in *object_list* which are ready. If *timeout* is a float then the call blocks for at most that many seconds. If *timeout* is *None* then it will block for an unlimited period. A negative timeout is equivalent to a zero timeout.

For both Unix and Windows, an object can appear in *object_list* if it is

- a readable *Connection* object;
- a connected and readable *socket.socket* object; or
- the *sentinel* attribute of a *Process* object.

A connection or socket object is ready when there is data available to be read from it, or the other end has been closed.

Unix: `wait(object_list, timeout)` almost equivalent `select.select(object_list, [], [], timeout)`. The difference is that, if `select.select()` is interrupted by a signal, it can raise *OSError* with an error number of *EINTR*, whereas `wait()` will not.

Windows: An item in *object_list* must either be an integer handle which is waitable (according to the definition used by the documentation of the Win32 function `WaitForMultipleObjects()`) or it can be an object with a *fileno()* method which returns a socket handle or pipe handle. (Note that pipe handles and socket handles are **not** waitable handles.)

在 3.3 版新加入.

Examples

The following server code creates a listener which uses 'secret password' as an authentication key. It then waits for a connection and sends some data to the client:

```
from multiprocessing.connection import Listener
from array import array

address = ('localhost', 6000)      # family is deduced to be 'AF_INET'

with Listener(address, authkey=b'secret password') as listener:
    with listener.accept() as conn:
        print('connection accepted from', listener.last_accepted)

        conn.send([2.25, None, 'junk', float])
```

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```
conn.send_bytes(b'hello')

conn.send_bytes(array('i', [42, 1729]))
```

The following code connects to the server and receives some data from the server:

```
from multiprocessing.connection import Client
from array import array

address = ('localhost', 6000)

with Client(address, authkey=b'secret password') as conn:
    print(conn.recv())           # => [2.25, None, 'junk', float]

    print(conn.recv_bytes())     # => 'hello'

    arr = array('i', [0, 0, 0, 0, 0])
    print(conn.recv_bytes_into(arr)) # => 8
    print(arr)                   # => array('i', [42, 1729, 0, 0, 0])
```

The following code uses `wait()` to wait for messages from multiple processes at once:

```
import time, random
from multiprocessing import Process, Pipe, current_process
from multiprocessing.connection import wait

def foo(w):
    for i in range(10):
        w.send((i, current_process().name))
    w.close()

if __name__ == '__main__':
    readers = []

    for i in range(4):
        r, w = Pipe(duplex=False)
        readers.append(r)
        p = Process(target=foo, args=(w,))
        p.start()
        # We close the writable end of the pipe now to be sure that
        # p is the only process which owns a handle for it. This
        # ensures that when p closes its handle for the writable end,
        # wait() will promptly report the readable end as being ready.
        w.close()

    while readers:
        for r in wait(readers):
            try:
                msg = r.recv()
            except EOFError:
                readers.remove(r)
            else:
                print(msg)
```

Address Formats

- An 'AF_INET' address is a tuple of the form (hostname, port) where *hostname* is a string and *port* is an integer.
- An 'AF_UNIX' address is a string representing a filename on the filesystem.
- An 'AF_PIPE' address is a string of the form r'\\.pipe\PipeName'. To use `Client()` to connect to a named pipe on a remote computer called *ServerName* one should use an address of the form r'\\.ServerName\pipe\PipeName' instead.

Note that any string beginning with two backslashes is assumed by default to be an 'AF_PIPE' address rather than an 'AF_UNIX' address.

Authentication keys

When one uses `Connection.recv`, the data received is automatically unpickled. Unfortunately unpickling data from an untrusted source is a security risk. Therefore `Listener` and `Client()` use the `hmac` module to provide digest authentication.

An authentication key is a byte string which can be thought of as a password: once a connection is established both ends will demand proof that the other knows the authentication key. (Demonstrating that both ends are using the same key does **not** involve sending the key over the connection.)

If authentication is requested but no authentication key is specified then the return value of `current_process().authkey` is used (see `Process`). This value will be automatically inherited by any `Process` object that the current process creates. This means that (by default) all processes of a multi-process program will share a single authentication key which can be used when setting up connections between themselves.

Suitable authentication keys can also be generated by using `os.urandom()`.

Logging

Some support for logging is available. Note, however, that the `logging` package does not use process shared locks so it is possible (depending on the handler type) for messages from different processes to get mixed up.

`multiprocessing.get_logger()`

Returns the logger used by `multiprocessing`. If necessary, a new one will be created.

When first created the logger has level `logging.NOTSET` and no default handler. Messages sent to this logger will not by default propagate to the root logger.

Note that on Windows child processes will only inherit the level of the parent process's logger -- any other customization of the logger will not be inherited.

`multiprocessing.log_to_stderr(level=None)`

This function performs a call to `get_logger()` but in addition to returning the logger created by `get_logger`, it adds a handler which sends output to `sys.stderr` using format '%(levelname)s/%(processName)s] %(message)s'. You can modify `levelname` of the logger by passing a `level` argument.

Below is an example session with logging turned on:

```
>>> import multiprocessing, logging
>>> logger = multiprocessing.log_to_stderr()
>>> logger.setLevel(logging.INFO)
>>> logger.warning('doomed')
[WARNING/MainProcess] doomed
>>> m = multiprocessing.Manager()
[INFO/SyncManager-...] child process calling self.run()
[INFO/SyncManager-...] created temp directory /.../pymp-...
```

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```
[INFO/SyncManager-...] manager serving at '/.../listener-...'  
>>> del m  
[INFO/MainProcess] sending shutdown message to manager  
[INFO/SyncManager-...] manager exiting with exitcode 0
```

For a full table of logging levels, see the *logging* module.

The `multiprocessing.dummy` module

`multiprocessing.dummy` replicates the API of `multiprocessing` but is no more than a wrapper around the `threading` module.

In particular, the `Pool` function provided by `multiprocessing.dummy` returns an instance of `ThreadPool`, which is a subclass of `Pool` that supports all the same method calls but uses a pool of worker threads rather than worker processes.

class `multiprocessing.pool.ThreadPool` (`[processes[, initializer[, initargs]]]`)

A thread pool object which controls a pool of worker threads to which jobs can be submitted. `ThreadPool` instances are fully interface compatible with `Pool` instances, and their resources must also be properly managed, either by using the pool as a context manager or by calling `close()` and `terminate()` manually.

`processes` is the number of worker threads to use. If `processes` is `None` then the number returned by `os.cpu_count()` is used.

If `initializer` is not `None` then each worker process will call `initializer(*initargs)` when it starts.

Unlike `Pool`, `maxtasksperchild` and `context` cannot be provided.

備 F: A `ThreadPool` shares the same interface as `Pool`, which is designed around a pool of processes and predates the introduction of the `concurrent.futures` module. As such, it inherits some operations that don't make sense for a pool backed by threads, and it has its own type for representing the status of asynchronous jobs, `AsyncResult`, that is not understood by any other libraries.

Users should generally prefer to use `concurrent.futures.ThreadPoolExecutor`, which has a simpler interface that was designed around threads from the start, and which returns `concurrent.futures.Future` instances that are compatible with many other libraries, including `asyncio`.

17.2.3 Programming guidelines

There are certain guidelines and idioms which should be adhered to when using `multiprocessing`.

All start methods

The following applies to all start methods.

Avoid shared state

As far as possible one should try to avoid shifting large amounts of data between processes.

It is probably best to stick to using queues or pipes for communication between processes rather than using the lower level synchronization primitives.

Picklability

Ensure that the arguments to the methods of proxies are picklable.

Thread safety of proxies

Do not use a proxy object from more than one thread unless you protect it with a lock.

(There is never a problem with different processes using the *same* proxy.)

Joining zombie processes

On Unix when a process finishes but has not been joined it becomes a zombie. There should never be very many because each time a new process starts (or `active_children()` is called) all completed processes which have not yet been joined will be joined. Also calling a finished process's `Process.is_alive` will join the process. Even so it is probably good practice to explicitly join all the processes that you start.

Better to inherit than pickle/unpickle

When using the `spawn` or `forkserver` start methods many types from `multiprocessing` need to be picklable so that child processes can use them. However, one should generally avoid sending shared objects to other processes using pipes or queues. Instead you should arrange the program so that a process which needs access to a shared resource created elsewhere can inherit it from an ancestor process.

Avoid terminating processes

Using the `Process.terminate` method to stop a process is liable to cause any shared resources (such as locks, semaphores, pipes and queues) currently being used by the process to become broken or unavailable to other processes.

Therefore it is probably best to only consider using `Process.terminate` on processes which never use any shared resources.

Joining processes that use queues

Bear in mind that a process that has put items in a queue will wait before terminating until all the buffered items are fed by the "feeder" thread to the underlying pipe. (The child process can call the `Queue.cancel_join_thread` method of the queue to avoid this behaviour.)

This means that whenever you use a queue you need to make sure that all items which have been put on the queue will eventually be removed before the process is joined. Otherwise you cannot be sure that processes which have put items on the queue will terminate. Remember also that non-daemonic processes will be joined automatically.

An example which will deadlock is the following:

```
from multiprocessing import Process, Queue

def f(q):
    q.put('X' * 1000000)

if __name__ == '__main__':
    queue = Queue()
    p = Process(target=f, args=(queue,))
    p.start()
    p.join()                # this deadlocks
    obj = queue.get()
```

A fix here would be to swap the last two lines (or simply remove the `p.join()` line).

Explicitly pass resources to child processes

On Unix using the `fork` start method, a child process can make use of a shared resource created in a parent process using a global resource. However, it is better to pass the object as an argument to the constructor for the child process.

Apart from making the code (potentially) compatible with Windows and the other start methods this also ensures that as long as the child process is still alive the object will not be garbage collected in the parent process. This might be important if some resource is freed when the object is garbage collected in the parent process.

So for instance

```

from multiprocessing import Process, Lock

def f():
    ... do something using "lock" ...

if __name__ == '__main__':
    lock = Lock()
    for i in range(10):
        Process(target=f).start()

```

should be rewritten as

```

from multiprocessing import Process, Lock

def f(l):
    ... do something using "l" ...

if __name__ == '__main__':
    lock = Lock()
    for i in range(10):
        Process(target=f, args=(lock,)).start()

```

Beware of replacing `sys.stdin` with a "file like object"

`multiprocessing` originally unconditionally called:

```
os.close(sys.stdin.fileno())
```

in the `multiprocessing.Process._bootstrap()` method --- this resulted in issues with processes-in-processes. This has been changed to:

```

sys.stdin.close()
sys.stdin = open(os.open(os.devnull, os.O_RDONLY), closefd=False)

```

Which solves the fundamental issue of processes colliding with each other resulting in a bad file descriptor error, but introduces a potential danger to applications which replace `sys.stdin()` with a "file-like object" with output buffering. This danger is that if multiple processes call `close()` on this file-like object, it could result in the same data being flushed to the object multiple times, resulting in corruption.

If you write a file-like object and implement your own caching, you can make it fork-safe by storing the pid whenever you append to the cache, and discarding the cache when the pid changes. For example:

```

@property
def cache(self):
    pid = os.getpid()
    if pid != self._pid:
        self._pid = pid
        self._cache = []
    return self._cache

```

For more information, see [bpo-5155](#), [bpo-5313](#) and [bpo-5331](#)

The *spawn* and *forkserver* start methods

There are a few extra restrictions which don't apply to the *fork* start method.

More picklability

Ensure that all arguments to `Process.__init__()` are picklable. Also, if you subclass `Process` then make sure that instances will be picklable when the `Process.start` method is called.

Global variables

Bear in mind that if code run in a child process tries to access a global variable, then the value it sees (if any) may not be the same as the value in the parent process at the time that `Process.start` was called.

However, global variables which are just module level constants cause no problems.

Safe importing of main module

Make sure that the main module can be safely imported by a new Python interpreter without causing unintended side effects (such as starting a new process).

For example, using the *spawn* or *forkserver* start method running the following module would fail with a `RuntimeError`:

```
from multiprocessing import Process

def foo():
    print('hello')

p = Process(target=foo)
p.start()
```

Instead one should protect the "entry point" of the program by using `if __name__ == '__main__':` as follows:

```
from multiprocessing import Process, freeze_support, set_start_method

def foo():
    print('hello')

if __name__ == '__main__':
    freeze_support()
    set_start_method('spawn')
    p = Process(target=foo)
    p.start()
```

(The `freeze_support()` line can be omitted if the program will be run normally instead of frozen.)

This allows the newly spawned Python interpreter to safely import the module and then run the module's `foo()` function.

Similar restrictions apply if a pool or manager is created in the main module.

17.2.4 范例

Demonstration of how to create and use customized managers and proxies:

```
from multiprocessing import freeze_support
from multiprocessing.managers import BaseManager, BaseProxy
import operator

##

class Foo:
    def f(self):
        print('you called Foo.f()')
    def g(self):
        print('you called Foo.g()')
    def _h(self):
        print('you called Foo._h()')

# A simple generator function
def baz():
    for i in range(10):
        yield i*i

# Proxy type for generator objects
class GeneratorProxy(BaseProxy):
    _exposed_ = ['__next__']
    def __iter__(self):
        return self
    def __next__(self):
        return self._callmethod('__next__')

# Function to return the operator module
def get_operator_module():
    return operator

##

class MyManager(BaseManager):
    pass

# register the Foo class; make `f()` and `g()` accessible via proxy
MyManager.register('Foo1', Foo)

# register the Foo class; make `g()` and `_h()` accessible via proxy
MyManager.register('Foo2', Foo, exposed=('g', '_h'))

# register the generator function baz; use `GeneratorProxy` to make proxies
MyManager.register('baz', baz, proxytype=GeneratorProxy)

# register get_operator_module(); make public functions accessible via proxy
MyManager.register('operator', get_operator_module)

##

def test():
    manager = MyManager()
    manager.start()

    print('-' * 20)

    f1 = manager.Foo1()
    f1.f()
```

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```

f1.g()
assert not hasattr(f1, '_h')
assert sorted(f1._exposed_) == sorted(['f', 'g'])

print('-' * 20)

f2 = manager.Foo2()
f2.g()
f2._h()
assert not hasattr(f2, 'f')
assert sorted(f2._exposed_) == sorted(['g', '_h'])

print('-' * 20)

it = manager.baz()
for i in it:
    print('<%d>' % i, end=' ')
print()

print('-' * 20)

op = manager.operator()
print('op.add(23, 45) =', op.add(23, 45))
print('op.pow(2, 94) =', op.pow(2, 94))
print('op._exposed_ =', op._exposed_)

##

if __name__ == '__main__':
    freeze_support()
    test()

```

Using *Pool*:

```

import multiprocessing
import time
import random
import sys

#
# Functions used by test code
#

def calculate(func, args):
    result = func(*args)
    return '%s says that %s%s = %s' % (
        multiprocessing.current_process().name,
        func.__name__, args, result
    )

def calculatestar(args):
    return calculate(*args)

def mul(a, b):
    time.sleep(0.5 * random.random())
    return a * b

def plus(a, b):
    time.sleep(0.5 * random.random())
    return a + b

```

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```

def f(x):
    return 1.0 / (x - 5.0)

def pow3(x):
    return x ** 3

def noop(x):
    pass

#
# Test code
#

def test():
    PROCESSES = 4
    print('Creating pool with %d processes\n' % PROCESSES)

    with multiprocessing.Pool(PROCESSES) as pool:
        #
        # Tests
        #

        TASKS = [(mul, (i, 7)) for i in range(10)] + \
            [(plus, (i, 8)) for i in range(10)]

        results = [pool.apply_async(calculate, t) for t in TASKS]
        imap_it = pool.imap(calculatestar, TASKS)
        imap_unordered_it = pool.imap_unordered(calculatestar, TASKS)

        print('Ordered results using pool.apply_async():')
        for r in results:
            print('\t', r.get())
        print()

        print('Ordered results using pool.imap():')
        for x in imap_it:
            print('\t', x)
        print()

        print('Unordered results using pool.imap_unordered():')
        for x in imap_unordered_it:
            print('\t', x)
        print()

        print('Ordered results using pool.map() --- will block till complete:')
        for x in pool.map(calculatestar, TASKS):
            print('\t', x)
        print()

        #
        # Test error handling
        #

        print('Testing error handling:')

        try:
            print(pool.apply(f, (5,)))
        except ZeroDivisionError:
            print('\tGot ZeroDivisionError as expected from pool.apply()')
        else:
            raise AssertionError('expected ZeroDivisionError')

```

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```

try:
    print(pool.map(f, list(range(10))))
except ZeroDivisionError:
    print('\tGot ZeroDivisionError as expected from pool.map()')
else:
    raise AssertionError('expected ZeroDivisionError')

try:
    print(list(pool.imap(f, list(range(10)))))
except ZeroDivisionError:
    print('\tGot ZeroDivisionError as expected from list(pool.imap())')
else:
    raise AssertionError('expected ZeroDivisionError')

it = pool.imap(f, list(range(10)))
for i in range(10):
    try:
        x = next(it)
    except ZeroDivisionError:
        if i == 5:
            pass
    except StopIteration:
        break
    else:
        if i == 5:
            raise AssertionError('expected ZeroDivisionError')

assert i == 9
print('\tGot ZeroDivisionError as expected from IMapIterator.next()')
print()

#
# Testing timeouts
#

print('Testing ApplyResult.get() with timeout:', end=' ')
res = pool.apply_async(calculate, TASKS[0])
while 1:
    sys.stdout.flush()
    try:
        sys.stdout.write('\n\t%s' % res.get(0.02))
        break
    except multiprocessing.TimeoutError:
        sys.stdout.write('.')
print()
print()

print('Testing IMapIterator.next() with timeout:', end=' ')
it = pool.imap(calculatestar, TASKS)
while 1:
    sys.stdout.flush()
    try:
        sys.stdout.write('\n\t%s' % it.next(0.02))
    except StopIteration:
        break
    except multiprocessing.TimeoutError:
        sys.stdout.write('.')
print()
print()

```

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```
if __name__ == '__main__':
    multiprocessing.freeze_support()
    test()
```

An example showing how to use queues to feed tasks to a collection of worker processes and collect the results:

```
import time
import random

from multiprocessing import Process, Queue, current_process, freeze_support

#
# Function run by worker processes
#

def worker(input, output):
    for func, args in iter(input.get, 'STOP'):
        result = calculate(func, args)
        output.put(result)

#
# Function used to calculate result
#

def calculate(func, args):
    result = func(*args)
    return '%s says that %s%s = %s' % \
        (current_process().name, func.__name__, args, result)

#
# Functions referenced by tasks
#

def mul(a, b):
    time.sleep(0.5*random.random())
    return a * b

def plus(a, b):
    time.sleep(0.5*random.random())
    return a + b

#
#
#

def test():
    NUMBER_OF_PROCESSES = 4
    TASKS1 = [(mul, (i, 7)) for i in range(20)]
    TASKS2 = [(plus, (i, 8)) for i in range(10)]

    # Create queues
    task_queue = Queue()
    done_queue = Queue()

    # Submit tasks
    for task in TASKS1:
        task_queue.put(task)

    # Start worker processes
    for i in range(NUMBER_OF_PROCESSES):
```

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```

    Process(target=worker, args=(task_queue, done_queue)).start()

    # Get and print results
    print('Unordered results:')
    for i in range(len(TASKS1)):
        print('\t', done_queue.get())

    # Add more tasks using `put()`
    for task in TASKS2:
        task_queue.put(task)

    # Get and print some more results
    for i in range(len(TASKS2)):
        print('\t', done_queue.get())

    # Tell child processes to stop
    for i in range(NUMBER_OF_PROCESSES):
        task_queue.put('STOP')

if __name__ == '__main__':
    freeze_support()
    test()

```

17.3 multiprocessing.shared_memory --- Shared memory for direct access across processes

原始碼: `Lib/multiprocessing/shared_memory.py`

在 3.8 版新加入。

This module provides a class, *SharedMemory*, for the allocation and management of shared memory to be accessed by one or more processes on a multicore or symmetric multiprocessor (SMP) machine. To assist with the life-cycle management of shared memory especially across distinct processes, a *BaseManager* subclass, *SharedMemoryManager*, is also provided in the *multiprocessing.managers* module.

In this module, shared memory refers to "POSIX style" shared memory blocks (though is not necessarily implemented explicitly as such) and does not refer to "distributed shared memory". This style of shared memory permits distinct processes to potentially read and write to a common (or shared) region of volatile memory. Processes are conventionally limited to only have access to their own process memory space but shared memory permits the sharing of data between processes, avoiding the need to instead send messages between processes containing that data. Sharing data directly via memory can provide significant performance benefits compared to sharing data via disk or socket or other communications requiring the serialization/deserialization and copying of data.

class `multiprocessing.shared_memory.SharedMemory` (*name=None, create=False, size=0*)

Create an instance of the *SharedMemory* class for either creating a new shared memory block or attaching to an existing shared memory block. Each shared memory block is assigned a unique name. In this way, one process can create a shared memory block with a particular name and a different process can attach to that same shared memory block using that same name.

As a resource for sharing data across processes, shared memory blocks may outlive the original process that created them. When one process no longer needs access to a shared memory block that might still be needed by other processes, the *close()* method should be called. When a shared memory block is no longer needed by any process, the *unlink()* method should be called to ensure proper cleanup.

參數

- **name** (*str* / *None*) -- The unique name for the requested shared memory, specified as a string. When creating a new shared memory block, if *None* (the default) is supplied for the name, a novel name will be generated.
- **create** (*bool*) -- Control whether a new shared memory block is created (*True*) or an existing shared memory block is attached (*False*).
- **size** (*int*) -- The requested number of bytes when creating a new shared memory block. Because some platforms choose to allocate chunks of memory based upon that platform's memory page size, the exact size of the shared memory block may be larger or equal to the size requested. When attaching to an existing shared memory block, the *size* parameter is ignored.

close()

Close access to the shared memory from this instance. In order to ensure proper cleanup of resources, all instances should call `close()` once the instance is no longer needed. Note that calling `close()` does not cause the shared memory block itself to be destroyed.

unlink()

Request that the underlying shared memory block be destroyed. In order to ensure proper cleanup of resources, `unlink()` should be called once (and only once) across all processes which have need for the shared memory block. After requesting its destruction, a shared memory block may or may not be immediately destroyed and this behavior may differ across platforms. Attempts to access data inside the shared memory block after `unlink()` has been called may result in memory access errors. Note: the last process relinquishing its hold on a shared memory block may call `unlink()` and `close()` in either order.

buf

A memoryview of contents of the shared memory block.

name

Read-only access to the unique name of the shared memory block.

size

Read-only access to size in bytes of the shared memory block.

The following example demonstrates low-level use of `SharedMemory` instances:

```
>>> from multiprocessing import shared_memory
>>> shm_a = shared_memory.SharedMemory(create=True, size=10)
>>> type(shm_a.buf)
<class 'memoryview'>
>>> buffer = shm_a.buf
>>> len(buffer)
10
>>> buffer[:4] = bytearray([22, 33, 44, 55]) # Modify multiple at once
>>> buffer[4] = 100 # Modify single byte at a time
>>> # Attach to an existing shared memory block
>>> shm_b = shared_memory.SharedMemory(shm_a.name)
>>> import array
>>> array.array('b', shm_b.buf[:5]) # Copy the data into a new array.array
array('b', [22, 33, 44, 55, 100])
>>> shm_b.buf[:5] = b'howdy' # Modify via shm_b using bytes
>>> bytes(shm_a.buf[:5]) # Access via shm_a
b'howdy'
>>> shm_b.close() # Close each SharedMemory instance
>>> shm_a.close()
>>> shm_a.unlink() # Call unlink only once to release the shared memory
```

The following example demonstrates a practical use of the `SharedMemory` class with `NumPy` arrays, accessing the same `numpy.ndarray` from two distinct Python shells:

```

>>> # In the first Python interactive shell
>>> import numpy as np
>>> a = np.array([1, 1, 2, 3, 5, 8]) # Start with an existing NumPy array
>>> from multiprocessing import shared_memory
>>> shm = shared_memory.SharedMemory(create=True, size=a.nbytes)
>>> # Now create a NumPy array backed by shared memory
>>> b = np.ndarray(a.shape, dtype=a.dtype, buffer=shm.buf)
>>> b[:] = a[:] # Copy the original data into shared memory
>>> b
array([1, 1, 2, 3, 5, 8])
>>> type(b)
<class 'numpy.ndarray'>
>>> type(a)
<class 'numpy.ndarray'>
>>> shm.name # We did not specify a name so one was chosen for us
'psm_21467_46075'

>>> # In either the same shell or a new Python shell on the same machine
>>> import numpy as np
>>> from multiprocessing import shared_memory
>>> # Attach to the existing shared memory block
>>> existing_shm = shared_memory.SharedMemory(name='psm_21467_46075')
>>> # Note that a.shape is (6,) and a.dtype is np.int64 in this example
>>> c = np.ndarray((6,), dtype=np.int64, buffer=existing_shm.buf)
>>> c
array([1, 1, 2, 3, 5, 8])
>>> c[-1] = 888
>>> c
array([ 1,  1,  2,  3,  5, 888])

>>> # Back in the first Python interactive shell, b reflects this change
>>> b
array([ 1,  1,  2,  3,  5, 888])

>>> # Clean up from within the second Python shell
>>> del c # Unnecessary; merely emphasizing the array is no longer used
>>> existing_shm.close()

>>> # Clean up from within the first Python shell
>>> del b # Unnecessary; merely emphasizing the array is no longer used
>>> shm.close()
>>> shm.unlink() # Free and release the shared memory block at the very end

```

class multiprocessing.managers.**SharedMemoryManager** ([address[, authkey]])

A subclass of *multiprocessing.managers.BaseManager* which can be used for the management of shared memory blocks across processes.

A call to *start()* on a *SharedMemoryManager* instance causes a new process to be started. This new process's sole purpose is to manage the life cycle of all shared memory blocks created through it. To trigger the release of all shared memory blocks managed by that process, call *shutdown()* on the instance. This triggers a *unlink()* call on all of the *SharedMemory* objects managed by that process and then stops the process itself. By creating *SharedMemory* instances through a *SharedMemoryManager*, we avoid the need to manually track and trigger the freeing of shared memory resources.

This class provides methods for creating and returning *SharedMemory* instances and for creating a list-like object (*ShareableList*) backed by shared memory.

Refer to *BaseManager* for a description of the inherited *address* and *authkey* optional input arguments and how they may be used to connect to an existing *SharedMemoryManager* service from other processes.

SharedMemory (size)

Create and return a new *SharedMemory* object with the specified *size* in bytes.

ShareableList (*sequence*)

Create and return a new *ShareableList* object, initialized by the values from the input *sequence*.

The following example demonstrates the basic mechanisms of a *SharedMemoryManager*:

```
>>> from multiprocessing.managers import SharedMemoryManager
>>> smm = SharedMemoryManager()
>>> smm.start() # Start the process that manages the shared memory blocks
>>> sl = smm.ShareableList(range(4))
>>> sl
ShareableList([0, 1, 2, 3], name='psm_6572_7512')
>>> raw_shm = smm.SharedMemory(size=128)
>>> another_sl = smm.ShareableList('alpha')
>>> another_sl
ShareableList(['a', 'l', 'p', 'h', 'a'], name='psm_6572_12221')
>>> smm.shutdown() # Calls unlink() on sl, raw_shm, and another_sl
```

The following example depicts a potentially more convenient pattern for using *SharedMemoryManager* objects via the *with* statement to ensure that all shared memory blocks are released after they are no longer needed:

```
>>> with SharedMemoryManager() as smm:
...     sl = smm.ShareableList(range(2000))
...     # Divide the work among two processes, storing partial results in sl
...     p1 = Process(target=do_work, args=(sl, 0, 1000))
...     p2 = Process(target=do_work, args=(sl, 1000, 2000))
...     p1.start()
...     p2.start() # A multiprocessing.Pool might be more efficient
...     p1.join()
...     p2.join() # Wait for all work to complete in both processes
...     total_result = sum(sl) # Consolidate the partial results now in sl
```

When using a *SharedMemoryManager* in a *with* statement, the shared memory blocks created using that manager are all released when the *with* statement's code block finishes execution.

class multiprocessing.shared_memory.**ShareableList** (*sequence=None*, *, *name=None*)

Provide a mutable list-like object where all values stored within are stored in a shared memory block. This constrains storable values to the following built-in data types:

- *int* (signed 64-bit)
- *float*
- *bool*
- *str* (less than 10M bytes each when encoded as UTF-8)
- *bytes* (less than 10M bytes each)
- *None*

It also notably differs from the built-in *list* type in that these lists can not change their overall length (i.e. no *append()*, *insert()*, etc.) and do not support the dynamic creation of new *ShareableList* instances via slicing.

sequence is used in populating a new *ShareableList* full of values. Set to *None* to instead attach to an already existing *ShareableList* by its unique shared memory name.

name is the unique name for the requested shared memory, as described in the definition for *SharedMemory*. When attaching to an existing *ShareableList*, specify its shared memory block's unique name while leaving *sequence* set to *None*.

備註: A known issue exists for *bytes* and *str* values. If they end with `\x00` nul bytes or characters, those may be *silently stripped* when fetching them by index from the *ShareableList*. This `.rstrip(b'\x00')` behavior is considered a bug and may go away in the future. See [gh-106939](#).

For applications where `rstripping` of trailing nulls is a problem, work around it by always unconditionally appending an extra non-0 byte to the end of such values when storing and unconditionally removing it when fetching:

```
>>> from multiprocessing import shared_memory
>>> nul_bug_demo = shared_memory.ShareableList(['?\x00', b'\x03\x02\x01\x00\
↪\x00\x00'])
>>> nul_bug_demo[0]
'?'
>>> nul_bug_demo[1]
b'\x03\x02\x01'
>>> nul_bug_demo.shm.unlink()
>>> padded = shared_memory.ShareableList(['?\x00\x07', b'\x03\x02\x01\x00\x00\
↪\x00\x07'])
>>> padded[0][: -1]
'?\x00'
>>> padded[1][: -1]
b'\x03\x02\x01\x00\x00\x00'
>>> padded.shm.unlink()
```

count (*value*)

Return the number of occurrences of *value*.

index (*value*)

Return first index position of *value*. Raise *ValueError* if *value* is not present.

format

Read-only attribute containing the *struct* packing format used by all currently stored values.

shm

The *SharedMemory* instance where the values are stored.

The following example demonstrates basic use of a *ShareableList* instance:

```
>>> from multiprocessing import shared_memory
>>> a = shared_memory.ShareableList(['howdy', b'HoWdY', -273.154, 100, None, True, ↵
↪42])
>>> [ type(entry) for entry in a ]
[<class 'str'>, <class 'bytes'>, <class 'float'>, <class 'int'>, <class 'NoneType'>
↪, <class 'bool'>, <class 'int'>]
>>> a[2]
-273.154
>>> a[2] = -78.5
>>> a[2]
-78.5
>>> a[2] = 'dry ice' # Changing data types is supported as well
>>> a[2]
'dry ice'
>>> a[2] = 'larger than previously allocated storage space'
Traceback (most recent call last):
...
ValueError: exceeds available storage for existing str
>>> a[2]
'dry ice'
>>> len(a)
7
>>> a.index(42)
6
>>> a.count(b'howdy')
0
>>> a.count(b'HoWdY')
1
```

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```
>>> a.shm.close()
>>> a.shm.unlink()
>>> del a # Use of a ShareableList after call to unlink() is unsupported
```

The following example depicts how one, two, or many processes may access the same *ShareableList* by supplying the name of the shared memory block behind it:

```
>>> b = shared_memory.ShareableList(range(5)) # In a first process
>>> c = shared_memory.ShareableList(name=b.shm.name) # In a second process
>>> c
ShareableList([0, 1, 2, 3, 4], name='...')
>>> c[-1] = -999
>>> b[-1]
-999
>>> b.shm.close()
>>> c.shm.close()
>>> c.shm.unlink()
```

The following examples demonstrates that *ShareableList* (and underlying *SharedMemory*) objects can be pickled and unpickled if needed. Note, that it will still be the same shared object. This happens, because the deserialized object has the same unique name and is just attached to an existing object with the same name (if the object is still alive):

```
>>> import pickle
>>> from multiprocessing import shared_memory
>>> sl = shared_memory.ShareableList(range(10))
>>> list(sl)
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

```
>>> deserialized_sl = pickle.loads(pickle.dumps(sl))
>>> list(deserialized_sl)
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

```
>>> sl[0] = -1
>>> deserialized_sl[1] = -2
>>> list(sl)
[-1, -2, 2, 3, 4, 5, 6, 7, 8, 9]
>>> list(deserialized_sl)
[-1, -2, 2, 3, 4, 5, 6, 7, 8, 9]
```

```
>>> sl.shm.close()
>>> sl.shm.unlink()
```

17.4 The concurrent package

目前此套件只有一個模組：

- `concurrent.futures` -- 動平行任務

17.5 `concurrent.futures` -- 動平行任務

在 3.2 版新加入。

原始碼：Lib/concurrent/futures/thread.py 與 Lib/concurrent/futures/process.py

`concurrent.futures` 模組提供了一個高階介面來非同步地 (asynchronously) 執行可呼叫物件 (callable)。

非同步執行可以透過 `ThreadPoolExecutor` 來使用執行緒 (thread) 執行，或透過 `ProcessPoolExecutor` 來使用單獨行程 (process) 執行。兩者都實作了相同的介面，該介面由抽象的 `Executor` 類定義。

適用：非 Emscripten、非 WASI。

此模組在 WebAssembly 平台 `wasm32-emscripten` 和 `wasm32-wasi` 上¹有作用或不可使用。更多資訊，請參² WebAssembly 平台。

17.5.1 Executor 物件

class `concurrent.futures.Executor`

提供非同步執行呼叫方法的抽象類¹。不應直接使用它，而應透過其具體子類²來使用。

submit (*fn*, /, **args*, ***kwargs*)

¹可呼叫物件 *fn* 排程來以 `fn(*args, **kwargs)` 的形式執行²回傳一個表示可呼叫的執行的 `Future` 物件。

```
with ThreadPoolExecutor(max_workers=1) as executor:
    future = executor.submit(pow, 323, 1235)
    print(future.result())
```

map (*fn*, **iterables*, *timeout=None*, *chunksize=1*)

Similar to `map(fn, *iterables)` except:

- *iterables* 立即被收集而不是延遲 (lazily) 收集；
- *fn* is executed asynchronously and several calls to *fn* may be made concurrently.

如果 `__next__()` 被呼叫，且在原先呼叫 `Executor.map()` 的 *timeout* 秒後結果仍不可用，回傳的³代器就會引發 `TimeoutError`。 *timeout* 可以是整數或浮點數。如果未指定 *timeout* 或⁴ `None`，則等待時間就不會有限制。

If a *fn* call raises an exception, then that exception will be raised when its value is retrieved from the iterator.

使用 `ProcessPoolExecutor` 時，此方法將 *iterables* 分成許多分塊 (chunks)，⁵將其作⁶獨立的任務來提交給池 (pool)。可以透過將 *chunksize* 設定⁷正整數來指定這些分塊的（約略）大小。對於非常長的可⁸代物件，*chunksize* 使用較大的值（與預設大小 1 相比）可以顯著提高性能。對於 `ThreadPoolExecutor`，*chunksize* 無效。

在 3.5 版的變更：新增 *chunksize* 引數。

shutdown (*wait=True*, *, *cancel_futures=False*)

向 `executor` 發出訊號 (signal)，表明它應該在當前未定 (pending) 的 `future` 完成執行時釋放它正在使用的任何資源。在關閉後呼叫 `Executor.submit()` 和 `Executor.map()` 將引發 `RuntimeError`。

如果 `wait` 為 `True` 則此方法將不會回傳，直到所有未定的 `futures` 完成執行且與 `executor` 關聯的資源都被釋放。如果 `wait` 為 `False` 則此方法將立即回傳，且當所有未定的 `future` 執行完畢時，與 `executor` 關聯的資源將被釋放。不管 `wait` 的值如何，整個 Python 程式都不會退出，直到所有未定的 `futures` 執行完畢。

如果 `cancel_futures` 為 `True`，此方法將取消 `executor` 尚未開始運行的所有未定 `future`。無論 `cancel_futures` 的值如何，任何已完成或正在運行的 `future` 都不會被取消。

如果 `cancel_futures` 和 `wait` 都為 `True`，則 `executor` 已開始運行的所有 `future` 將在此方法回傳之前完成。剩余的 `future` 被取消。

如果使用 `with` 陳述句，你就可以不用明確地呼叫此方法，這將會自己關閉 `Executor` (如同呼叫 `Executor.shutdown()` 時 `wait` 被設定為 `True` 般等待)：

```
import shutil
with ThreadPoolExecutor(max_workers=4) as e:
    e.submit(shutil.copy, 'src1.txt', 'dest1.txt')
    e.submit(shutil.copy, 'src2.txt', 'dest2.txt')
    e.submit(shutil.copy, 'src3.txt', 'dest3.txt')
    e.submit(shutil.copy, 'src4.txt', 'dest4.txt')
```

在 3.9 版的變更: 新增 `cancel_futures`。

17.5.2 ThreadPoolExecutor

`ThreadPoolExecutor` 是一個 `Executor` 子類，它使用執行緒池來非同步地執行呼叫。

當與 `Future` 關聯的可呼叫物件等待另一個 `Future` 的結果時，可能會發生死鎖 (deadlock)。例如：

```
import time
def wait_on_b():
    time.sleep(5)
    print(b.result()) # b will never complete because it is waiting on a.
    return 5

def wait_on_a():
    time.sleep(5)
    print(a.result()) # a will never complete because it is waiting on b.
    return 6

executor = ThreadPoolExecutor(max_workers=2)
a = executor.submit(wait_on_b)
b = executor.submit(wait_on_a)
```

和：

```
def wait_on_future():
    f = executor.submit(pow, 5, 2)
    # This will never complete because there is only one worker thread and
    # it is executing this function.
    print(f.result())

executor = ThreadPoolExecutor(max_workers=1)
executor.submit(wait_on_future)
```

```
class concurrent.futures.ThreadPoolExecutor (max_workers=None, thread_name_prefix="",
                                              initializer=None, initargs=())
```

一個 *Executor* 子類，它使用最多有 *max_workers* 個執行緒的池來非同步地執行呼叫。

所有排隊到 *ThreadPoolExecutor* 的執行緒都將在直譯器退出之前加入。請注意，執行此操作的退出處理程式會在任何使用 *atexit* 新增的退出處理程式之前執行。這意味著必須捕獲處理主執行緒中的例外，以便向執行緒發出訊號來正常退出 (*gracefully exit*)。因此，建議不要將 *ThreadPoolExecutor* 用於長時間運行的任務。

initializer 是一個可選的可呼叫物件，在每個工作執行緒開始時呼叫；*initargs* 是傳遞給 *initializer* 的引數元組 (tuple)。如果 *initializer* 引發例外，所有當前未定的作業以及任何向池中提交 (*submit*) 更多作業的嘗試都將引發 *BrokenThreadPool*。

在 3.5 版的變更：如果 *max_workers* 為 *None* 或未給定，它將預設機器上的處理器數量乘以 5，這假定了 *ThreadPoolExecutor* 通常用於 I/O 重而非 CPU 密集的作業，且 *worker* 的數量應該高於 *ProcessPoolExecutor* 的 *worker* 數量。

在 3.6 版的變更：Added the *thread_name_prefix* parameter to allow users to control the *threading.Thread* names for worker threads created by the pool for easier debugging.

在 3.7 版的變更：新增 *initializer* 與 *initargs* 引數。

在 3.8 版的變更：*max_workers* 的預設值改為 `min(32, os.cpu_count() + 4)`。此預設值 I/O 密集任務至少保留了 5 個 *worker*。它最多使用 32 個 CPU 核心來執行 CPU 密集任務，以釋放 GIL。且它避免了在多核機器上隱晦地使用非常大量的資源。

ThreadPoolExecutor 現在在啟動 *max_workers* 工作執行緒之前會重用 (*reuse*) 空的工作執行緒。

ThreadPoolExecutor 范例

```
import concurrent.futures
import urllib.request

URLS = ['http://www.foxnews.com/',
        'http://www.cnn.com/',
        'http://europe.wsj.com/',
        'http://www.bbc.co.uk/',
        'http://nonexistant-subdomain.python.org/']

# Retrieve a single page and report the URL and contents
def load_url(url, timeout):
    with urllib.request.urlopen(url, timeout=timeout) as conn:
        return conn.read()

# We can use a with statement to ensure threads are cleaned up promptly
with concurrent.futures.ThreadPoolExecutor(max_workers=5) as executor:
    # Start the load operations and mark each future with its URL
    future_to_url = {executor.submit(load_url, url, 60): url for url in URLS}
    for future in concurrent.futures.as_completed(future_to_url):
        url = future_to_url[future]
        try:
            data = future.result()
        except Exception as exc:
            print('%r generated an exception: %s' % (url, exc))
        else:
            print('%r page is %d bytes' % (url, len(data)))
```

17.5.3 ProcessPoolExecutor

`ProcessPoolExecutor` 類是一個 `Executor` 的子類，它使用行程池來非同步地執行呼叫。`ProcessPoolExecutor` 使用了 `multiprocessing` 模組，這允許它避開全域直譯器鎖 (*Global Interpreter Lock*)，但也意味著只能執行和回傳可被 `pickle` 的 (picklable) 物件。

`__main__` 模組必須可以被工作子行程 (worker subprocess) 引入。這意味著 `ProcessPoolExecutor` 將無法在交互式直譯器 (interactive interpreter) 中工作。

從提交給 `ProcessPoolExecutor` 的可呼叫物件中呼叫 `Executor` 或 `Future` 方法將導致死鎖。

```
class concurrent.futures.ProcessPoolExecutor (max_workers=None, mp_context=None,
                                              initializer=None, initargs=(),
                                              max_tasks_per_child=None)
```

一個 `Executor` 子類，它使用了最多有 `max_workers` 個行程的池來非同步地執行呼叫。如果 `max_workers` 為 `None` 或未給定，它將被預設為機器上的處理器數量。如果 `max_workers` 小於或等於 0，則會引發 `ValueError`。在 Windows 上，`max_workers` 必須小於或等於 61。如果不是，則會引發 `ValueError`。如果 `max_workers` 為 `None`，則預設選擇最多 61，即便有更多處理器可用。`mp_context` 可以是 `multiprocessing` 情境 (context) 或 `None`。它將用於啟動 worker。如果 `mp_context` 為 `None` 或未給定，則使用預設的 `multiprocessing` 情境。

`initializer` 是一個可選的可呼叫物件，在每個工作行程 (worker process) 開始時呼叫；`initargs` 是傳遞給 `initializer` 的引數元組。如果 `initializer` 引發例外，所有當前未定的作業以及任何向池中提交更多作業的嘗試都將引發 `BrokenProcessPool`。

`max_tasks_per_child` 是一個可選引數，它指定單個行程在退出前被新的工作行程替換之前可以執行的最大任務數。預設情況下 `max_tasks_per_child` 是 `None`，這意味著工作行程的生命週期將與池一樣長。當指定最大值時，在具有 `mp_context` 參數的情況下，將預設使用 "spawn" 做 multiprocessing 啟動方法。此功能與 "fork" 啟動方法不相容。

在 3.3 版的變更: When one of the worker processes terminates abruptly, a `BrokenProcessPool` error is now raised. Previously, behaviour was undefined but operations on the executor or its futures would often freeze or deadlock.

在 3.7 版的變更: 新增了 `mp_context` 引數以允許使用者控制由池所建立的工作行程的 `start_method`。

新增 `initializer` 與 `initargs` 引數。

在 3.11 版的變更: 新增了 `max_tasks_per_child` 引數以允許使用者控制池中 worker 的生命週期。

ProcessPoolExecutor 範例

```
import concurrent.futures
import math

PRIMES = [
    112272535095293,
    112582705942171,
    112272535095293,
    115280095190773,
    115797848077099,
    1099726899285419]

def is_prime(n):
    if n < 2:
        return False
    if n == 2:
        return True
    if n % 2 == 0:
        return False

    sqrt_n = int(math.floor(math.sqrt(n)))
```

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```

for i in range(3, sqrt_n + 1, 2):
    if n % i == 0:
        return False
return True

def main():
    with concurrent.futures.ProcessPoolExecutor() as executor:
        for number, prime in zip(PRIMES, executor.map(is_prime, PRIMES)):
            print('%d is prime: %s' % (number, prime))

if __name__ == '__main__':
    main()

```

17.5.4 Future 物件

Future 類 F 封裝了可呼叫物件的非同步執行。*Future* 實例由 *Executor.submit()* 建立。

class `concurrent.futures.Future`

封裝可呼叫物件的非同步執行。*Future* 實例由 *Executor.submit()* 建立，且除測試外不應直接建立。

cancel()

嘗試取消呼叫。如果呼叫當前正在執行或已完成運行且無法取消，則該方法將回傳 `False`，否則呼叫將被取消 F 且該方法將回傳 `True`。

cancelled()

如果該呼叫成功被取消，則回傳 `True`。

running()

如果呼叫正在執行且無法取消，則回傳 `True`。

done()

如果呼叫成功被取消或結束運行，則回傳 `True`。

result(timeout=None)

回傳該呼叫回傳的值。如果呼叫尚未完成，則此方法將等待至多 *timeout* 秒。如果呼叫在 *timeout* 秒 F 未完成，則會引發 *TimeoutError*。*timeout* 可以是整數或浮點數。如果未指定 *timeout* 或 F `None`，則等待時間就不會有限制。

如果 *future* 在完成之前被取消，那 F *CancelledError* 將被引發。

如果該呼叫引發了例外，此方法將引發相同的例外。

exception(timeout=None)

回傳該呼叫引發的例外。如果呼叫尚未完成，則此方法將等待至多 *timeout* 秒。如果呼叫在 *timeout* 秒 F 未完成，則會引發 *TimeoutError*。*timeout* 可以是整數或浮點數。如果未指定 *timeout* 或 F `None`，則等待時間就不會有限制。

如果 *future* 在完成之前被取消，那 F *CancelledError* 將被引發。

如果呼叫在 F 有引發的情 F 下完成，則回傳 `None`。

add_done_callback(fn)

將可呼叫的 *fn* 附加到 *future* 上。當 *future* 被取消或完成運行時，*fn* 將被以 *future* 作 F 其唯一引數來呼叫。

新增的可呼叫物件按新增順序呼叫，F 且始終在屬於新增它們的行程的執行緒中呼叫。如果可呼叫物件引發 *Exception* 子類 F，它將被記 F (log) F 忽略。如果可呼叫物件引發 *BaseException* 子類 F，該行 F 未定義。

如果 *future* 已經完成或被取消，*fn* 將立即被呼叫。

以下 *Future* 方法旨在用於單元測試和 *Executor* 實作。

set_running_or_notify_cancel()

此方法只能在與 *Future* 關聯的工作被執行之前於 *Executor* 實作中呼叫，或者在單元測試中呼叫。

如果該方法回傳 `False` 則 *Future* 已被取消，即 *Future.cancel()* 被呼叫回傳 `True`。任何等待 *Future* 完成的執行緒（即透過 *as_completed()* 或 *wait()*）將被醒。

如果該方法回傳 `True` 則代表 *Future* 未被取消已進入運行狀態，意即呼叫 *Future.running()* 將回傳 `True`。

此方法只能呼叫一次，且不能在呼叫 *Future.set_result()* 或 *Future.set_exception()* 之後呼叫。

set_result(result)

將與 *Future* 關聯的工作結果設定 `result`。

此方法只能在 *Executor* 實作中和單元測試中使用。

在 3.8 版的變更：如果 *Future* 已經完成，此方法會引發 *concurrent.futures.InvalidStateError*。

set_exception(exception)

將與 *Future* 關聯的工作結果設定 *Exception* `exception`。

此方法只能在 *Executor* 實作中和單元測試中使用。

在 3.8 版的變更：如果 *Future* 已經完成，此方法會引發 *concurrent.futures.InvalidStateError*。

17.5.5 模組函式

concurrent.futures.wait(fs, timeout=None, return_when=ALL_COMPLETED)

等待 *fs* 給定的 *Future* 實例（可能由不同的 *Executor* 實例建立）完成。提供給 *fs* 的重 `Future` 將被除，且只會回傳一次。回傳一個集合的附名二元組 (named 2-tuple of sets)。第一組名 `done`，包含在等待完成之前完成的 *future*（已完成或被取消的 *future*）。第二組名 `not_done`，包含未完成的 *future*（未定或運行中的 *future*）。

timeout 可用於控制回傳前等待的最大秒數。*timeout* 可以是整數或浮點數。如果未指定 *timeout* 或 `None`，則等待時間就有限制。

return_when 表示此函式應回傳的時間。它必須是以下常數之一：

常數	描述
<code>concurrent.futures.FIRST_COMPLETED</code>	當任何 <i>future</i> 完成或被取消時，該函式就會回傳。
<code>concurrent.futures.FIRST_EXCEPTION</code>	The function will return when any future finishes by raising an exception. If no future raises an exception then it is equivalent to <i>ALL_COMPLETED</i> .
<code>concurrent.futures.ALL_COMPLETED</code>	當所有 <i>future</i> 都完成或被取消時，該函式才會回傳。

concurrent.futures.as_completed(fs, timeout=None)

回傳由 *fs* 給定的 *Future* 實例（可能由不同的 *Executor* 實例建立）的代器，它在完成時生 *future*（已完成或被取消的 *future*）。*fs* 給定的任何重的 *future* 將只被回傳一次。呼叫 *as_completed()* 之前完成的任何 *future* 將首先生。如果 *__next__()* 被呼叫，且在原

先呼叫 `as_completed()` 的 `timeout` 秒後結果仍不可用，則回傳的 `Future` 代器會引發 `TimeoutError`。
`timeout` 可以是整數或浮點數。如果未指定 `timeout` 或 `None`，則等待時間就有限制。

也參考：

PEP 3148 -- futures - 非同步地執行運算

描述此功能提出被包含於 Python 標準函式庫中的提案。

17.5.6 例外類

exception `concurrent.futures.CancelledError`

當 `future` 被取消時引發。

exception `concurrent.futures.TimeoutError`

`TimeoutError` 的別名，在 `future` 操作超過給定超時 (`timeout`) 時引發。

在 3.11 版的變更：這個類是 `TimeoutError` 的別名。

exception `concurrent.futures.BrokenExecutor`

衍生自 `RuntimeError`，當執行器因某種原因損壞時會引發此例外類，且不能用於提交或執行新任務。

在 3.7 版新加入。

exception `concurrent.futures.InvalidStateError`

當前狀態下不允許的 `future` 操作被執行時而引發。

在 3.8 版新加入。

exception `concurrent.futures.thread.BrokenThreadPool`

Derived from `BrokenExecutor`, this exception class is raised when one of the workers of a `ThreadPoolExecutor` has failed initializing.

在 3.7 版新加入。

exception `concurrent.futures.process.BrokenProcessPool`

Derived from `BrokenExecutor` (formerly `RuntimeError`), this exception class is raised when one of the workers of a `ProcessPoolExecutor` has terminated in a non-clean fashion (for example, if it was killed from the outside).

在 3.3 版新加入。

17.6 subprocess --- Subprocess management

原始碼： `Lib/subprocess.py`

The `subprocess` module allows you to spawn new processes, connect to their input/output/error pipes, and obtain their return codes. This module intends to replace several older modules and functions:

```
os.system
os.spawn*
```

Information about how the `subprocess` module can be used to replace these modules and functions can be found in the following sections.

也參考：

PEP 324 -- PEP proposing the subprocess module

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

17.6.1 Using the subprocess Module

The recommended approach to invoking subprocesses is to use the `run()` function for all use cases it can handle. For more advanced use cases, the underlying `Popen` interface can be used directly.

```
subprocess.run(args, *, stdin=None, input=None, stdout=None, stderr=None, capture_output=False,
               shell=False, cwd=None, timeout=None, check=False, encoding=None, errors=None,
               text=None, env=None, universal_newlines=None, **other_popen_kwargs)
```

Run the command described by `args`. Wait for command to complete, then return a `CompletedProcess` instance.

The arguments shown above are merely the most common ones, described below in [Frequently Used Arguments](#) (hence the use of keyword-only notation in the abbreviated signature). The full function signature is largely the same as that of the `Popen` constructor - most of the arguments to this function are passed through to that interface. (`timeout`, `input`, `check`, and `capture_output` are not.)

If `capture_output` is true, `stdout` and `stderr` will be captured. When used, the internal `Popen` object is automatically created with `stdout` and `stdin` both set to `PIPE`. The `stdout` and `stderr` arguments may not be supplied at the same time as `capture_output`. If you wish to capture and combine both streams into one, set `stdout` to `PIPE` and `stderr` to `STDOUT`, instead of using `capture_output`.

A `timeout` may be specified in seconds, it is internally passed on to `Popen.communicate()`. If the timeout expires, the child process will be killed and waited for. The `TimeoutExpired` exception will be re-raised after the child process has terminated. The initial process creation itself cannot be interrupted on many platform APIs so you are not guaranteed to see a timeout exception until at least after however long process creation takes.

The `input` argument is passed to `Popen.communicate()` and thus to the subprocess's `stdin`. If used it must be a byte sequence, or a string if `encoding` or `errors` is specified or `text` is true. When used, the internal `Popen` object is automatically created with `stdin` set to `PIPE`, and the `stdin` argument may not be used as well.

If `check` is true, and the process exits with a non-zero exit code, a `CalledProcessError` exception will be raised. Attributes of that exception hold the arguments, the exit code, and `stdout` and `stderr` if they were captured.

If `encoding` or `errors` are specified, or `text` is true, file objects for `stdin`, `stdout` and `stderr` are opened in text mode using the specified `encoding` and `errors` or the `io.TextIOWrapper` default. The `universal_newlines` argument is equivalent to `text` and is provided for backwards compatibility. By default, file objects are opened in binary mode.

If `env` is not `None`, it must be a mapping that defines the environment variables for the new process; these are used instead of the default behavior of inheriting the current process' environment. It is passed directly to `Popen`. This mapping can be str to str on any platform or bytes to bytes on POSIX platforms much like `os.environ` or `os.environb`.

範例：

```
>>> subprocess.run(["ls", "-l"]) # doesn't capture output
CompletedProcess(args=['ls', '-l'], returncode=0)

>>> subprocess.run("exit 1", shell=True, check=True)
Traceback (most recent call last):
...
subprocess.CalledProcessError: Command 'exit 1' returned non-zero exit status 1

>>> subprocess.run(["ls", "-l", "/dev/null"], capture_output=True)
CompletedProcess(args=['ls', '-l', '/dev/null'], returncode=0,
stdout=b'crw-rw-rw- 1 root root 1, 3 Jan 23 16:23 /dev/null\n', stderr=b'')
```

在 3.5 版新加入。

在 3.6 版的變更: 新增 *encoding* 與 *errors* 參數。

在 3.7 版的變更: Added the *text* parameter, as a more understandable alias of *universal_newlines*. Added the *capture_output* parameter.

在 3.11.3 版的變更: Changed Windows shell search order for *shell=True*. The current directory and *%PATH%* are replaced with *%COMSPEC%* and *%SystemRoot%\System32\cmd.exe*. As a result, dropping a malicious program named *cmd.exe* into a current directory no longer works.

class `subprocess.CompletedProcess`

The return value from `run()`, representing a process that has finished.

args

The arguments used to launch the process. This may be a list or a string.

returncode

Exit status of the child process. Typically, an exit status of 0 indicates that it ran successfully.

A negative value $-N$ indicates that the child was terminated by signal *N* (POSIX only).

stdout

Captured stdout from the child process. A bytes sequence, or a string if `run()` was called with an encoding, errors, or *text=True*. None if stdout was not captured.

If you ran the process with *stderr=subprocess.STDOUT*, stdout and stderr will be combined in this attribute, and *stderr* will be None.

stderr

Captured stderr from the child process. A bytes sequence, or a string if `run()` was called with an encoding, errors, or *text=True*. None if stderr was not captured.

check_returncode()

If *returncode* is non-zero, raise a *CalledProcessError*.

在 3.5 版新加入。

`subprocess.DEVNULL`

Special value that can be used as the *stdin*, *stdout* or *stderr* argument to *Popen* and indicates that the special file *os.devnull* will be used.

在 3.3 版新加入。

`subprocess.PIPE`

Special value that can be used as the *stdin*, *stdout* or *stderr* argument to *Popen* and indicates that a pipe to the standard stream should be opened. Most useful with *Popen.communicate()*.

`subprocess.STDOUT`

Special value that can be used as the *stderr* argument to *Popen* and indicates that standard error should go into the same handle as standard output.

exception `subprocess.SubprocessError`

Base class for all other exceptions from this module.

在 3.3 版新加入。

exception `subprocess.TimeoutExpired`

Subclass of *SubprocessError*, raised when a timeout expires while waiting for a child process.

cmd

Command that was used to spawn the child process.

timeout

Timeout in seconds.

output

Output of the child process if it was captured by `run()` or `check_output()`. Otherwise, `None`. This is always `bytes` when any output was captured regardless of the `text=True` setting. It may remain `None` instead of `b''` when no output was observed.

stdout

Alias for output, for symmetry with `stderr`.

stderr

Stderr output of the child process if it was captured by `run()`. Otherwise, `None`. This is always `bytes` when stderr output was captured regardless of the `text=True` setting. It may remain `None` instead of `b''` when no stderr output was observed.

在 3.3 版新加入.

在 3.5 版的變更: `stdout` and `stderr` attributes added

exception subprocess.CalledProcessError

Subclass of `SubprocessError`, raised when a process run by `check_call()`, `check_output()`, or `run()` (with `check=True`) returns a non-zero exit status.

returncode

Exit status of the child process. If the process exited due to a signal, this will be the negative signal number.

cmd

Command that was used to spawn the child process.

output

Output of the child process if it was captured by `run()` or `check_output()`. Otherwise, `None`.

stdout

Alias for output, for symmetry with `stderr`.

stderr

Stderr output of the child process if it was captured by `run()`. Otherwise, `None`.

在 3.5 版的變更: `stdout` and `stderr` attributes added

Frequently Used Arguments

To support a wide variety of use cases, the `Popen` constructor (and the convenience functions) accept a large number of optional arguments. For most typical use cases, many of these arguments can be safely left at their default values. The arguments that are most commonly needed are:

`args` is required for all calls and should be a string, or a sequence of program arguments. Providing a sequence of arguments is generally preferred, as it allows the module to take care of any required escaping and quoting of arguments (e.g. to permit spaces in file names). If passing a single string, either `shell` must be `True` (see below) or else the string must simply name the program to be executed without specifying any arguments.

`stdin`, `stdout` and `stderr` specify the executed program's standard input, standard output and standard error file handles, respectively. Valid values are `PIPE`, `DEVNULL`, an existing file descriptor (a positive integer), an existing file object with a valid file descriptor, and `None`. `PIPE` indicates that a new pipe to the child should be created. `DEVNULL` indicates that the special file `os.devnull` will be used. With the default settings of `None`, no redirection will occur; the child's file handles will be inherited from the parent. Additionally, `stderr` can be `STDOUT`, which indicates that the stderr data from the child process should be captured into the same file handle as for `stdout`.

If `encoding` or `errors` are specified, or `text` (also known as `universal_newlines`) is true, the file objects `stdin`, `stdout` and `stderr` will be opened in text mode using the `encoding` and `errors` specified in the call or the defaults for `io.TextIOWrapper`.

For *stdin*, line ending characters `'\n'` in the input will be converted to the default line separator `os.linesep`. For *stdout* and *stderr*, all line endings in the output will be converted to `'\n'`. For more information see the documentation of the `io.TextIOWrapper` class when the *newline* argument to its constructor is `None`.

If text mode is not used, *stdin*, *stdout* and *stderr* will be opened as binary streams. No encoding or line ending conversion is performed.

在 3.6 版的變更: Added the *encoding* and *errors* parameters.

在 3.7 版的變更: Added the *text* parameter as an alias for *universal_newlines*.

備 註: The *newlines* attribute of the file objects `Popen.stdin`, `Popen.stdout` and `Popen.stderr` are not updated by the `Popen.communicate()` method.

If *shell* is `True`, the specified command will be executed through the shell. This can be useful if you are using Python primarily for the enhanced control flow it offers over most system shells and still want convenient access to other shell features such as shell pipes, filename wildcards, environment variable expansion, and expansion of `~` to a user's home directory. However, note that Python itself offers implementations of many shell-like features (in particular, `glob`, `fnmatch`, `os.walk()`, `os.path.expandvars()`, `os.path.expanduser()`, and `shutil`).

在 3.3 版的變更: When *universal_newlines* is `True`, the class uses the encoding `locale.getpreferredencoding(False)` instead of `locale.getpreferredencoding()`. See the `io.TextIOWrapper` class for more information on this change.

備 註: Read the *Security Considerations* section before using *shell=True*.

These options, along with all of the other options, are described in more detail in the `Popen` constructor documentation.

Popen Constructor

The underlying process creation and management in this module is handled by the `Popen` class. It offers a lot of flexibility so that developers are able to handle the less common cases not covered by the convenience functions.

```
class subprocess.Popen (args, bufsize=-1, executable=None, stdin=None, stdout=None, stderr=None,
                        preexec_fn=None, close_fds=True, shell=False, cwd=None, env=None,
                        universal_newlines=None, startupinfo=None, creationflags=0,
                        restore_signals=True, start_new_session=False, pass_fds=(), *, group=None,
                        extra_groups=None, user=None, umask=-1, encoding=None, errors=None,
                        text=None, pipesize=-1, process_group=None)
```

Execute a child program in a new process. On POSIX, the class uses `os.execvpe()`-like behavior to execute the child program. On Windows, the class uses the Windows `CreateProcess()` function. The arguments to `Popen` are as follows.

args should be a sequence of program arguments or else a single string or *path-like object*. By default, the program to execute is the first item in *args* if *args* is a sequence. If *args* is a string, the interpretation is platform-dependent and described below. See the *shell* and *executable* arguments for additional differences from the default behavior. Unless otherwise stated, it is recommended to pass *args* as a sequence.

警告: For maximum reliability, use a fully qualified path for the executable. To search for an unqualified name on `PATH`, use `shutil.which()`. On all platforms, passing `sys.executable` is the recommended way to launch the current Python interpreter again, and use the `-m` command-line format to launch an installed module.

Resolving the path of *executable* (or the first item of *args*) is platform dependent. For POSIX, see `os.execvp()`, and note that when resolving or searching for the executable path, *cwd* overrides the current working directory and *env* can override the `PATH` environment variable. For Windows, see the documentation of the `lpApplicationName` and `lpCommandLine` parameters of `WinAPI.CreateProcess`, and note that when resolving or searching for the executable path with `shell=False`, *cwd* does not override the current working directory and *env* cannot override the `PATH` environment variable. Using a full path avoids all of these variations.

An example of passing some arguments to an external program as a sequence is:

```
Popen(["usr/bin/git", "commit", "-m", "Fixes a bug."])
```

On POSIX, if *args* is a string, the string is interpreted as the name or path of the program to execute. However, this can only be done if not passing arguments to the program.

備 F: It may not be obvious how to break a shell command into a sequence of arguments, especially in complex cases. `shlex.split()` can illustrate how to determine the correct tokenization for *args*:

```
>>> import shlex, subprocess
>>> command_line = input()
/bin/vikings -input eggs.txt -output "spam spam.txt" -cmd "echo '$MONEY'"
>>> args = shlex.split(command_line)
>>> print(args)
['/bin/vikings', '-input', 'eggs.txt', '-output', 'spam spam.txt', '-cmd',
↪ "echo '$MONEY'"]
>>> p = subprocess.Popen(args) # Success!
```

Note in particular that options (such as *-input*) and arguments (such as *eggs.txt*) that are separated by whitespace in the shell go in separate list elements, while arguments that need quoting or backslash escaping when used in the shell (such as filenames containing spaces or the *echo* command shown above) are single list elements.

On Windows, if *args* is a sequence, it will be converted to a string in a manner described in [Converting an argument sequence to a string on Windows](#). This is because the underlying `CreateProcess()` operates on strings.

在 3.6 版的變更: *args* parameter accepts a *path-like object* if *shell* is `False` and a sequence containing path-like objects on POSIX.

在 3.8 版的變更: *args* parameter accepts a *path-like object* if *shell* is `False` and a sequence containing bytes and path-like objects on Windows.

The *shell* argument (which defaults to `False`) specifies whether to use the shell as the program to execute. If *shell* is `True`, it is recommended to pass *args* as a string rather than as a sequence.

On POSIX with *shell=True*, the shell defaults to `/bin/sh`. If *args* is a string, the string specifies the command to execute through the shell. This means that the string must be formatted exactly as it would be when typed at the shell prompt. This includes, for example, quoting or backslash escaping filenames with spaces in them. If *args* is a sequence, the first item specifies the command string, and any additional items will be treated as additional arguments to the shell itself. That is to say, *Popen* does the equivalent of:

```
Popen(['/bin/sh', '-c', args[0], args[1], ...])
```

On Windows with *shell=True*, the `COMSPEC` environment variable specifies the default shell. The only time you need to specify *shell=True* on Windows is when the command you wish to execute is built into the shell (e.g. `dir` or `copy`). You do not need *shell=True* to run a batch file or console-based executable.

備 F: Read the [Security Considerations](#) section before using *shell=True*.

bufsize will be supplied as the corresponding argument to the `open()` function when creating the `stdin/stdout/stderr` pipe file objects:

- 0 means unbuffered (read and write are one system call and can return short)
- 1 means line buffered (only usable if `text=True` or `universal_newlines=True`)
- any other positive value means use a buffer of approximately that size
- negative *bufsize* (the default) means the system default of `io.DEFAULT_BUFFER_SIZE` will be used.

在 3.3.1 版的變更: *bufsize* now defaults to -1 to enable buffering by default to match the behavior that most code expects. In versions prior to Python 3.2.4 and 3.3.1 it incorrectly defaulted to 0 which was unbuffered and allowed short reads. This was unintentional and did not match the behavior of Python 2 as most code expected.

The *executable* argument specifies a replacement program to execute. It is very seldom needed. When `shell=False`, *executable* replaces the program to execute specified by *args*. However, the original *args* is still passed to the program. Most programs treat the program specified by *args* as the command name, which can then be different from the program actually executed. On POSIX, the *args* name becomes the display name for the executable in utilities such as `ps`. If `shell=True`, on POSIX the *executable* argument specifies a replacement shell for the default `/bin/sh`.

在 3.6 版的變更: *executable* parameter accepts a *path-like object* on POSIX.

在 3.8 版的變更: *executable* parameter accepts a bytes and *path-like object* on Windows.

在 3.11.3 版的變更: Changed Windows shell search order for `shell=True`. The current directory and `%PATH%` are replaced with `%COMSPEC%` and `%SystemRoot%\System32\cmd.exe`. As a result, dropping a malicious program named `cmd.exe` into a current directory no longer works.

stdin, *stdout* and *stderr* specify the executed program's standard input, standard output and standard error file handles, respectively. Valid values are `PIPE`, `DEVNULL`, an existing file descriptor (a positive integer), an existing *file object* with a valid file descriptor, and `None`. `PIPE` indicates that a new pipe to the child should be created. `DEVNULL` indicates that the special file `os.devnull` will be used. With the default settings of `None`, no redirection will occur; the child's file handles will be inherited from the parent. Additionally, *stderr* can be `STDOUT`, which indicates that the `stderr` data from the applications should be captured into the same file handle as for `stdout`.

If *preexec_fn* is set to a callable object, this object will be called in the child process just before the child is executed. (POSIX only)

警告: The *preexec_fn* parameter is NOT SAFE to use in the presence of threads in your application. The child process could deadlock before `exec` is called.

備註: If you need to modify the environment for the child use the *env* parameter rather than doing it in a *preexec_fn*. The *start_new_session* and *process_group* parameters should take the place of code using *preexec_fn* to call `os.setsid()` or `os.setpgid()` in the child.

在 3.8 版的變更: The *preexec_fn* parameter is no longer supported in subinterpreters. The use of the parameter in a subinterpreter raises `RuntimeError`. The new restriction may affect applications that are deployed in `mod_wsgi`, `uWSGI`, and other embedded environments.

If *close_fds* is true, all file descriptors except 0, 1 and 2 will be closed before the child process is executed. Otherwise when *close_fds* is false, file descriptors obey their inheritable flag as described in *Inheritance of File Descriptors*.

On Windows, if *close_fds* is true then no handles will be inherited by the child process unless explicitly passed in the *handle_list* element of `STARTUPINFO.lpAttributeList`, or by standard handle redirection.

在 3.2 版的變更: The default for *close_fds* was changed from `False` to what is described above.

在 3.7 版的變更: On Windows the default for *close_fds* was changed from `False` to `True` when redirecting the standard handles. It's now possible to set *close_fds* to `True` when redirecting the standard handles.

pass_fds is an optional sequence of file descriptors to keep open between the parent and child. Providing any *pass_fds* forces *close_fds* to be *True*. (POSIX only)

在 3.2 版的變更: 新增 *pass_fds* 參數。

If *cwd* is not *None*, the function changes the working directory to *cwd* before executing the child. *cwd* can be a string, bytes or *path-like* object. On POSIX, the function looks for *executable* (or for the first item in *args*) relative to *cwd* if the executable path is a relative path.

在 3.6 版的變更: *cwd* parameter accepts a *path-like object* on POSIX.

在 3.7 版的變更: *cwd* parameter accepts a *path-like object* on Windows.

在 3.8 版的變更: *cwd* parameter accepts a bytes object on Windows.

If *restore_signals* is true (the default) all signals that Python has set to SIG_IGN are restored to SIG_DFL in the child process before the exec. Currently this includes the SIGPIPE, SIGXFZ and SIGXFSZ signals. (POSIX only)

在 3.2 版的變更: 新增 *restore_signals*。

If *start_new_session* is true the *setsid()* system call will be made in the child process prior to the execution of the subprocess.

適用: POSIX

在 3.2 版的變更: 新增 *start_new_session*。

If *process_group* is a non-negative integer, the *setpgid(0, value)* system call will be made in the child process prior to the execution of the subprocess.

適用: POSIX

在 3.11 版的變更: 新增 *process_group*。

If *group* is not *None*, the *setregid()* system call will be made in the child process prior to the execution of the subprocess. If the provided value is a string, it will be looked up via *grp.getgrnam()* and the value in *gr_gid* will be used. If the value is an integer, it will be passed verbatim. (POSIX only)

適用: POSIX

在 3.9 版新加入。

If *extra_groups* is not *None*, the *setgroups()* system call will be made in the child process prior to the execution of the subprocess. Strings provided in *extra_groups* will be looked up via *grp.getgrnam()* and the values in *gr_gid* will be used. Integer values will be passed verbatim. (POSIX only)

適用: POSIX

在 3.9 版新加入。

If *user* is not *None*, the *setreuid()* system call will be made in the child process prior to the execution of the subprocess. If the provided value is a string, it will be looked up via *pwd.getpwnam()* and the value in *pw_uid* will be used. If the value is an integer, it will be passed verbatim. (POSIX only)

適用: POSIX

在 3.9 版新加入。

If *umask* is not negative, the *umask()* system call will be made in the child process prior to the execution of the subprocess.

適用: POSIX

在 3.9 版新加入。

If *env* is not *None*, it must be a mapping that defines the environment variables for the new process; these are used instead of the default behavior of inheriting the current process' environment. This mapping can be str to str on any platform or bytes to bytes on POSIX platforms much like *os.environ* or *os.environb*.

備 F: If specified, *env* must provide any variables required for the program to execute. On Windows, in order to run a *side-by-side assembly* the specified *env* **must** include a valid `SystemRoot`.

If *encoding* or *errors* are specified, or *text* is true, the file objects *stdin*, *stdout* and *stderr* are opened in text mode with the specified *encoding* and *errors*, as described above in *Frequently Used Arguments*. The *universal_newlines* argument is equivalent to *text* and is provided for backwards compatibility. By default, file objects are opened in binary mode.

在 3.6 版新加入: 新增 *encoding* 與 *errors*。

在 3.7 版新加入: *text* was added as a more readable alias for *universal_newlines*.

If given, *startupinfo* will be a `STARTUPINFO` object, which is passed to the underlying `CreateProcess` function.

If given, *creationflags*, can be one or more of the following flags:

- `CREATE_NEW_CONSOLE`
- `CREATE_NEW_PROCESS_GROUP`
- `ABOVE_NORMAL_PRIORITY_CLASS`
- `BELOW_NORMAL_PRIORITY_CLASS`
- `HIGH_PRIORITY_CLASS`
- `IDLE_PRIORITY_CLASS`
- `NORMAL_PRIORITY_CLASS`
- `REALTIME_PRIORITY_CLASS`
- `CREATE_NO_WINDOW`
- `DETACHED_PROCESS`
- `CREATE_DEFAULT_ERROR_MODE`
- `CREATE_BREAKAWAY_FROM_JOB`

pipesize can be used to change the size of the pipe when *PIPE* is used for *stdin*, *stdout* or *stderr*. The size of the pipe is only changed on platforms that support this (only Linux at this time of writing). Other platforms will ignore this parameter.

在 3.10 版的變更: Added the *pipesize* parameter.

Popen objects are supported as context managers via the `with` statement: on exit, standard file descriptors are closed, and the process is waited for.

```
with Popen(["ifconfig"], stdout=PIPE) as proc:
    log.write(proc.stdout.read())
```

引發一個附帶引數 *executable*、*args*、*cwd*、*env* 的稽核事件 `subprocess.Popen`。

在 3.2 版的變更: Added context manager support.

在 3.6 版的變更: Popen destructor now emits a *ResourceWarning* warning if the child process is still running.

在 3.8 版的變更: Popen can use `os.posix_spawn()` in some cases for better performance. On Windows Subsystem for Linux and QEMU User Emulation, Popen constructor using `os.posix_spawn()` no longer raise an exception on errors like missing program, but the child process fails with a non-zero *returncode*.

例外

Exceptions raised in the child process, before the new program has started to execute, will be re-raised in the parent.

The most common exception raised is `OSError`. This occurs, for example, when trying to execute a non-existent file. Applications should prepare for `OSError` exceptions. Note that, when `shell=True`, `OSError` will be raised by the child only if the selected shell itself was not found. To determine if the shell failed to find the requested application, it is necessary to check the return code or output from the subprocess.

A `ValueError` will be raised if `Popen` is called with invalid arguments.

`check_call()` and `check_output()` will raise `CalledProcessError` if the called process returns a non-zero return code.

All of the functions and methods that accept a `timeout` parameter, such as `run()` and `Popen.communicate()` will raise `TimeoutExpired` if the timeout expires before the process exits.

Exceptions defined in this module all inherit from `SubprocessError`.

在 3.3 版新加入: The `SubprocessError` base class was added.

17.6.2 Security Considerations

Unlike some other `popen` functions, this implementation will never implicitly call a system shell. This means that all characters, including shell metacharacters, can safely be passed to child processes. If the shell is invoked explicitly, via `shell=True`, it is the application's responsibility to ensure that all whitespace and metacharacters are quoted appropriately to avoid [shell injection](#) vulnerabilities. On *some platforms*, it is possible to use `shlex.quote()` for this escaping.

17.6.3 Popen Objects

Instances of the `Popen` class have the following methods:

`Popen.poll()`

Check if child process has terminated. Set and return `returncode` attribute. Otherwise, returns `None`.

`Popen.wait(timeout=None)`

Wait for child process to terminate. Set and return `returncode` attribute.

If the process does not terminate after `timeout` seconds, raise a `TimeoutExpired` exception. It is safe to catch this exception and retry the wait.

備 F: This will deadlock when using `stdout=PIPE` or `stderr=PIPE` and the child process generates enough output to a pipe such that it blocks waiting for the OS pipe buffer to accept more data. Use `Popen.communicate()` when using pipes to avoid that.

備 F: When the `timeout` parameter is not `None`, then (on POSIX) the function is implemented using a busy loop (non-blocking call and short sleeps). Use the `asyncio` module for an asynchronous wait: see `asyncio.create_subprocess_exec`.

在 3.3 版的變更: 新增 `timeout`。

`Popen.communicate(input=None, timeout=None)`

Interact with process: Send data to stdin. Read data from stdout and stderr, until end-of-file is reached. Wait for process to terminate and set the `returncode` attribute. The optional `input` argument should be data to be sent to the child process, or `None`, if no data should be sent to the child. If streams were opened in text mode, `input` must be a string. Otherwise, it must be bytes.

`communicate()` returns a tuple (`stdout_data`, `stderr_data`). The data will be strings if streams were opened in text mode; otherwise, bytes.

Note that if you want to send data to the process's stdin, you need to create the `Popen` object with `stdin=PIPE`. Similarly, to get anything other than `None` in the result tuple, you need to give `stdout=PIPE` and/or `stderr=PIPE` too.

If the process does not terminate after *timeout* seconds, a *TimeoutExpired* exception will be raised. Catching this exception and retrying communication will not lose any output.

The child process is not killed if the timeout expires, so in order to cleanup properly a well-behaved application should kill the child process and finish communication:

```
proc = subprocess.Popen(...)
try:
    outs, errs = proc.communicate(timeout=15)
except TimeoutExpired:
    proc.kill()
    outs, errs = proc.communicate()
```

備 F: The data read is buffered in memory, so do not use this method if the data size is large or unlimited.

在 3.3 版的變更: 新增 *timeout*。

`Popen.send_signal(signal)`

Sends the signal *signal* to the child.

Do nothing if the process completed.

備 F: On Windows, `SIGTERM` is an alias for *terminate()*. `CTRL_C_EVENT` and `CTRL_BREAK_EVENT` can be sent to processes started with a *creationflags* parameter which includes `CREATE_NEW_PROCESS_GROUP`.

`Popen.terminate()`

Stop the child. On POSIX OSs the method sends *SIGTERM* to the child. On Windows the Win32 API function `TerminateProcess()` is called to stop the child.

`Popen.kill()`

Kills the child. On POSIX OSs the function sends `SIGKILL` to the child. On Windows *kill()* is an alias for *terminate()*.

The following attributes are also set by the class for you to access. Reassigning them to new values is unsupported:

`Popen.args`

The *args* argument as it was passed to *Popen* -- a sequence of program arguments or else a single string.

在 3.3 版新加入。

`Popen.stdin`

If the *stdin* argument was *PIPE*, this attribute is a writeable stream object as returned by *open()*. If the *encoding* or *errors* arguments were specified or the *text* or *universal_newlines* argument was `True`, the stream is a text stream, otherwise it is a byte stream. If the *stdin* argument was not *PIPE*, this attribute is `None`.

`Popen.stdout`

If the *stdout* argument was *PIPE*, this attribute is a readable stream object as returned by *open()*. Reading from the stream provides output from the child process. If the *encoding* or *errors* arguments were specified or the *text* or *universal_newlines* argument was `True`, the stream is a text stream, otherwise it is a byte stream. If the *stdout* argument was not *PIPE*, this attribute is `None`.

Popen.stderr

If the *stderr* argument was *PIPE*, this attribute is a readable stream object as returned by *open()*. Reading from the stream provides error output from the child process. If the *encoding* or *errors* arguments were specified or the *text* or *universal_newlines* argument was *True*, the stream is a text stream, otherwise it is a byte stream. If the *stderr* argument was not *PIPE*, this attribute is *None*.

警告: Use *communicate()* rather than *.stdin.write*, *.stdout.read* or *.stderr.read* to avoid deadlocks due to any of the other OS pipe buffers filling up and blocking the child process.

Popen.pid

The process ID of the child process.

Note that if you set the *shell* argument to *True*, this is the process ID of the spawned shell.

Popen.returncode

The child return code. Initially *None*, *returncode* is set by a call to the *poll()*, *wait()*, or *communicate()* methods if they detect that the process has terminated.

A *None* value indicates that the process hadn't yet terminated at the time of the last method call.

A negative value *-N* indicates that the child was terminated by signal *N* (POSIX only).

17.6.4 Windows Popen Helpers

The *STARTUPINFO* class and following constants are only available on Windows.

```
class subprocess.STARTUPINFO (*, dwFlags=0, hStdInput=None, hStdOutput=None, hStdError=None,
                               wShowWindow=0, lpAttributeList=None)
```

Partial support of the Windows *STARTUPINFO* structure is used for *Popen* creation. The following attributes can be set by passing them as keyword-only arguments.

在 3.7 版的變更: Keyword-only argument support was added.

dwFlags

A bit field that determines whether certain *STARTUPINFO* attributes are used when the process creates a window.

```
si = subprocess.STARTUPINFO()
si.dwFlags = subprocess.STARTF_USESTDHANDLES | subprocess.STARTF_
↳ USESHOWWINDOW
```

hStdInput

If *dwFlags* specifies *STARTF_USESTDHANDLES*, this attribute is the standard input handle for the process. If *STARTF_USESTDHANDLES* is not specified, the default for standard input is the keyboard buffer.

hStdOutput

If *dwFlags* specifies *STARTF_USESTDHANDLES*, this attribute is the standard output handle for the process. Otherwise, this attribute is ignored and the default for standard output is the console window's buffer.

hStdError

If *dwFlags* specifies *STARTF_USESTDHANDLES*, this attribute is the standard error handle for the process. Otherwise, this attribute is ignored and the default for standard error is the console window's buffer.

wShowWindow

If *dwFlags* specifies *STARTF_USESHOWWINDOW*, this attribute can be any of the values that can be specified in the *nCmdShow* parameter for the *ShowWindow* function, except for *SW_SHOWDEFAULT*. Otherwise, this attribute is ignored.

SW_HIDE is provided for this attribute. It is used when *Popen* is called with *shell=True*.

lpAttributeList

A dictionary of additional attributes for process creation as given in *STARTUPINFOEX*, see *UpdateProcThreadAttribute*.

Supported attributes:

handle_list

Sequence of handles that will be inherited. *close_fds* must be true if non-empty.

The handles must be temporarily made inheritable by *os.set_handle_inheritable()* when passed to the *Popen* constructor, else *OSError* will be raised with Windows error *ERROR_INVALID_PARAMETER* (87).

警告: In a multithreaded process, use caution to avoid leaking handles that are marked inheritable when combining this feature with concurrent calls to other process creation functions that inherit all handles such as *os.system()*. This also applies to standard handle redirection, which temporarily creates inheritable handles.

在 3.7 版新加入.

Windows Constants

The *subprocess* module exposes the following constants.

subprocess.STD_INPUT_HANDLE

The standard input device. Initially, this is the console input buffer, *CONIN\$*.

subprocess.STD_OUTPUT_HANDLE

The standard output device. Initially, this is the active console screen buffer, *CONOUT\$*.

subprocess.STD_ERROR_HANDLE

The standard error device. Initially, this is the active console screen buffer, *CONOUT\$*.

subprocess.SW_HIDE

Hides the window. Another window will be activated.

subprocess.STARTF_USESTDHANDLES

Specifies that the *STARTUPINFO.hStdInput*, *STARTUPINFO.hStdOutput*, and *STARTUPINFO.hStdError* attributes contain additional information.

subprocess.STARTF_USESHOWWINDOW

Specifies that the *STARTUPINFO.wShowWindow* attribute contains additional information.

subprocess.CREATE_NEW_CONSOLE

The new process has a new console, instead of inheriting its parent's console (the default).

subprocess.CREATE_NEW_PROCESS_GROUP

A *Popen* *creationflags* parameter to specify that a new process group will be created. This flag is necessary for using *os.kill()* on the subprocess.

This flag is ignored if *CREATE_NEW_CONSOLE* is specified.

`subprocess.ABOVE_NORMAL_PRIORITY_CLASS`

A *Popen* `creationflags` parameter to specify that a new process will have an above average priority.
在 3.7 版新加入。

`subprocess.BELOW_NORMAL_PRIORITY_CLASS`

A *Popen* `creationflags` parameter to specify that a new process will have a below average priority.
在 3.7 版新加入。

`subprocess.HIGH_PRIORITY_CLASS`

A *Popen* `creationflags` parameter to specify that a new process will have a high priority.
在 3.7 版新加入。

`subprocess.IDLE_PRIORITY_CLASS`

A *Popen* `creationflags` parameter to specify that a new process will have an idle (lowest) priority.
在 3.7 版新加入。

`subprocess.NORMAL_PRIORITY_CLASS`

A *Popen* `creationflags` parameter to specify that a new process will have an normal priority. (default)
在 3.7 版新加入。

`subprocess.REALTIME_PRIORITY_CLASS`

A *Popen* `creationflags` parameter to specify that a new process will have realtime priority. You should almost never use `REALTIME_PRIORITY_CLASS`, because this interrupts system threads that manage mouse input, keyboard input, and background disk flushing. This class can be appropriate for applications that “talk” directly to hardware or that perform brief tasks that should have limited interruptions.
在 3.7 版新加入。

`subprocess.CREATE_NO_WINDOW`

A *Popen* `creationflags` parameter to specify that a new process will not create a window.
在 3.7 版新加入。

`subprocess.DETACHED_PROCESS`

A *Popen* `creationflags` parameter to specify that a new process will not inherit its parent’s console. This value cannot be used with `CREATE_NEW_CONSOLE`.
在 3.7 版新加入。

`subprocess.CREATE_DEFAULT_ERROR_MODE`

A *Popen* `creationflags` parameter to specify that a new process does not inherit the error mode of the calling process. Instead, the new process gets the default error mode. This feature is particularly useful for multithreaded shell applications that run with hard errors disabled.
在 3.7 版新加入。

`subprocess.CREATE_BREAKAWAY_FROM_JOB`

A *Popen* `creationflags` parameter to specify that a new process is not associated with the job.
在 3.7 版新加入。

17.6.5 Older high-level API

Prior to Python 3.5, these three functions comprised the high level API to subprocess. You can now use `run()` in many cases, but lots of existing code calls these functions.

```
subprocess.call(args, *, stdin=None, stdout=None, stderr=None, shell=False, cwd=None, timeout=None,
                **other_popen_kwargs)
```

Run the command described by `args`. Wait for command to complete, then return the `returncode` attribute.

Code needing to capture stdout or stderr should use `run()` instead:

```
run(...).returncode
```

To suppress stdout or stderr, supply a value of `DEVNULL`.

The arguments shown above are merely some common ones. The full function signature is the same as that of the `Popen` constructor - this function passes all supplied arguments other than `timeout` directly through to that interface.

備註: Do not use `stdout=PIPE` or `stderr=PIPE` with this function. The child process will block if it generates enough output to a pipe to fill up the OS pipe buffer as the pipes are not being read from.

在 3.3 版的變更: 新增 `timeout`。

在 3.11.3 版的變更: Changed Windows shell search order for `shell=True`. The current directory and `%PATH%` are replaced with `%COMSPEC%` and `%SystemRoot%\System32\cmd.exe`. As a result, dropping a malicious program named `cmd.exe` into a current directory no longer works.

```
subprocess.check_call(args, *, stdin=None, stdout=None, stderr=None, shell=False, cwd=None,
                      timeout=None, **other_popen_kwargs)
```

Run command with arguments. Wait for command to complete. If the return code was zero then return, otherwise raise `CalledProcessError`. The `CalledProcessError` object will have the return code in the `returncode` attribute. If `check_call()` was unable to start the process it will propagate the exception that was raised.

Code needing to capture stdout or stderr should use `run()` instead:

```
run(..., check=True)
```

To suppress stdout or stderr, supply a value of `DEVNULL`.

The arguments shown above are merely some common ones. The full function signature is the same as that of the `Popen` constructor - this function passes all supplied arguments other than `timeout` directly through to that interface.

備註: Do not use `stdout=PIPE` or `stderr=PIPE` with this function. The child process will block if it generates enough output to a pipe to fill up the OS pipe buffer as the pipes are not being read from.

在 3.3 版的變更: 新增 `timeout`。

在 3.11.3 版的變更: Changed Windows shell search order for `shell=True`. The current directory and `%PATH%` are replaced with `%COMSPEC%` and `%SystemRoot%\System32\cmd.exe`. As a result, dropping a malicious program named `cmd.exe` into a current directory no longer works.

```
subprocess.check_output(args, *, stdin=None, stderr=None, shell=False, cwd=None, encoding=None,
                        errors=None, universal_newlines=None, timeout=None, text=None,
                        **other_popen_kwargs)
```

Run command with arguments and return its output.

If the return code was non-zero it raises a `CalledProcessError`. The `CalledProcessError` object will have the return code in the `returncode` attribute and any output in the `output` attribute.

This is equivalent to:

```
run(..., check=True, stdout=PIPE).stdout
```

The arguments shown above are merely some common ones. The full function signature is largely the same as that of `run()` - most arguments are passed directly through to that interface. One API deviation from `run()` behavior exists: passing `input=None` will behave the same as `input=b''` (or `input=''`, depending on other arguments) rather than using the parent's standard input file handle.

By default, this function will return the data as encoded bytes. The actual encoding of the output data may depend on the command being invoked, so the decoding to text will often need to be handled at the application level.

This behaviour may be overridden by setting `text`, `encoding`, `errors`, or `universal_newlines` to `True` as described in *Frequently Used Arguments* and `run()`.

To also capture standard error in the result, use `stderr=subprocess.STDOUT`:

```
>>> subprocess.check_output (
...     "ls non_existent_file; exit 0",
...     stderr=subprocess.STDOUT,
...     shell=True)
'ls: non_existent_file: No such file or directory\n'
```

在 3.1 版新加入。

在 3.3 版的變更: 新增 `timeout`。

在 3.4 版的變更: 新增 `input` 關鍵字引數的支援。

在 3.6 版的變更: 新增 `encoding` 與 `errors`。細節請見 `run()`。

在 3.7 版新加入: `text` was added as a more readable alias for `universal_newlines`.

在 3.11.3 版的變更: Changed Windows shell search order for `shell=True`. The current directory and `%PATH%` are replaced with `%COMSPEC%` and `%SystemRoot%\System32\cmd.exe`. As a result, dropping a malicious program named `cmd.exe` into a current directory no longer works.

17.6.6 Replacing Older Functions with the `subprocess` Module

In this section, "a becomes b" means that b can be used as a replacement for a.

備 F: All "a" functions in this section fail (more or less) silently if the executed program cannot be found; the "b" replacements raise `OSError` instead.

In addition, the replacements using `check_output()` will fail with a `CalledProcessError` if the requested operation produces a non-zero return code. The output is still available as the `output` attribute of the raised exception.

In the following examples, we assume that the relevant functions have already been imported from the `subprocess` module.

Replacing `/bin/sh` shell command substitution

```
output=$(mycmd myarg)
```

變成:

```
output = check_output(["mycmd", "myarg"])
```

Replacing shell pipeline

```
output=$(dmesg | grep hda)
```

變成:

```
p1 = Popen(["dmesg"], stdout=PIPE)
p2 = Popen(["grep", "hda"], stdin=p1.stdout, stdout=PIPE)
p1.stdout.close() # Allow p1 to receive a SIGPIPE if p2 exits.
output = p2.communicate()[0]
```

The `p1.stdout.close()` call after starting the `p2` is important in order for `p1` to receive a `SIGPIPE` if `p2` exits before `p1`.

Alternatively, for trusted input, the shell's own pipeline support may still be used directly:

```
output=$(dmesg | grep hda)
```

變成:

```
output = check_output("dmesg | grep hda", shell=True)
```

Replacing `os.system()`

```
sts = os.system("mycmd" + " myarg")
# becomes
retcode = call("mycmd" + " myarg", shell=True)
```

解:

- Calling the program through the shell is usually not required.
- The `call()` return value is encoded differently to that of `os.system()`.
- The `os.system()` function ignores `SIGINT` and `SIGQUIT` signals while the command is running, but the caller must do this separately when using the `subprocess` module.

A more realistic example would look like this:

```
try:
    retcode = call("mycmd" + " myarg", shell=True)
    if retcode < 0:
        print("Child was terminated by signal", -retcode, file=sys.stderr)
    else:
        print("Child returned", retcode, file=sys.stderr)
except OSError as e:
    print("Execution failed:", e, file=sys.stderr)
```

Replacing the `os.spawn` family

P_NOWAIT 範例:

```
pid = os.spawnlp(os.P_NOWAIT, "/bin/mycmd", "mycmd", "myarg")
==>
pid = Popen(["/bin/mycmd", "myarg"]).pid
```

P_WAIT 範例:

```
retcode = os.spawnlp(os.P_WAIT, "/bin/mycmd", "mycmd", "myarg")
==>
retcode = call(["/bin/mycmd", "myarg"])
```

Vector example:

```
os.spawnvp(os.P_NOWAIT, path, args)
==>
Popen([path] + args[1:])
```

Environment example:

```
os.spawnlpe(os.P_NOWAIT, "/bin/mycmd", "mycmd", "myarg", env)
==>
Popen(["/bin/mycmd", "myarg"], env={"PATH": "/usr/bin"})
```

Replacing `os.popen()`, `os.popen2()`, `os.popen3()`

```
(child_stdin, child_stdout) = os.popen2(cmd, mode, bufsize)
==>
p = Popen(cmd, shell=True, bufsize=bufsize,
          stdin=PIPE, stdout=PIPE, close_fds=True)
(child_stdin, child_stdout) = (p.stdin, p.stdout)
```

```
(child_stdin,
 child_stdout,
 child_stderr) = os.popen3(cmd, mode, bufsize)
==>
p = Popen(cmd, shell=True, bufsize=bufsize,
          stdin=PIPE, stdout=PIPE, stderr=PIPE, close_fds=True)
(child_stdin,
 child_stdout,
 child_stderr) = (p.stdin, p.stdout, p.stderr)
```

```
(child_stdin, child_stdout_and_stderr) = os.popen4(cmd, mode, bufsize)
==>
p = Popen(cmd, shell=True, bufsize=bufsize,
          stdin=PIPE, stdout=PIPE, stderr=STDOUT, close_fds=True)
(child_stdin, child_stdout_and_stderr) = (p.stdin, p.stdout)
```

Return code handling translates as follows:

```
pipe = os.popen(cmd, 'w')
...
rc = pipe.close()
if rc is not None and rc >> 8:
    print("There were some errors")
==>
process = Popen(cmd, stdin=PIPE)
```

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```
...
process.stdin.close()
if process.wait() != 0:
    print("There were some errors")
```

Replacing functions from the `popen2` module

備: If the `cmd` argument to `popen2` functions is a string, the command is executed through `/bin/sh`. If it is a list, the command is directly executed.

```
(child_stdout, child_stdin) = popen2.popen2("somestring", bufsize, mode)
==>
p = Popen("somestring", shell=True, bufsize=bufsize,
          stdin=PIPE, stdout=PIPE, close_fds=True)
(child_stdout, child_stdin) = (p.stdout, p.stdin)
```

```
(child_stdout, child_stdin) = popen2.popen2(["mycmd", "myarg"], bufsize, mode)
==>
p = Popen(["mycmd", "myarg"], bufsize=bufsize,
          stdin=PIPE, stdout=PIPE, close_fds=True)
(child_stdout, child_stdin) = (p.stdout, p.stdin)
```

`popen2.Popen3` and `popen2.Popen4` basically work as `subprocess.Popen`, except that:

- `Popen` raises an exception if the execution fails.
- The `capturestderr` argument is replaced with the `stderr` argument.
- `stdin=PIPE` and `stdout=PIPE` must be specified.
- `popen2` closes all file descriptors by default, but you have to specify `close_fds=True` with `Popen` to guarantee this behavior on all platforms or past Python versions.

17.6.7 Legacy Shell Invocation Functions

This module also provides the following legacy functions from the 2.x `commands` module. These operations implicitly invoke the system shell and none of the guarantees described above regarding security and exception handling consistency are valid for these functions.

`subprocess.getstatusoutput(cmd, *, encoding=None, errors=None)`

Return (exitcode, output) of executing `cmd` in a shell.

Execute the string `cmd` in a shell with `Popen.check_output()` and return a 2-tuple (exitcode, output). `encoding` and `errors` are used to decode output; see the notes on *Frequently Used Arguments* for more details.

A trailing newline is stripped from the output. The exit code for the command can be interpreted as the return code of `subprocess`. Example:

```
>>> subprocess.getstatusoutput('ls /bin/ls')
(0, '/bin/ls')
>>> subprocess.getstatusoutput('cat /bin/junk')
(1, 'cat: /bin/junk: No such file or directory')
>>> subprocess.getstatusoutput('/bin/junk')
(127, 'sh: /bin/junk: not found')
>>> subprocess.getstatusoutput('/bin/kill $$')
(-15, '')
```

適用：Unix 和 Windows。

在 3.3.4 版的變更：Windows support was added.

The function now returns (exitcode, output) instead of (status, output) as it did in Python 3.3.3 and earlier. exitcode has the same value as *returncode*.

在 3.11 版的變更：Added the *encoding* and *errors* parameters.

`subprocess.getoutput (cmd, *, encoding=None, errors=None)`

Return output (stdout and stderr) of executing *cmd* in a shell.

Like *getstatusoutput()*, except the exit code is ignored and the return value is a string containing the command's output. Example:

```
>>> subprocess.getoutput('ls /bin/ls')
'/bin/ls'
```

適用：Unix 和 Windows。

在 3.3.4 版的變更：Windows support added

在 3.11 版的變更：Added the *encoding* and *errors* parameters.

17.6.8 解

Converting an argument sequence to a string on Windows

On Windows, an *args* sequence is converted to a string that can be parsed using the following rules (which correspond to the rules used by the MS C runtime):

1. Arguments are delimited by white space, which is either a space or a tab.
2. A string surrounded by double quotation marks is interpreted as a single argument, regardless of white space contained within. A quoted string can be embedded in an argument.
3. A double quotation mark preceded by a backslash is interpreted as a literal double quotation mark.
4. Backslashes are interpreted literally, unless they immediately precede a double quotation mark.
5. If backslashes immediately precede a double quotation mark, every pair of backslashes is interpreted as a literal backslash. If the number of backslashes is odd, the last backslash escapes the next double quotation mark as described in rule 3.

也參考：

shlex

Module which provides function to parse and escape command lines.

Disabling use of `vfork()` or `posix_spawn()`

On Linux, *subprocess* defaults to using the `vfork()` system call internally when it is safe to do so rather than `fork()`. This greatly improves performance.

If you ever encounter a presumed highly unusual situation where you need to prevent `vfork()` from being used by Python, you can set the `subprocess._USE_VFORK` attribute to a false value.

```
subprocess._USE_VFORK = False # See CPython issue gh-NNNNNN.
```

Setting this has no impact on use of `posix_spawn()` which could use `vfork()` internally within its libc implementation. There is a similar `subprocess._USE_POSIX_SPAWN` attribute if you need to prevent use of that.

```
subprocess._USE_POSIX_SPAWN = False # See CPython issue gh-NNNNNN.
```

It is safe to set these to false on any Python version. They will have no effect on older versions when unsupported. Do not assume the attributes are available to read. Despite their names, a true value does not indicate that the corresponding function will be used, only that it may be.

Please file issues any time you have to use these private knobs with a way to reproduce the issue you were seeing. Link to that issue from a comment in your code.

在 3.8 版新加入: `_USE_POSIX_SPAWN`

在 3.11 版新加入: `_USE_VFORK`

17.7 sched --- Event scheduler

原始碼: [Lib/sched.py](#)

The *sched* module defines a class which implements a general purpose event scheduler:

class `sched.scheduler` (*timefunc*=`time.monotonic`, *delayfunc*=`time.sleep`)

The *scheduler* class defines a generic interface to scheduling events. It needs two functions to actually deal with the "outside world" --- *timefunc* should be callable without arguments, and return a number (the "time", in any units whatsoever). The *delayfunc* function should be callable with one argument, compatible with the output of *timefunc*, and should delay that many time units. *delayfunc* will also be called with the argument 0 after each event is run to allow other threads an opportunity to run in multi-threaded applications.

在 3.3 版的變更: *timefunc* and *delayfunc* parameters are optional.

在 3.3 版的變更: *scheduler* class can be safely used in multi-threaded environments.

範例:

```
>>> import sched, time
>>> s = sched.scheduler(time.time, time.sleep)
>>> def print_time(a='default'):
...     print("From print_time", time.time(), a)
...
>>> def print_some_times():
...     print(time.time())
...     s.enter(10, 1, print_time)
...     s.enter(5, 2, print_time, argument=('positional',))
...     # despite having higher priority, 'keyword' runs after 'positional' as
...     ↪enter() is relative
...     s.enter(5, 1, print_time, kwargs={'a': 'keyword'})
...     s.enterabs(1_650_000_000, 10, print_time, argument=("first enterabs",))
...     s.enterabs(1_650_000_000, 5, print_time, argument=("second enterabs",))
...     s.run()
...     print(time.time())
...
>>> print_some_times()
1652342830.3640375
From print_time 1652342830.3642538 second enterabs
From print_time 1652342830.3643398 first enterabs
From print_time 1652342835.3694863 positional
From print_time 1652342835.3696074 keyword
From print_time 1652342840.369612 default
1652342840.3697174
```

17.7.1 Scheduler Objects

`scheduler` instances have the following methods and attributes:

`scheduler.enterabs` (*time*, *priority*, *action*, *argument*=(), *kwargs*={})

Schedule a new event. The *time* argument should be a numeric type compatible with the return value of the *timefunc* function passed to the constructor. Events scheduled for the same *time* will be executed in the order of their *priority*. A lower number represents a higher priority.

Executing the event means executing `action(*argument, **kwargs)`. *argument* is a sequence holding the positional arguments for *action*. *kwargs* is a dictionary holding the keyword arguments for *action*.

Return value is an event which may be used for later cancellation of the event (see `cancel()`).

在 3.3 版的變更: *argument* parameter is optional.

在 3.3 版的變更: 新增 *kwargs* 參數。

`scheduler.enter` (*delay*, *priority*, *action*, *argument*=(), *kwargs*={})

Schedule an event for *delay* more time units. Other than the relative time, the other arguments, the effect and the return value are the same as those for `enterabs()`.

在 3.3 版的變更: *argument* parameter is optional.

在 3.3 版的變更: 新增 *kwargs* 參數。

`scheduler.cancel` (*event*)

Remove the event from the queue. If *event* is not an event currently in the queue, this method will raise a `ValueError`.

`scheduler.empty` ()

Return `True` if the event queue is empty.

`scheduler.run` (*blocking*=`True`)

Run all scheduled events. This method will wait (using the *delayfunc* function passed to the constructor) for the next event, then execute it and so on until there are no more scheduled events.

If *blocking* is false executes the scheduled events due to expire soonest (if any) and then return the deadline of the next scheduled call in the scheduler (if any).

Either *action* or *delayfunc* can raise an exception. In either case, the scheduler will maintain a consistent state and propagate the exception. If an exception is raised by *action*, the event will not be attempted in future calls to `run()`.

If a sequence of events takes longer to run than the time available before the next event, the scheduler will simply fall behind. No events will be dropped; the calling code is responsible for canceling events which are no longer pertinent.

在 3.3 版的變更: 新增 *blocking* 參數。

`scheduler.queue`

Read-only attribute returning a list of upcoming events in the order they will be run. Each event is shown as a *named tuple* with the following fields: *time*, *priority*, *action*, *argument*, *kwargs*.

17.8 queue --- 同步列 (queue) class (類)

原始碼: [Lib/queue.py](#)

`queue` module (模組) 實作多生產者、多消費者列。在執行緒程式設計中，必須在多執行緒之間安全地交資訊時，特別有用。此 module 中的 `Queue` class 實作所有必需的鎖定語義 (locking semantics)。

此 module 實作三種型的列，它們僅在取出條目的順序上有所不同。在 FIFO 列中，先加入的任務是第一個被取出的。在 LIFO 列中，最近被加入的條目是第一個被取出的（像堆 (stack) 一樣操作）。使用優先列 (priority queue) 時，條目將保持排序狀態（使用 `heapq` module），先取出最低值條目。

在內部，這三種型的列使用鎖 (lock) 來暫時阻塞競執行緒；但是，它們不是被設計來處理執行緒的 reentrancy（可重入）。

此外，此 module 實作一個「簡單」的 FIFO 列型 `SimpleQueue`，其特定的實作是以較少的功能代價，來提供額外的保證。

`queue` module 定義了以下的 class 和例外：

class `queue.Queue` (*maxsize=0*)

FIFO 列的建構子 (constructor)。*maxsize* 是一個整數，用於設置列中可放置的項目數的上限。一旦達到此大小，插入將會阻塞，直到列中的項目被消耗。如果 *maxsize* 小於或等於零，則列大小無限。

class `queue.LifoQueue` (*maxsize=0*)

LIFO 列的建構子。*maxsize* 是一個整數，用於設置列中可放置的項目數的上限。一旦達到此大小，插入將被鎖定，到列中的項目被消耗。如果 *maxsize* 小於或等於零，則列大小無限。

class `queue.PriorityQueue` (*maxsize=0*)

優先列的建構子。*maxsize* 是一個整數，用於設置列中可放置的項目數的上限。一旦達到此大小，插入將被阻塞，直到列中的項目被消耗。如果 *maxsize* 小於或等於零，則列大小無限。

最低值的條目會最先被取出（最低值的條目是被會 `min(entries)` 回傳的那一個）。條目的典型模式是格式 (priority_number, data) 的 tuple (元組)。

如果 *data* 元素不可比較的，則可以將資料包裝在一個 class 中，該 class 忽略資料項目僅比較優先數：

```
from dataclasses import dataclass, field
from typing import Any

@dataclass(order=True)
class PrioritizedItem:
    priority: int
    item: Any = field(compare=False)
```

class `queue.SimpleQueue`

無界的 FIFO 列的建構子。簡單列缺少任務追等進階功能。

在 3.7 版新加入。

exception `queue.Empty`

當對一個空的 `Queue` 物件呼叫非阻塞的 `get()`（或 `get_nowait()`）將引發此例外。

exception `queue.Full`

當對一個已滿的 `Queue` 物件呼叫非阻塞的 `put()`（或 `put_nowait()`）將引發此例外。

17.8.1 列物件

列物件 (*Queue*、*LifoQueue*、*PriorityQueue*) 提供下面描述的公用 method。

`Queue.qsize()`

回傳列的近似大小。注意，`qsize() > 0` 不能保證後續的 `get()` 不會阻塞，`qsize() < maxsize` 也不會保證 `put()` 不會阻塞。

`Queue.empty()`

如果列空，則回傳 `True`，否則回傳 `False`。如果 `empty()` 回傳 `True`，則不保證後續呼叫 `put()` 不會阻塞。同樣，如果 `empty()` 回傳 `False`，則不保證後續呼叫 `get()` 不會阻塞。

`Queue.full()`

如果列已滿，則回傳 `True`，否則回傳 `False`。如果 `full()` 回傳 `True`，則不保證後續呼叫 `get()` 不會阻塞。同樣，如果 `full()` 回傳 `False`，則不保證後續呼叫 `put()` 不會阻塞。

`Queue.put(item, block=True, timeout=None)`

將 `item` 放入列中。如果可選的 args `block` 為 `true`、`timeout` 為 `None` (預設值)，則在必要時阻塞，直到自由槽 (free slot) 可用。如果 `timeout` 為正數，則最多阻塞 `timeout` 秒，如果該時間內有可用的自由槽，則會引發 `Full` 例外。否則 (`block` 為 `false`)，如果自由槽立即可用，則將項目放在列中，否則引發 `Full` 例外 (在這種情況下，`timeout` 將被忽略)。

`Queue.put_nowait(item)`

等效於 `put(item, block=False)`。

`Queue.get(block=True, timeout=None)`

從列中移除一個項目。如果可選的 args `block` 為 `true`，且 `timeout` 為 `None` (預設值)，則在必要時阻塞，直到有可用的項目。如果 `timeout` 是正數，則最多會阻塞 `timeout` 秒，如果該時間內有可用的項目，則會引發 `Empty` 例外。否則 (`block` 為 `false`)，如果立即可用，則回傳一個項目，否則引發 `Empty` 例外 (在這種情況下，`timeout` 將被忽略)。

在 POSIX 系統的 3.0 版之前，以及 Windows 的所有版本，如果 `block` 為 `true` 且 `timeout` 為 `None`，則此操作將在底層鎖上進入不間斷等待。這意味著不會發生例外，特別是 `SIGINT` (中斷訊號) 不會觸發 `KeyboardInterrupt`。

`Queue.get_nowait()`

等效於 `get(False)`。

有兩個 method 可以支援追放入列的任務是否已由常駐消費者執行緒 (daemon consumer threads) 完全處理。

`Queue.task_done()`

表示先前放入列的任務已完成。由列消費者執行緒使用。對於用來提取任務的每個 `get()`，隨後呼叫 `task_done()` 告訴列任務的處理已完成。

如果目前 `join()` 阻塞，它將會在所有項目都已處理完畢後恢復 (代表對於以 `put()` 放進列的每個項目，都要收到 `task_done()` 的呼叫)。

如果呼叫次數超過列中放置的項目數量，則引發 `ValueError`。

`Queue.join()`

持續阻塞直到列中的所有項目都被獲取處理完畢。

每當項目被加到列中時，未完成任務的計數都會增加。每當消費者執行緒呼叫 `task_done()` 以指示該項目已被取出且對其的所有工作都已完成時，計數就會下降。當未完成任務的計數降至零時，`join()` 將停止阻塞。

如何等待放入列的任務完成的範例：

```
import threading
import queue

q = queue.Queue()
```

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```
def worker():
    while True:
        item = q.get()
        print(f'Working on {item}')
        print(f'Finished {item}')
        q.task_done()

# Turn-on the worker thread.
threading.Thread(target=worker, daemon=True).start()

# Send thirty task requests to the worker.
for item in range(30):
    q.put(item)

# Block until all tasks are done.
q.join()
print('All work completed')
```

17.8.2 SimpleQueue 物件

SimpleQueue 物件提供下面描述的公用 method。

`SimpleQueue.qsize()`

傳回 F 列的近似大小。注意，`qsize() > 0` F 不能保證後續的 `get()` 不會阻塞。

`SimpleQueue.empty()`

如果 F 列 F 空，則回傳 `True`，否則回傳 `False`。如果 `empty()` 回傳 `False`，則不保證後續呼叫 `get()` 不會阻塞。

`SimpleQueue.put(item, block=True, timeout=None)`

將 *item* 放入 F 列中。此 method 從不阻塞，F 且都會成功（除了 F 在的低階錯誤，像是分配記憶體失敗）。可選的 args *block* 和 *timeout* 會被忽略，它們僅是 F 了與 *Queue.put()* 相容才存在。

CPython 實作細節：此 method 有一個可重入 (reentrant) 的 C 實作。意思就是，一個 `put()` 或 `get()` 呼叫，可以被同一執行緒中的另一個 `put()` 呼叫中斷，而不會造成死鎖 (deadlock) 或損壞 F 列中的 F 部狀態。這使得它適合在解構子 (destructor) 中使用，像是 `__del__` method 或 *weakref* 回呼函式 (callback)。

`SimpleQueue.put_nowait(item)`

等效於 `put(item, block=False)`，用於與 *Queue.put_nowait()* 相容。

`SimpleQueue.get(block=True, timeout=None)`

從 F 列中移除 F 回傳一個項目。如果可選的 args *block* F `true`，且 *timeout* F `None`（預設值），則在必要時阻塞，直到有可用的項目。如果 *timeout* 是正數，則最多會阻塞 *timeout* 秒，如果該時間 F F 有可用的項目，則會引發 *Empty* 例外。否則 (*block* F `false`)，如果立即可用，則回傳一個項目，否則引發 *Empty* 例外（在這種情 F 下，*timeout* 將被忽略）。

`SimpleQueue.get_nowait()`

等效於 `get(False)`。

也參考：

Class *multiprocessing.Queue*

用於多行程處理 (multi-processing)（而非多執行緒）情境 (context) 的 F 列 class。

collections.deque 是無界 F 列的替代實作，有快速且具原子性 (atomic) 的 *append()* 和 *popleft()* 操作，這些操作不需要鎖定，F 且還支持索引。

17.9 contextvars --- Context Variables

This module provides APIs to manage, store, and access context-local state. The `ContextVar` class is used to declare and work with *Context Variables*. The `copy_context()` function and the `Context` class should be used to manage the current context in asynchronous frameworks.

Context managers that have state should use Context Variables instead of `threading.local()` to prevent their state from bleeding to other code unexpectedly, when used in concurrent code.

額外資訊請見 [PEP 567](#)。

在 3.7 版新加入。

17.9.1 Context Variables

class `contextvars.ContextVar` (*name* [, *, *default*])

This class is used to declare a new Context Variable, e.g.:

```
var: ContextVar[int] = ContextVar('var', default=42)
```

The required *name* parameter is used for introspection and debug purposes.

The optional keyword-only *default* parameter is returned by `ContextVar.get()` when no value for the variable is found in the current context.

Important: Context Variables should be created at the top module level and never in closures. *Context* objects hold strong references to context variables which prevents context variables from being properly garbage collected.

name

The name of the variable. This is a read-only property.

在 3.7.1 版新加入。

get ([*default*])

Return a value for the context variable for the current context.

If there is no value for the variable in the current context, the method will:

- return the value of the *default* argument of the method, if provided; or
- return the default value for the context variable, if it was created with one; or
- raise a `LookupError`.

set (*value*)

Call to set a new value for the context variable in the current context.

The required *value* argument is the new value for the context variable.

Returns a *Token* object that can be used to restore the variable to its previous value via the `ContextVar.reset()` method.

reset (*token*)

Reset the context variable to the value it had before the `ContextVar.set()` that created the *token* was used.

舉例來 F:

```

var = ContextVar('var')

token = var.set('new value')
# code that uses 'var'; var.get() returns 'new value'.
var.reset(token)

# After the reset call the var has no value again, so
# var.get() would raise a LookupError.

```

class contextvars.Token

Token objects are returned by the `ContextVar.set()` method. They can be passed to the `ContextVar.reset()` method to revert the value of the variable to what it was before the corresponding `set`.

var

A read-only property. Points to the `ContextVar` object that created the token.

old_value

A read-only property. Set to the value the variable had before the `ContextVar.set()` method call that created the token. It points to `Token.MISSING` if the variable was not set before the call.

MISSING

A marker object used by `Token.old_value`.

17.9.2 Manual Context Management

contextvars.copy_context()

Returns a copy of the current `Context` object.

The following snippet gets a copy of the current context and prints all variables and their values that are set in it:

```

ctx: Context = copy_context()
print(list(ctx.items()))

```

The function has an $O(1)$ complexity, i.e. works equally fast for contexts with a few context variables and for contexts that have a lot of them.

class contextvars.Context

A mapping of `ContextVars` to their values.

`Context()` creates an empty context with no values in it. To get a copy of the current context use the `copy_context()` function.

Every thread will have a different top-level `Context` object. This means that a `ContextVar` object behaves in a similar fashion to `threading.local()` when values are assigned in different threads.

Context implements the `collections.abc.Mapping` interface.

run(callable, *args, **kwargs)

Execute `callable(*args, **kwargs)` code in the context object the `run` method is called on. Return the result of the execution or propagate an exception if one occurred.

Any changes to any context variables that `callable` makes will be contained in the context object:

```

var = ContextVar('var')
var.set('spam')

def main():
    # 'var' was set to 'spam' before
    # calling 'copy_context()' and 'ctx.run(main)', so:
    # var.get() == ctx[var] == 'spam'

```

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```

var.set('ham')

# Now, after setting 'var' to 'ham':
# var.get() == ctx[var] == 'ham'

ctx = copy_context()

# Any changes that the 'main' function makes to 'var'
# will be contained in 'ctx'.
ctx.run(main)

# The 'main()' function was run in the 'ctx' context,
# so changes to 'var' are contained in it:
# ctx[var] == 'ham'

# However, outside of 'ctx', 'var' is still set to 'spam':
# var.get() == 'spam'

```

The method raises a *RuntimeError* when called on the same context object from more than one OS thread, or when called recursively.

copy()

Return a shallow copy of the context object.

var in context

Return True if the *context* has a value for *var* set; return False otherwise.

context[var]

Return the value of the *var* *ContextVar* variable. If the variable is not set in the context object, a *KeyError* is raised.

get(var[, default])

Return the value for *var* if *var* has the value in the context object. Return *default* otherwise. If *default* is not given, return None.

iter(context)

Return an iterator over the variables stored in the context object.

len(proxy)

Return the number of variables set in the context object.

keys()

Return a list of all variables in the context object.

values()

Return a list of all variables' values in the context object.

items()

Return a list of 2-tuples containing all variables and their values in the context object.

17.9.3 asyncio support

Context variables are natively supported in *asyncio* and are ready to be used without any extra configuration. For example, here is a simple echo server, that uses a context variable to make the address of a remote client available in the Task that handles that client:

```
import asyncio
import contextvars

client_addr_var = contextvars.ContextVar('client_addr')

def render_goodbye():
    # The address of the currently handled client can be accessed
    # without passing it explicitly to this function.

    client_addr = client_addr_var.get()
    return f'Good bye, client @ {client_addr}\n'.encode()

async def handle_request(reader, writer):
    addr = writer.transport.get_extra_info('socket').getpeername()
    client_addr_var.set(addr)

    # In any code that we call is now possible to get
    # client's address by calling 'client_addr_var.get()'.

    while True:
        line = await reader.readline()
        print(line)
        if not line.strip():
            break
        writer.write(line)

    writer.write(render_goodbye())
    writer.close()

async def main():
    srv = await asyncio.start_server(
        handle_request, '127.0.0.1', 8081)

    async with srv:
        await srv.serve_forever()

asyncio.run(main())

# To test it you can use telnet:
#     telnet 127.0.0.1 8081
```

以下是支援部份上述服務的模組：

17.10 _thread --- Low-level threading API

This module provides low-level primitives for working with multiple threads (also called *light-weight processes* or *tasks*) --- multiple threads of control sharing their global data space. For synchronization, simple locks (also called *mutexes* or *binary semaphores*) are provided. The *threading* module provides an easier to use and higher-level threading API built on top of this module.

在 3.7 版的變更: This module used to be optional, it is now always available.

This module defines the following constants and functions:

exception `_thread.error`

Raised on thread-specific errors.

在 3.3 版的變更: This is now a synonym of the built-in `RuntimeError`.

`_thread.LockType`

This is the type of lock objects.

`_thread.start_new_thread` (*function*, *args* [, *kwargs*])

Start a new thread and return its identifier. The thread executes the function *function* with the argument list *args* (which must be a tuple). The optional *kwargs* argument specifies a dictionary of keyword arguments.

When the function returns, the thread silently exits.

When the function terminates with an unhandled exception, `sys.unraisablehook()` is called to handle the exception. The *object* attribute of the hook argument is *function*. By default, a stack trace is printed and then the thread exits (but other threads continue to run).

When the function raises a `SystemExit` exception, it is silently ignored.

在 3.8 版的變更: `sys.unraisablehook()` is now used to handle unhandled exceptions.

`_thread.interrupt_main` (*signum*=`signal.SIGINT`, /)

Simulate the effect of a signal arriving in the main thread. A thread can use this function to interrupt the main thread, though there is no guarantee that the interruption will happen immediately.

If given, *signum* is the number of the signal to simulate. If *signum* is not given, `signal.SIGINT` is simulated.

If the given signal isn't handled by Python (it was set to `signal.SIG_DFL` or `signal.SIG_IGN`), this function does nothing.

在 3.10 版的變更: The *signum* argument is added to customize the signal number.

備註: This does not emit the corresponding signal but schedules a call to the associated handler (if it exists). If you want to truly emit the signal, use `signal.raise_signal()`.

`_thread.exit` ()

Raise the `SystemExit` exception. When not caught, this will cause the thread to exit silently.

`_thread.allocate_lock` ()

Return a new lock object. Methods of locks are described below. The lock is initially unlocked.

`_thread.get_ident` ()

Return the 'thread identifier' of the current thread. This is a nonzero integer. Its value has no direct meaning; it is intended as a magic cookie to be used e.g. to index a dictionary of thread-specific data. Thread identifiers may be recycled when a thread exits and another thread is created.

`_thread.get_native_id` ()

Return the native integral Thread ID of the current thread assigned by the kernel. This is a non-negative integer. Its value may be used to uniquely identify this particular thread system-wide (until the thread terminates, after which the value may be recycled by the OS).

Availability: Windows, FreeBSD, Linux, macOS, OpenBSD, NetBSD, AIX.

在 3.8 版新加入.

`_thread.stack_size` ([*size*])

Return the thread stack size used when creating new threads. The optional *size* argument specifies the stack size to be used for subsequently created threads, and must be 0 (use platform or configured default) or a positive integer value of at least 32,768 (32 KiB). If *size* is not specified, 0 is used. If changing the thread stack size is unsupported, a `RuntimeError` is raised. If the specified stack size is invalid, a `ValueError` is raised and the stack size is unmodified. 32 KiB is currently the minimum supported stack size value to guarantee sufficient stack space for the interpreter itself. Note that some platforms may have particular restrictions on

values for the stack size, such as requiring a minimum stack size > 32 KiB or requiring allocation in multiples of the system memory page size - platform documentation should be referred to for more information (4 KiB pages are common; using multiples of 4096 for the stack size is the suggested approach in the absence of more specific information).

適用：Windows, pthreads。

Unix platforms with POSIX threads support.

`_thread.TIMEOUT_MAX`

The maximum value allowed for the *timeout* parameter of `Lock.acquire`. Specifying a timeout greater than this value will raise an `OverflowError`.

在 3.2 版新加入。

Lock objects have the following methods:

`lock.acquire (blocking=True, timeout=-1)`

Without any optional argument, this method acquires the lock unconditionally, if necessary waiting until it is released by another thread (only one thread at a time can acquire a lock --- that's their reason for existence).

If the *blocking* argument is present, the action depends on its value: if it is `False`, the lock is only acquired if it can be acquired immediately without waiting, while if it is `True`, the lock is acquired unconditionally as above.

If the floating-point *timeout* argument is present and positive, it specifies the maximum wait time in seconds before returning. A negative *timeout* argument specifies an unbounded wait. You cannot specify a *timeout* if *blocking* is `False`.

The return value is `True` if the lock is acquired successfully, `False` if not.

在 3.2 版的變更: The *timeout* parameter is new.

在 3.2 版的變更: Lock acquires can now be interrupted by signals on POSIX.

`lock.release ()`

Releases the lock. The lock must have been acquired earlier, but not necessarily by the same thread.

`lock.locked ()`

Return the status of the lock: `True` if it has been acquired by some thread, `False` if not.

In addition to these methods, lock objects can also be used via the `with` statement, e.g.:

```
import _thread

a_lock = _thread.allocate_lock()

with a_lock:
    print("a_lock is locked while this executes")
```

Caveats:

- Threads interact strangely with interrupts: the `KeyboardInterrupt` exception will be received by an arbitrary thread. (When the `signal` module is available, interrupts always go to the main thread.)
- Calling `sys.exit ()` or raising the `SystemExit` exception is equivalent to calling `_thread.exit ()`.
- It is not possible to interrupt the `acquire ()` method on a lock --- the `KeyboardInterrupt` exception will happen after the lock has been acquired.
- When the main thread exits, it is system defined whether the other threads survive. On most systems, they are killed without executing `try ... finally` clauses or executing object destructors.
- When the main thread exits, it does not do any of its usual cleanup (except that `try ... finally` clauses are honored), and the standard I/O files are not flushed.

Networking and Interprocess Communication

The modules described in this chapter provide mechanisms for networking and inter-processes communication.

Some modules only work for two processes that are on the same machine, e.g. *signal* and *mmap*. Other modules support networking protocols that two or more processes can use to communicate across machines.

The list of modules described in this chapter is:

18.1 asyncio --- 非同步 I/O

Hello World!

```
import asyncio

async def main():
    print('Hello ...')
    await asyncio.sleep(1)
    print('... World!')

asyncio.run(main())
```

asyncio 是讓使用者以 **async/await** 語法來編寫**行 (concurrent)** 程式碼的函式庫 (library)。

asyncio 作**多個 Python** 非同步框架的基礎，在高效能網路與網頁伺服器、資料庫連**行**函式庫、分散式任務**行**列等服務都可以看得到它。

asyncio 往往是個建構 **IO 密集型**與**高階層結構化**網路程式碼的完美選擇。

asyncio 提供了一系列**高階 API**：

- **行地運行 Python 協程 (coroutine)** **行**擁有完整控制權；
- 執行網路 **IO** 與 **IPC**；
- 控制子行程 (subprocess)；
- 透過**行**列 (queue) 分配任務；

- 同步F行程式碼；

此外，還有一些給函式庫與框架 (*framework*) 開發者的低階 API：

- create and manage *event loops*, which provide asynchronous APIs for *networking*, running *subprocesses*, handling *OS signals*, etc;
- 使用*transports* (*asyncio* 底層傳輸相關類F) 來實作高效能協定；
- 透過 *async/await* 語法來橋接基於回呼 (callback-based) 的函式庫與程式碼。

You can experiment with an `asyncio` concurrent context in the REPL:

```
$ python -m asyncio
asyncio REPL ...
Use "await" directly instead of "asyncio.run()".
Type "help", "copyright", "credits" or "license" for more information.
>>> import asyncio
>>> await asyncio.sleep(10, result='hello')
'hello'
```

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscrip`ten and `wasm32-wasi`. See *WebAssembly* 平台 for more information.

參F

18.1.1 Runners

原始碼： `Lib/asyncio/runners.py`

This section outlines high-level `asyncio` primitives to run `asyncio` code.

They are built on top of an *event loop* with the aim to simplify `async` code usage for common wide-spread scenarios.

- *Running an asyncio Program*
- *Runner context manager*
- *Handling Keyboard Interruption*

Running an asyncio Program

`asyncio.run(coro, *, debug=None)`

Execute the *coroutine* `coro` and return the result.

This function runs the passed coroutine, taking care of managing the `asyncio` event loop, *finalizing asynchronous generators*, and closing the threadpool.

This function cannot be called when another `asyncio` event loop is running in the same thread.

If `debug` is `True`, the event loop will be run in debug mode. `False` disables debug mode explicitly. `None` is used to respect the global 除錯模式 settings.

This function always creates a new event loop and closes it at the end. It should be used as a main entry point for `asyncio` programs, and should ideally only be called once.

範例：

```

async def main():
    await asyncio.sleep(1)
    print('hello')

asyncio.run(main())

```

在 3.7 版新加入。

在 3.9 版的變更: Updated to use `loop.shutdown_default_executor()`.

在 3.10 版的變更: `debug` is `None` by default to respect the global debug mode settings.

Runner context manager

class `asyncio.Runner` (*, `debug=None`, `loop_factory=None`)

A context manager that simplifies *multiple* async function calls in the same context.

Sometimes several top-level async functions should be called in the same *event loop* and *contextvars.Context*.

If `debug` is `True`, the event loop will be run in debug mode. `False` disables debug mode explicitly. `None` is used to respect the global 除錯模式 settings.

`loop_factory` could be used for overriding the loop creation. It is the responsibility of the `loop_factory` to set the created loop as the current one. By default `asyncio.new_event_loop()` is used and set as current event loop with `asyncio.set_event_loop()` if `loop_factory` is `None`.

Basically, `asyncio.run()` example can be rewritten with the runner usage:

```

async def main():
    await asyncio.sleep(1)
    print('hello')

with asyncio.Runner() as runner:
    runner.run(main())

```

在 3.11 版新加入。

run (*coro*, *, `context=None`)

Run a *coroutine* *coro* in the embedded loop.

Return the coroutine's result or raise its exception.

An optional keyword-only *context* argument allows specifying a custom *contextvars.Context* for the *coro* to run in. The runner's default context is used if `None`.

This function cannot be called when another asyncio event loop is running in the same thread.

close ()

Close the runner.

Finalize asynchronous generators, shutdown default executor, close the event loop and release embedded *contextvars.Context*.

get_loop ()

Return the event loop associated with the runner instance.

備 F: *Runner* uses the lazy initialization strategy, its constructor doesn't initialize underlying low-level structures.

Embedded *loop* and *context* are created at the `with` body entering or the first call of `run()` or `get_loop()`.

Handling Keyboard Interruption

在 3.11 版新加入.

When `signal.SIGINT` is raised by Ctrl-C, `KeyboardInterrupt` exception is raised in the main thread by default. However this doesn't work with `asyncio` because it can interrupt asyncio internals and can hang the program from exiting.

To mitigate this issue, `asyncio` handles `signal.SIGINT` as follows:

1. `asyncio.Runner.run()` installs a custom `signal.SIGINT` handler before any user code is executed and removes it when exiting from the function.
2. The `Runner` creates the main task for the passed coroutine for its execution.
3. When `signal.SIGINT` is raised by Ctrl-C, the custom signal handler cancels the main task by calling `asyncio.Task.cancel()` which raises `asyncio.CancelledError` inside the main task. This causes the Python stack to unwind, `try/except` and `try/finally` blocks can be used for resource cleanup. After the main task is cancelled, `asyncio.Runner.run()` raises `KeyboardInterrupt`.
4. A user could write a tight loop which cannot be interrupted by `asyncio.Task.cancel()`, in which case the second following Ctrl-C immediately raises the `KeyboardInterrupt` without cancelling the main task.

18.1.2 Coroutines and Tasks

This section outlines high-level asyncio APIs to work with coroutines and Tasks.

- 協程
- *Awaitables*
- *Creating Tasks*
- *Task Cancellation*
- *Task Groups*
- *Sleeping*
- *Running Tasks Concurrently*
- *Shielding From Cancellation*
- *Timeouts*
- *Waiting Primitives*
- *Running in Threads*
- *Scheduling From Other Threads*
- *Introspection*
- *Task Object*

協程

原始碼: [Lib/asyncio/coroutines.py](#)

Coroutines declared with the `async/await` syntax is the preferred way of writing `asyncio` applications. For example, the following snippet of code prints "hello", waits 1 second, and then prints "world":

```
>>> import asyncio

>>> async def main():
...     print('hello')
...     await asyncio.sleep(1)
...     print('world')

>>> asyncio.run(main())
hello
world
```

Note that simply calling a coroutine will not schedule it to be executed:

```
>>> main()
<coroutine object main at 0x1053bb7c8>
```

To actually run a coroutine, `asyncio` provides the following mechanisms:

- The `asyncio.run()` function to run the top-level entry point "main()" function (see the above example.)
- Awaiting on a coroutine. The following snippet of code will print "hello" after waiting for 1 second, and then print "world" after waiting for *another* 2 seconds:

```
import asyncio
import time

async def say_after(delay, what):
    await asyncio.sleep(delay)
    print(what)

async def main():
    print(f"started at {time.strftime('%X')}")

    await say_after(1, 'hello')
    await say_after(2, 'world')

    print(f"finished at {time.strftime('%X')}")

asyncio.run(main())
```

Expected output:

```
started at 17:13:52
hello
world
finished at 17:13:55
```

- The `asyncio.create_task()` function to run coroutines concurrently as `asyncio Tasks`.

Let's modify the above example and run two `say_after` coroutines *concurrently*:

```
async def main():
    task1 = asyncio.create_task(
        say_after(1, 'hello'))
```

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```

task2 = asyncio.create_task(
    say_after(2, 'world'))

print(f"started at {time.strftime('%X')}")

# Wait until both tasks are completed (should take
# around 2 seconds.)
await task1
await task2

print(f"finished at {time.strftime('%X')}")

```

Note that expected output now shows that the snippet runs 1 second faster than before:

```

started at 17:14:32
hello
world
finished at 17:14:34

```

- The `asyncio.TaskGroup` class provides a more modern alternative to `create_task()`. Using this API, the last example becomes:

```

async def main():
    async with asyncio.TaskGroup() as tg:
        task1 = tg.create_task(
            say_after(1, 'hello'))

        task2 = tg.create_task(
            say_after(2, 'world'))

    print(f"started at {time.strftime('%X')}")

    # The await is implicit when the context manager exits.

    print(f"finished at {time.strftime('%X')}")

```

The timing and output should be the same as for the previous version.

在 3.11 版新加入: `asyncio.TaskGroup`.

Awaitables

We say that an object is an **awaitable** object if it can be used in an `await` expression. Many asyncio APIs are designed to accept awaitables.

There are three main types of *awaitable* objects: **coroutines**, **Tasks**, and **Futures**.

協程

Python coroutines are *awaitables* and therefore can be awaited from other coroutines:

```

import asyncio

async def nested():
    return 42

async def main():
    # Nothing happens if we just call "nested()".
    # A coroutine object is created but not awaited,

```

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```
# so it *won't run at all*.
nested()

# Let's do it differently now and await it:
print(await nested()) # will print "42".

asyncio.run(main())
```

重要: In this documentation the term "coroutine" can be used for two closely related concepts:

- a *coroutine function*: an `async def` function;
- a *coroutine object*: an object returned by calling a *coroutine function*.

Tasks

Tasks are used to schedule coroutines *concurrently*.

When a coroutine is wrapped into a *Task* with functions like `asyncio.create_task()` the coroutine is automatically scheduled to run soon:

```
import asyncio

async def nested():
    return 42

async def main():
    # Schedule nested() to run soon concurrently
    # with "main()".
    task = asyncio.create_task(nested())

    # "task" can now be used to cancel "nested()", or
    # can simply be awaited to wait until it is complete:
    await task

asyncio.run(main())
```

Futures

A *Future* is a special **low-level** awaitable object that represents an **eventual result** of an asynchronous operation.

When a Future object is *awaited* it means that the coroutine will wait until the Future is resolved in some other place.

Future objects in asyncio are needed to allow callback-based code to be used with `async/await`.

Normally **there is no need** to create Future objects at the application level code.

Future objects, sometimes exposed by libraries and some asyncio APIs, can be awaited:

```
async def main():
    await function_that_returns_a_future_object()

    # this is also valid:
    await asyncio.gather(
        function_that_returns_a_future_object(),
        some_python_coroutine()
    )
```

A good example of a low-level function that returns a Future object is `loop.run_in_executor()`.

Creating Tasks

原始碼: [Lib/asyncio/tasks.py](#)

`asyncio.create_task(coro, *, name=None, context=None)`

Wrap the *coro* *coroutine* into a *Task* and schedule its execution. Return the *Task* object.

If *name* is not *None*, it is set as the name of the task using *Task.set_name()*.

An optional keyword-only *context* argument allows specifying a custom *contextvars.Context* for the *coro* to run in. The current context copy is created when no *context* is provided.

The task is executed in the loop returned by *get_running_loop()*, *RuntimeError* is raised if there is no running loop in current thread.

備 F: *asyncio.TaskGroup.create_task()* is a newer alternative that allows for convenient waiting for a group of related tasks.

重要: Save a reference to the result of this function, to avoid a task disappearing mid-execution. The event loop only keeps weak references to tasks. A task that isn't referenced elsewhere may get garbage collected at any time, even before it's done. For reliable "fire-and-forget" background tasks, gather them in a collection:

```
background_tasks = set()

for i in range(10):
    task = asyncio.create_task(some_coro(param=i))

    # Add task to the set. This creates a strong reference.
    background_tasks.add(task)

    # To prevent keeping references to finished tasks forever,
    # make each task remove its own reference from the set after
    # completion:
    task.add_done_callback(background_tasks.discard)
```

在 3.7 版新加入.

在 3.8 版的變更: 新增 *name* 參數.

在 3.11 版的變更: 新增 *context* 參數.

Task Cancellation

Tasks can easily and safely be cancelled. When a task is cancelled, *asyncio.CancelledError* will be raised in the task at the next opportunity.

It is recommended that coroutines use *try/finally* blocks to robustly perform clean-up logic. In case *asyncio.CancelledError* is explicitly caught, it should generally be propagated when clean-up is complete. *asyncio.CancelledError* directly subclasses *BaseException* so most code will not need to be aware of it.

The *asyncio* components that enable structured concurrency, like *asyncio.TaskGroup* and *asyncio.timeout()*, are implemented using cancellation internally and might misbehave if a coroutine swallows *asyncio.CancelledError*. Similarly, user code should not generally call *uncancel*. However, in cases when suppressing *asyncio.CancelledError* is truly desired, it is necessary to also call *uncancel()* to completely remove the cancellation state.

Task Groups

Task groups combine a task creation API with a convenient and reliable way to wait for all tasks in the group to finish.

class `asyncio.TaskGroup`

An asynchronous context manager holding a group of tasks. Tasks can be added to the group using `create_task()`. All tasks are awaited when the context manager exits.

在 3.11 版新加入。

create_task (*coro*, *, *name=None*, *context=None*)

Create a task in this task group. The signature matches that of `asyncio.create_task()`.

範例：

```
async def main():
    async with asyncio.TaskGroup() as tg:
        task1 = tg.create_task(some_coro(...))
        task2 = tg.create_task(another_coro(...))
    print("Both tasks have completed now.")
```

The `async with` statement will wait for all tasks in the group to finish. While waiting, new tasks may still be added to the group (for example, by passing `tg` into one of the coroutines and calling `tg.create_task()` in that coroutine). Once the last task has finished and the `async with` block is exited, no new tasks may be added to the group.

The first time any of the tasks belonging to the group fails with an exception other than `asyncio.CancelledError`, the remaining tasks in the group are cancelled. No further tasks can then be added to the group. At this point, if the body of the `async with` statement is still active (i.e., `__aexit__()` hasn't been called yet), the task directly containing the `async with` statement is also cancelled. The resulting `asyncio.CancelledError` will interrupt an `await`, but it will not bubble out of the containing `async with` statement.

Once all tasks have finished, if any tasks have failed with an exception other than `asyncio.CancelledError`, those exceptions are combined in an `ExceptionGroup` or `BaseExceptionGroup` (as appropriate; see their documentation) which is then raised.

Two base exceptions are treated specially: If any task fails with `KeyboardInterrupt` or `SystemExit`, the task group still cancels the remaining tasks and waits for them, but then the initial `KeyboardInterrupt` or `SystemExit` is re-raised instead of `ExceptionGroup` or `BaseExceptionGroup`.

If the body of the `async with` statement exits with an exception (so `__aexit__()` is called with an exception set), this is treated the same as if one of the tasks failed: the remaining tasks are cancelled and then waited for, and non-cancellation exceptions are grouped into an exception group and raised. The exception passed into `__aexit__()`, unless it is `asyncio.CancelledError`, is also included in the exception group. The same special case is made for `KeyboardInterrupt` and `SystemExit` as in the previous paragraph.

Sleeping

coroutine `asyncio.sleep` (*delay*, *result=None*)

Block for *delay* seconds.

If *result* is provided, it is returned to the caller when the coroutine completes.

`sleep()` always suspends the current task, allowing other tasks to run.

Setting the delay to 0 provides an optimized path to allow other tasks to run. This can be used by long-running functions to avoid blocking the event loop for the full duration of the function call.

Example of coroutine displaying the current date every second for 5 seconds:

```
import asyncio
import datetime

async def display_date():
    loop = asyncio.get_running_loop()
    end_time = loop.time() + 5.0
    while True:
        print(datetime.datetime.now())
        if (loop.time() + 1.0) >= end_time:
            break
        await asyncio.sleep(1)

asyncio.run(display_date())
```

在 3.10 版的變更: 移除 `loop` 參數。

Running Tasks Concurrently

awaitable `asyncio.gather(*aws, return_exceptions=False)`

Run *awaitable objects* in the *aws* sequence *concurrently*.

If any awaitable in *aws* is a coroutine, it is automatically scheduled as a Task.

If all awaitables are completed successfully, the result is an aggregate list of returned values. The order of result values corresponds to the order of awaitables in *aws*.

If *return_exceptions* is `False` (default), the first raised exception is immediately propagated to the task that awaits on `gather()`. Other awaitables in the *aws* sequence **won't be cancelled** and will continue to run.

If *return_exceptions* is `True`, exceptions are treated the same as successful results, and aggregated in the result list.

If `gather()` is *cancelled*, all submitted awaitables (that have not completed yet) are also *cancelled*.

If any Task or Future from the *aws* sequence is *cancelled*, it is treated as if it raised `CancelledError` -- the `gather()` call is **not** cancelled in this case. This is to prevent the cancellation of one submitted Task/Future to cause other Tasks/Futures to be cancelled.

備 F: A more modern way to create and run tasks concurrently and wait for their completion is `asyncio.TaskGroup`.

範例:

```
import asyncio

async def factorial(name, number):
    f = 1
    for i in range(2, number + 1):
        print(f"Task {name}: Compute factorial({number}), currently i={i}...")
        await asyncio.sleep(1)
        f *= i
    print(f"Task {name}: factorial({number}) = {f}")
    return f

async def main():
    # Schedule three calls *concurrently*:
    L = await asyncio.gather(
        factorial("A", 2),
        factorial("B", 3),
        factorial("C", 4),
```

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```

    )
    print(L)

asyncio.run(main())

# Expected output:
#
#     Task A: Compute factorial(2), currently i=2...
#     Task B: Compute factorial(3), currently i=2...
#     Task C: Compute factorial(4), currently i=2...
#     Task A: factorial(2) = 2
#     Task B: Compute factorial(3), currently i=3...
#     Task C: Compute factorial(4), currently i=3...
#     Task B: factorial(3) = 6
#     Task C: Compute factorial(4), currently i=4...
#     Task C: factorial(4) = 24
#     [2, 6, 24]
```

備 F: If `return_exceptions` is `False`, cancelling `gather()` after it has been marked done won't cancel any submitted awaitables. For instance, `gather` can be marked done after propagating an exception to the caller, therefore, calling `gather.cancel()` after catching an exception (raised by one of the awaitables) from `gather` won't cancel any other awaitables.

在 3.7 版的變更: If the *gather* itself is cancelled, the cancellation is propagated regardless of *return_exceptions*.

在 3.10 版的變更: 移除 *loop* 參數。

在 3.10 版之後被 F 用: Deprecation warning is emitted if no positional arguments are provided or not all positional arguments are Future-like objects and there is no running event loop.

Shielding From Cancellation

awaitable `asyncio.shield(aw)`

Protect an *awaitable object* from being *cancelled*.

If *aw* is a coroutine it is automatically scheduled as a Task.

The statement:

```
task = asyncio.create_task(something())
res = await shield(task)
```

is equivalent to:

```
res = await something()
```

except that if the coroutine containing it is cancelled, the Task running in `something()` is not cancelled. From the point of view of `something()`, the cancellation did not happen. Although its caller is still cancelled, so the "await" expression still raises a *CancelledError*.

If `something()` is cancelled by other means (i.e. from within itself) that would also cancel `shield()`.

If it is desired to completely ignore cancellation (not recommended) the `shield()` function should be combined with a try/except clause, as follows:

```
task = asyncio.create_task(something())
try:
    res = await shield(task)
except CancelledError:
    res = None
```

重要: Save a reference to tasks passed to this function, to avoid a task disappearing mid-execution. The event loop only keeps weak references to tasks. A task that isn't referenced elsewhere may get garbage collected at any time, even before it's done.

在 3.10 版的變更: 移除 *loop* 參數。

在 3.10 版之後被 F 用: Deprecation warning is emitted if *aw* is not Future-like object and there is no running event loop.

Timeouts

`asyncio.timeout(delay)`

Return an asynchronous context manager that can be used to limit the amount of time spent waiting on something.

delay can either be `None`, or a float/int number of seconds to wait. If *delay* is `None`, no time limit will be applied; this can be useful if the delay is unknown when the context manager is created.

In either case, the context manager can be rescheduled after creation using `Timeout.reschedule()`.

範例:

```
async def main():
    async with asyncio.timeout(10):
        await long_running_task()
```

If `long_running_task` takes more than 10 seconds to complete, the context manager will cancel the current task and handle the resulting `asyncio.CancelledError` internally, transforming it into a `TimeoutError` which can be caught and handled.

備 F: The `asyncio.timeout()` context manager is what transforms the `asyncio.CancelledError` into a `TimeoutError`, which means the `TimeoutError` can only be caught *outside* of the context manager.

Example of catching `TimeoutError`:

```
async def main():
    try:
        async with asyncio.timeout(10):
            await long_running_task()
    except TimeoutError:
        print("The long operation timed out, but we've handled it.")

    print("This statement will run regardless.")
```

The context manager produced by `asyncio.timeout()` can be rescheduled to a different deadline and inspected.

class `asyncio.Timeout(when)`

An asynchronous context manager for cancelling overdue coroutines.

when should be an absolute time at which the context should time out, as measured by the event loop's clock:

- If *when* is `None`, the timeout will never trigger.
- If *when* < `loop.time()`, the timeout will trigger on the next iteration of the event loop.

when() → *float* | *None*

Return the current deadline, or *None* if the current deadline is not set.

reschedule (*when*: *float* | *None*)

Reschedule the timeout.

expired() → *bool*

Return whether the context manager has exceeded its deadline (expired).

範例：

```
async def main():
    try:
        # We do not know the timeout when starting, so we pass ``None``.
        async with asyncio.timeout(None) as cm:
            # We know the timeout now, so we reschedule it.
            new_deadline = get_running_loop().time() + 10
            cm.reschedule(new_deadline)

            await long_running_task()
    except TimeoutError:
        pass

    if cm.expired():
        print("Looks like we haven't finished on time.")
```

Timeout context managers can be safely nested.

在 3.11 版新加入。

asyncio.timeout_at (*when*)

Similar to *asyncio.timeout()*, except *when* is the absolute time to stop waiting, or *None*.

範例：

```
async def main():
    loop = get_running_loop()
    deadline = loop.time() + 20
    try:
        async with asyncio.timeout_at(deadline):
            await long_running_task()
    except TimeoutError:
        print("The long operation timed out, but we've handled it.")

    print("This statement will run regardless.")
```

在 3.11 版新加入。

coroutine **asyncio.wait_for** (*aw*, *timeout*)

Wait for the *aw* *awaitable* to complete with a timeout.

If *aw* is a coroutine it is automatically scheduled as a Task.

timeout can either be *None* or a float or int number of seconds to wait for. If *timeout* is *None*, block until the future completes.

If a timeout occurs, it cancels the task and raises *TimeoutError*.

To avoid the task *cancellation*, wrap it in *shield()*.

The function will wait until the future is actually cancelled, so the total wait time may exceed the *timeout*. If an exception happens during cancellation, it is propagated.

If the wait is cancelled, the future *aw* is also cancelled.

範例：

```

async def eternity():
    # Sleep for one hour
    await asyncio.sleep(3600)
    print('yay!')

async def main():
    # Wait for at most 1 second
    try:
        await asyncio.wait_for(eternity(), timeout=1.0)
    except TimeoutError:
        print('timeout!')

asyncio.run(main())

# Expected output:
#
#     timeout!

```

在 3.7 版的變更: When *aw* is cancelled due to a timeout, *wait_for* waits for *aw* to be cancelled. Previously, it raised *TimeoutError* immediately.

在 3.10 版的變更: 移除 *loop* 參數。

在 3.11 版的變更: Raises *TimeoutError* instead of *asyncio.TimeoutError*.

Waiting Primitives

coroutine *asyncio.wait* (*aws*, *, *timeout=None*, *return_when=ALL_COMPLETED*)

Run *Future* and *Task* instances in the *aws* iterable concurrently and block until the condition specified by *return_when*.

The *aws* iterable must not be empty and generators yielding tasks are not accepted.

Returns two sets of Tasks/Futures: (*done*, *pending*).

用法:

```
done, pending = await asyncio.wait(aws)
```

timeout (a float or int), if specified, can be used to control the maximum number of seconds to wait before returning.

Note that this function does not raise *TimeoutError*. Futures or Tasks that aren't done when the timeout occurs are simply returned in the second set.

return_when indicates when this function should return. It must be one of the following constants:

常數	描述
<code>asyncio.FIRST_COMPLETED</code>	The function will return when any future finishes or is cancelled.
<code>asyncio.FIRST_EXCEPTION</code>	The function will return when any future finishes by raising an exception. If no future raises an exception then it is equivalent to <i>ALL_COMPLETED</i> .
<code>asyncio.ALL_COMPLETED</code>	The function will return when all futures finish or are cancelled.

Unlike *wait_for*(), *wait*() does not cancel the futures when a timeout occurs.

在 3.10 版的變更: 移除 *loop* 參數。

在 3.11 版的變更: Passing coroutine objects to `wait()` directly is forbidden.

`asyncio.as_completed(aws, *, timeout=None)`

Run *awaitable objects* in the *aws* iterable concurrently. Generators yielding tasks are not accepted as *aws* iterable. Return an iterator of coroutines. Each coroutine returned can be awaited to get the earliest next result from the iterable of the remaining awaitables.

Raises *TimeoutError* if the timeout occurs before all Futures are done.

範例:

```
for coro in as_completed(aws):
    earliest_result = await coro
    # ...
```

在 3.10 版的變更: 移除 *loop* 參數。

在 3.10 版之後被 F 用: Deprecation warning is emitted if not all awaitable objects in the *aws* iterable are Future-like objects and there is no running event loop.

Running in Threads

coroutine `asyncio.to_thread(func, /, *args, **kwargs)`

Asynchronously run function *func* in a separate thread.

Any **args* and ***kwargs* supplied for this function are directly passed to *func*. Also, the current *contextvars.Context* is propagated, allowing context variables from the event loop thread to be accessed in the separate thread.

Return a coroutine that can be awaited to get the eventual result of *func*.

This coroutine function is primarily intended to be used for executing IO-bound functions/methods that would otherwise block the event loop if they were run in the main thread. For example:

```
def blocking_io():
    print(f"start blocking_io at {time.strftime('%X')}")
    # Note that time.sleep() can be replaced with any blocking
    # IO-bound operation, such as file operations.
    time.sleep(1)
    print(f"blocking_io complete at {time.strftime('%X')}")

async def main():
    print(f"started main at {time.strftime('%X')}")

    await asyncio.gather(
        asyncio.to_thread(blocking_io),
        asyncio.sleep(1))

    print(f"finished main at {time.strftime('%X')}")

asyncio.run(main())

# Expected output:
#
# started main at 19:50:53
# start blocking_io at 19:50:53
# blocking_io complete at 19:50:54
# finished main at 19:50:54
```

Directly calling `blocking_io()` in any coroutine would block the event loop for its duration, resulting in an additional 1 second of run time. Instead, by using `asyncio.to_thread()`, we can run it in a separate thread without blocking the event loop.

備 備: Due to the *GIL*, `asyncio.to_thread()` can typically only be used to make IO-bound functions non-blocking. However, for extension modules that release the GIL or alternative Python implementations that don't have one, `asyncio.to_thread()` can also be used for CPU-bound functions.

在 3.9 版新加入.

Scheduling From Other Threads

`asyncio.run_coroutine_threadsafe(coro, loop)`

Submit a coroutine to the given event loop. Thread-safe.

Return a `concurrent.futures.Future` to wait for the result from another OS thread.

This function is meant to be called from a different OS thread than the one where the event loop is running.

Example:

```
# Create a coroutine
coro = asyncio.sleep(1, result=3)

# Submit the coroutine to a given loop
future = asyncio.run_coroutine_threadsafe(coro, loop)

# Wait for the result with an optional timeout argument
assert future.result(timeout) == 3
```

If an exception is raised in the coroutine, the returned Future will be notified. It can also be used to cancel the task in the event loop:

```
try:
    result = future.result(timeout)
except TimeoutError:
    print('The coroutine took too long, cancelling the task...')
    future.cancel()
except Exception as exc:
    print(f'The coroutine raised an exception: {exc!r}')
else:
    print(f'The coroutine returned: {result!r}')
```

See the *concurrency and multithreading* section of the documentation.

Unlike other asyncio functions this function requires the *loop* argument to be passed explicitly.

在 3.5.1 版新加入.

Introspection

`asyncio.current_task(loop=None)`

Return the currently running *Task* instance, or None if no task is running.

If *loop* is None `get_running_loop()` is used to get the current loop.

在 3.7 版新加入.

`asyncio.all_tasks(loop=None)`

Return a set of not yet finished *Task* objects run by the loop.

If *loop* is None, `get_running_loop()` is used for getting current loop.

在 3.7 版新加入.

`asyncio.iscoroutine(obj)`

Return `True` if *obj* is a coroutine object.

在 3.4 版新加入。

Task Object

class `asyncio.Task`(*coro*, *, *loop=None*, *name=None*, *context=None*)

A *Future-like* object that runs a Python *coroutine*. Not thread-safe.

Tasks are used to run coroutines in event loops. If a coroutine awaits on a Future, the Task suspends the execution of the coroutine and waits for the completion of the Future. When the Future is *done*, the execution of the wrapped coroutine resumes.

Event loops use cooperative scheduling: an event loop runs one Task at a time. While a Task awaits for the completion of a Future, the event loop runs other Tasks, callbacks, or performs IO operations.

Use the high-level `asyncio.create_task()` function to create Tasks, or the low-level `loop.create_task()` or `ensure_future()` functions. Manual instantiation of Tasks is discouraged.

To cancel a running Task use the `cancel()` method. Calling it will cause the Task to throw a `CancelledError` exception into the wrapped coroutine. If a coroutine is awaiting on a Future object during cancellation, the Future object will be cancelled.

`cancelled()` can be used to check if the Task was cancelled. The method returns `True` if the wrapped coroutine did not suppress the `CancelledError` exception and was actually cancelled.

`asyncio.Task` inherits from `Future` all of its APIs except `Future.set_result()` and `Future.set_exception()`.

An optional keyword-only *context* argument allows specifying a custom `contextvars.Context` for the *coro* to run in. If no *context* is provided, the Task copies the current context and later runs its coroutine in the copied context.

在 3.7 版的變更: Added support for the `contextvars` module.

在 3.8 版的變更: 新增 *name* 參數。

在 3.10 版之後被回用: Deprecation warning is emitted if *loop* is not specified and there is no running event loop.

在 3.11 版的變更: 新增 *context* 參數。

done()

Return `True` if the Task is *done*.

A Task is *done* when the wrapped coroutine either returned a value, raised an exception, or the Task was cancelled.

result()

Return the result of the Task.

If the Task is *done*, the result of the wrapped coroutine is returned (or if the coroutine raised an exception, that exception is re-raised.)

If the Task has been *cancelled*, this method raises a `CancelledError` exception.

If the Task's result isn't yet available, this method raises a `InvalidStateError` exception.

exception()

Return the exception of the Task.

If the wrapped coroutine raised an exception that exception is returned. If the wrapped coroutine returned normally this method returns `None`.

If the Task has been *cancelled*, this method raises a `CancelledError` exception.

If the Task isn't *done* yet, this method raises an `InvalidStateError` exception.

add_done_callback (*callback*, *, *context=None*)

Add a callback to be run when the Task is *done*.

This method should only be used in low-level callback-based code.

See the documentation of `Future.add_done_callback()` for more details.

remove_done_callback (*callback*)

Remove *callback* from the callbacks list.

This method should only be used in low-level callback-based code.

See the documentation of `Future.remove_done_callback()` for more details.

get_stack (*, *limit=None*)

Return the list of stack frames for this Task.

If the wrapped coroutine is not done, this returns the stack where it is suspended. If the coroutine has completed successfully or was cancelled, this returns an empty list. If the coroutine was terminated by an exception, this returns the list of traceback frames.

The frames are always ordered from oldest to newest.

Only one stack frame is returned for a suspended coroutine.

The optional *limit* argument sets the maximum number of frames to return; by default all available frames are returned. The ordering of the returned list differs depending on whether a stack or a traceback is returned: the newest frames of a stack are returned, but the oldest frames of a traceback are returned. (This matches the behavior of the traceback module.)

print_stack (*, *limit=None*, *file=None*)

Print the stack or traceback for this Task.

This produces output similar to that of the traceback module for the frames retrieved by `get_stack()`.

The *limit* argument is passed to `get_stack()` directly.

The *file* argument is an I/O stream to which the output is written; by default output is written to `sys.stdout`.

get_coro ()

Return the coroutine object wrapped by the *Task*.

在 3.8 版新加入.

get_name ()

Return the name of the Task.

If no name has been explicitly assigned to the Task, the default asyncio Task implementation generates a default name during instantiation.

在 3.8 版新加入.

set_name (*value*)

Set the name of the Task.

The *value* argument can be any object, which is then converted to a string.

In the default Task implementation, the name will be visible in the `repr()` output of a task object.

在 3.8 版新加入.

cancel (*msg=None*)

Request the Task to be cancelled.

This arranges for a `CancelledError` exception to be thrown into the wrapped coroutine on the next cycle of the event loop.

The coroutine then has a chance to clean up or even deny the request by suppressing the exception with a `try ... except CancelledError ... finally` block. Therefore, unlike `Future.cancel()`, `Task.cancel()` does not guarantee that the Task will be cancelled, although suppressing cancellation completely is not common and is actively discouraged. Should the coroutine nevertheless decide to suppress the cancellation, it needs to call `Task.uncancel()` in addition to catching the exception.

在 3.9 版的變更: 新增 `msg` 參數。

在 3.11 版的變更: The `msg` parameter is propagated from cancelled task to its awaiter. The following example illustrates how coroutines can intercept the cancellation request:

```

async def cancel_me():
    print('cancel_me(): before sleep')

    try:
        # Wait for 1 hour
        await asyncio.sleep(3600)
    except asyncio.CancelledError:
        print('cancel_me(): cancel sleep')
        raise
    finally:
        print('cancel_me(): after sleep')

async def main():
    # Create a "cancel_me" Task
    task = asyncio.create_task(cancel_me())

    # Wait for 1 second
    await asyncio.sleep(1)

    task.cancel()
    try:
        await task
    except asyncio.CancelledError:
        print("main(): cancel_me is cancelled now")

asyncio.run(main())

# Expected output:
#
#     cancel_me(): before sleep
#     cancel_me(): cancel sleep
#     cancel_me(): after sleep
#     main(): cancel_me is cancelled now

```

cancelled()

Return True if the Task is *cancelled*.

The Task is *cancelled* when the cancellation was requested with `cancel()` and the wrapped coroutine propagated the `CancelledError` exception thrown into it.

uncancel()

Decrement the count of cancellation requests to this Task.

Returns the remaining number of cancellation requests.

Note that once execution of a cancelled task completed, further calls to `uncancel()` are ineffective.

在 3.11 版新加入。

This method is used by asyncio's internals and isn't expected to be used by end-user code. In particular, if a Task gets successfully uncanceled, this allows for elements of structured concurrency like *Task Groups* and `asyncio.timeout()` to continue running, isolating cancellation to the respective structured block. For example:

```

async def make_request_with_timeout():
    try:
        async with asyncio.timeout(1):
            # Structured block affected by the timeout:
            await make_request()
            await make_another_request()
    except TimeoutError:
        log("There was a timeout")
    # Outer code not affected by the timeout:
    await unrelated_code()

```

While the block with `make_request()` and `make_another_request()` might get cancelled due to the timeout, `unrelated_code()` should continue running even in case of the timeout. This is implemented with `uncancel()`. `TaskGroup` context managers use `uncancel()` in a similar fashion.

If end-user code is, for some reason, suppressing cancellation by catching `CancelledError`, it needs to call this method to remove the cancellation state.

`cancelling()`

Return the number of pending cancellation requests to this Task, i.e., the number of calls to `cancel()` less the number of `uncancel()` calls.

Note that if this number is greater than zero but the Task is still executing, `cancelled()` will still return `False`. This is because this number can be lowered by calling `uncancel()`, which can lead to the task not being cancelled after all if the cancellation requests go down to zero.

This method is used by `asyncio`'s internals and isn't expected to be used by end-user code. See `uncancel()` for more details.

在 3.11 版新加入。

18.1.3 串流

原始碼: `Lib/asyncio/streams.py`

串流是支援 `async/await` (`async/await-ready`) 的高階原始物件 (high-level primitive), 用於處理網路連 F。串流不需要使用回呼 (callback) 或低階協定和傳輸 (transport) 就能 F 傳送和接收資料。

這是一個使用 `asyncio` 串流編寫的 TCP echo 客 F 端範例:

```

import asyncio

async def tcp_echo_client(message):
    reader, writer = await asyncio.open_connection(
        '127.0.0.1', 8888)

    print(f'Send: {message!r}')
    writer.write(message.encode())
    await writer.drain()

    data = await reader.read(100)
    print(f'Received: {data.decode()!r}')

    print('Close the connection')
    writer.close()
    await writer.wait_closed()

asyncio.run(tcp_echo_client('Hello World!'))

```

另請參 F 下方 *Examples* 段落。

串流函式

下面的高階 `asyncio` 函式可以用來建立和處理串流：

```
coroutine asyncio.open_connection (host=None, port=None, *, limit=None, ssl=None, family=0,
                                         proto=0, flags=0, sock=None, local_addr=None,
                                         server_hostname=None, ssl_handshake_timeout=None,
                                         ssl_shutdown_timeout=None, happy_eyeballs_delay=None,
                                         interleave=None)
```

建立網路連^[1]回傳一對 (`reader`, `writer`) 物件。

回傳的 `reader` 和 `writer` 物件是 `StreamReader` 和 `StreamWriter` 類^[2]的實例。

`limit` 指定了回傳的 `StreamReader` 實例所使用的緩衝區 (buffer) 大小限制。`limit` 預設^[3] 64 KiB。

其余的引數會直接傳遞到 `loop.create_connection()`。

備^[4]： The `sock` argument transfers ownership of the socket to the `StreamWriter` created. To close the socket, call its `close()` method.

在 3.7 版的變更：新增 `ssl_handshake_timeout` 參數。

在 3.8 版的變更：Added the `happy_eyeballs_delay` and `interleave` parameters.

在 3.10 版的變更：移除 `loop` 參數。

在 3.11 版的變更：新增 `ssl_shutdown_timeout` 參數。

```
coroutine asyncio.start_server (client_connected_cb, host=None, port=None, *, limit=None,
                                   family=socket.AF_UNSPEC, flags=socket.AI_PASSIVE, sock=None,
                                   backlog=100, ssl=None, reuse_address=None, reuse_port=None,
                                   ssl_handshake_timeout=None, ssl_shutdown_timeout=None,
                                   start_serving=True)
```

^[1]動 socket 伺服器。

當一個新的客^[2]端連^[3]被建立時，回呼函式 `client_connected_cb` 就會被呼叫。該函式會接收到一對引數 (`reader`, `writer`)，分^[4]`StreamReader` 和 `StreamWriter` 的實例。

`client_connected_cb` 既可以是普通的可呼叫物件 (callable)，也可以是一個協程函式；如果它是一個協程函式，它將自動作^[5]`Task` 來被排程。

`limit` 指定了回傳的 `StreamReader` 實例所使用的緩衝區 (buffer) 大小限制。`limit` 預設^[6] 64 KiB。

剩下的引數將會直接傳遞給 `loop.create_server()`。

備^[7]： The `sock` argument transfers ownership of the socket to the server created. To close the socket, call the server's `close()` method.

在 3.7 版的變更：新增 `ssl_handshake_timeout` 與 `start_serving` 參數。

在 3.10 版的變更：移除 `loop` 參數。

在 3.11 版的變更：新增 `ssl_shutdown_timeout` 參數。

Unix Sockets

coroutine `asyncio.open_unix_connection` (*path=None, *, limit=None, ssl=None, sock=None, server_hostname=None, ssl_handshake_timeout=None, ssl_shutdown_timeout=None*)

建立一個 Unix socket 連 F F 回傳一對 (reader, writer)。

與 `open_connection()` 相似，但是是操作 Unix sockets。

另請參 F `loop.create_unix_connection()` 文件。

備 F: The *sock* argument transfers ownership of the socket to the *StreamWriter* created. To close the socket, call its *close()* method.

適用：Unix。

在 3.7 版的變更：新增 *ssl_handshake_timeout* 參數。*path* 參數現在可以是個 *path-like object*

在 3.10 版的變更：移除 *loop* 參數。

在 3.11 版的變更：新增 *ssl_shutdown_timeout* 參數。

coroutine `asyncio.start_unix_server` (*client_connected_cb, path=None, *, limit=None, sock=None, backlog=100, ssl=None, ssl_handshake_timeout=None, ssl_shutdown_timeout=None, start_serving=True*)

F 動一個 Unix socket 伺服器。

與 `start_server()` 相似，但會是操作 Unix sockets。

另請參 F `loop.create_unix_server()` 文件。

備 F: The *sock* argument transfers ownership of the socket to the server created. To close the socket, call the server's *close()* method.

適用：Unix。

在 3.7 版的變更：新增 *ssl_handshake_timeout* 與 *start_serving* 參數。*path* 參數現在可以是個 *path-like object*。

在 3.10 版的變更：移除 *loop* 參數。

在 3.11 版的變更：新增 *ssl_shutdown_timeout* 參數。

StreamReader

class `asyncio.StreamReader`

表示一個有提供 API 來從 IO 串流中讀取資料的 reader 物件。作 F 一個 *asynchronous iterable*，此物件支援 `async for` 陳述式。

不建議直接實例化 *StreamReader* 物件；使用 `open_connection()` 和 `start_server()` 會是較好的做法。

feed_eof()

Acknowledge the EOF.

coroutine `read(n=-1)`

從串流中讀取至多 *n* 個位元組的資料。

如果 F 有設定 *n* 或是被設 F -1，則會持續讀取直到 EOF，然後回傳所有讀取到的 *bytes*。讀取到 EOF 且 F 部緩衝區是空的，則回傳一個空的 *bytes* 物件。

如果 $n \leq 0$ ，則立即回傳一個空的 bytes 物件。

If n is positive, return at most n available bytes as soon as at least 1 byte is available in the internal buffer. If EOF is received before any byte is read, return an empty bytes object.

coroutine readline()

讀取一行，其中“行”指的是以 `\n` 結尾的位元組序列。

如果讀取到 EOF 而沒有找到 `\n`，該方法會回傳部分的已讀取資料。

如果讀取到 EOF 且內部緩衝區是空的，則回傳一個空的 bytes 物件。

coroutine readexactly(n)

讀取剛好 n 個位元組。

如果在讀取完 n 個位元組之前讀取到 EOF，則會引發 `IncompleteReadError`。使用 `IncompleteReadError.partial` 屬性來獲取串流結束前已讀取的部分資料。

coroutine readuntil($separator=b'\n'$)

從串流中持續讀取資料直到出現 `separator`。

成功後，資料和 `separator`（分隔符號）會從內部緩衝區中刪除（或者它被消費掉（consumed））。回傳的資料在末尾會有一個 `separator`。

如果讀取的資料量超過了設定的串流限制，將會引發 `LimitOverrunError` 例外，資料將被留在內部緩衝區中，它可以再次被讀取。

如果在完整的 `separator` 被找到之前就讀取到 EOF，則會引發 `IncompleteReadError` 例外，且內部緩衝區會被重置。`IncompleteReadError.partial` 屬性可能包含一部分的 `separator`。

在 3.5.2 版新加入。

at_eof()

如果緩衝區是空的且 `feed_eof()` 曾被呼叫則回傳 `True`。

StreamWriter

class asyncio.StreamWriter

表示一個有提供 API 來將資料寫入 IO 串流的 writer 物件。

不建議直接實例化 `StreamWriter` 物件；使用 `open_connection()` 和 `start_server()` 會是較好的做法。

write($data$)

此方法會嘗試立即將 `data` 寫入到底層的 socket。如果失敗，資料會被放到內部寫入緩衝中排隊等待（queue），直到它可被發送。

此方法應當與 `drain()` 方法一起使用：

```
stream.write(data)
await stream.drain()
```

writelines($data$)

此方法會立即嘗試將一個位元組 list（或任何可迭代物件（iterable））寫入到底層的 socket。如果失敗，資料會被放到內部寫入緩衝中排隊等待，直到它可被發送。

此方法應當與 `drain()` 方法一起使用：

```
stream.writelines(lines)
await stream.drain()
```


close()

此方法會關閉串流以及底層的 socket。

此方法應與 `wait_closed()` 方法一起使用，但非強制：

```
stream.close()
await stream.wait_closed()
```

can_write_eof()

如果底層的傳輸支援 `write_eof()` 方法就回傳 `True`，否則回傳 `False`。

write_eof()

在已緩衝的寫入資料被清理 (flush) 後關閉串流的寫入端。

transport

回傳底層的 asyncio 傳輸。

get_extra_info(name, default=None)

存取可選的傳輸資訊；詳情請見 `BaseTransport.get_extra_info()`。

coroutine drain()

等待直到可以繼續寫入到串流。範例：

```
writer.write(data)
await writer.drain()
```

這是一個與底層 IO 寫入緩衝區互動的流程控制方法。當緩衝區大小達到最高標記位 (high watermark) 時，`drain()` 會阻塞直到緩衝區大小至少至最低標記位 (low watermark) 以便繼續寫入。當有要等待的資料時，`drain()` 會立即回傳。

coroutine start_tls(sslcontext, *, server_hostname=None, ssl_handshake_timeout=None)

Upgrade an existing stream-based connection to TLS.

Parameters:

- `sslcontext`: a configured instance of `SSLContext`.
- `server_hostname`: sets or overrides the host name that the target server's certificate will be matched against.
- `ssl_handshake_timeout` is the time in seconds to wait for the TLS handshake to complete before aborting the connection. 60.0 seconds if None (default).

在 3.11 版新加入。

is_closing()

如果串流已被關閉或正在被關閉則回傳 `True`。

在 3.7 版新加入。

coroutine wait_closed()

等待直到串流被關閉。

應當在 `close()` 之後才被呼叫，這會持續等待直到底層的連接被關閉，以確保在這之前（例如在程式退出前）所有資料都已經被清空

在 3.7 版新加入。

范例

使用串流的 TCP echo 客端

使用 `asyncio.open_connection()` 函式的 TCP echo 客端：

```
import asyncio

async def tcp_echo_client(message):
    reader, writer = await asyncio.open_connection(
        '127.0.0.1', 8888)

    print(f'Send: {message!r}')
    writer.write(message.encode())
    await writer.drain()

    data = await reader.read(100)
    print(f'Received: {data.decode()!r}')

    print('Close the connection')
    writer.close()
    await writer.wait_closed()

asyncio.run(tcp_echo_client('Hello World!'))
```

也參考：

使用低階 `loop.create_connection()` 方法的 TCP echo 客端協定範例。

使用串流的 TCP echo 伺服器

TCP echo 伺服器使用 `asyncio.start_server()` 函式：

```
import asyncio

async def handle_echo(reader, writer):
    data = await reader.read(100)
    message = data.decode()
    addr = writer.get_extra_info('peername')

    print(f"Received {message!r} from {addr!r}")

    print(f"Send: {message!r}")
    writer.write(data)
    await writer.drain()

    print("Close the connection")
    writer.close()
    await writer.wait_closed()

async def main():
    server = await asyncio.start_server(
        handle_echo, '127.0.0.1', 8888)

    addrs = ', '.join(str(sock.getsockname()) for sock in server.sockets)
    print(f'Serving on {addrs}')

    async with server:
        await server.serve_forever()

asyncio.run(main())
```

也參考:

使用 `loop.create_server()` 方法的 *TCP echo* 伺服器協定 範例。

獲取 HTTP 標頭

查詢自命令列傳入之 URL 所帶有 HTTP 標頭的簡單範例:

```
import asyncio
import urllib.parse
import sys

async def print_http_headers(url):
    url = urllib.parse.urlsplit(url)
    if url.scheme == 'https':
        reader, writer = await asyncio.open_connection(
            url.hostname, 443, ssl=True)
    else:
        reader, writer = await asyncio.open_connection(
            url.hostname, 80)

    query = (
        f"HEAD {url.path or '/'} HTTP/1.0\r\n"
        f"Host: {url.hostname}\r\n"
        f"\r\n"
    )

    writer.write(query.encode('latin-1'))
    while True:
        line = await reader.readline()
        if not line:
            break

        line = line.decode('latin1').rstrip()
        if line:
            print(f'HTTP header> {line}')

    # Ignore the body, close the socket
    writer.close()
    await writer.wait_closed()

url = sys.argv[1]
asyncio.run(print_http_headers(url))
```

用法:

```
python example.py http://example.com/path/page.html
```

或使用 HTTPS:

```
python example.py https://example.com/path/page.html
```

一個使用串流來等待資料的開放 socket

等待直到 socket 透過使用 `open_connection()` 函式接收到資料的協程：

```

import asyncio
import socket

async def wait_for_data():
    # Get a reference to the current event loop because
    # we want to access low-level APIs.
    loop = asyncio.get_running_loop()

    # Create a pair of connected sockets.
    rsock, wsock = socket.socketpair()

    # Register the open socket to wait for data.
    reader, writer = await asyncio.open_connection(sock=rsock)

    # Simulate the reception of data from the network
    loop.call_soon(wsock.send, 'abc'.encode())

    # Wait for data
    data = await reader.read(100)

    # Got data, we are done: close the socket
    print("Received:", data.decode())
    writer.close()
    await writer.wait_closed()

    # Close the second socket
    wsock.close()

asyncio.run(wait_for_data())

```

也參考：

在 一個開 的 socket 以等待有使用協定的資料範例中，有使用了低階協定以及 `loop.create_connection()` 方法。

在監視檔案描述器以讀取事件範例中，有使用低階的 `loop.add_reader()` 方法來監視檔案描述器。

18.1.4 同步化原始物件 (Synchronization Primitives)

原始碼： `Lib/asyncio/locks.py`

`asyncio` 的同步化原始物件被設計成和那些 `threading` 模組 (module) 中的同名物件相似，但有兩個重要的限制條件：

- `asyncio` 原始物件 不支援執行緒安全 (thread-safe)，因此他們不可被用於 OS 執行緒同步化（請改用 `threading`）；
- 這些同步化原始物件的方法 (method) 不接受 `timeout` 引數；要達成有超時 (timeout) 設定的操作請改用 `asyncio.wait_for()` 函式。

`asyncio` 有以下基礎同步化原始物件：

- `Lock`
- `Event`
- `Condition`
- `Semaphore`

- *BoundedSemaphore*
 - *Barrier*
-

Lock

class `asyncio.Lock`

實作了一個給 `asyncio` 任務 (task) 用的互斥鎖 (mutex lock)。不支援執行緒安全。

一個 `asyncio` 的鎖可以用來確保一個共享資源的存取權被獨佔。

使用 `Lock` 的推薦方式是透過 `async with` 陳述式：

```
lock = asyncio.Lock()

# ... later
async with lock:
    # access shared state
```

這等價於：

```
lock = asyncio.Lock()

# ... later
await lock.acquire()
try:
    # access shared state
finally:
    lock.release()
```

在 3.10 版的變更：移除 `loop` 參數。

coroutine `acquire()`

獲得鎖。

此方法會持續等待直到鎖的狀態成 `unlocked`，將其設置 `locked` 和回傳 `True`。

當多於一個的協程 (coroutine) 在 `acquire()` 中等待解鎖而被阻塞，最終只會有其中的一個被處理。

鎖的獲取方式是公平的：被處理的協程會是最早開始等待解鎖的那一個。

release()

釋放鎖。

如果鎖的狀態 `locked` 則將其重置 `unlocked` 回傳。

如果鎖的狀態 `unlocked` 則 `RuntimeError` 會被引發。

locked()

如果鎖的狀態 `locked` 則回傳 `True`。

Event

`class asyncio.Event`

一個事件 (event) 物件。不支援執行緒安全。

一個 `asyncio` 事件可以被用於通知多個有發生某些事件於其中的 `asyncio` 任務。

一個 `Event` 物件會管理一個內部旗標 (flag)，它可以透過 `set()` 方法來被設 `True` 透過 `clear()` 方法來重置 `False`。 `wait()` 方法會被阻塞 (block) 直到該旗標被設 `True`。該旗標初始設置 `False`。

在 3.10 版的變更: 移除 `loop` 參數。 範例:

```
async def waiter(event):
    print('waiting for it ...')
    await event.wait()
    print('... got it!')

async def main():
    # Create an Event object.
    event = asyncio.Event()

    # Spawn a Task to wait until 'event' is set.
    waiter_task = asyncio.create_task(waiter(event))

    # Sleep for 1 second and set the event.
    await asyncio.sleep(1)
    event.set()

    # Wait until the waiter task is finished.
    await waiter_task

asyncio.run(main())
```

`coroutine wait()`

持續等待直到事件被設置。

如果事件有被設置則立刻回傳 `True`。否則持續阻塞直到另一個任務呼叫 `set()`。

`set()`

設置事件。

所有正在等待事件被設置的任務會立即被 `True` 醒。

`clear()`

清除 (還原) 事件。

正透過 `wait()` 等待的 Tasks 現在會持續阻塞直到 `set()` 方法再次被呼叫。

`is_set()`

如果事件有被設置則回傳 `True`。

Condition

`class asyncio.Condition (lock=None)`

一個條件 (condition) 物件。不支援執行緒安全。

一個 `asyncio` 條件原始物件可以被任務用來等待某事件發生，獲得一個共享資源的獨存取權。

本質上，一個 `Condition` 物件會結合 `Event` 和 `Lock` 的功能。多個 `Condition` 物件共享一個 `Lock` 是有可能發生的，這能協調關注同一共享資源的不同狀態以獲取其獨存取權的多個任務。

可選的 `lock` 引數必須是一個 `Lock` 物件或者 `None`。如後者則一個新的 `Lock` 物件會被自動建立。

在 3.10 版的變更: 移除 `loop` 參數。

使用 `Condition` 的推薦方式是透過 `async with` 陳述式:

```
cond = asyncio.Condition()

# ... later
async with cond:
    await cond.wait()
```

這等價於:

```
cond = asyncio.Condition()

# ... later
await cond.acquire()
try:
    await cond.wait()
finally:
    cond.release()
```

coroutine acquire()

獲取底層的鎖。

此方法會持續等待直到底層的鎖 `unlocked`, 將其設 `locked` 回傳 `True`。

notify(*n=1*)

醒至多 *n* 個正在等待此條件的任務 (預設 1), 如果有正在等待的任務則此方法空操作 (no-op)。

在此方法被呼叫前必須先獲得鎖, 在之後立刻將其釋放。如果呼叫於一個 `unlocked` 的鎖則 `RuntimeError` 錯誤會被引發。

locked()

如果已獲取底層的鎖則回傳 `True`。

notify_all()

醒所有正在等待此條件的任務。

這個方法的行就像 `notify()`, 但會醒所有正在等待的任務。

在此方法被呼叫前必須先獲得鎖, 在之後立刻將其釋放。如果呼叫於一個 `unlocked` 的鎖則 `RuntimeError` 錯誤會被引發。

release()

釋放底層的鎖。

當調用於一個未被解開的鎖之上時, 會引發一個 `RuntimeError`。

coroutine wait()

持續等待直到被通知 (notify)。

當此方法被呼叫時, 如果呼叫它的任務還有獲取鎖的話, `RuntimeError` 會被引發。

此方法會釋放底層的鎖, 然後持續阻塞直到被 `notify()` 或 `notify_all()` 的呼叫所醒。一但被醒, `Condition` 會重新獲取該鎖且此方法會回傳 `True`。

coroutine wait_for(*predicate*)

持續等待直到謂語 (*predicate*) 成 `true`。

謂語必須是一個結果可被直譯成一個 `boolean` 值的可呼叫物件 (callable)。最終值回傳值。

Semaphore

class `asyncio.Semaphore` (*value=1*)

一個旗號 (semaphore) 物件。不支援執行緒安全。

一個旗號物件會管理一個內部計數器，會在每次呼叫 `acquire()` 時減少一、每次呼叫 `release()` 時增加一。此計數器永遠不會少於零；當 `acquire()` 發現它是零時，它會持續阻塞等待某任務呼叫 `release()`。

可選的 *value* 引數給定了內部計數器的初始值（預設 1）。如給定的值少於 0 則 `ValueError` 會被引發。

在 3.10 版的變更: 移除 `loop` 參數。

使用 `Semaphore` 的推薦方式是透過 `async with` 陳述式：

```
sem = asyncio.Semaphore(10)

# ... later
async with sem:
    # work with shared resource
```

這等價於：

```
sem = asyncio.Semaphore(10)

# ... later
await sem.acquire()
try:
    # work with shared resource
finally:
    sem.release()
```

coroutine `acquire()`

獲取一個旗號。

如果內部計數器大於零，將其減一並立刻回傳 `True`。如果為零，則持續等待直到 `release()` 被呼叫，並回傳 `True`。

locked()

如果旗號無法立即被取得則回傳 `True`。

release()

釋放一個旗號，使其內部的計數器數值增加一。可以把一個正在等待獲取旗號的任務叫醒。

和 `BoundedSemaphore` 不同，`Semaphore` 允許 `release()` 的呼叫次數多於 `acquire()`。

BoundedSemaphore

class `asyncio.BoundedSemaphore` (*value=1*)

一個有界的旗號物件。不支援執行緒安全。

`Bounded Semaphore` 是 `Semaphore` 的另一版本，如果其內部的計數器數值增加至大於初始 *value* 值的話，`ValueError` 會在 `release()` 時被引發。

在 3.10 版的變更: 移除 `loop` 參數。

Barrier

class `asyncio.Barrier` (*parties*)

一個屏障 (barrier) 物件。不支援執行緒安全。

A barrier is a simple synchronization primitive that allows to block until *parties* number of tasks are waiting on it. Tasks can wait on the `wait()` method and would be blocked until the specified number of tasks end up waiting on `wait()`. At that point all of the waiting tasks would unblock simultaneously.

`async with` can be used as an alternative to awaiting on `wait()`.

The barrier can be reused any number of times.

範例：

```
async def example_barrier():
    # barrier with 3 parties
    b = asyncio.Barrier(3)

    # create 2 new waiting tasks
    asyncio.create_task(b.wait())
    asyncio.create_task(b.wait())

    await asyncio.sleep(0)
    print(b)

    # The third .wait() call passes the barrier
    await b.wait()
    print(b)
    print("barrier passed")

    await asyncio.sleep(0)
    print(b)

asyncio.run(example_barrier())
```

Result of this example is:

```
<asyncio.locks.Barrier object at 0x... [filling, waiters:2/3]>
<asyncio.locks.Barrier object at 0x... [draining, waiters:0/3]>
barrier passed
<asyncio.locks.Barrier object at 0x... [filling, waiters:0/3]>
```

在 3.11 版新加入。

coroutine `wait()`

Pass the barrier. When all the tasks party to the barrier have called this function, they are all unblocked simultaneously.

When a waiting or blocked task in the barrier is cancelled, this task exits the barrier which stays in the same state. If the state of the barrier is "filling", the number of waiting task decreases by 1.

The return value is an integer in the range of 0 to *parties*-1, different for each task. This can be used to select a task to do some special housekeeping, e.g.:

```
...
async with barrier as position:
    if position == 0:
        # Only one task prints this
        print('End of *draining phase*')
```

This method may raise a `BrokenBarrierError` exception if the barrier is broken or reset while a task is waiting. It could raise a `CancelledError` if a task is cancelled.

coroutine reset()

Return the barrier to the default, empty state. Any tasks waiting on it will receive the *BrokenBarrierError* exception.

If a barrier is broken it may be better to just leave it and create a new one.

coroutine abort()

Put the barrier into a broken state. This causes any active or future calls to *wait()* to fail with the *BrokenBarrierError*. Use this for example if one of the tasks needs to abort, to avoid infinite waiting tasks.

parties

The number of tasks required to pass the barrier.

n_waiting

The number of tasks currently waiting in the barrier while filling.

broken

A boolean that is True if the barrier is in the broken state.

exception asyncio.BrokenBarrierError

This exception, a subclass of *RuntimeError*, is raised when the *Barrier* object is reset or broken.

在 3.9 版的變更: 透過 *await lock* 或 *yield from lock* 和/或 *with* 陳述式 (*with await lock*, *with (yield from lock)*) 來獲取鎖的方式已被移除。請改用 *async with lock*。

18.1.5 子行程

原始碼: [Lib/asyncio/subprocess.py](#)、[Lib/asyncio/base_subprocess.py](#)

This section describes high-level *async/await* *asyncio* APIs to create and manage subprocesses.

Here's an example of how *asyncio* can run a shell command and obtain its result:

```
import asyncio

async def run(cmd):
    proc = await asyncio.create_subprocess_shell(
        cmd,
        stdout=asyncio.subprocess.PIPE,
        stderr=asyncio.subprocess.PIPE)

    stdout, stderr = await proc.communicate()

    print(f'[{cmd!r} exited with {proc.returncode}]')
    if stdout:
        print(f'[stdout]\n{stdout.decode()}')
    if stderr:
        print(f'[stderr]\n{stderr.decode()}')

asyncio.run(run('ls /zzz'))
```

will print:

```
[ 'ls /zzz' exited with 1 ]
[ stderr ]
ls: /zzz: No such file or directory
```

Because all `asyncio` subprocess functions are asynchronous and `asyncio` provides many tools to work with such functions, it is easy to execute and monitor multiple subprocesses in parallel. It is indeed trivial to modify the above example to run several commands simultaneously:

```
async def main():
    await asyncio.gather(
        run('ls /zzz'),
        run('sleep 1; echo "hello"'))

asyncio.run(main())
```

另請參 F Examples。

建立子行程

coroutine `asyncio.create_subprocess_exec` (*program*, **args*, *stdin=None*, *stdout=None*, *stderr=None*, *limit=None*, ***kwds*)

Create a subprocess.

The *limit* argument sets the buffer limit for `StreamReader` wrappers for `Process.stdout` and `Process.stderr` (if `subprocess.PIPE` is passed to *stdout* and *stderr* arguments).

Return a `Process` instance.

See the documentation of `loop.subprocess_exec()` for other parameters.

在 3.10 版的變更: Removed the *loop* parameter.

coroutine `asyncio.create_subprocess_shell` (*cmd*, *stdin=None*, *stdout=None*, *stderr=None*, *limit=None*, ***kwds*)

Run the *cmd* shell command.

The *limit* argument sets the buffer limit for `StreamReader` wrappers for `Process.stdout` and `Process.stderr` (if `subprocess.PIPE` is passed to *stdout* and *stderr* arguments).

Return a `Process` instance.

See the documentation of `loop.subprocess_shell()` for other parameters.

重要: It is the application's responsibility to ensure that all whitespace and special characters are quoted appropriately to avoid `shell injection` vulnerabilities. The `shlex.quote()` function can be used to properly escape whitespace and special shell characters in strings that are going to be used to construct shell commands.

在 3.10 版的變更: Removed the *loop* parameter.

備 F: Subprocesses are available for Windows if a `ProactorEventLoop` is used. See *Subprocess Support on Windows* for details.

也參考:

`asyncio` also has the following *low-level* APIs to work with subprocesses: `loop.subprocess_exec()`, `loop.subprocess_shell()`, `loop.connect_read_pipe()`, `loop.connect_write_pipe()`, as well as the *Subprocess Transports* and *Subprocess Protocols*.

常數

`asyncio.subprocess.PIPE`

Can be passed to the *stdin*, *stdout* or *stderr* parameters.

If *PIPE* is passed to *stdin* argument, the *Process.stdin* attribute will point to a *StreamWriter* instance.

If *PIPE* is passed to *stdout* or *stderr* arguments, the *Process.stdout* and *Process.stderr* attributes will point to *StreamReader* instances.

`asyncio.subprocess.STDOUT`

Special value that can be used as the *stderr* argument and indicates that standard error should be redirected into standard output.

`asyncio.subprocess.DEVNULL`

Special value that can be used as the *stdin*, *stdout* or *stderr* argument to process creation functions. It indicates that the special file *os.devnull* will be used for the corresponding subprocess stream.

Interacting with Subprocesses

Both *create_subprocess_exec()* and *create_subprocess_shell()* functions return instances of the *Process* class. *Process* is a high-level wrapper that allows communicating with subprocesses and watching for their completion.

class `asyncio.subprocess.Process`

An object that wraps OS processes created by the *create_subprocess_exec()* and *create_subprocess_shell()* functions.

This class is designed to have a similar API to the *subprocess.Popen* class, but there are some notable differences:

- unlike *Popen*, *Process* instances do not have an equivalent to the *poll()* method;
- the *communicate()* and *wait()* methods don't have a *timeout* parameter: use the *wait_for()* function;
- the *Process.wait()* method is asynchronous, whereas *subprocess.Popen.wait()* method is implemented as a blocking busy loop;
- the *universal_newlines* parameter is not supported.

This class is *not thread safe*.

See also the *Subprocess and Threads* section.

coroutine `wait()`

Wait for the child process to terminate.

Set and return the *returncode* attribute.

備註: This method can deadlock when using *stdout=PIPE* or *stderr=PIPE* and the child process generates so much output that it blocks waiting for the OS pipe buffer to accept more data. Use the *communicate()* method when using pipes to avoid this condition.

coroutine `communicate(input=None)`

Interact with process:

1. send data to *stdin* (if *input* is not *None*);
2. read data from *stdout* and *stderr*, until EOF is reached;
3. wait for process to terminate.

The optional *input* argument is the data (*bytes* object) that will be sent to the child process.

Return a tuple (*stdout_data*, *stderr_data*).

If either *BrokenPipeError* or *ConnectionResetError* exception is raised when writing *input* into *stdin*, the exception is ignored. This condition occurs when the process exits before all data are written into *stdin*.

If it is desired to send data to the process' *stdin*, the process needs to be created with *stdin=PIPE*. Similarly, to get anything other than *None* in the result tuple, the process has to be created with *stdout=PIPE* and/or *stderr=PIPE* arguments.

Note, that the data read is buffered in memory, so do not use this method if the data size is large or unlimited.

send_signal (*signal*)

Sends the signal *signal* to the child process.

備 註: On Windows, *SIGTERM* is an alias for *terminate()*. *CTRL_C_EVENT* and *CTRL_BREAK_EVENT* can be sent to processes started with a *creationflags* parameter which includes *CREATE_NEW_PROCESS_GROUP*.

terminate ()

Stop the child process.

On POSIX systems this method sends *SIGTERM* to the child process.

On Windows the Win32 API function *TerminateProcess()* is called to stop the child process.

kill ()

Kill the child process.

On POSIX systems this method sends *SIGKILL* to the child process.

On Windows this method is an alias for *terminate()*.

stdin

Standard input stream (*StreamWriter*) or *None* if the process was created with *stdin=None*.

stdout

Standard output stream (*StreamReader*) or *None* if the process was created with *stdout=None*.

stderr

Standard error stream (*StreamReader*) or *None* if the process was created with *stderr=None*.

警告: Use the *communicate()* method rather than *process.stdin.write()*, *await process.stdout.read()* or *await process.stderr.read()*. This avoids deadlocks due to streams pausing reading or writing and blocking the child process.

pid

Process identification number (PID).

Note that for processes created by the *create_subprocess_shell()* function, this attribute is the PID of the spawned shell.

returncode

Return code of the process when it exits.

A *None* value indicates that the process has not terminated yet.

A negative value *-N* indicates that the child was terminated by signal *N* (POSIX only).

子行程與程

Standard `asyncio` event loop supports running subprocesses from different threads by default.

On Windows subprocesses are provided by `ProactorEventLoop` only (default), `SelectorEventLoop` has no subprocess support.

On UNIX *child watchers* are used for subprocess finish waiting, see *Process Watchers* for more info.

在 3.8 版的變更: UNIX switched to use `ThreadedChildWatcher` for spawning subprocesses from different threads without any limitation.

Spawning a subprocess with *inactive* current child watcher raises `RuntimeError`.

Note that alternative event loop implementations might have own limitations; please refer to their documentation.

也參考:

The *Concurrency and multithreading in asyncio* section.

范例

An example using the `Process` class to control a subprocess and the `StreamReader` class to read from its standard output.

The subprocess is created by the `create_subprocess_exec()` function:

```
import asyncio
import sys

async def get_date():
    code = 'import datetime; print(datetime.datetime.now())'

    # Create the subprocess; redirect the standard output
    # into a pipe.
    proc = await asyncio.create_subprocess_exec(
        sys.executable, '-c', code,
        stdout=asyncio.subprocess.PIPE)

    # Read one line of output.
    data = await proc.stdout.readline()
    line = data.decode('ascii').rstrip()

    # Wait for the subprocess exit.
    await proc.wait()
    return line

date = asyncio.run(get_date())
print(f"Current date: {date}")
```

See also the *same example* written using low-level APIs.

18.1.6 列 (Queues)

原始碼: [Lib/asyncio/queues.py](#)

asyncio 列被設計成與 `queue` 模組類似。儘管 asyncio 列不支援執行緒安全 (thread-safe)，但他們是被設計來專用於 `async/await` 程式。

注意 asyncio 的列有 `timeout` 參數；請使用 `asyncio.wait_for()` 函式來列新增具有超時 (timeout) 設定的操作。

另請參下方 *Examples*。

Queue

class `asyncio.Queue(maxsize=0)`

先進先出 (FIFO) 列。

如果 `maxsize` 小於或等於零，則列尺寸是無限制的。如果是大於 0 的整數，則當列達到 `maxsize` 時，`await put()` 將會阻塞 (block)，直到某個元素被 `get()` 取出。

不像標準函式庫中執行緒類型的 `queue`，列的尺寸一直是已知的，可以透過呼叫 `qsize()` 方法回傳。

在 3.10 版的變更: 移除 `loop` 參數。

這個類是不支援執行緒安全的。

maxsize

列中可存放的元素數量。

empty()

如果列空則回傳 `True`，否則回傳 `False`。

full()

如果有 `maxsize` 個條目在列中，則回傳 `True`。

如果列用 `maxsize=0` (預設) 初始化，則 `full()` 永遠不會回傳 `True`。

coroutine get()

從列中除回傳一個元素。如果列空，則持續等待直到列中有元素。

get_nowait()

如果列有值則立即回傳列中的元素，否則引發 `QueueEmpty`。

coroutine join()

持續阻塞直到列中所有的元素都被接收和處理完畢。

當條目新增到列的時候，未完成任務的計數就會增加。每當一個消耗者 (consumer) 協程呼叫 `task_done()`，表示這個條目已經被取回且被它包含的所有工作都已完成，未完成任務計數就會少。當未完成計數降到零的時候，`join()` 阻塞會被解除 (unblock)。

coroutine put(item)

將一個元素放進列。如果列滿了，在新增元素之前，會持續等待直到有空插槽 (free slot) 能被使用。

put_nowait(item)

不阻塞地將一個元素放入列。

如果列有立即可用的空插槽，引發 `QueueFull`。

qsize()

回傳列中的元素數量。

task_done()

表示前面一個排隊的任務已經完成。

由`Queue`消費者使用。對於每個用於獲取一個任務的`get()`，接續的`task_done()`呼叫會告訴`Queue`這個任務的處理已經完成。

如果`join()`當前正在阻塞，在所有項目都被處理後會解除阻塞（意味著每個以`put()`放進`Queue`的條目都會收到一個`task_done()`）。

如果被呼叫的次數多於放入`Queue`中的項目數量，將引發`ValueError`。

Priority Queue (優先`Queue`)**class asyncio.PriorityQueue**

`Queue` 的變形；按優先順序取出條目（最小的先取出）。

條目通常是 `(priority_number, data)` 形式的 `tuple`（元組）。

LIFO Queue**class asyncio.LifoQueue**

`Queue` 的變形，先取出最近新增的條目（後進先出）。

例外**exception asyncio.QueueEmpty**

當`Queue`空的時候，呼叫`get_nowait()`方法會引發這個例外。

exception asyncio.QueueFull

當`Queue`中條目數量已經達到它的 `maxsize` 時，呼叫`put_nowait()`方法會引發這個例外。

范例

`Queue` 能被用於多個`Queue`行任務的工作分配：

```
import asyncio
import random
import time

async def worker(name, queue):
    while True:
        # Get a "work item" out of the queue.
        sleep_for = await queue.get()

        # Sleep for the "sleep_for" seconds.
        await asyncio.sleep(sleep_for)

        # Notify the queue that the "work item" has been processed.
        queue.task_done()

        print(f'{name} has slept for {sleep_for:.2f} seconds')

async def main():
    # Create a queue that we will use to store our "workload".
    queue = asyncio.Queue()
```

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```

# Generate random timings and put them into the queue.
total_sleep_time = 0
for _ in range(20):
    sleep_for = random.uniform(0.05, 1.0)
    total_sleep_time += sleep_for
    queue.put_nowait(sleep_for)

# Create three worker tasks to process the queue concurrently.
tasks = []
for i in range(3):
    task = asyncio.create_task(worker(f'worker-{i}', queue))
    tasks.append(task)

# Wait until the queue is fully processed.
started_at = time.monotonic()
await queue.join()
total_slept_for = time.monotonic() - started_at

# Cancel our worker tasks.
for task in tasks:
    task.cancel()
# Wait until all worker tasks are cancelled.
await asyncio.gather(*tasks, return_exceptions=True)

print('====')
print(f'3 workers slept in parallel for {total_slept_for:.2f} seconds')
print(f'total expected sleep time: {total_sleep_time:.2f} seconds')

asyncio.run(main())

```

18.1.7 例外

原始碼: `Lib/asyncio/exceptions.py`

exception `asyncio.TimeoutError`

`TimeoutError` 的一個已被用的名，當操作已超過規定的截止時間時被引發。

在 3.11 版的變更: 此 class 是 `TimeoutError` 的一個名。

exception `asyncio.CancelledError`

該操作已被取消。

當 `asyncio Task` 被取消時，可以捕獲此例外以執行客化操作。在幾乎所有情況下，該例外必須重新被引發。

在 3.8 版的變更: `CancelledError` 現在是 `BaseException` 而非 `Exception` 的子類。

exception `asyncio.InvalidStateError`

`Task` 或 `Future` 的無效部狀態。

可以在像是已設定結果值的 `Future` 物件設定結果值的情況下引發。

exception `asyncio.SendfileNotAvailableError`

“sendfile”系統呼叫不適用於給定的 socket 或檔案型。

一個 `RuntimeError` 的子類。

exception `asyncio.IncompleteReadError`

請求的讀取操作未全部完成。

由 `asyncio` 串流 APIs 引發。

此例外是 `EOFError` 的子類 F。

expected

預期的位元組總數 (`int`)。

partial

串流結束之前讀取的 `bytes` 字串。

exception `asyncio.LimitOverrunError`

在查詢分隔符號 (separator) 時達到緩衝區 (buffer) 大小限制。

由 `asyncio` 串流 APIs 引發。

consumed

要消耗的位元組總數。

18.1.8 Event Loop

原始碼: `Lib/asyncio/events.py`、`Lib/asyncio/base_events.py`

Preface

The event loop is the core of every asyncio application. Event loops run asynchronous tasks and callbacks, perform network IO operations, and run subprocesses.

Application developers should typically use the high-level asyncio functions, such as `asyncio.run()`, and should rarely need to reference the loop object or call its methods. This section is intended mostly for authors of lower-level code, libraries, and frameworks, who need finer control over the event loop behavior.

Obtaining the Event Loop

The following low-level functions can be used to get, set, or create an event loop:

`asyncio.get_running_loop()`

Return the running event loop in the current OS thread.

Raise a `RuntimeError` if there is no running event loop.

This function can only be called from a coroutine or a callback.

在 3.7 版新加入。

`asyncio.get_event_loop()`

Get the current event loop.

When called from a coroutine or a callback (e.g. scheduled with `call_soon` or similar API), this function will always return the running event loop.

If there is no running event loop set, the function will return the result of the `get_event_loop_policy().get_event_loop()` call.

Because this function has rather complex behavior (especially when custom event loop policies are in use), using the `get_running_loop()` function is preferred to `get_event_loop()` in coroutines and callbacks.

As noted above, consider using the higher-level `asyncio.run()` function, instead of using these lower level functions to manually create and close an event loop.

備 F: In Python versions 3.10.0--3.10.8 and 3.11.0 this function (and other functions which use it implicitly) emitted a *DeprecationWarning* if there was no running event loop, even if the current loop was set on the policy. In Python versions 3.10.9, 3.11.1 and 3.12 they emit a *DeprecationWarning* if there is no running event loop and no current loop is set. In some future Python release this will become an error.

`asyncio.set_event_loop(loop)`

Set *loop* as the current event loop for the current OS thread.

`asyncio.new_event_loop()`

Create and return a new event loop object.

Note that the behaviour of `get_event_loop()`, `set_event_loop()`, and `new_event_loop()` functions can be altered by *setting a custom event loop policy*.



This documentation page contains the following sections:

- The *Event Loop Methods* section is the reference documentation of the event loop APIs;
- The *Callback Handles* section documents the *Handle* and *TimerHandle* instances which are returned from scheduling methods such as `loop.call_soon()` and `loop.call_later()`;
- The *Server Objects* section documents types returned from event loop methods like `loop.create_server()`;
- The *Event Loop Implementations* section documents the *SelectorEventLoop* and *ProactorEventLoop* classes;
- The *Examples* section showcases how to work with some event loop APIs.

Event Loop Methods

Event loops have **low-level** APIs for the following:

- *Running and stopping the loop*
- *Scheduling callbacks*
- *Scheduling delayed callbacks*
- *Creating Futures and Tasks*
- *Opening network connections*
- *Creating network servers*
- *Transferring files*
- *TLS Upgrade*
- *Watching file descriptors*
- *Working with socket objects directly*
- *DNS*
- *Working with pipes*
- *Unix signals*
- *Executing code in thread or process pools*
- *Error Handling API*

- *Enabling debug mode*
- *Running Subprocesses*

Running and stopping the loop

`loop.run_until_complete(future)`

Run until the *future* (an instance of *Future*) has completed.

If the argument is a *coroutine object* it is implicitly scheduled to run as a *asyncio.Task*.

Return the Future's result or raise its exception.

`loop.run_forever()`

Run the event loop until *stop()* is called.

If *stop()* is called before *run_forever()* is called, the loop will poll the I/O selector once with a timeout of zero, run all callbacks scheduled in response to I/O events (and those that were already scheduled), and then exit.

If *stop()* is called while *run_forever()* is running, the loop will run the current batch of callbacks and then exit. Note that new callbacks scheduled by callbacks will not run in this case; instead, they will run the next time *run_forever()* or *run_until_complete()* is called.

`loop.stop()`

Stop the event loop.

`loop.is_running()`

Return True if the event loop is currently running.

`loop.is_closed()`

Return True if the event loop was closed.

`loop.close()`

Close the event loop.

The loop must not be running when this function is called. Any pending callbacks will be discarded.

This method clears all queues and shuts down the executor, but does not wait for the executor to finish.

This method is idempotent and irreversible. No other methods should be called after the event loop is closed.

coroutine `loop.shutdown_asyncgens()`

Schedule all currently open *asynchronous generator* objects to close with an *aclose()* call. After calling this method, the event loop will issue a warning if a new asynchronous generator is iterated. This should be used to reliably finalize all scheduled asynchronous generators.

Note that there is no need to call this function when *asyncio.run()* is used.

範例：

```
try:
    loop.run_forever()
finally:
    loop.run_until_complete(loop.shutdown_asyncgens())
    loop.close()
```

在 3.6 版新加入。

coroutine `loop.shutdown_default_executor()`

Schedule the closure of the default executor and wait for it to join all of the threads in the *ThreadPoolExecutor*. Once this method has been called, using the default executor with *loop.run_in_executor()* will raise a *RuntimeError*.

備 F: Do not call this method when using `asyncio.run()`, as the latter handles default executor shutdown automatically.

在 3.9 版新加入.

Scheduling callbacks

`loop.call_soon(callback, *args, context=None)`

Schedule the *callback* `callback` to be called with *args* arguments at the next iteration of the event loop.

Return an instance of `asyncio.Handle`, which can be used later to cancel the callback.

Callbacks are called in the order in which they are registered. Each callback will be called exactly once.

The optional keyword-only *context* argument specifies a custom `contextvars.Context` for the *callback* to run in. Callbacks use the current context when no *context* is provided.

Unlike `call_soon_threadsafe()`, this method is not thread-safe.

`loop.call_soon_threadsafe(callback, *args, context=None)`

A thread-safe variant of `call_soon()`. When scheduling callbacks from another thread, this function *must* be used, since `call_soon()` is not thread-safe.

Raises `RuntimeError` if called on a loop that's been closed. This can happen on a secondary thread when the main application is shutting down.

See the *concurrency and multithreading* section of the documentation.

在 3.7 版的變更: The *context* keyword-only parameter was added. See [PEP 567](#) for more details.

備 F: Most `asyncio` scheduling functions don't allow passing keyword arguments. To do that, use `functools.partial()`:

```
# will schedule "print('Hello', flush=True)"
loop.call_soon(
    functools.partial(print, "Hello", flush=True))
```

Using partial objects is usually more convenient than using lambdas, as `asyncio` can render partial objects better in debug and error messages.

Scheduling delayed callbacks

Event loop provides mechanisms to schedule callback functions to be called at some point in the future. Event loop uses monotonic clocks to track time.

`loop.call_later(delay, callback, *args, context=None)`

Schedule *callback* to be called after the given *delay* number of seconds (can be either an int or a float).

An instance of `asyncio.TimerHandle` is returned which can be used to cancel the callback.

callback will be called exactly once. If two callbacks are scheduled for exactly the same time, the order in which they are called is undefined.

The optional positional *args* will be passed to the callback when it is called. If you want the callback to be called with keyword arguments use `functools.partial()`.

An optional keyword-only *context* argument allows specifying a custom `contextvars.Context` for the *callback* to run in. The current context is used when no *context* is provided.

在 3.7 版的變更: The *context* keyword-only parameter was added. See [PEP 567](#) for more details.

在 3.8 版的變更: In Python 3.7 and earlier with the default event loop implementation, the *delay* could not exceed one day. This has been fixed in Python 3.8.

`loop.call_at (when, callback, *args, context=None)`

Schedule *callback* to be called at the given absolute timestamp *when* (an int or a float), using the same time reference as `loop.time()`.

This method's behavior is the same as `call_later()`.

An instance of `asyncio.TimerHandle` is returned which can be used to cancel the callback.

在 3.7 版的變更: The *context* keyword-only parameter was added. See [PEP 567](#) for more details.

在 3.8 版的變更: In Python 3.7 and earlier with the default event loop implementation, the difference between *when* and the current time could not exceed one day. This has been fixed in Python 3.8.

`loop.time()`

Return the current time, as a *float* value, according to the event loop's internal monotonic clock.

備註: 在 3.8 版的變更: In Python 3.7 and earlier timeouts (relative *delay* or absolute *when*) should not exceed one day. This has been fixed in Python 3.8.

也參考:

The `asyncio.sleep()` function.

Creating Futures and Tasks

`loop.create_future()`

Create an `asyncio.Future` object attached to the event loop.

This is the preferred way to create Futures in asyncio. This lets third-party event loops provide alternative implementations of the Future object (with better performance or instrumentation).

在 3.5.2 版新加入。

`loop.create_task (coro, *, name=None, context=None)`

Schedule the execution of *coroutine* *coro*. Return a *Task* object.

Third-party event loops can use their own subclass of *Task* for interoperability. In this case, the result type is a subclass of *Task*.

If the *name* argument is provided and not *None*, it is set as the name of the task using `Task.set_name()`.

An optional keyword-only *context* argument allows specifying a custom `contextvars.Context` for the *coro* to run in. The current context copy is created when no *context* is provided.

在 3.8 版的變更: 加入 *name* 參數。

在 3.11 版的變更: 加入 *context* 參數。

`loop.set_task_factory (factory)`

Set a task factory that will be used by `loop.create_task()`.

If *factory* is *None* the default task factory will be set. Otherwise, *factory* must be a *callable* with the signature matching `(loop, coro, context=None)`, where *loop* is a reference to the active event loop, and *coro* is a coroutine object. The callable must return a `asyncio.Future`-compatible object.

`loop.get_task_factory()`

Return a task factory or *None* if the default one is in use.

Opening network connections

coroutine `loop.create_connection` (*protocol_factory*, *host=None*, *port=None*, *, *ssl=None*, *family=0*, *proto=0*, *flags=0*, *sock=None*, *local_addr=None*, *server_hostname=None*, *ssl_handshake_timeout=None*, *ssl_shutdown_timeout=None*, *happy_eyeballs_delay=None*, *interleave=None*)

Open a streaming transport connection to a given address specified by *host* and *port*.

The socket family can be either `AF_INET` or `AF_INET6` depending on *host* (or the *family* argument, if provided).

The socket type will be `SOCK_STREAM`.

protocol_factory must be a callable returning an *asyncio protocol* implementation.

This method will try to establish the connection in the background. When successful, it returns a (*transport*, *protocol*) pair.

The chronological synopsis of the underlying operation is as follows:

1. The connection is established and a *transport* is created for it.
2. *protocol_factory* is called without arguments and is expected to return a *protocol* instance.
3. The protocol instance is coupled with the transport by calling its `connection_made()` method.
4. A (*transport*, *protocol*) tuple is returned on success.

The created transport is an implementation-dependent bidirectional stream.

Other arguments:

- *ssl*: if given and not false, a SSL/TLS transport is created (by default a plain TCP transport is created). If *ssl* is a `ssl.SSLContext` object, this context is used to create the transport; if *ssl* is `True`, a default context returned from `ssl.create_default_context()` is used.

也參考:

SSL/TLS security considerations

- *server_hostname* sets or overrides the hostname that the target server's certificate will be matched against. Should only be passed if *ssl* is not `None`. By default the value of the *host* argument is used. If *host* is empty, there is no default and you must pass a value for *server_hostname*. If *server_hostname* is an empty string, hostname matching is disabled (which is a serious security risk, allowing for potential man-in-the-middle attacks).
- *family*, *proto*, *flags* are the optional address family, protocol and flags to be passed through to `getaddrinfo()` for *host* resolution. If given, these should all be integers from the corresponding `socket` module constants.
- *happy_eyeballs_delay*, if given, enables Happy Eyeballs for this connection. It should be a floating-point number representing the amount of time in seconds to wait for a connection attempt to complete, before starting the next attempt in parallel. This is the "Connection Attempt Delay" as defined in [RFC 8305](#). A sensible default value recommended by the RFC is 0.25 (250 milliseconds).
- *interleave* controls address reordering when a host name resolves to multiple IP addresses. If 0 or unspecified, no reordering is done, and addresses are tried in the order returned by `getaddrinfo()`. If a positive integer is specified, the addresses are interleaved by address family, and the given integer is interpreted as "First Address Family Count" as defined in [RFC 8305](#). The default is 0 if *happy_eyeballs_delay* is not specified, and 1 if it is.
- *sock*, if given, should be an existing, already connected `socket.socket` object to be used by the transport. If *sock* is given, none of *host*, *port*, *family*, *proto*, *flags*, *happy_eyeballs_delay*, *interleave* and *local_addr* should be specified.

備註: The *sock* argument transfers ownership of the socket to the transport created. To close the socket, call the transport's *close()* method.

- *local_addr*, if given, is a (*local_host*, *local_port*) tuple used to bind the socket locally. The *local_host* and *local_port* are looked up using *getaddrinfo()*, similarly to *host* and *port*.
- *ssl_handshake_timeout* is (for a TLS connection) the time in seconds to wait for the TLS handshake to complete before aborting the connection. 60.0 seconds if None (default).
- *ssl_shutdown_timeout* is the time in seconds to wait for the SSL shutdown to complete before aborting the connection. 30.0 seconds if None (default).

在 3.5 版的變更: Added support for SSL/TLS in *ProactorEventLoop*.

在 3.6 版的變更: The socket option *socket.TCP_NODELAY* is set by default for all TCP connections.

在 3.7 版的變更: 增加 *ssl_handshake_timeout* 參數。

在 3.8 版的變更: 加入 *happy_eyeballs_delay* 和 *interleave* 參數。

Happy Eyeballs Algorithm: Success with Dual-Stack Hosts. When a server's IPv4 path and protocol are working, but the server's IPv6 path and protocol are not working, a dual-stack client application experiences significant connection delay compared to an IPv4-only client. This is undesirable because it causes the dual-stack client to have a worse user experience. This document specifies requirements for algorithms that reduce this user-visible delay and provides an algorithm.

更多資訊請見: <https://datatracker.ietf.org/doc/html/rfc6555>

在 3.11 版的變更: 增加 *ssl_shutdown_timeout* 參數。

也參考:

The *open_connection()* function is a high-level alternative API. It returns a pair of (*StreamReader*, *StreamWriter*) that can be used directly in *async/await* code.

```
coroutine loop.create_datagram_endpoint(protocol_factory, local_addr=None,
                                         remote_addr=None, *, family=0, proto=0, flags=0,
                                         reuse_port=None, allow_broadcast=None,
                                         sock=None)
```

Create a datagram connection.

The socket family can be either *AF_INET*, *AF_INET6*, or *AF_UNIX*, depending on *host* (or the *family* argument, if provided).

The socket type will be *SOCK_DGRAM*.

protocol_factory must be a callable returning a *protocol* implementation.

A tuple of (*transport*, *protocol*) is returned on success.

Other arguments:

- *local_addr*, if given, is a (*local_host*, *local_port*) tuple used to bind the socket locally. The *local_host* and *local_port* are looked up using *getaddrinfo()*.
- *remote_addr*, if given, is a (*remote_host*, *remote_port*) tuple used to connect the socket to a remote address. The *remote_host* and *remote_port* are looked up using *getaddrinfo()*.
- *family*, *proto*, *flags* are the optional address family, protocol and flags to be passed through to *getaddrinfo()* for *host* resolution. If given, these should all be integers from the corresponding *socket* module constants.
- *reuse_port* tells the kernel to allow this endpoint to be bound to the same port as other existing endpoints are bound to, so long as they all set this flag when being created. This option is not supported on Windows and some Unixes. If the *socket.SO_REUSEPORT* constant is not defined then this capability is unsupported.

- *allow_broadcast* tells the kernel to allow this endpoint to send messages to the broadcast address.
- *sock* can optionally be specified in order to use a preexisting, already connected, *socket.socket* object to be used by the transport. If specified, *local_addr* and *remote_addr* should be omitted (must be *None*).

備 F: The *sock* argument transfers ownership of the socket to the transport created. To close the socket, call the transport's *close()* method.

See *UDP echo client protocol* and *UDP echo server protocol* examples.

在 3.4.4 版的變更: The *family*, *proto*, *flags*, *reuse_address*, *reuse_port*, *allow_broadcast*, and *sock* parameters were added.

在 3.8 版的變更: 新增對於 Windows 的支援。

在 3.8.1 版的變更: The *reuse_address* parameter is no longer supported, as using *socket.SO_REUSEADDR* poses a significant security concern for UDP. Explicitly passing *reuse_address=True* will raise an exception.

When multiple processes with differing UIDs assign sockets to an identical UDP socket address with *SO_REUSEADDR*, incoming packets can become randomly distributed among the sockets.

For supported platforms, *reuse_port* can be used as a replacement for similar functionality. With *reuse_port*, *socket.SO_REUSEPORT* is used instead, which specifically prevents processes with differing UIDs from assigning sockets to the same socket address.

在 3.11 版的變更: The *reuse_address* parameter, disabled since Python 3.8.1, 3.7.6 and 3.6.10, has been entirely removed.

coroutine `loop.create_unix_connection` (*protocol_factory*, *path=None*, *, *ssl=None*, *sock=None*, *server_hostname=None*, *ssl_handshake_timeout=None*, *ssl_shutdown_timeout=None*)

Create a Unix connection.

The socket family will be *AF_UNIX*; socket type will be *SOCK_STREAM*.

A tuple of (*transport*, *protocol*) is returned on success.

path is the name of a Unix domain socket and is required, unless a *sock* parameter is specified. Abstract Unix sockets, *str*, *bytes*, and *Path* paths are supported.

See the documentation of the `loop.create_connection()` method for information about arguments to this method.

適用: Unix。

在 3.7 版的變更: Added the *ssl_handshake_timeout* parameter. The *path* parameter can now be a *path-like object*.

在 3.11 版的變更: 增加 *ssl_shutdown_timeout* 參數。

Creating network servers

coroutine `loop.create_server` (*protocol_factory*, *host=None*, *port=None*, *, *family=socket.AF_UNSPEC*, *flags=socket.AI_PASSIVE*, *sock=None*, *backlog=100*, *ssl=None*, *reuse_address=None*, *reuse_port=None*, *ssl_handshake_timeout=None*, *ssl_shutdown_timeout=None*, *start_serving=True*)

Create a TCP server (socket type *SOCK_STREAM*) listening on *port* of the *host* address.

Returns a *Server* object.

引數:

- *protocol_factory* must be a callable returning a *protocol* implementation.
- The *host* parameter can be set to several types which determine where the server would be listening:
 - If *host* is a string, the TCP server is bound to a single network interface specified by *host*.
 - If *host* is a sequence of strings, the TCP server is bound to all network interfaces specified by the sequence.
 - If *host* is an empty string or `None`, all interfaces are assumed and a list of multiple sockets will be returned (most likely one for IPv4 and another one for IPv6).
- The *port* parameter can be set to specify which port the server should listen on. If 0 or `None` (the default), a random unused port will be selected (note that if *host* resolves to multiple network interfaces, a different random port will be selected for each interface).
- *family* can be set to either `socket.AF_INET` or `AF_INET6` to force the socket to use IPv4 or IPv6. If not set, the *family* will be determined from host name (defaults to `AF_UNSPEC`).
- *flags* is a bitmask for `getaddrinfo()`.
- *sock* can optionally be specified in order to use a preexisting socket object. If specified, *host* and *port* must not be specified.

備註: The *sock* argument transfers ownership of the socket to the server created. To close the socket, call the server's `close()` method.

- *backlog* is the maximum number of queued connections passed to `listen()` (defaults to 100).
- *ssl* can be set to an `SSLContext` instance to enable TLS over the accepted connections.
- *reuse_address* tells the kernel to reuse a local socket in `TIME_WAIT` state, without waiting for its natural timeout to expire. If not specified will automatically be set to `True` on Unix.
- *reuse_port* tells the kernel to allow this endpoint to be bound to the same port as other existing endpoints are bound to, so long as they all set this flag when being created. This option is not supported on Windows.
- *ssl_handshake_timeout* is (for a TLS server) the time in seconds to wait for the TLS handshake to complete before aborting the connection. 60.0 seconds if `None` (default).
- *ssl_shutdown_timeout* is the time in seconds to wait for the SSL shutdown to complete before aborting the connection. 30.0 seconds if `None` (default).
- *start_serving* set to `True` (the default) causes the created server to start accepting connections immediately. When set to `False`, the user should await on `Server.start_serving()` or `Server.serve_forever()` to make the server to start accepting connections.

在 3.5 版的變更: Added support for SSL/TLS in `ProactorEventLoop`.

在 3.5.1 版的變更: The *host* parameter can be a sequence of strings.

在 3.6 版的變更: Added *ssl_handshake_timeout* and *start_serving* parameters. The socket option `socket.TCP_NODELAY` is set by default for all TCP connections.

在 3.11 版的變更: 增加 *ssl_shutdown_timeout* 參數。

也參考:

The `start_server()` function is a higher-level alternative API that returns a pair of `StreamReader` and `StreamWriter` that can be used in an `async/await` code.

```
coroutine loop.create_unix_server(protocol_factory, path=None, *, sock=None, backlog=100,
                                  ssl=None, ssl_handshake_timeout=None,
                                  ssl_shutdown_timeout=None, start_serving=True)
```

Similar to `loop.create_server()` but works with the `AF_UNIX` socket family.

path is the name of a Unix domain socket, and is required, unless a *sock* argument is provided. Abstract Unix sockets, `str`, `bytes`, and `Path` paths are supported.

See the documentation of the `loop.create_server()` method for information about arguments to this method.

適用：Unix。

在 3.7 版的變更：新增 `ssl_handshake_timeout` 與 `start_serving` 參數。`path` 參數現在可 F 一個 `Path` 物件。

在 3.11 版的變更：增加 `ssl_shutdown_timeout` 參數。

coroutine `loop.connect_accepted_socket` (`protocol_factory`, `sock`, *, `ssl=None`,
`ssl_handshake_timeout=None`,
`ssl_shutdown_timeout=None`)

Wrap an already accepted connection into a transport/protocol pair.

This method can be used by servers that accept connections outside of asyncio but that use asyncio to handle them.

參數：

- `protocol_factory` must be a callable returning a *protocol* implementation.
- `sock` is a preexisting socket object returned from `socket.accept`.

備 F：The `sock` argument transfers ownership of the socket to the transport created. To close the socket, call the transport's `close()` method.

- `ssl` can be set to an `SSLContext` to enable SSL over the accepted connections.
- `ssl_handshake_timeout` is (for an SSL connection) the time in seconds to wait for the SSL handshake to complete before aborting the connection. 60.0 seconds if None (default).
- `ssl_shutdown_timeout` is the time in seconds to wait for the SSL shutdown to complete before aborting the connection. 30.0 seconds if None (default).

Returns a (transport, protocol) pair.

在 3.5.3 版新加入。

在 3.7 版的變更：增加 `ssl_handshake_timeout` 參數。

在 3.11 版的變更：增加 `ssl_shutdown_timeout` 參數。

Transferring files

coroutine `loop.sendfile` (`transport`, `file`, `offset=0`, `count=None`, *, `fallback=True`)

Send a *file* over a *transport*. Return the total number of bytes sent.

The method uses high-performance `os.sendfile()` if available.

file must be a regular file object opened in binary mode.

offset tells from where to start reading the file. If specified, *count* is the total number of bytes to transmit as opposed to sending the file until EOF is reached. File position is always updated, even when this method raises an error, and `file.tell()` can be used to obtain the actual number of bytes sent.

fallback set to `True` makes asyncio to manually read and send the file when the platform does not support the `sendfile` system call (e.g. Windows or SSL socket on Unix).

Raise `SendfileNotAvailableError` if the system does not support the `sendfile` syscall and *fallback* is `False`.

在 3.7 版新加入。

TLS Upgrade

coroutine `loop.start_tls` (*transport*, *protocol*, *sslcontext*, *, *server_side=False*, *server_hostname=None*, *ssl_handshake_timeout=None*, *ssl_shutdown_timeout=None*)

Upgrade an existing transport-based connection to TLS.

Create a TLS coder/decoder instance and insert it between the *transport* and the *protocol*. The coder/decoder implements both *transport*-facing protocol and *protocol*-facing transport.

Return the created two-interface instance. After *await*, the *protocol* must stop using the original *transport* and communicate with the returned object only because the coder caches *protocol*-side data and sporadically exchanges extra TLS session packets with *transport*.

In some situations (e.g. when the passed transport is already closing) this may return `None`.

參數:

- *transport* and *protocol* instances that methods like `create_server()` and `create_connection()` return.
- *sslcontext*: a configured instance of `SSLContext`.
- *server_side* pass `True` when a server-side connection is being upgraded (like the one created by `create_server()`).
- *server_hostname*: sets or overrides the host name that the target server's certificate will be matched against.
- *ssl_handshake_timeout* is (for a TLS connection) the time in seconds to wait for the TLS handshake to complete before aborting the connection. `60.0` seconds if `None` (default).
- *ssl_shutdown_timeout* is the time in seconds to wait for the SSL shutdown to complete before aborting the connection. `30.0` seconds if `None` (default).

在 3.7 版新加入。

在 3.11 版的變更: 增加 `ssl_shutdown_timeout` 參數。

Watching file descriptors

`loop.add_reader` (*fd*, *callback*, **args*)

Start monitoring the *fd* file descriptor for read availability and invoke *callback* with the specified arguments once *fd* is available for reading.

`loop.remove_reader` (*fd*)

Stop monitoring the *fd* file descriptor for read availability. Returns `True` if *fd* was previously being monitored for reads.

`loop.add_writer` (*fd*, *callback*, **args*)

Start monitoring the *fd* file descriptor for write availability and invoke *callback* with the specified arguments once *fd* is available for writing.

Use `functools.partial()` to pass keyword arguments to *callback*.

`loop.remove_writer` (*fd*)

Stop monitoring the *fd* file descriptor for write availability. Returns `True` if *fd* was previously being monitored for writes.

See also [Platform Support](#) section for some limitations of these methods.

Working with socket objects directly

In general, protocol implementations that use transport-based APIs such as `loop.create_connection()` and `loop.create_server()` are faster than implementations that work with sockets directly. However, there are some use cases when performance is not critical, and working with `socket` objects directly is more convenient.

coroutine `loop.sock_recv(sock, nbytes)`

Receive up to *nbytes* from *sock*. Asynchronous version of `socket.recv()`.

Return the received data as a bytes object.

sock must be a non-blocking socket.

在 3.7 版的變更: Even though this method was always documented as a coroutine method, releases before Python 3.7 returned a `Future`. Since Python 3.7 this is an `async def` method.

coroutine `loop.sock_recv_into(sock, buf)`

Receive data from *sock* into the *buf* buffer. Modeled after the blocking `socket.recv_into()` method.

Return the number of bytes written to the buffer.

sock must be a non-blocking socket.

在 3.7 版新加入.

coroutine `loop.sock_recvfrom(sock, bufsize)`

Receive a datagram of up to *bufsize* from *sock*. Asynchronous version of `socket.recvfrom()`.

Return a tuple of (received data, remote address).

sock must be a non-blocking socket.

在 3.11 版新加入.

coroutine `loop.sock_recvfrom_into(sock, buf, nbytes=0)`

Receive a datagram of up to *nbytes* from *sock* into *buf*. Asynchronous version of `socket.recvfrom_into()`.

Return a tuple of (number of bytes received, remote address).

sock must be a non-blocking socket.

在 3.11 版新加入.

coroutine `loop.sock_sendall(sock, data)`

Send *data* to the *sock* socket. Asynchronous version of `socket.sendall()`.

This method continues to send to the socket until either all data in *data* has been sent or an error occurs. None is returned on success. On error, an exception is raised. Additionally, there is no way to determine how much data, if any, was successfully processed by the receiving end of the connection.

sock must be a non-blocking socket.

在 3.7 版的變更: Even though the method was always documented as a coroutine method, before Python 3.7 it returned a `Future`. Since Python 3.7, this is an `async def` method.

coroutine `loop.sock_sendto(sock, data, address)`

Send a datagram from *sock* to *address*. Asynchronous version of `socket.sendto()`.

Return the number of bytes sent.

sock must be a non-blocking socket.

在 3.11 版新加入.

coroutine `loop.sock_connect(sock, address)`

Connect *sock* to a remote socket at *address*.

Asynchronous version of `socket.connect()`.

sock must be a non-blocking socket.

在 3.5.2 版的變更: *address* no longer needs to be resolved. `sock_connect` will try to check if the *address* is already resolved by calling `socket.inet_pton()`. If not, `loop.getaddrinfo()` will be used to resolve the *address*.

也參考:

`loop.create_connection()` and `asyncio.open_connection()`.

coroutine `loop.sock_accept(sock)`

Accept a connection. Modeled after the blocking `socket.accept()` method.

The socket must be bound to an address and listening for connections. The return value is a pair (*conn*, *address*) where *conn* is a new socket object usable to send and receive data on the connection, and *address* is the address bound to the socket on the other end of the connection.

sock must be a non-blocking socket.

在 3.7 版的變更: Even though the method was always documented as a coroutine method, before Python 3.7 it returned a `Future`. Since Python 3.7, this is an `async def` method.

也參考:

`loop.create_server()` 和 `start_server()`。

coroutine `loop.sock_sendfile(sock, file, offset=0, count=None, *, fallback=True)`

Send a file using high-performance `os.sendfile` if possible. Return the total number of bytes sent.

Asynchronous version of `socket.sendfile()`.

sock must be a non-blocking `socket.SOCK_STREAM` socket.

file must be a regular file object open in binary mode.

offset tells from where to start reading the file. If specified, *count* is the total number of bytes to transmit as opposed to sending the file until EOF is reached. File position is always updated, even when this method raises an error, and `file.tell()` can be used to obtain the actual number of bytes sent.

fallback, when set to `True`, makes `asyncio` manually read and send the file when the platform does not support the `sendfile` syscall (e.g. Windows or SSL socket on Unix).

Raise `SendfileNotAvailableError` if the system does not support `sendfile` syscall and *fallback* is `False`.

sock must be a non-blocking socket.

在 3.7 版新加入。

DNS

coroutine `loop.getaddrinfo(host, port, *, family=0, type=0, proto=0, flags=0)`

Asynchronous version of `socket.getaddrinfo()`.

coroutine `loop.getnameinfo(sockaddr, flags=0)`

Asynchronous version of `socket.getnameinfo()`.

在 3.7 版的變更: Both `getaddrinfo` and `getnameinfo` methods were always documented to return a coroutine, but prior to Python 3.7 they were, in fact, returning `asyncio.Future` objects. Starting with Python 3.7 both methods are coroutines.

Working with pipes

coroutine `loop.connect_read_pipe(protocol_factory, pipe)`

Register the read end of *pipe* in the event loop.

protocol_factory must be a callable returning an *asyncio protocol* implementation.

pipe is a *file-like object*.

Return pair (*transport*, *protocol*), where *transport* supports the *ReadTransport* interface and *protocol* is an object instantiated by the *protocol_factory*.

With *SelectorEventLoop* event loop, the *pipe* is set to non-blocking mode.

coroutine `loop.connect_write_pipe(protocol_factory, pipe)`

Register the write end of *pipe* in the event loop.

protocol_factory must be a callable returning an *asyncio protocol* implementation.

pipe is *file-like object*.

Return pair (*transport*, *protocol*), where *transport* supports *WriteTransport* interface and *protocol* is an object instantiated by the *protocol_factory*.

With *SelectorEventLoop* event loop, the *pipe* is set to non-blocking mode.

備F: *SelectorEventLoop* does not support the above methods on Windows. Use *ProactorEventLoop* instead for Windows.

也參考:

The `loop.subprocess_exec()` and `loop.subprocess_shell()` methods.

Unix signals

`loop.add_signal_handler(signum, callback, *args)`

Set *callback* as the handler for the *signum* signal.

The callback will be invoked by *loop*, along with other queued callbacks and runnable coroutines of that event loop. Unlike signal handlers registered using `signal.signal()`, a callback registered with this function is allowed to interact with the event loop.

Raise *ValueError* if the signal number is invalid or uncatchable. Raise *RuntimeError* if there is a problem setting up the handler.

Use `functools.partial()` to pass keyword arguments to *callback*.

Like `signal.signal()`, this function must be invoked in the main thread.

`loop.remove_signal_handler(sig)`

Remove the handler for the *sig* signal.

Return *True* if the signal handler was removed, or *False* if no handler was set for the given signal.

適用: Unix。

也參考:

The *signal* module.

Executing code in thread or process pools

awaitable `loop.run_in_executor(executor, func, *args)`

Arrange for *func* to be called in the specified executor.

The *executor* argument should be an `concurrent.futures.Executor` instance. The default executor is used if *executor* is `None`.

範例：

```
import asyncio
import concurrent.futures

def blocking_io():
    # File operations (such as logging) can block the
    # event loop: run them in a thread pool.
    with open('/dev/urandom', 'rb') as f:
        return f.read(100)

def cpu_bound():
    # CPU-bound operations will block the event loop:
    # in general it is preferable to run them in a
    # process pool.
    return sum(i * i for i in range(10 ** 7))

async def main():
    loop = asyncio.get_running_loop()

    ## Options:

    # 1. Run in the default loop's executor:
    result = await loop.run_in_executor(
        None, blocking_io)
    print('default thread pool', result)

    # 2. Run in a custom thread pool:
    with concurrent.futures.ThreadPoolExecutor() as pool:
        result = await loop.run_in_executor(
            pool, blocking_io)
        print('custom thread pool', result)

    # 3. Run in a custom process pool:
    with concurrent.futures.ProcessPoolExecutor() as pool:
        result = await loop.run_in_executor(
            pool, cpu_bound)
        print('custom process pool', result)

if __name__ == '__main__':
    asyncio.run(main())
```

Note that the entry point guard (`if __name__ == '__main__':`) is required for option 3 due to the peculiarities of *multiprocessing*, which is used by `ProcessPoolExecutor`. See *Safe importing of main module*.

This method returns a `asyncio.Future` object.

Use `functools.partial()` to pass keyword arguments to *func*.

在 3.5.3 版的變更: `loop.run_in_executor()` no longer configures the `max_workers` of the thread pool executor it creates, instead leaving it up to the thread pool executor (`ThreadPoolExecutor`) to set the default.

`loop.set_default_executor(executor)`

Set *executor* as the default executor used by `run_in_executor()`. *executor* must be an instance of

ThreadPoolExecutor.

在 3.11 版的變更: *executor* must be an instance of *ThreadPoolExecutor*.

Error Handling API

Allows customizing how exceptions are handled in the event loop.

`loop.set_exception_handler(handler)`

Set *handler* as the new event loop exception handler.

If *handler* is `None`, the default exception handler will be set. Otherwise, *handler* must be a callable with the signature matching `(loop, context)`, where *loop* is a reference to the active event loop, and *context* is a `dict` object containing the details of the exception (see `call_exception_handler()` documentation for details about context).

`loop.get_exception_handler()`

Return the current exception handler, or `None` if no custom exception handler was set.

在 3.5.2 版新加入.

`loop.default_exception_handler(context)`

Default exception handler.

This is called when an exception occurs and no exception handler is set. This can be called by a custom exception handler that wants to defer to the default handler behavior.

context parameter has the same meaning as in `call_exception_handler()`.

`loop.call_exception_handler(context)`

Call the current event loop exception handler.

context is a `dict` object containing the following keys (new keys may be introduced in future Python versions):

- 'message': Error message;
- 'exception' (optional): Exception object;
- 'future' (optional): *asyncio.Future* instance;
- 'task' (optional): *asyncio.Task* instance;
- 'handle' (optional): *asyncio.Handle* instance;
- 'protocol' (optional): *Protocol* instance;
- 'transport' (optional): *Transport* instance;
- 'socket' (optional): *socket.socket* instance;
- 'asyncgen' (optional): **Asynchronous generator that caused the exception.**

備 F: This method should not be overloaded in subclassed event loops. For custom exception handling, use the `set_exception_handler()` method.

Enabling debug mode

`loop.get_debug()`

Get the debug mode (*bool*) of the event loop.

The default value is `True` if the environment variable `PYTHONASYNCIODEBUG` is set to a non-empty string, `False` otherwise.

`loop.set_debug(enabled: bool)`

Set the debug mode of the event loop.

在 3.7 版的變更: The new *Python Development Mode* can now also be used to enable the debug mode.

`loop.slow_callback_duration`

This attribute can be used to set the minimum execution duration in seconds that is considered "slow". When debug mode is enabled, "slow" callbacks are logged.

Default value is 100 milliseconds.

也參考:

The *debug mode of asyncio*.

Running Subprocesses

Methods described in this subsections are low-level. In regular `async/await` code consider using the high-level `asyncio.create_subprocess_shell()` and `asyncio.create_subprocess_exec()` convenience functions instead.

備 F: On Windows, the default event loop *ProactorEventLoop* supports subprocesses, whereas *SelectorEventLoop* does not. See *Subprocess Support on Windows* for details.

coroutine `loop.subprocess_exec(protocol_factory, *args, stdin=subprocess.PIPE, stdout=subprocess.PIPE, stderr=subprocess.PIPE, **kwargs)`

Create a subprocess from one or more string arguments specified by *args*.

args must be a list of strings represented by:

- *str*;
- or *bytes*, encoded to the *filesystem encoding*.

The first string specifies the program executable, and the remaining strings specify the arguments. Together, string arguments form the `argv` of the program.

This is similar to the standard library `subprocess.Popen` class called with `shell=False` and the list of strings passed as the first argument; however, where `Popen` takes a single argument which is list of strings, `subprocess_exec` takes multiple string arguments.

The *protocol_factory* must be a callable returning a subclass of the `asyncio.SubprocessProtocol` class.

其他參數:

- *stdin* can be any of these:
 - a file-like object representing a pipe to be connected to the subprocess's standard input stream using `connect_write_pipe()`
 - the `subprocess.PIPE` constant (default) which will create a new pipe and connect it,
 - the value `None` which will make the subprocess inherit the file descriptor from this process

- the `subprocess.DEVNULL` constant which indicates that the special `os.devnull` file will be used
- `stdout` can be any of these:
 - a file-like object representing a pipe to be connected to the subprocess’s standard output stream using `connect_write_pipe()`
 - the `subprocess.PIPE` constant (default) which will create a new pipe and connect it,
 - the value `None` which will make the subprocess inherit the file descriptor from this process
 - the `subprocess.DEVNULL` constant which indicates that the special `os.devnull` file will be used
- `stderr` can be any of these:
 - a file-like object representing a pipe to be connected to the subprocess’s standard error stream using `connect_write_pipe()`
 - the `subprocess.PIPE` constant (default) which will create a new pipe and connect it,
 - the value `None` which will make the subprocess inherit the file descriptor from this process
 - the `subprocess.DEVNULL` constant which indicates that the special `os.devnull` file will be used
 - the `subprocess.STDOUT` constant which will connect the standard error stream to the process’ standard output stream
- All other keyword arguments are passed to `subprocess.Popen` without interpretation, except for `bufsize`, `universal_newlines`, `shell`, `text`, `encoding` and `errors`, which should not be specified at all.

The `asyncio` subprocess API does not support decoding the streams as text. `bytes.decode()` can be used to convert the bytes returned from the stream to text.

See the constructor of the `subprocess.Popen` class for documentation on other arguments.

Returns a pair of (`transport`, `protocol`), where `transport` conforms to the `asyncio.SubprocessTransport` base class and `protocol` is an object instantiated by the `protocol_factory`.

coroutine `loop.subprocess_shell(protocol_factory, cmd, *, stdin=subprocess.PIPE, stdout=subprocess.PIPE, stderr=subprocess.PIPE, **kwargs)`

Create a subprocess from `cmd`, which can be a `str` or a `bytes` string encoded to the `filesystem encoding`, using the platform’s “shell” syntax.

This is similar to the standard library `subprocess.Popen` class called with `shell=True`.

The `protocol_factory` must be a callable returning a subclass of the `SubprocessProtocol` class.

See `subprocess_exec()` for more details about the remaining arguments.

Returns a pair of (`transport`, `protocol`), where `transport` conforms to the `SubprocessTransport` base class and `protocol` is an object instantiated by the `protocol_factory`.

備 F: It is the application’s responsibility to ensure that all whitespace and special characters are quoted appropriately to avoid `shell injection` vulnerabilities. The `shlex.quote()` function can be used to properly escape whitespace and special characters in strings that are going to be used to construct shell commands.

Callback Handles

class `asyncio.Handle`

A callback wrapper object returned by `loop.call_soon()`, `loop.call_soon_threadsafe()`.

cancel()

Cancel the callback. If the callback has already been canceled or executed, this method has no effect.

cancelled()

Return `True` if the callback was cancelled.

在 3.7 版新加入。

class `asyncio.TimerHandle`

A callback wrapper object returned by `loop.call_later()`, and `loop.call_at()`.

This class is a subclass of `Handle`.

when()

Return a scheduled callback time as `float` seconds.

The time is an absolute timestamp, using the same time reference as `loop.time()`.

在 3.7 版新加入。

Server Objects

Server objects are created by `loop.create_server()`, `loop.create_unix_server()`, `start_server()`, and `start_unix_server()` functions.

Do not instantiate the `Server` class directly.

class `asyncio.Server`

`Server` objects are asynchronous context managers. When used in an `async with` statement, it's guaranteed that the `Server` object is closed and not accepting new connections when the `async with` statement is completed:

```
srv = await loop.create_server(...)

async with srv:
    # some code

# At this point, srv is closed and no longer accepts new connections.
```

在 3.7 版的變更: `Server` object is an asynchronous context manager since Python 3.7.

在 3.11 版的變更: This class was exposed publicly as `asyncio.Server` in Python 3.9.11, 3.10.3 and 3.11.

close()

Stop serving: close listening sockets and set the `sockets` attribute to `None`.

The sockets that represent existing incoming client connections are left open.

The server is closed asynchronously, use the `wait_closed()` coroutine to wait until the server is closed.

get_loop()

Return the event loop associated with the server object.

在 3.7 版新加入。

coroutine start_serving()

Start accepting connections.

This method is idempotent, so it can be called when the server is already serving.

The `start_serving` keyword-only parameter to `loop.create_server()` and `asyncio.start_server()` allows creating a `Server` object that is not accepting connections initially. In this case `Server.start_serving()`, or `Server.serve_forever()` can be used to make the `Server` start accepting connections.

在 3.7 版新加入.

coroutine serve_forever()

Start accepting connections until the coroutine is cancelled. Cancellation of `serve_forever` task causes the server to be closed.

This method can be called if the server is already accepting connections. Only one `serve_forever` task can exist per one `Server` object.

範例:

```
async def client_connected(reader, writer):
    # Communicate with the client with
    # reader/writer streams. For example:
    await reader.readline()

async def main(host, port):
    srv = await asyncio.start_server(
        client_connected, host, port)
    await srv.serve_forever()

asyncio.run(main('127.0.0.1', 0))
```

在 3.7 版新加入.

is_serving()

Return True if the server is accepting new connections.

在 3.7 版新加入.

coroutine wait_closed()

Wait until the `close()` method completes.

sockets

List of socket-like objects, `asyncio.trsock.TransportSocket`, which the server is listening on.

在 3.7 版的變更: Prior to Python 3.7 `Server.sockets` used to return an internal list of server sockets directly. In 3.7 a copy of that list is returned.

Event Loop Implementations

`asyncio` ships with two different event loop implementations: `SelectorEventLoop` and `ProactorEventLoop`.

By default `asyncio` is configured to use `SelectorEventLoop` on Unix and `ProactorEventLoop` on Windows.

class asyncio.SelectorEventLoop

An event loop based on the `selectors` module.

Uses the most efficient *selector* available for the given platform. It is also possible to manually configure the exact selector implementation to be used:

```
import asyncio
import selectors

class MyPolicy(asyncio.DefaultEventLoopPolicy):
    def new_event_loop(self):
        selector = selectors.SelectSelector()
        return asyncio.SelectorEventLoop(selector)

asyncio.set_event_loop_policy(MyPolicy())
```

適用：Unix、Windows。

class `asyncio.ProactorEventLoop`

An event loop for Windows that uses "I/O Completion Ports" (IOCP).

適用：Windows。

也参考：

[MSDN documentation on I/O Completion Ports](#).

class `asyncio.AbstractEventLoop`

Abstract base class for asyncio-compliant event loops.

The *Event Loop Methods* section lists all methods that an alternative implementation of `AbstractEventLoop` should have defined.

范例

Note that all examples in this section **purposefully** show how to use the low-level event loop APIs, such as `loop.run_forever()` and `loop.call_soon()`. Modern asyncio applications rarely need to be written this way; consider using the high-level functions like `asyncio.run()`.

Hello World with `call_soon()`

An example using the `loop.call_soon()` method to schedule a callback. The callback displays "Hello World" and then stops the event loop:

```
import asyncio

def hello_world(loop):
    """A callback to print 'Hello World' and stop the event loop"""
    print('Hello World')
    loop.stop()

loop = asyncio.new_event_loop()

# Schedule a call to hello_world()
loop.call_soon(hello_world, loop)

# Blocking call interrupted by loop.stop()
try:
    loop.run_forever()
finally:
    loop.close()
```

也参考：

A similar *Hello World* example created with a coroutine and the `run()` function.

Display the current date with `call_later()`

An example of a callback displaying the current date every second. The callback uses the `loop.call_later()` method to reschedule itself after 5 seconds, and then stops the event loop:

```
import asyncio
import datetime

def display_date(end_time, loop):
    print(datetime.datetime.now())
    if (loop.time() + 1.0) < end_time:
        loop.call_later(1, display_date, end_time, loop)
    else:
        loop.stop()

loop = asyncio.new_event_loop()

# Schedule the first call to display_date()
end_time = loop.time() + 5.0
loop.call_soon(display_date, end_time, loop)

# Blocking call interrupted by loop.stop()
try:
    loop.run_forever()
finally:
    loop.close()
```

也參考:

A similar *current date* example created with a coroutine and the `run()` function.

Watch a file descriptor for read events

Wait until a file descriptor received some data using the `loop.add_reader()` method and then close the event loop:

```
import asyncio
from socket import socketpair

# Create a pair of connected file descriptors
rsock, wsock = socketpair()

loop = asyncio.new_event_loop()

def reader():
    data = rsock.recv(100)
    print("Received:", data.decode())

    # We are done: unregister the file descriptor
    loop.remove_reader(rsock)

    # Stop the event loop
    loop.stop()

# Register the file descriptor for read event
loop.add_reader(rsock, reader)

# Simulate the reception of data from the network
loop.call_soon(wsock.send, 'abc'.encode())

try:
```

(繼續下一頁)

(繼續上一頁)

```

    # Run the event loop
    loop.run_forever()
finally:
    # We are done. Close sockets and the event loop.
    rsock.close()
    wsock.close()
    loop.close()

```

也參考:

- A similar *example* using transports, protocols, and the `loop.create_connection()` method.
- Another similar *example* using the high-level `asyncio.open_connection()` function and streams.

Set signal handlers for SIGINT and SIGTERM

(This signals example only works on Unix.)

Register handlers for signals `SIGINT` and `SIGTERM` using the `loop.add_signal_handler()` method:

```

import asyncio
import functools
import os
import signal

def ask_exit(signame, loop):
    print("got signal %s: exit" % signame)
    loop.stop()

async def main():
    loop = asyncio.get_running_loop()

    for signame in {'SIGINT', 'SIGTERM'}:
        loop.add_signal_handler(
            getattr(signal, signame),
            functools.partial(ask_exit, signame, loop))

    await asyncio.sleep(3600)

print("Event loop running for 1 hour, press Ctrl+C to interrupt.")
print(f"pid {os.getpid()}: send SIGINT or SIGTERM to exit.")

asyncio.run(main())

```

18.1.9 Futures

原始碼: `Lib/asyncio/futures.py`、`Lib/asyncio/base_futures.py`

Future 物件被用來連結低階回呼式程式和高階 `async/await` 程式。

Future 函式

`asyncio.isfuture(obj)`

如果 *obj* 是下面任意物件，回傳 True：

- 一個 `asyncio.Future` 的實例、
- 一個 `asyncio.Task` 的實例、
- 帶有 `_asyncio_future_blocking` 屬性的類 Future 物件 (Future-like object)。

在 3.5 版新加入。

`asyncio.ensure_future(obj, *, loop=None)`

回傳：

- *obj* 引數會保持原樣，*obj* 須是 `Future`、`Task` 或類 Future 物件（可以用 `isfuture()` 來進行檢查。）
- 包裝 (wrap) 了 *obj* 的 `Task` 物件，如果 *obj* 是一個協程 (coroutine) (可以用 `iscoroutine()` 來進行檢查)；在此情況下該協程將透過 `ensure_future()` 來排程。
- 一個會等待 *obj* 的 `Task` 物件，*obj* 須是一個可等待物件 (`inspect.isawaitable()` 用於測試。)

如果 *obj* 不是上述物件的話會引發一個 `TypeError` 例外。

重要：請見 `create_task()` 函式，它是建立新 Task 的推薦方法。

將參照 (reference) 儲存至此函式的結果，用以防止任務在執行中消失。

在 3.5.1 版的變更：這個函式接受任意 `awaitable` 物件。

在 3.10 版之後被啟用：如果 *obj* 不是類 Future 物件且 *loop* 未被指定，同時有正在執行的事件圈 (event loop)，則會發出警告。

`asyncio.wrap_future(future, *, loop=None)`

將一個 `concurrent.futures.Future` 物件包裝到 `asyncio.Future` 物件中。

在 3.10 版之後被啟用：如果 *future* 不是類 Future 物件且 *loop* 未被指定，同時有正在執行的事件圈，則會發出警告。

Future 物件

`class asyncio.Future(*, loop=None)`

一個 Future 代表一個非同步運算的最終結果。它不支援執行緒安全 (thread-safe)。

Future 是一個 `awaitable` 物件。協程可以等待 Future 物件直到它們有結果或例外被設置、或者被取消。一個 Future 可被多次等待而結果都會是相同的。

Future 通常用於讓低階基於回呼的程式（例如在協定實作中使用 `asyncio transports`）能與高階 `async/await` 程式互動。

經驗法則：永遠不要在提供給使用者的 API 中公開發 Future 物件，同時建議使用 `loop.create_future()` 來建立 Future 物件。如此一來，不同實作的事件圈可以注入自己最佳化實作的 Future 物件。

在 3.7 版的變更：加入對 `contextvars` 模組的支援。

在 3.10 版之後被啟用：如果未指定 *loop* 且有正在執行的事件圈則會發出警告。

result()

回傳 Future 的結果。

如果 Future 狀態是 `done` (完成)，它擁有 `set_result()` 方法設定的一個結果，則回傳該結果之值。

如果 Future 狀態是 `done`，它擁有 `set_exception()` 方法設定的一個例外，那麼這個方法會引發該例外。

如果 Future 已被 `cancelled` (取消)，此方法會引發一個 `CancelledError` 例外。

如果 Future 的結果還不可用，此方法會引發一個 `InvalidStateError` 例外。

set_result(result)

將 Future 標記為 `done` 並設定其結果。

如果 Future 已經 `done` 則引發一個 `InvalidStateError` 錯誤。

set_exception(exception)

將 Future 標記為 `done` 並設定一個例外。

如果 Future 已經 `done` 則引發一個 `InvalidStateError` 錯誤。

done()

如果 Future 已 `done` 則回傳 `True`。

如果 Future 有被 `cancelled`、`set_result()` 有被呼叫來其設定結果、或 `set_exception()` 有被呼叫其設定例外，那麼它就是 `done`。

cancelled()

如果 Future 已經被 `cancelled` 則回傳 `True`。

這個方法通常在 Future 設定結果或例外前用來確認它還未被 `cancelled`：

```
if not fut.cancelled():
    fut.set_result(42)
```

add_done_callback(callback, *, context=None)

新增一個在 Future 是 `done` 時執行的回呼函式。

呼叫 `callback` 時附帶做其唯一引數的 Future 物件。

如果呼叫這個方法時 Future 已經 `done`，回呼函式會被 `loop.call_soon()` 排程。

可選僅限關鍵字引數 `context` 用來指定一個讓 `callback` 執行於其中的客體化 `ContextVars` `Context` 物件。如果沒有提供 `context`，則使用當前情境。

可以用 `functools.partial()` 傳遞引數給回呼函式，例如：

```
# Call 'print("Future:", fut)' when "fut" is done.
fut.add_done_callback(
    functools.partial(print, "Future:"))
```

在 3.7 版的變更：加入僅限關鍵字參數 `context`。更多細節請參閱 [PEP 567](#)。

remove_done_callback(callback)

從回呼列表中移除 `callback`。

回傳被移除的回呼函式數量，通常為 1，除非一個回呼函式被多次加入。

cancel(msg=None)

取消 Future 的回呼函式排程。

如果 Future 已經是 `done` 或 `cancelled`，回傳 `False`。否則將 Future 狀態改為 `cancelled` 並在回呼函式排程後回傳 `True`。

在 3.9 版的變更：新增 `msg` 參數。

exception()

回傳被設定於此 Future 的例外。

只有 Future 在 *done* 時才回傳例外（如果沒有設定例外則回傳 None）。

如果 Future 已被 *cancelled*（取消），此方法會引發一個 *CancelledError* 例外。

如果 Future 還不 *done*，此方法會引發一個 *InvalidStateError* 例外。

get_loop()

回傳已被 Future 物件綁結 (bind) 的事件圈。

在 3.7 版新加入。

這個例子建立一個 Future 物件，建立一個非同步 Task 其排程以設定 Future 結果，然後等待 Future 結果出現：

```
async def set_after(fut, delay, value):
    # Sleep for *delay* seconds.
    await asyncio.sleep(delay)

    # Set *value* as a result of *fut* Future.
    fut.set_result(value)

async def main():
    # Get the current event loop.
    loop = asyncio.get_running_loop()

    # Create a new Future object.
    fut = loop.create_future()

    # Run "set_after()" coroutine in a parallel Task.
    # We are using the low-level "loop.create_task()" API here because
    # we already have a reference to the event loop at hand.
    # Otherwise we could have just used "asyncio.create_task()".
    loop.create_task(
        set_after(fut, 1, '... world'))

    print('hello ...')

    # Wait until *fut* has a result (1 second) and print it.
    print(await fut)

asyncio.run(main())
```

重要：該 Future 物件是模仿 *concurrent.futures.Future* 而設計。主要差別包含：

- 與 *asyncio* 的 Future 不同，*concurrent.futures.Future* 實例不可被等待。
- *asyncio.Future.result()* 和 *asyncio.Future.exception()* 不接受 *timeout* 引數。
- Future 不 *done* 時 *asyncio.Future.result()* 和 *asyncio.Future.exception()* 會引發一個 *InvalidStateError* 例外。
- 使用 *asyncio.Future.add_done_callback()* 綁結的回呼函式不會立即呼叫，而是被 *loop.call_soon()* 排程。
- *asyncio* Future 不能與 *concurrent.futures.wait()* 和 *concurrent.futures.as_completed()* 函式相容。
- *asyncio.Future.cancel()* accepts an optional msg argument, but *concurrent.futures.Future.cancel()* does not.

18.1.10 Transports and Protocols

Preface

Transports and Protocols are used by the **low-level** event loop APIs such as `loop.create_connection()`. They use callback-based programming style and enable high-performance implementations of network or IPC protocols (e.g. HTTP).

Essentially, transports and protocols should only be used in libraries and frameworks and never in high-level asyncio applications.

This documentation page covers both *Transports* and *Protocols*.

Introduction

At the highest level, the transport is concerned with *how* bytes are transmitted, while the protocol determines *which* bytes to transmit (and to some extent when).

A different way of saying the same thing: a transport is an abstraction for a socket (or similar I/O endpoint) while a protocol is an abstraction for an application, from the transport's point of view.

Yet another view is the transport and protocol interfaces together define an abstract interface for using network I/O and interprocess I/O.

There is always a 1:1 relationship between transport and protocol objects: the protocol calls transport methods to send data, while the transport calls protocol methods to pass it data that has been received.

Most of connection oriented event loop methods (such as `loop.create_connection()`) usually accept a *protocol_factory* argument used to create a *Protocol* object for an accepted connection, represented by a *Transport* object. Such methods usually return a tuple of (transport, protocol).



This documentation page contains the following sections:

- The *Transports* section documents asyncio *BaseTransport*, *ReadTransport*, *WriteTransport*, *Transport*, *DatagramTransport*, and *SubprocessTransport* classes.
- The *Protocols* section documents asyncio *BaseProtocol*, *Protocol*, *BufferedProtocol*, *DatagramProtocol*, and *SubprocessProtocol* classes.
- The *Examples* section showcases how to work with transports, protocols, and low-level event loop APIs.

Transports

原始碼: [Lib/asyncio/transports.py](https://github.com/python/asyncio/blob/master/lib/asyncio/transports.py)

Transports are classes provided by *asyncio* in order to abstract various kinds of communication channels.

Transport objects are always instantiated by an *asyncio event loop*.

asyncio implements transports for TCP, UDP, SSL, and subprocess pipes. The methods available on a transport depend on the transport's kind.

The transport classes are *not thread safe*.

Transports Hierarchy

class `asyncio.BaseTransport`

Base class for all transports. Contains methods that all asyncio transports share.

class `asyncio.WriteTransport` (*BaseTransport*)

A base transport for write-only connections.

Instances of the *WriteTransport* class are returned from the `loop.connect_write_pipe()` event loop method and are also used by subprocess-related methods like `loop.subprocess_exec()`.

class `asyncio.ReadTransport` (*BaseTransport*)

A base transport for read-only connections.

Instances of the *ReadTransport* class are returned from the `loop.connect_read_pipe()` event loop method and are also used by subprocess-related methods like `loop.subprocess_exec()`.

class `asyncio.Transport` (*WriteTransport*, *ReadTransport*)

Interface representing a bidirectional transport, such as a TCP connection.

The user does not instantiate a transport directly; they call a utility function, passing it a protocol factory and other information necessary to create the transport and protocol.

Instances of the *Transport* class are returned from or used by event loop methods like `loop.create_connection()`, `loop.create_unix_connection()`, `loop.create_server()`, `loop.sendfile()`, etc.

class `asyncio.DatagramTransport` (*BaseTransport*)

A transport for datagram (UDP) connections.

Instances of the *DatagramTransport* class are returned from the `loop.create_datagram_endpoint()` event loop method.

class `asyncio.SubprocessTransport` (*BaseTransport*)

An abstraction to represent a connection between a parent and its child OS process.

Instances of the *SubprocessTransport* class are returned from event loop methods `loop.subprocess_shell()` and `loop.subprocess_exec()`.

Base Transport

`BaseTransport.close()`

Close the transport.

If the transport has a buffer for outgoing data, buffered data will be flushed asynchronously. No more data will be received. After all buffered data is flushed, the protocol's `protocol.connection_lost()` method will be called with *None* as its argument. The transport should not be used once it is closed.

`BaseTransport.is_closing()`

Return True if the transport is closing or is closed.

`BaseTransport.get_extra_info` (*name*, *default=None*)

Return information about the transport or underlying resources it uses.

name is a string representing the piece of transport-specific information to get.

default is the value to return if the information is not available, or if the transport does not support querying it with the given third-party event loop implementation or on the current platform.

For example, the following code attempts to get the underlying socket object of the transport:

```
sock = transport.get_extra_info('socket')
if sock is not None:
    print(sock.getsockopt(...))
```

Categories of information that can be queried on some transports:

- **socket:**
 - 'peername': the remote address to which the socket is connected, result of `socket.socket.getpeername()` (None on error)
 - 'socket': `socket.socket` instance
 - 'sockname': the socket's own address, result of `socket.socket.getsockname()`
- **SSL socket:**
 - 'compression': the compression algorithm being used as a string, or None if the connection isn't compressed; result of `ssl.SSLSocket.compression()`
 - 'cipher': a three-value tuple containing the name of the cipher being used, the version of the SSL protocol that defines its use, and the number of secret bits being used; result of `ssl.SSLSocket.cipher()`
 - 'peercert': peer certificate; result of `ssl.SSLSocket.getpeercert()`
 - 'sslcontext': `ssl.SSLContext` instance
 - 'ssl_object': `ssl.SSLObject` or `ssl.SSLSocket` instance
- **pipe:**
 - 'pipe': pipe object
- **subprocess:**
 - 'subprocess': `subprocess.Popen` instance

`BaseTransport.set_protocol(protocol)`

Set a new protocol.

Switching protocol should only be done when both protocols are documented to support the switch.

`BaseTransport.get_protocol()`

Return the current protocol.

Read-only Transports

`ReadTransport.is_reading()`

Return True if the transport is receiving new data.

在 3.7 版新加入.

`ReadTransport.pause_reading()`

Pause the receiving end of the transport. No data will be passed to the protocol's `protocol.data_received()` method until `resume_reading()` is called.

在 3.7 版的變更: The method is idempotent, i.e. it can be called when the transport is already paused or closed.

`ReadTransport.resume_reading()`

Resume the receiving end. The protocol's `protocol.data_received()` method will be called once again if some data is available for reading.

在 3.7 版的變更: The method is idempotent, i.e. it can be called when the transport is already reading.

Write-only Transports

`WriteTransport.abort()`

Close the transport immediately, without waiting for pending operations to complete. Buffered data will be lost. No more data will be received. The protocol's `protocol.connection_lost()` method will eventually be called with `None` as its argument.

`WriteTransport.can_write_eof()`

Return `True` if the transport supports `write_eof()`, `False` if not.

`WriteTransport.get_write_buffer_size()`

Return the current size of the output buffer used by the transport.

`WriteTransport.get_write_buffer_limits()`

Get the *high* and *low* watermarks for write flow control. Return a tuple (*low*, *high*) where *low* and *high* are positive number of bytes.

Use `set_write_buffer_limits()` to set the limits.

在 3.4.2 版新加入.

`WriteTransport.set_write_buffer_limits(high=None, low=None)`

Set the *high* and *low* watermarks for write flow control.

These two values (measured in number of bytes) control when the protocol's `protocol.pause_writing()` and `protocol.resume_writing()` methods are called. If specified, the low watermark must be less than or equal to the high watermark. Neither *high* nor *low* can be negative.

`pause_writing()` is called when the buffer size becomes greater than or equal to the *high* value. If writing has been paused, `resume_writing()` is called when the buffer size becomes less than or equal to the *low* value.

The defaults are implementation-specific. If only the high watermark is given, the low watermark defaults to an implementation-specific value less than or equal to the high watermark. Setting *high* to zero forces *low* to zero as well, and causes `pause_writing()` to be called whenever the buffer becomes non-empty. Setting *low* to zero causes `resume_writing()` to be called only once the buffer is empty. Use of zero for either limit is generally sub-optimal as it reduces opportunities for doing I/O and computation concurrently.

Use `get_write_buffer_limits()` to get the limits.

`WriteTransport.write(data)`

Write some *data* bytes to the transport.

This method does not block; it buffers the data and arranges for it to be sent out asynchronously.

`WriteTransport.writelines(list_of_data)`

Write a list (or any iterable) of data bytes to the transport. This is functionally equivalent to calling `write()` on each element yielded by the iterable, but may be implemented more efficiently.

`WriteTransport.write_eof()`

Close the write end of the transport after flushing all buffered data. Data may still be received.

This method can raise `NotImplementedError` if the transport (e.g. SSL) doesn't support half-closed connections.

Datagram Transports

`DatagramTransport.sendto(data, addr=None)`

Send the *data* bytes to the remote peer given by *addr* (a transport-dependent target address). If *addr* is *None*, the data is sent to the target address given on transport creation.

This method does not block; it buffers the data and arranges for it to be sent out asynchronously.

`DatagramTransport.abort()`

Close the transport immediately, without waiting for pending operations to complete. Buffered data will be lost. No more data will be received. The protocol's `protocol.connection_lost()` method will eventually be called with *None* as its argument.

Subprocess Transports

`SubprocessTransport.get_pid()`

Return the subprocess process id as an integer.

`SubprocessTransport.get_pipe_transport(fd)`

Return the transport for the communication pipe corresponding to the integer file descriptor *fd*:

- 0: readable streaming transport of the standard input (*stdin*), or *None* if the subprocess was not created with `stdin=PIPE`
- 1: writable streaming transport of the standard output (*stdout*), or *None* if the subprocess was not created with `stdout=PIPE`
- 2: writable streaming transport of the standard error (*stderr*), or *None* if the subprocess was not created with `stderr=PIPE`
- other *fd*: *None*

`SubprocessTransport.get_returncode()`

Return the subprocess return code as an integer or *None* if it hasn't returned, which is similar to the `subprocess.Popen.returncode` attribute.

`SubprocessTransport.kill()`

Kill the subprocess.

On POSIX systems, the function sends SIGKILL to the subprocess. On Windows, this method is an alias for `terminate()`.

另請參閱 `subprocess.Popen.kill()`。

`SubprocessTransport.send_signal(signal)`

Send the *signal* number to the subprocess, as in `subprocess.Popen.send_signal()`.

`SubprocessTransport.terminate()`

Stop the subprocess.

On POSIX systems, this method sends `SIGTERM` to the subprocess. On Windows, the Windows API function `TerminateProcess()` is called to stop the subprocess.

另請參閱 `subprocess.Popen.terminate()`。

`SubprocessTransport.close()`

Kill the subprocess by calling the `kill()` method.

If the subprocess hasn't returned yet, and close transports of *stdin*, *stdout*, and *stderr* pipes.

Protocols

原始碼: <Lib/asyncio/protocols.py>

asyncio provides a set of abstract base classes that should be used to implement network protocols. Those classes are meant to be used together with *transports*.

Subclasses of abstract base protocol classes may implement some or all methods. All these methods are callbacks: they are called by transports on certain events, for example when some data is received. A base protocol method should be called by the corresponding transport.

Base Protocols

class `asyncio.BaseProtocol`

Base protocol with methods that all protocols share.

class `asyncio.Protocol` (*BaseProtocol*)

The base class for implementing streaming protocols (TCP, Unix sockets, etc).

class `asyncio.BufferedProtocol` (*BaseProtocol*)

A base class for implementing streaming protocols with manual control of the receive buffer.

class `asyncio.DatagramProtocol` (*BaseProtocol*)

The base class for implementing datagram (UDP) protocols.

class `asyncio.SubprocessProtocol` (*BaseProtocol*)

The base class for implementing protocols communicating with child processes (unidirectional pipes).

Base Protocol

All asyncio protocols can implement Base Protocol callbacks.

Connection Callbacks

Connection callbacks are called on all protocols, exactly once per a successful connection. All other protocol callbacks can only be called between those two methods.

`BaseProtocol.connection_made` (*transport*)

Called when a connection is made.

The *transport* argument is the transport representing the connection. The protocol is responsible for storing the reference to its transport.

`BaseProtocol.connection_lost` (*exc*)

Called when the connection is lost or closed.

The argument is either an exception object or *None*. The latter means a regular EOF is received, or the connection was aborted or closed by this side of the connection.

Flow Control Callbacks

Flow control callbacks can be called by transports to pause or resume writing performed by the protocol.

See the documentation of the `set_write_buffer_limits()` method for more details.

`BaseProtocol.pause_writing()`

Called when the transport's buffer goes over the high watermark.

`BaseProtocol.resume_writing()`

Called when the transport's buffer drains below the low watermark.

If the buffer size equals the high watermark, `pause_writing()` is not called: the buffer size must go strictly over.

Conversely, `resume_writing()` is called when the buffer size is equal or lower than the low watermark. These end conditions are important to ensure that things go as expected when either mark is zero.

Streaming Protocols

Event methods, such as `loop.create_server()`, `loop.create_unix_server()`, `loop.create_connection()`, `loop.create_unix_connection()`, `loop.connect_accepted_socket()`, `loop.connect_read_pipe()`, and `loop.connect_write_pipe()` accept factories that return streaming protocols.

`Protocol.data_received(data)`

Called when some data is received. `data` is a non-empty bytes object containing the incoming data.

Whether the data is buffered, chunked or reassembled depends on the transport. In general, you shouldn't rely on specific semantics and instead make your parsing generic and flexible. However, data is always received in the correct order.

The method can be called an arbitrary number of times while a connection is open.

However, `protocol.eof_received()` is called at most once. Once `eof_received()` is called, `data_received()` is not called anymore.

`Protocol.eof_received()`

Called when the other end signals it won't send any more data (for example by calling `transport.write_eof()`, if the other end also uses asyncio).

This method may return a false value (including `None`), in which case the transport will close itself. Conversely, if this method returns a true value, the protocol used determines whether to close the transport. Since the default implementation returns `None`, it implicitly closes the connection.

Some transports, including SSL, don't support half-closed connections, in which case returning true from this method will result in the connection being closed.

State machine:

```
start -> connection_made
      [-> data_received]*
      [-> eof_received]?
      -> connection_lost -> end
```

Buffered Streaming Protocols

在 3.7 版新加入。

Buffered Protocols can be used with any event loop method that supports *Streaming Protocols*.

BufferedProtocol implementations allow explicit manual allocation and control of the receive buffer. Event loops can then use the buffer provided by the protocol to avoid unnecessary data copies. This can result in noticeable performance improvement for protocols that receive big amounts of data. Sophisticated protocol implementations can significantly reduce the number of buffer allocations.

The following callbacks are called on *BufferedProtocol* instances:

BufferedProtocol.**get_buffer**(*sizehint*)

Called to allocate a new receive buffer.

sizehint is the recommended minimum size for the returned buffer. It is acceptable to return smaller or larger buffers than what *sizehint* suggests. When set to -1, the buffer size can be arbitrary. It is an error to return a buffer with a zero size.

`get_buffer()` must return an object implementing the buffer protocol.

BufferedProtocol.**buffer_updated**(*nbytes*)

Called when the buffer was updated with the received data.

nbytes is the total number of bytes that were written to the buffer.

BufferedProtocol.**eof_received**()

See the documentation of the *protocol.eof_received()* method.

get_buffer() can be called an arbitrary number of times during a connection. However, *protocol.eof_received()* is called at most once and, if called, *get_buffer()* and *buffer_updated()* won't be called after it.

State machine:

```
start -> connection_made
      [-> get_buffer
        [-> buffer_updated]?
      ]*
      [-> eof_received]?
-> connection_lost -> end
```

Datagram Protocols

Datagram Protocol instances should be constructed by protocol factories passed to the *loop.create_datagram_endpoint()* method.

DatagramProtocol.**datagram_received**(*data*, *addr*)

Called when a datagram is received. *data* is a bytes object containing the incoming data. *addr* is the address of the peer sending the data; the exact format depends on the transport.

DatagramProtocol.**error_received**(*exc*)

Called when a previous send or receive operation raises an *OSError*. *exc* is the *OSError* instance.

This method is called in rare conditions, when the transport (e.g. UDP) detects that a datagram could not be delivered to its recipient. In many conditions though, undeliverable datagrams will be silently dropped.

備 F: On BSD systems (macOS, FreeBSD, etc.) flow control is not supported for datagram protocols, because there is no reliable way to detect send failures caused by writing too many packets.

The socket always appears 'ready' and excess packets are dropped. An `OSError` with `errno` set to `errno.ENOBUFS` may or may not be raised; if it is raised, it will be reported to `DatagramProtocol.error_received()` but otherwise ignored.

Subprocess Protocols

Subprocess Protocol instances should be constructed by protocol factories passed to the `loop.subprocess_exec()` and `loop.subprocess_shell()` methods.

`SubprocessProtocol.pipe_data_received(fd, data)`

Called when the child process writes data into its stdout or stderr pipe.

`fd` is the integer file descriptor of the pipe.

`data` is a non-empty bytes object containing the received data.

`SubprocessProtocol.pipe_connection_lost(fd, exc)`

Called when one of the pipes communicating with the child process is closed.

`fd` is the integer file descriptor that was closed.

`SubprocessProtocol.process_exited()`

Called when the child process has exited.

It can be called before `pipe_data_received()` and `pipe_connection_lost()` methods.

范例

TCP Echo Server

Create a TCP echo server using the `loop.create_server()` method, send back received data, and close the connection:

```
import asyncio

class EchoServerProtocol(asyncio.Protocol):
    def connection_made(self, transport):
        peername = transport.get_extra_info('peername')
        print('Connection from {}'.format(peername))
        self.transport = transport

    def data_received(self, data):
        message = data.decode()
        print('Data received: {!r}'.format(message))

        print('Send: {!r}'.format(message))
        self.transport.write(data)

        print('Close the client socket')
        self.transport.close()

async def main():
    # Get a reference to the event loop as we plan to use
    # low-level APIs.
    loop = asyncio.get_running_loop()

    server = await loop.create_server(
```

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```
lambda: EchoServerProtocol(),
      '127.0.0.1', 8888)

async with server:
    await server.serve_forever()

asyncio.run(main())
```

也參考:

The *TCP echo server using streams* example uses the high-level `asyncio.start_server()` function.

TCP Echo Client

A TCP echo client using the `loop.create_connection()` method, sends data, and waits until the connection is closed:

```
import asyncio

class EchoClientProtocol(asyncio.Protocol):
    def __init__(self, message, on_con_lost):
        self.message = message
        self.on_con_lost = on_con_lost

    def connection_made(self, transport):
        transport.write(self.message.encode())
        print('Data sent: {!r}'.format(self.message))

    def data_received(self, data):
        print('Data received: {!r}'.format(data.decode()))

    def connection_lost(self, exc):
        print('The server closed the connection')
        self.on_con_lost.set_result(True)

async def main():
    # Get a reference to the event loop as we plan to use
    # low-level APIs.
    loop = asyncio.get_running_loop()

    on_con_lost = loop.create_future()
    message = 'Hello World!'

    transport, protocol = await loop.create_connection(
        lambda: EchoClientProtocol(message, on_con_lost),
        '127.0.0.1', 8888)

    # Wait until the protocol signals that the connection
    # is lost and close the transport.
    try:
        await on_con_lost
    finally:
        transport.close()

asyncio.run(main())
```

也參考:

The *TCP echo client using streams* example uses the high-level `asyncio.open_connection()` function.

UDP Echo Server

A UDP echo server, using the `loop.create_datagram_endpoint()` method, sends back received data:

```
import asyncio

class EchoServerProtocol:
    def connection_made(self, transport):
        self.transport = transport

    def datagram_received(self, data, addr):
        message = data.decode()
        print('Received %r from %s' % (message, addr))
        print('Send %r to %s' % (message, addr))
        self.transport.sendto(data, addr)

async def main():
    print("Starting UDP server")

    # Get a reference to the event loop as we plan to use
    # low-level APIs.
    loop = asyncio.get_running_loop()

    # One protocol instance will be created to serve all
    # client requests.
    transport, protocol = await loop.create_datagram_endpoint(
        lambda: EchoServerProtocol(),
        local_addr=('127.0.0.1', 9999))

    try:
        await asyncio.sleep(3600) # Serve for 1 hour.
    finally:
        transport.close()

asyncio.run(main())
```

UDP Echo Client

A UDP echo client, using the `loop.create_datagram_endpoint()` method, sends data and closes the transport when it receives the answer:

```
import asyncio

class EchoClientProtocol:
    def __init__(self, message, on_con_lost):
        self.message = message
        self.on_con_lost = on_con_lost
        self.transport = None

    def connection_made(self, transport):
        self.transport = transport
```

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```

        print('Send:', self.message)
        self.transport.sendto(self.message.encode())

    def datagram_received(self, data, addr):
        print("Received:", data.decode())

        print("Close the socket")
        self.transport.close()

    def error_received(self, exc):
        print('Error received:', exc)

    def connection_lost(self, exc):
        print("Connection closed")
        self.on_con_lost.set_result(True)

async def main():
    # Get a reference to the event loop as we plan to use
    # low-level APIs.
    loop = asyncio.get_running_loop()

    on_con_lost = loop.create_future()
    message = "Hello World!"

    transport, protocol = await loop.create_datagram_endpoint(
        lambda: EchoClientProtocol(message, on_con_lost),
        remote_addr=('127.0.0.1', 9999))

    try:
        await on_con_lost
    finally:
        transport.close()

asyncio.run(main())

```

Connecting Existing Sockets

Wait until a socket receives data using the `loop.create_connection()` method with a protocol:

```

import asyncio
import socket

class MyProtocol(asyncio.Protocol):

    def __init__(self, on_con_lost):
        self.transport = None
        self.on_con_lost = on_con_lost

    def connection_made(self, transport):
        self.transport = transport

    def data_received(self, data):
        print("Received:", data.decode())

        # We are done: close the transport;
        # connection_lost() will be called automatically.

```

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```

        self.transport.close()

    def connection_lost(self, exc):
        # The socket has been closed
        self.on_con_lost.set_result(True)

async def main():
    # Get a reference to the event loop as we plan to use
    # low-level APIs.
    loop = asyncio.get_running_loop()
    on_con_lost = loop.create_future()

    # Create a pair of connected sockets
    rsock, wsock = socket.socketpair()

    # Register the socket to wait for data.
    transport, protocol = await loop.create_connection(
        lambda: MyProtocol(on_con_lost), sock=rsock)

    # Simulate the reception of data from the network.
    loop.call_soon(wsock.send, 'abc'.encode())

    try:
        await protocol.on_con_lost
    finally:
        transport.close()
        wsock.close()

asyncio.run(main())

```

也參考:

The *watch a file descriptor for read events* example uses the low-level `loop.add_reader()` method to register an FD.

The *register an open socket to wait for data using streams* example uses high-level streams created by the `open_connection()` function in a coroutine.

loop.subprocess_exec() and SubprocessProtocol

An example of a subprocess protocol used to get the output of a subprocess and to wait for the subprocess exit.

The subprocess is created by the `loop.subprocess_exec()` method:

```

import asyncio
import sys

class DateProtocol(asyncio.SubprocessProtocol):
    def __init__(self, exit_future):
        self.exit_future = exit_future
        self.output = bytearray()
        self.pipe_closed = False
        self.exited = False

    def pipe_connection_lost(self, fd, exc):
        self.pipe_closed = True
        self.check_for_exit()

    def pipe_data_received(self, fd, data):
        self.output.extend(data)

```

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```

def process_exited(self):
    self.exited = True
    # process_exited() method can be called before
    # pipe_connection_lost() method: wait until both methods are
    # called.
    self.check_for_exit()

def check_for_exit(self):
    if self.pipe_closed and self.exited:
        self.exit_future.set_result(True)

async def get_date():
    # Get a reference to the event loop as we plan to use
    # low-level APIs.
    loop = asyncio.get_running_loop()

    code = 'import datetime; print(datetime.datetime.now())'
    exit_future = asyncio.Future(loop=loop)

    # Create the subprocess controlled by DateProtocol;
    # redirect the standard output into a pipe.
    transport, protocol = await loop.subprocess_exec(
        lambda: DateProtocol(exit_future),
        sys.executable, '-c', code,
        stdin=None, stderr=None)

    # Wait for the subprocess exit using the process_exited()
    # method of the protocol.
    await exit_future

    # Close the stdout pipe.
    transport.close()

    # Read the output which was collected by the
    # pipe_data_received() method of the protocol.
    data = bytes(protocol.output)
    return data.decode('ascii').rstrip()

date = asyncio.run(get_date())
print(f"Current date: {date}")

```

See also the *same example* written using high-level APIs.

18.1.11 Policies

An event loop policy is a global object used to get and set the current *event loop*, as well as create new event loops. The default policy can be *replaced* with *built-in alternatives* to use different event loop implementations, or substituted by a *custom policy* that can override these behaviors.

The *policy object* gets and sets a separate event loop per *context*. This is per-thread by default, though custom policies could define *context* differently.

Custom event loop policies can control the behavior of `get_event_loop()`, `set_event_loop()`, and `new_event_loop()`.

Policy objects should implement the APIs defined in the `AbstractEventLoopPolicy` abstract base class.

Getting and Setting the Policy

The following functions can be used to get and set the policy for the current process:

```
asyncio.get_event_loop_policy()
```

Return the current process-wide policy.

```
asyncio.set_event_loop_policy(policy)
```

Set the current process-wide policy to *policy*.
If *policy* is set to `None`, the default policy is restored.

Policy Objects

The abstract event loop policy base class is defined as follows:

```
class asyncio.AbstractEventLoopPolicy
```

An abstract base class for asyncio policies.

```
get_event_loop()
```

Get the event loop for the current context.
Return an event loop object implementing the *AbstractEventLoop* interface.
This method should never return `None`.
在 3.6 版的變更.

```
set_event_loop(loop)
```

Set the event loop for the current context to *loop*.

```
new_event_loop()
```

Create and return a new event loop object.
This method should never return `None`.

```
get_child_watcher()
```

Get a child process watcher object.
Return a watcher object implementing the *AbstractChildWatcher* interface.
This function is Unix specific.

```
set_child_watcher(watcher)
```

Set the current child process watcher to *watcher*.
This function is Unix specific.

asyncio ships with the following built-in policies:

```
class asyncio.DefaultEventLoopPolicy
```

The default asyncio policy. Uses *SelectorEventLoop* on Unix and *ProactorEventLoop* on Windows.

There is no need to install the default policy manually. asyncio is configured to use the default policy automatically.

在 3.8 版的變更: On Windows, *ProactorEventLoop* is now used by default.

備 F: In Python versions 3.10.9, 3.11.1 and 3.12 the *get_event_loop()* method of the default asyncio policy emits a *DeprecationWarning* if there is no running event loop and no current loop is set. In some future Python release this will become an error.

class `asyncio.WindowsSelectorEventLoopPolicy`

An alternative event loop policy that uses the *SelectorEventLoop* event loop implementation.

適用: Windows。

class `asyncio.WindowsProactorEventLoopPolicy`

An alternative event loop policy that uses the *ProactorEventLoop* event loop implementation.

適用: Windows。

Process Watchers

A process watcher allows customization of how an event loop monitors child processes on Unix. Specifically, the event loop needs to know when a child process has exited.

In `asyncio`, child processes are created with *create_subprocess_exec()* and *loop.subprocess_exec()* functions.

`asyncio` defines the *AbstractChildWatcher* abstract base class, which child watchers should implement, and has four different implementations: *ThreadedChildWatcher* (configured to be used by default), *MultiLoopChildWatcher*, *SafeChildWatcher*, and *FastChildWatcher*.

See also the *Subprocess and Threads* section.

The following two functions can be used to customize the child process watcher implementation used by the `asyncio` event loop:

`asyncio.get_child_watcher()`

Return the current child watcher for the current policy.

`asyncio.set_child_watcher(watcher)`

Set the current child watcher to *watcher* for the current policy. *watcher* must implement methods defined in the *AbstractChildWatcher* base class.

備 F: Third-party event loops implementations might not support custom child watchers. For such event loops, using *set_child_watcher()* might be prohibited or have no effect.

class `asyncio.AbstractChildWatcher`

`add_child_handler(pid, callback, *args)`

Register a new child handler.

Arrange for *callback(pid, returncode, *args)* to be called when a process with PID equal to *pid* terminates. Specifying another callback for the same process replaces the previous handler.

The *callback* callable must be thread-safe.

`remove_child_handler(pid)`

Removes the handler for process with PID equal to *pid*.

The function returns `True` if the handler was successfully removed, `False` if there was nothing to remove.

`attach_loop(loop)`

Attach the watcher to an event loop.

If the watcher was previously attached to an event loop, then it is first detached before attaching to the new loop.

Note: *loop* may be `None`.

is_active()

Return True if the watcher is ready to use.

Spawning a subprocess with *inactive* current child watcher raises *RuntimeError*.

在 3.8 版新加入。

close()

Close the watcher.

This method has to be called to ensure that underlying resources are cleaned-up.

class asyncio.ThreadedChildWatcher

This implementation starts a new waiting thread for every subprocess spawn.

It works reliably even when the asyncio event loop is run in a non-main OS thread.

There is no noticeable overhead when handling a big number of children ($O(1)$ each time a child terminates), but starting a thread per process requires extra memory.

This watcher is used by default.

在 3.8 版新加入。

class asyncio.MultiLoopChildWatcher

This implementation registers a SIGCHLD signal handler on instantiation. That can break third-party code that installs a custom handler for SIGCHLD signal.

The watcher avoids disrupting other code spawning processes by polling every process explicitly on a SIGCHLD signal.

There is no limitation for running subprocesses from different threads once the watcher is installed.

The solution is safe but it has a significant overhead when handling a big number of processes ($O(n)$ each time a SIGCHLD is received).

在 3.8 版新加入。

class asyncio.SafeChildWatcher

This implementation uses active event loop from the main thread to handle SIGCHLD signal. If the main thread has no running event loop another thread cannot spawn a subprocess (*RuntimeError* is raised).

The watcher avoids disrupting other code spawning processes by polling every process explicitly on a SIGCHLD signal.

This solution is as safe as *MultiLoopChildWatcher* and has the same $O(n)$ complexity but requires a running event loop in the main thread to work.

class asyncio.FastChildWatcher

This implementation reaps every terminated processes by calling `os.waitpid(-1)` directly, possibly breaking other code spawning processes and waiting for their termination.

There is no noticeable overhead when handling a big number of children ($O(1)$ each time a child terminates).

This solution requires a running event loop in the main thread to work, as *SafeChildWatcher*.

class asyncio.PidfdChildWatcher

This implementation polls process file descriptors (pidfds) to await child process termination. In some respects, *PidfdChildWatcher* is a "Goldilocks" child watcher implementation. It doesn't require signals or threads, doesn't interfere with any processes launched outside the event loop, and scales linearly with the number of subprocesses launched by the event loop. The main disadvantage is that pidfds are specific to Linux, and only work on recent (5.3+) kernels.

在 3.9 版新加入。

Custom Policies

To implement a new event loop policy, it is recommended to subclass `DefaultEventLoopPolicy` and override the methods for which custom behavior is wanted, e.g.:

```
class MyEventLoopPolicy(asyncio.DefaultEventLoopPolicy):

    def get_event_loop(self):
        """Get the event loop.

        This may be None or an instance of EventLoop.
        """
        loop = super().get_event_loop()
        # Do something with loop ...
        return loop

asyncio.set_event_loop_policy(MyEventLoopPolicy())
```

18.1.12 平台支援

`asyncio` module (模組) 被設計成可移植的 (portable)，但由於平臺的底層架構和功能不同，在一些平臺上存在細微的差異和限制。

所有平台

- `loop.add_reader()` 和 `loop.add_writer()` 不能用來監視檔案 I/O。

Windows

原始碼: `Lib/asyncio/proactor_events.py`、`Lib/asyncio/windows_events.py`、`Lib/asyncio/windows_utils.py`

在 3.8 版的變更: 在 Windows 上，現在 `ProactorEventLoop` 是預設的事件圈。

Windows 上的所有事件圈都不支援以下 method (方法):

- `loop.create_unix_connection()` 和 `loop.create_unix_server()` are not supported. The `socket.AF_UNIX` socket family is specific to Unix.
- 不支援 `loop.add_signal_handler()` 和 `loop.remove_signal_handler()`。

`SelectorEventLoop` 有以下限制:

- `SelectSelector` 只被用於等待 socket 事件: 它支援 socket 且最多支援 512 個 socket。
- `loop.add_reader()` 和 `loop.add_writer()` 只接受 socket 處理函式 (例如不支援 pipe 檔案描述器 (pipe file descriptor))。
- 因 不支援 pipe, 所以 `loop.connect_read_pipe()` 和 `loop.connect_write_pipe()` method 沒有被實作出來。
- 不支援子行程 (subprocess), 也就是 `loop.subprocess_exec()` 和 `loop.subprocess_shell()` method 沒有被實作出來。

`ProactorEventLoop` 有以下限制:

- 不支援 `loop.add_reader()` 和 `loop.add_writer()` method。

Windows 上單調時鐘 (monotonic clock) 的解析度大約 15.6 毫秒。最佳的解析度是 0.5 毫秒。解析度和硬體 (HPET 是否可用) 與 Windows 的設定有關。

Windows 的子行程支援

在 Windows 上，預設的事件圈 `ProactorEventLoop` 支援子行程，而 `SelectorEventLoop` 則不支援。

也不支援 `policy.set_child_watcher()` 函式，`ProactorEventLoop` 在監視子行程上有不同的機制。

macOS

完整支援現在普遍流行的 macOS 版本。

macOS <= 10.8

在 macOS 10.6、10.7 和 10.8 上，預設的事件圈是使用 `selectors.KqueueSelector`，在這些版本上它不支援字元裝置 (character device)。可以手工設置 `SelectorEventLoop` 來使用 `SelectSelector` 或 `PollSelector` 以在這些舊版 macOS 上支援字元裝置。例如：

```
import asyncio
import selectors

selector = selectors.SelectSelector()
loop = asyncio.SelectorEventLoop(selector)
asyncio.set_event_loop(loop)
```

18.1.13 Extending

The main direction for `asyncio` extending is writing custom *event loop* classes. Asyncio has helpers that could be used to simplify this task.

備註： Third-parties should reuse existing asyncio code with caution, a new Python version is free to break backward compatibility in *internal* part of API.

Writing a Custom Event Loop

`asyncio.AbstractEventLoop` declares very many methods. Implementing all them from scratch is a tedious job.

A loop can get many common methods implementation for free by inheriting from `asyncio.BaseEventLoop`.

In turn, the successor should implement a bunch of *private* methods declared but not implemented in `asyncio.BaseEventLoop`.

For example, `loop.create_connection()` checks arguments, resolves DNS addresses, and calls `loop._make_socket_transport()` that should be implemented by inherited class. The `_make_socket_transport()` method is not documented and is considered as an *internal* API.

Future and Task private constructors

`asyncio.Future` and `asyncio.Task` should be never created directly, please use corresponding `loop.create_future()` and `loop.create_task()`, or `asyncio.create_task()` factories instead.

However, third-party *event loops* may *reuse* built-in future and task implementations for the sake of getting a complex and highly optimized code for free.

For this purpose the following, *private* constructors are listed:

`Future.__init__(*, loop=None)`

Create a built-in future instance.

`loop` is an optional event loop instance.

`Task.__init__(coro, *, loop=None, name=None, context=None)`

Create a built-in task instance.

`loop` is an optional event loop instance. The rest of arguments are described in `loop.create_task()` description.

在 3.11 版的變更: `context` argument is added.

Task lifetime support

A third party task implementation should call the following functions to keep a task visible by `asyncio.all_tasks()` and `asyncio.current_task()`:

`asyncio._register_task(task)`

Register a new *task* as managed by *asyncio*.

Call the function from a task constructor.

`asyncio._unregister_task(task)`

Unregister a *task* from *asyncio* internal structures.

The function should be called when a task is about to finish.

`asyncio._enter_task(loop, task)`

Switch the current task to the *task* argument.

Call the function just before executing a portion of embedded *coroutine* (`coroutine.send()` or `coroutine.throw()`).

`asyncio._leave_task(loop, task)`

Switch the current task back from *task* to `None`.

Call the function just after `coroutine.send()` or `coroutine.throw()` execution.

18.1.14 高階 API 索引

這個頁面列出了所有能使用 `async/await` 的高階 `asyncio` API。

任務 (Tasks)

用於執行非同步程式、建立 Task 物件、帶有超時 (timeout) 設定地等待多個事件的工具程式。

<code>run()</code>	建立事件圈 (event loop)、執行一個協程 (coroutine)、關閉事件圈。
<code>Runner</code>	A context manager that simplifies multiple async function calls.
<code>Task</code>	Task 物件。
<code>TaskGroup</code>	A context manager that holds a group of tasks. Provides a convenient and reliable way to wait for all tasks in the group to finish.
<code>create_task()</code>	啟動一個 asyncio 的 Task 物件，然後回傳它。
<code>current_task()</code>	回傳當前 Task 物件。
<code>all_tasks()</code>	回傳事件圈中所有未完成的 task 物件。
<code>await sleep()</code>	休眠數秒鐘。
<code>await gather()</code>	行 (concurrent) 地執行事件的排程與等待。
<code>await wait_for()</code>	有超時設置的執行。
<code>await shield()</code>	屏蔽取消操作。
<code>await wait()</code>	監控完成情。
<code>timeout()</code>	Run with a timeout. Useful in cases when wait_for is not suitable.
<code>to_thread()</code>	在不同的 OS 執行緒 (thread) 中非同步地執行一個函式。
<code>run_coroutine_threadsafe()</code>	從其他 OS 執行緒中一個協程排程。
<code>for in as_completed()</code>	用 for 圈來監控完成情。

范例

- 使用 `asyncio.gather()` 平行 (parallel) 執行。
- 使用 `asyncio.wait_for()` 制設置超時。
- 取消任務。
- 使用 `asyncio.sleep()`。
- 請參 Tasks 文件頁面。

列 (Queues)

列應被用於多個 asyncio Task 物件分配工作、實作 connection pools (連池) 以及 pub/sub (發行/訂) 模式。

<code>Queue</code>	一個先進先出 (FIFO) 列。
<code>PriorityQueue</code>	一個優先列 (priority queue)。
<code>LifoQueue</code>	一個後進先出 (LIFO) 列。

范例

- 使用 `asyncio.Queue` 多個 *Task* 分配工作。
- 請參 列文件頁面。

子行程 (Subprocesses)

用於衍生 (spawn) 子行程和執行 shell 指令的工具程式。

<code>await create_subprocess_exec()</code>	建立一個子行程。
<code>await create_subprocess_shell()</code>	執行一個 shell 命令。

范例

- 執行一個 *shell* 指令。
- 請參 子行程 *APIs* 相關文件。

串流 (Streams)

用於網路 IO 處理的高階 API。

<code>await open_connection()</code>	建立一個 TCP 連。
<code>await open_unix_connection()</code>	建立一個 Unix socket 連。
<code>await start_server()</code>	動一個 TCP 伺服器。
<code>await start_unix_server()</code>	動一個 Unix socket 伺服器。
<code>StreamReader</code>	接收網路資料的高階 <i>async/await</i> 物件。
<code>StreamWriter</code>	傳送網路資料的高階 <i>async/await</i> 物件。

范例

- *TCP* 客端範例。
- 請參 串流 *APIs* 文件。

同步化 (Synchronization)

類似執行緒且能被用於 *Task* 中的同步化原始物件 (primitive)。

<code>Lock</code>	一個互斥鎖 (mutex lock)。
<code>Event</code>	一個事件物件。
<code>Condition</code>	一個條件物件。
<code>Semaphore</code>	一個旗號 (semaphore) 物件。
<code>BoundedSemaphore</code>	一個有界的旗號物件。
<code>Barrier</code>	一個屏障物件。

范例

- 使用 `asyncio.Event`。
- 使用 `asyncio.Barrier`。
- 請參 [F](#) `asyncio` 關於同步化原始物件的文件。

例外

<code>asyncio.CancelledError</code>	當一 <code>Task</code> 物件被取消時被引發。請參 F <code>Task.cancel()</code> 。
<code>asyncio.BrokenBarrierError</code>	當一 <code>Barrier</code> 物件損壞時被引發。請參 F <code>Barrier.wait()</code> 。

范例

- 在取消請求發生的程式中處理 `CancelledError` 例外。
- 請參 [F](#) `asyncio` 專用例外完整列表。

18.1.15 低階 API 索引

本頁列出所有低階 `asyncio` APIs。

獲取事件 [F](#) 圈

<code>asyncio.get_running_loop()</code>	推薦使用於獲取當前運行事件 F 圈 (event loop) 的函式。
<code>asyncio.get_event_loop()</code>	獲得一個（正在運行的或透過當前 <code>policy</code> 建立的）事件 F 圈實例。
<code>asyncio.set_event_loop()</code>	透過當前 <code>policy</code> 來設定當前事件 F 圈。
<code>asyncio.new_event_loop()</code>	建立一個新的事件 F 圈。

范例

- 使用 `asyncio.get_running_loop()`。

事件 [F](#) 圈方法

也請查 [F](#) 文件中關於 *Event Loop Methods* 的主要段落。

生命期

<code>loop.run_until_complete()</code>	執行一個 <code>Future/Task/awaitable</code> (可等待物件) 直到完成。
<code>loop.run_forever()</code>	持續運行事件圈。
<code>loop.stop()</code>	停止事件圈。
<code>loop.close()</code>	關閉事件圈。
<code>loop.is_running()</code>	如果事件圈正在執行則回傳 <code>True</code> 。
<code>loop.is_closed()</code>	如果事件圈已經被關閉則回傳 <code>True</code> 。
<code>await loop.shutdown_asyncgens()</code>	關閉非同步生成器 (asynchronous generators)。

除錯

<code>loop.set_debug()</code>	開或禁用除錯模式。
<code>loop.get_debug()</code>	獲取當前除錯模式。

回呼函式排程

<code>loop.call_soon()</code>	快調用回呼函式 (callback)。
<code>loop.call_soon_threadsafe()</code>	<code>loop.call_soon()</code> 方法之有支援執行緒安全 (thread-safe) 變體。
<code>loop.call_later()</code>	在給定時間之後調用回呼函式。
<code>loop.call_at()</code>	在給定時間當下調用回呼函式。

執行緒 (Thread)/行程池 (Process Pool)

<code>await loop.run_in_executor()</code>	在 <code>concurrent.futures</code> 執行器 (excutor) 中執行一個 CPU 密集型 (CPU-bound) 或其它阻塞型式的函式。
<code>loop.set_default_executor()</code>	設 <code>loop.run_in_executor()</code> 設定預設執行器。

Tasks 與 Futures

<code>loop.create_future()</code>	建立一個 <code>Future</code> 物件。
<code>loop.create_task()</code>	像是 <code>Task</code> 一樣，協程 (coroutine) 排程。
<code>loop.set_task_factory()</code>	設定被 <code>loop.create_task()</code> 用來建立 <code>Tasks</code> 的工廠函式 (factory)。
<code>loop.get_task_factory()</code>	獲取被 <code>loop.create_task()</code> 用來建立 <code>Tasks</code> 的工廠函式。

DNS

<code>await loop.getaddrinfo()</code>	非同步版本的 <code>socket.getaddrinfo()</code> 。
<code>await loop.getnameinfo()</code>	非同步版本的 <code>socket.getnameinfo()</code> 。

網路和 IPC

<code>await loop.create_connection()</code>	開一個 TCP 連。
<code>await loop.create_server()</code>	建立一個 TCP 伺服器。
<code>await loop.create_unix_connection()</code>	開一個 Unix socket 連。
<code>await loop.create_unix_server()</code>	建立一個 Unix socket 伺服器。
<code>await loop.connect_accepted_socket()</code>	將 <code>socket</code> 包裝成 (transport, protocol)。
<code>await loop.create_datagram_endpoint()</code>	開一個資料單元 (datagram) (UDP) 連。
<code>await loop.sendfile()</code>	透過傳輸通道傳送一個檔案。
<code>await loop.start_tls()</code>	將一個已存在的連升級到 TLS。
<code>await loop.connect_read_pipe()</code>	將 pipe (管道) 讀取端包裝成 (transport, protocol)。
<code>await loop.connect_write_pipe()</code>	將 pipe 寫入端包裝成 (transport, protocol)。

Sockets

<code>await loop.sock_recv()</code>	從 <code>socket</code> 接收資料。
<code>await loop.sock_recv_into()</code>	將從 <code>socket</code> 接收到的資料存放於一個緩衝區 (buffer) 中。
<code>await loop.sock_recvfrom()</code>	從 <code>socket</code> 接收一個資料單元。
<code>await loop.sock_recvfrom_into()</code>	將從 <code>socket</code> 接收到的資料單元存放於一個緩衝區中。
<code>await loop.sock_sendall()</code>	傳送資料到 <code>socket</code> 。
<code>await loop.sock_sendto()</code>	透過 <code>socket</code> 將資料單元傳送至給定的地址。
<code>await loop.sock_connect()</code>	連接 <code>socket</code> 。
<code>await loop.sock_accept()</code>	接受一個 <code>socket</code> 連。
<code>await loop.sock_sendfile()</code>	透過 <code>socket</code> 傳送一個檔案。
<code>loop.add_reader()</code>	開始監控一個檔案描述器 (file descriptor) 的可讀取性。
<code>loop.remove_reader()</code>	停止監控一個檔案描述器的可讀取性。
<code>loop.add_writer()</code>	開始監控一個檔案描述器的可寫入性。
<code>loop.remove_writer()</code>	停止監控一個檔案描述器的可寫入性。

Unix 信號

<code>loop.add_signal_handler()</code>	新增一個處理函式 (handler)。
<code>loop.remove_signal_handler()</code>	除 <code>signal</code> 的處理函式。

子行程

<code>loop.subprocess_exec()</code>	衍生 (spawn) 一個子行程 (subprocess)。
<code>loop.subprocess_shell()</code>	從 shell 指令衍生一個子行程。

錯誤處理

<code>loop.call_exception_handler()</code>	呼叫例外處理函式。
<code>loop.set_exception_handler()</code>	設定一個新的例外處理函式。
<code>loop.get_exception_handler()</code>	獲取當前例外處理函式。
<code>loop.default_exception_handler()</code>	預設例外處理函式實作。

范例

- 使用 `asyncio.new_event_loop()` 和 `loop.run_forever()`。
- 使用 `loop.call_later()`。
- 使用 `loop.create_connection()` 以實作一個 *echo* 客戶端。
- 使用 `loop.create_connection()` 來連接 *socket*。
- 使用 `add_reader()` 監控 *FD* 的讀取事件。
- 使用 `loop.add_signal_handler()`。
- 使用 `loop.add_signal_handler()`。

傳輸

所有傳輸方式都有實作以下方法：

<code>transport.close()</code>	關閉傳輸。
<code>transport.is_closing()</code>	如果傳輸正在關閉或已經關閉則回傳 <code>True</code> 。
<code>transport.get_extra_info()</code>	請求傳輸的相關資訊。
<code>transport.set_protocol()</code>	設定一個新協定。
<code>transport.get_protocol()</code>	回傳當前協定。

可以接收資料 (TCP 和 Unix 連 F、pipe 等) 的傳輸。它由 `loop.create_connection()`、`loop.create_unix_connection()`、`loop.connect_read_pipe()` 等方法回傳：

讀取傳輸

<code>transport.is_reading()</code>	如果傳輸正在接收則回傳 <code>True</code> 。
<code>transport.pause_reading()</code>	暫停接收。
<code>transport.resume_reading()</code>	繼續接收。

可以傳送資料 (TCP 和 Unix 連 F、pipe 等) 的傳輸。它由 `loop.create_connection()`、`loop.create_unix_connection()`、`loop.connect_write_pipe()` 等方法回傳：

寫入傳輸

<code>transport.write()</code>	將資料寫入傳輸。
<code>transport.writelines()</code>	將緩衝區資料寫入傳輸。
<code>transport.can_write_eof()</code>	如果傳輸支援傳送 EOF 則回傳 <code>True</code> 。
<code>transport.write_eof()</code>	在清除 (flush) 已緩衝的資料後關閉傳輸並傳送 EOF。
<code>transport.abort()</code>	立即關閉傳輸。
<code>transport.get_write_buffer_size()</code>	回傳當前輸出緩衝區的大小。
<code>transport.get_write_buffer_limits()</code>	回傳用於寫入流量控制 (write flow control) 的高低標記位 (high and low water marks)。
<code>transport.set_write_buffer_limits()</code>	寫入流量控制設定高低標記位。

由 `loop.create_datagram_endpoint()` 回傳的傳輸：

資料單元傳輸

<code>transport.sendto()</code>	傳送資料到連埠遠端。
<code>transport.abort()</code>	立即關閉傳輸。

基於子行程的低階傳輸抽象，它會由 `loop.subprocess_exec()` 和 `loop.subprocess_shell()` 所回傳：

子行程傳輸

<code>transport.get_pid()</code>	回傳子行程的行程 id。
<code>transport.get_pipe_transport()</code>	回傳被請求用於通訊 pipe (<code>stdin</code> 、 <code>stdout</code> 或 <code>stderr</code>) 的傳輸。
<code>transport.get_returncode()</code>	回傳子行程的回傳代號 (return code)。
<code>transport.kill()</code>	殺死子行程。
<code>transport.send_signal()</code>	傳送一個訊號到子行程。
<code>transport.terminate()</code>	停止子行程。
<code>transport.close()</code>	殺死子行程並關閉所有 pipes。

協定

協定類可以實作以下回呼方法：

<code>callback connection_made()</code>	在連埠建立時被呼叫。
<code>callback connection_lost()</code>	在失去連埠或連埠關閉時被呼叫。
<code>callback pause_writing()</code>	在傳輸緩衝區超過高標記位時被呼叫。
<code>callback resume_writing()</code>	在傳輸緩衝區低於低標記位時被呼叫。

串流協定 (TCP, Unix socket, Pipes)

<code>callback data_received()</code>	在接收到資料時被呼叫。
<code>callback eof_received()</code>	在接收到 EOF 時被呼叫。

緩沖串流協定

<code>callback get_buffer()</code>	呼叫後會分配新的接收緩衝區。
<code>callback buffer_updated()</code>	在以接收到的資料更新緩衝區時被呼叫。
<code>callback eof_received()</code>	在接收到 EOF 時被呼叫。

資料單元協定

<code>callback datagram_received()</code>	在接收到資料單元時被呼叫。
<code>callback error_received()</code>	在前一個傳送或接收操作引發 <code>OSError</code> 時被呼叫。

子行程協定

<code>callback pipe_data_received()</code>	在子行程向 <code>stdout</code> 或 <code>stderr</code> pipe 寫入資料時被呼叫。
<code>callback pipe_connection_lost()</code>	在與子行程通訊的其中一個 pipes 關閉時被呼叫。
<code>callback process_exited()</code>	Called when the child process has exited. It can be called before <code>pipe_data_received()</code> and <code>pipe_connection_lost()</code> methods.

事件 圈 Policies

Policy 是改變 `asyncio.get_event_loop()` 這類函式行的一個低階機制。更多細節請見 *Policy* 相關段落。

存取 Policy

<code>asyncio.get_event_loop_policy()</code>	回傳當前整個行程中的 Policy。
<code>asyncio.set_event_loop_policy()</code>	設定整個行程中的一個新 Policy。
<code>AbstractEventLoopPolicy</code>	Policy 物件的基礎類。

18.1.16 使用 asyncio 開發

非同步程式設計 (asynchronous programming) 與傳統的“順序”程式設計 (sequential programming) 不同。本頁列出常見的錯誤和陷阱，解釋如何避免它們。

除錯模式

在預設情況下 asyncio 以正式生產模式 (production mode) 執行。為了讓開發更輕鬆，asyncio 還有一種除錯模式 (debug mode)。

有幾種方法可以用 asyncio 除錯模式：

- 將 PYTHONASYNCIODEBUG 環境變數設定為 1。
- 使用 *Python 開發模式 (Development Mode)*。
- 將 debug=True 傳遞給 `asyncio.run()`。
- 呼叫 `loop.set_debug()`。

除了用除錯模式外，還要考慮：

- setting the log level of the *asyncio logger* to `logging.DEBUG`, for example the following snippet of code can be run at startup of the application:

```
logging.basicConfig(level=logging.DEBUG)
```

- 配置 *warnings* 模組以顯示 *ResourceWarning* 警告。一種方法是使用 `-W default` 命令列選項。

用除錯模式時：

- asyncio 會檢查未被等待的協程並提醒他們；這會減輕“被遺忘的等待 (forgotten await)”問題。
- 許多非執行緒安全 (non-threadsafe) 的 asyncio APIs (例如 `loop.call_soon()` 和 `loop.call_at()` 方法)，如果從錯誤的執行緒呼叫就會引發例外。
- 如果執行一個 I/O 操作花費的時間太長，則將 I/O 選擇器 (selector) 的執行時間記到日誌中。
- 執行時間超過 100 毫秒的回呼 (callback) 將會被記於日誌。屬性 `loop.slow_callback_duration` 可用於設定以秒為單位的最小執行持續時間，超過這個值執行時間就會被視為“緩慢”。

執行性和多執行緒 (Concurrency and Multithreading)

事件圈在執行緒中運行（通常是主執行緒），在其執行緒中執行所有回呼和 Tasks（任務）。當一個 Task 在事件圈中運行時，有其他 Task 可以在同一個執行緒中運行。當一個 Task 執行一個 `await` 運算式時，正在執行的 Task 會被暫停，而事件圈會執行下一個 Task。

要從不同的 OS 執行緒加一個 callback 排程，應該使用 `loop.call_soon_threadsafe()` 方法。例如：

```
loop.call_soon_threadsafe(callback, *args)
```

幾乎所有 asyncio 物件都不支援執行緒安全 (thread safe)，這通常不是問題，除非在 Task 或回呼函式之外有程式需要和它們一起運作。如果需要這樣的程式來呼叫低階 asyncio API，應該使用 `loop.call_soon_threadsafe()` 方法，例如：

```
loop.call_soon_threadsafe(fut.cancel)
```

要從不同的 OS 執行緒加一個協程物件排程，應該使用 `run_coroutine_threadsafe()` 函式。它會回傳一個 `concurrent.futures.Future` 以存取結果：

```

async def coro_func():
    return await asyncio.sleep(1, 42)

# Later in another OS thread:

future = asyncio.run_coroutine_threadsafe(coro_func(), loop)
# Wait for the result:
result = future.result()

```

To handle signals the event loop must be run in the main thread.

`loop.run_in_executor()` 方法可以和 `concurrent.futures.ThreadPoolExecutor` 一起使用，這能`在作業系統上另一個不同的執行緒中執行阻塞程式，且避免阻塞執行事件圈`的執行緒。

目前`有什辦法能直接從另一個行程（例如透過multiprocessing 動的程序）來協程或回呼排程`。`Event Loop Methods`小節列出了可以從 pipes（管道）讀取`監視 file descriptor（檔案描述器）而不會阻塞事件圈的 API`。此外，`asyncio` 的子行程 API 提供了一種`動行程從事件圈與其通訊的辦法`。最後，之前提到的 `loop.run_in_executor()` 方法也可和 `concurrent.futures.ProcessPoolExecutor` 搭配使用，以在另一個行程中執行程式。

執行阻塞的程式

不應該直接呼叫阻塞（CPU 密集型）程式。例如一個執行 1 秒 CPU 密集型計算的函式，那`所有行非同步 Tasks 和 IO 操作都會被延遲 1 秒`。

一個 executor（執行器）可以被用來在不同的執行緒、或甚至不同的行程中執行任務，以避免使用事件圈阻塞 OS 執行緒。詳情請見 `loop.run_in_executor()` 方法。

日誌

`asyncio` 使用 `logging` 模組，所有日誌都是透過 "asyncio" logger 執行的。

The default log level is `logging.INFO`, which can be easily adjusted:

```
logging.getLogger("asyncio").setLevel(logging.WARNING)
```

網路日誌可能會阻塞事件圈。建議使用獨立的執行緒來處理日誌或使用非阻塞 IO，範例請參見 `blocking-handlers`。

偵測從未被等待的 (never-awaited) 協程

當協程函式被呼叫而不是被等待時（即執行 `coro()` 而不是 `await coro()`）或者協程`有透過 asyncio.create_task() 被排程，asyncio 將會發出 RuntimeWarning`：

```

import asyncio

async def test():
    print("never scheduled")

async def main():
    test()

asyncio.run(main())

```

輸出：

```
test.py:7: RuntimeWarning: coroutine 'test' was never awaited
  test()
```

除錯模式中的輸出：


```
test.py:7: RuntimeWarning: coroutine 'test' was never awaited
Coroutine created at (most recent call last)
  File "../t.py", line 9, in <module>
    asyncio.run(main(), debug=True)

< .. >

File "../t.py", line 7, in main
    test()
test()
```

常用的修復方法是去等待協程或者呼叫 `asyncio.create_task()` 函式：

```
async def main():
    await test()
```

偵測從未被獲取的 (never-retrieved) 例外

如果呼叫 `Future.set_exception()`，但 `Future` 物件從未被等待，例外將無法被傳播 (propagate) 到使用者程式。在這種情況下，當 `Future` 物件被垃圾回收 (garbage collected) 時，`asyncio` 將發出一則日誌訊息。未處理例外的例子：

```
import asyncio

async def bug():
    raise Exception("not consumed")

async def main():
    asyncio.create_task(bug())

asyncio.run(main())
```

輸出：

```
Task exception was never retrieved
future: <Task finished coro=<bug() done, defined at test.py:3>
exception=Exception('not consumed')>

Traceback (most recent call last):
  File "test.py", line 4, in bug
    raise Exception("not consumed")
Exception: not consumed
```

用除錯模式以取得任務建立處的追朔資訊 (traceback)：

```
asyncio.run(main(), debug=True)
```

除錯模式中的輸出：

```
Task exception was never retrieved
future: <Task finished coro=<bug() done, defined at test.py:3>
exception=Exception('not consumed') created at asyncio/tasks.py:321>

source_traceback: Object created at (most recent call last):
  File "../t.py", line 9, in <module>
    asyncio.run(main(), debug=True)

< .. >
```

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```
Traceback (most recent call last):
  File "../t.py", line 4, in bug
    raise Exception("not consumed")
Exception: not consumed
```

備 F: `asyncio` 的原始碼可以在 [Lib/asyncio/](#) 中找到。

18.2 socket --- Low-level networking interface

原始碼: [Lib/socket.py](#)

This module provides access to the BSD *socket* interface. It is available on all modern Unix systems, Windows, MacOS, and probably additional platforms.

備 F: Some behavior may be platform dependent, since calls are made to the operating system socket APIs.

適用: 非 Emscripten、非 WASI。

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

The Python interface is a straightforward transliteration of the Unix system call and library interface for sockets to Python's object-oriented style: the `socket()` function returns a *socket object* whose methods implement the various socket system calls. Parameter types are somewhat higher-level than in the C interface: as with `read()` and `write()` operations on Python files, buffer allocation on receive operations is automatic, and buffer length is implicit on send operations.

也參考:

`socketserver` 模組

Classes that simplify writing network servers.

`ssl` 模組

A TLS/SSL wrapper for socket objects.

18.2.1 Socket 系列家族

Depending on the system and the build options, various socket families are supported by this module.

The address format required by a particular socket object is automatically selected based on the address family specified when the socket object was created. Socket addresses are represented as follows:

- The address of an `AF_UNIX` socket bound to a file system node is represented as a string, using the file system encoding and the `'surrogateescape'` error handler (see [PEP 383](#)). An address in Linux's abstract namespace is returned as a *bytes-like object* with an initial null byte; note that sockets in this namespace can communicate with normal file system sockets, so programs intended to run on Linux may need to deal with both types of address. A string or bytes-like object can be used for either type of address when passing it as an argument.

在 3.3 版的變更: Previously, `AF_UNIX` socket paths were assumed to use UTF-8 encoding.

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

- A pair (`host`, `port`) is used for the `AF_INET` address family, where `host` is a string representing either a hostname in internet domain notation like `'daring.cwi.nl'` or an IPv4 address like `'100.50.200.5'`, and `port` is an integer.

- For IPv4 addresses, two special forms are accepted instead of a host address: `' '` represents `INADDR_ANY`, which is used to bind to all interfaces, and the string `'<broadcast>'` represents `INADDR_BROADCAST`. This behavior is not compatible with IPv6, therefore, you may want to avoid these if you intend to support IPv6 with your Python programs.
- For `AF_INET6` address family, a four-tuple (`host`, `port`, `flowinfo`, `scope_id`) is used, where `flowinfo` and `scope_id` represent the `sin6_flowinfo` and `sin6_scope_id` members in `struct sockaddr_in6` in C. For `socket` module methods, `flowinfo` and `scope_id` can be omitted just for backward compatibility. Note, however, omission of `scope_id` can cause problems in manipulating scoped IPv6 addresses.

在 3.7 版的變更: For multicast addresses (with `scope_id` meaningful) `address` may not contain `%scope_id` (or `zone id`) part. This information is superfluous and may be safely omitted (recommended).

- `AF_NETLINK` sockets are represented as pairs (`pid`, `groups`).
- Linux-only support for TIPC is available using the `AF_TIPC` address family. TIPC is an open, non-IP based networked protocol designed for use in clustered computer environments. Addresses are represented by a tuple, and the fields depend on the address type. The general tuple form is (`addr_type`, `v1`, `v2`, `v3` [, `scope`]), where:
 - `addr_type` is one of `TIPC_ADDR_NAMESEQ`, `TIPC_ADDR_NAME`, or `TIPC_ADDR_ID`.
 - `scope` is one of `TIPC_ZONE_SCOPE`, `TIPC_CLUSTER_SCOPE`, and `TIPC_NODE_SCOPE`.
 - If `addr_type` is `TIPC_ADDR_NAME`, then `v1` is the server type, `v2` is the port identifier, and `v3` should be 0.
 - If `addr_type` is `TIPC_ADDR_NAMESEQ`, then `v1` is the server type, `v2` is the lower port number, and `v3` is the upper port number.
 - If `addr_type` is `TIPC_ADDR_ID`, then `v1` is the node, `v2` is the reference, and `v3` should be set to 0.
- A tuple (`interface`,) is used for the `AF_CAN` address family, where `interface` is a string representing a network interface name like `'can0'`. The network interface name `' '` can be used to receive packets from all network interfaces of this family.
 - `CAN_ISOTP` protocol require a tuple (`interface`, `rx_addr`, `tx_addr`) where both additional parameters are unsigned long integer that represent a CAN identifier (standard or extended).
 - `CAN_J1939` protocol require a tuple (`interface`, `name`, `pgn`, `addr`) where additional parameters are 64-bit unsigned integer representing the ECU name, a 32-bit unsigned integer representing the Parameter Group Number (PGN), and an 8-bit integer representing the address.
- A string or a tuple (`id`, `unit`) is used for the `SYSPROTO_CONTROL` protocol of the `PF_SYSTEM` family. The string is the name of a kernel control using a dynamically assigned ID. The tuple can be used if ID and unit number of the kernel control are known or if a registered ID is used.

在 3.3 版新加入.

- `AF_BLUETOOTH` supports the following protocols and address formats:
 - `BTPROTO_L2CAP` accepts (`bdaddr`, `psm`) where `bdaddr` is the Bluetooth address as a string and `psm` is an integer.
 - `BTPROTO_RFCOMM` accepts (`bdaddr`, `channel`) where `bdaddr` is the Bluetooth address as a string and `channel` is an integer.
 - `BTPROTO_HCI` accepts (`device_id`,) where `device_id` is either an integer or a string with the Bluetooth address of the interface. (This depends on your OS; NetBSD and DragonFlyBSD expect a Bluetooth address while everything else expects an integer.)

在 3.2 版的變更: 加入對 NetBSD 和 DragonFlyBSD 的支援。

 - `BTPROTO_SCO` accepts `bdaddr` where `bdaddr` is a `bytes` object containing the Bluetooth address in a string format. (ex. `b'12:23:34:45:56:67'`) This protocol is not supported under FreeBSD.
- `AF_ALG` is a Linux-only socket based interface to Kernel cryptography. An algorithm socket is configured with a tuple of two to four elements (`type`, `name` [, `feat` [, `mask`]]), where:

- *type* is the algorithm type as string, e.g. `aeap`, `hash`, `skcipher` or `rng`.
- *name* is the algorithm name and operation mode as string, e.g. `sha256`, `hmac (sha256)`, `cbc (aes)` or `drbg_nopr_ctr_aes256`.
- *feat* and *mask* are unsigned 32bit integers.

適用：Linux >= 2.6.38。

Some algorithm types require more recent Kernels.

在 3.6 版新加入。

- `AF_VSOCK` allows communication between virtual machines and their hosts. The sockets are represented as a `(CID, port)` tuple where the context ID or CID and port are integers.

適用：Linux 3.9 以上。

請見 `vsock(7)`

在 3.7 版新加入。

- `AF_PACKET` is a low-level interface directly to network devices. The addresses are represented by the tuple `(ifname, proto[, pkttype[, hatype[, addr]])` where:

- *ifname* - String specifying the device name.
- *proto* - An integer specifying the Ethernet protocol number.
- *pkttype* - Optional integer specifying the packet type:
 - * `PACKET_HOST` (the default) - Packet addressed to the local host.
 - * `PACKET_BROADCAST` - Physical-layer broadcast packet.
 - * `PACKET_MULTICAST` - Packet sent to a physical-layer multicast address.
 - * `PACKET_OTHERHOST` - Packet to some other host that has been caught by a device driver in promiscuous mode.
 - * `PACKET_OUTGOING` - Packet originating from the local host that is looped back to a packet socket.
- *hatype* - Optional integer specifying the ARP hardware address type.
- *addr* - Optional bytes-like object specifying the hardware physical address, whose interpretation depends on the device.

適用：Linux >= 2.2。

- `AF_QIPCRTR` is a Linux-only socket based interface for communicating with services running on co-processors in Qualcomm platforms. The address family is represented as a `(node, port)` tuple where the *node* and *port* are non-negative integers.

適用：Linux >= 4.7。

在 3.8 版新加入。

- `IPPROTO_UDPLITE` is a variant of UDP which allows you to specify what portion of a packet is covered with the checksum. It adds two socket options that you can change. `self.setsockopt(IPPROTO_UDPLITE, UDPLITE_SEND_CSCOV, length)` will change what portion of outgoing packets are covered by the checksum and `self.setsockopt(IPPROTO_UDPLITE, UDPLITE_RECV_CSCOV, length)` will filter out packets which cover too little of their data. In both cases *length* should be in range(8, 2*16, 8).

Such a socket should be constructed with `socket(AF_INET, SOCK_DGRAM, IPPROTO_UDPLITE)` for IPv4 or `socket(AF_INET6, SOCK_DGRAM, IPPROTO_UDPLITE)` for IPv6.

適用：Linux 2.6.20 以上、FreeBSD 10.1 以上。

在 3.9 版新加入。

If you use a hostname in the *host* portion of IPv4/v6 socket address, the program may show a nondeterministic behavior, as Python uses the first address returned from the DNS resolution. The socket address will be resolved differently into an actual IPv4/v6 address, depending on the results from DNS resolution and/or the host configuration. For deterministic behavior use a numeric address in *host* portion.

All errors raise exceptions. The normal exceptions for invalid argument types and out-of-memory conditions can be raised. Errors related to socket or address semantics raise *OSError* or one of its subclasses.

Non-blocking mode is supported through *setblocking()*. A generalization of this based on timeouts is supported through *settimeout()*.

18.2.2 模組內容

The module *socket* exports the following elements.

例外

exception *socket.error*

一個已用的 *OSError* 的別名。

在 3.3 版的變更: Following **PEP 3151**, this class was made an alias of *OSError*.

exception *socket.herror*

A subclass of *OSError*, this exception is raised for address-related errors, i.e. for functions that use *h_errno* in the POSIX C API, including *gethostbyname_ex()* and *gethostbyaddr()*. The accompanying value is a pair (*h_errno*, *string*) representing an error returned by a library call. *h_errno* is a numeric value, while *string* represents the description of *h_errno*, as returned by the *hstrerror()* C function.

在 3.3 版的變更: This class was made a subclass of *OSError*.

exception *socket.gaierror*

A subclass of *OSError*, this exception is raised for address-related errors by *getaddrinfo()* and *getnameinfo()*. The accompanying value is a pair (*error*, *string*) representing an error returned by a library call. *string* represents the description of *error*, as returned by the *gai_strerror()* C function. The numeric *error* value will match one of the *EAI_** constants defined in this module.

在 3.3 版的變更: This class was made a subclass of *OSError*.

exception *socket.timeout*

A deprecated alias of *TimeoutError*.

A subclass of *OSError*, this exception is raised when a timeout occurs on a socket which has had timeouts enabled via a prior call to *settimeout()* (or implicitly through *setdefaulttimeout()*). The accompanying value is a string whose value is currently always "timed out".

在 3.3 版的變更: This class was made a subclass of *OSError*.

在 3.10 版的變更: This class was made an alias of *TimeoutError*.

常數

The *AF_** and *SOCK_** constants are now *AddressFamily* and *SocketKind* *IntEnum* collections.

在 3.4 版新加入.

socket.AF_UNIX

socket.AF_INET

`socket.AF_INET6`

These constants represent the address (and protocol) families, used for the first argument to `socket()`. If the `AF_UNIX` constant is not defined then this protocol is unsupported. More constants may be available depending on the system.

`socket.AF_UNSPEC`

`AF_UNSPEC` means that `getaddrinfo()` should return socket addresses for any address family (either IPv4, IPv6, or any other) that can be used.

`socket.SOCK_STREAM`

`socket.SOCK_DGRAM`

`socket.SOCK_RAW`

`socket.SOCK_RDM`

`socket.SOCK_SEQPACKET`

These constants represent the socket types, used for the second argument to `socket()`. More constants may be available depending on the system. (Only `SOCK_STREAM` and `SOCK_DGRAM` appear to be generally useful.)

`socket.SOCK_CLOEXEC`

`socket.SOCK_NONBLOCK`

These two constants, if defined, can be combined with the socket types and allow you to set some flags atomically (thus avoiding possible race conditions and the need for separate calls).

也參考:

[Secure File Descriptor Handling](#) for a more thorough explanation.

適用: Linux >= 2.6.27。

在 3.2 版新加入。

`SO_*`

`socket.SOMAXCONN`

`MSG_*`

`SOL_*`

`SCM_*`

`IPPROTO_*`

`IPPORT_*`

`INADDR_*`

`IP_*`

`IPV6_*`

`EAI_*`

`AI_*`

`NI_*`

`TCP_*`

Many constants of these forms, documented in the Unix documentation on sockets and/or the IP protocol, are also defined in the socket module. They are generally used in arguments to the `setsockopt()` and `getsockopt()` methods of socket objects. In most cases, only those symbols that are defined in the Unix header files are defined; for a few symbols, default values are provided.

在 3.6 版的變更: `SO_DOMAIN`, `SO_PROTOCOL`, `SO_PEERSEC`, `SO_PASSSEC`, `TCP_USER_TIMEOUT`, `TCP_CONGESTION` were added.

在 3.6.5 版的變更: On Windows, `TCP_FASTOPEN`, `TCP_KEEPCNT` appear if run-time Windows supports.

在 3.7 版的變更: 新增 `TCP_NOTSENT_LOWAT`.

On Windows, `TCP_KEEPIRL`, `TCP_KEEPIRLVL` appear if run-time Windows supports.

在 3.10 版的變更: `IP_RECVTOS` was added. Added `TCP_KEEPALIVE`. On MacOS this constant can be used in the same way that `TCP_KEEPIDLE` is used on Linux.

在 3.11 版的變更: Added `TCP_CONNECTION_INFO`. On MacOS this constant can be used in the same way that `TCP_INFO` is used on Linux and BSD.

`socket.AF_CAN`

`socket.PF_CAN`

`SOL_CAN_*`

`CAN_*`

Many constants of these forms, documented in the Linux documentation, are also defined in the socket module.

適用: Linux 2.6.25 以上、NetBSD 8 以上。

在 3.3 版新加入。

在 3.11 版的變更: NetBSD support was added.

`socket.CAN_BCM`

`CAN_BCM_*`

`CAN_BCM`, in the CAN protocol family, is the broadcast manager (BCM) protocol. Broadcast manager constants, documented in the Linux documentation, are also defined in the socket module.

適用: Linux \geq 2.6.25。

備註: The `CAN_BCM_CAN_FD_FRAME` flag is only available on Linux \geq 4.8.

在 3.4 版新加入。

`socket.CAN_RAW_FD_FRAMES`

Enables CAN FD support in a `CAN_RAW` socket. This is disabled by default. This allows your application to send both CAN and CAN FD frames; however, you must accept both CAN and CAN FD frames when reading from the socket.

This constant is documented in the Linux documentation.

適用: Linux \geq 3.6。

在 3.5 版新加入。

`socket.CAN_RAW_JOIN_FILTERS`

Joins the applied CAN filters such that only CAN frames that match all given CAN filters are passed to user space.

This constant is documented in the Linux documentation.

適用: Linux \geq 4.1。

在 3.9 版新加入。

`socket.CAN_ISOTP`

`CAN_ISOTP`, in the CAN protocol family, is the ISO-TP (ISO 15765-2) protocol. ISO-TP constants, documented in the Linux documentation.

適用: Linux \geq 2.6.25。

在 3.7 版新加入。

`socket.CAN_J1939`

`CAN_J1939`, in the CAN protocol family, is the SAE J1939 protocol. J1939 constants, documented in the Linux documentation.

適用: Linux \geq 5.4。

在 3.9 版新加入。

`socket.AF_PACKET`

`socket.PF_PACKET`

PACKET_*

Many constants of these forms, documented in the Linux documentation, are also defined in the socket module.

適用: Linux >= 2.2。

`socket.AF_RDS`

`socket.PF_RDS`

`socket.SOL_RDS`

RDS_*

Many constants of these forms, documented in the Linux documentation, are also defined in the socket module.

適用: Linux >= 2.6.30。

在 3.3 版新加入。

`socket.SIO_RCVALL`

`socket.SIO_KEEPA_LIVE_VALS`

`socket.SIO_LOOPBACK_FAST_PATH`

RCVALL_*

Constants for Windows' `WSAIoctl()`. The constants are used as arguments to the `ioctl()` method of socket objects.

在 3.6 版的變更: 加入 `SIO_LOOPBACK_FAST_PATH`。

TIPC_*

TIPC related constants, matching the ones exported by the C socket API. See the TIPC documentation for more information.

`socket.AF_ALG`

`socket.SOL_ALG`

ALG_*

Constants for Linux Kernel cryptography.

適用: Linux >= 2.6.38。

在 3.6 版新加入。

`socket.AF_VSOCK`

`socket.IOCTL_VM_SOCKETS_GET_LOCAL_CID`

VMADDR*

SO_VM*

Constants for Linux host/guest communication.

適用: Linux >= 4.8。

在 3.7 版新加入。

`socket.AF_LINK`

適用: BSD、macOS。

在 3.4 版新加入。

`socket.has_ipv6`

This constant contains a boolean value which indicates if IPv6 is supported on this platform.

`socket.BDADDR_ANY`

`socket.BDADDR_LOCAL`

These are string constants containing Bluetooth addresses with special meanings. For example, `BDADDR_ANY` can be used to indicate any address when specifying the binding socket with `BTPROTO_RFCOMM`.

`socket.HCI_FILTER`

`socket.HCI_TIME_STAMP`

`socket.HCI_DATA_DIR`

For use with `BTPROTO_HCI`. `HCI_FILTER` is not available for NetBSD or DragonFlyBSD. `HCI_TIME_STAMP` and `HCI_DATA_DIR` are not available for FreeBSD, NetBSD, or DragonFlyBSD.

`socket.AF_QIPCRTR`

Constant for Qualcomm's IPC router protocol, used to communicate with service providing remote processors.

適用：Linux >= 4.7。

`socket.SCM_CREDS2`

`socket.LOCAL_CREDS`

`socket.LOCAL_CREDS_PERSISTENT`

`LOCAL_CREDS` and `LOCAL_CREDS_PERSISTENT` can be used with `SOCK_DGRAM`, `SOCK_STREAM` sockets, equivalent to Linux/DragonFlyBSD `SO_PASSCRED`, while `LOCAL_CREDS` sends the credentials at first read, `LOCAL_CREDS_PERSISTENT` sends for each read, `SCM_CREDS2` must be then used for the latter for the message type.

在 3.11 版新加入。

適用：FreeBSD。

`socket.SO_INCOMING_CPU`

Constant to optimize CPU locality, to be used in conjunction with `SO_REUSEPORT`.

在 3.11 版新加入。

適用：Linux 3.9 以上。

函式

建立 sockets

The following functions all create *socket objects*.

class `socket.socket` (*family*=`AF_INET`, *type*=`SOCK_STREAM`, *proto*=0, *fileno*=None)

Create a new socket using the given address family, socket type and protocol number. The address family should be `AF_INET` (the default), `AF_INET6`, `AF_UNIX`, `AF_CAN`, `AF_PACKET`, or `AF_RDS`. The socket type should be `SOCK_STREAM` (the default), `SOCK_DGRAM`, `SOCK_RAW` or perhaps one of the other `SOCK_` constants. The protocol number is usually zero and may be omitted or in the case where the address family is `AF_CAN` the protocol should be one of `CAN_RAW`, `CAN_BCM`, `CAN_ISOTP` or `CAN_J1939`.

If *fileno* is specified, the values for *family*, *type*, and *proto* are auto-detected from the specified file descriptor. Auto-detection can be overruled by calling the function with explicit *family*, *type*, or *proto* arguments. This only affects how Python represents e.g. the return value of `socket.getpeername()` but not the actual OS resource. Unlike `socket.fromfd()`, *fileno* will return the same socket and not a duplicate. This may help close a detached socket using `socket.close()`.

The newly created socket is *non-inheritable*.

引發一個附帶引數 `self`、`family`、`type`、`protocol` 的稽核事件 `socket.__new__`。

在 3.3 版的變更: The `AF_CAN` family was added. The `AF_RDS` family was added.

在 3.4 版的變更: 新增 `CAN_BCM` 協定。

在 3.4 版的變更: The returned socket is now non-inheritable.

在 3.7 版的變更: 新增 CAN_ISOTP 協定。

在 3.7 版的變更: When `SOCK_NONBLOCK` or `SOCK_CLOEXEC` bit flags are applied to `type` they are cleared, and `socket.type` will not reflect them. They are still passed to the underlying system `socket()` call. Therefore,

```
sock = socket.socket(
    socket.AF_INET,
    socket.SOCK_STREAM | socket.SOCK_NONBLOCK)
```

will still create a non-blocking socket on OSes that support `SOCK_NONBLOCK`, but `sock.type` will be set to `socket.SOCK_STREAM`.

在 3.9 版的變更: 新增 CAN_J1939 協定。

在 3.10 版的變更: 新增 IPPROTO_MPTCP 協定。

`socket.socketpair([family[, type[, proto]]])`

Build a pair of connected socket objects using the given address family, socket type, and protocol number. Address family, socket type, and protocol number are as for the `socket()` function above. The default family is `AF_UNIX` if defined on the platform; otherwise, the default is `AF_INET`.

The newly created sockets are *non-inheritable*.

在 3.2 版的變更: The returned socket objects now support the whole socket API, rather than a subset.

在 3.4 版的變更: The returned sockets are now non-inheritable.

在 3.5 版的變更: 新增對 Windows 的支援。

`socket.create_connection(address, timeout=GLOBAL_DEFAULT, source_address=None, *, all_errors=False)`

Connect to a TCP service listening on the internet *address* (a 2-tuple (host, port)), and return the socket object. This is a higher-level function than `socket.connect()`: if *host* is a non-numeric hostname, it will try to resolve it for both `AF_INET` and `AF_INET6`, and then try to connect to all possible addresses in turn until a connection succeeds. This makes it easy to write clients that are compatible to both IPv4 and IPv6.

Passing the optional *timeout* parameter will set the timeout on the socket instance before attempting to connect. If no *timeout* is supplied, the global default timeout setting returned by `getdefaulttimeout()` is used.

If supplied, *source_address* must be a 2-tuple (host, port) for the socket to bind to as its source address before connecting. If host or port are "" or 0 respectively the OS default behavior will be used.

When a connection cannot be created, an exception is raised. By default, it is the exception from the last address in the list. If *all_errors* is True, it is an `ExceptionGroup` containing the errors of all attempts.

在 3.2 版的變更: 新增 *source_address*。

在 3.11 版的變更: 新增 *all_errors*。

`socket.create_server(address, *, family=AF_INET, backlog=None, reuse_port=False, dualstack_ipv6=False)`

Convenience function which creates a TCP socket bound to *address* (a 2-tuple (host, port)) and return the socket object.

family should be either `AF_INET` or `AF_INET6`. *backlog* is the queue size passed to `socket.listen()`; if not specified, a default reasonable value is chosen. *reuse_port* dictates whether to set the `SO_REUSEPORT` socket option.

If *dualstack_ipv6* is true and the platform supports it the socket will be able to accept both IPv4 and IPv6 connections, else it will raise `ValueError`. Most POSIX platforms and Windows are supposed to support this functionality. When this functionality is enabled the address returned by `socket.getpeername()` when an IPv4 connection occurs will be an IPv6 address represented as an IPv4-mapped IPv6 address. If *dualstack_ipv6* is false it will explicitly disable this functionality on platforms that enable it by default (e.g. Linux). This parameter can be used in conjunction with `has_dualstack_ipv6()`:

```
import socket

addr = ("", 8080) # all interfaces, port 8080
if socket.has_dualstack_ipv6():
    s = socket.create_server(addr, family=socket.AF_INET6, dualstack_ipv6=True)
else:
    s = socket.create_server(addr)
```

備註: On POSIX platforms the `SO_REUSEADDR` socket option is set in order to immediately reuse previous sockets which were bound on the same *address* and remained in `TIME_WAIT` state.

在 3.8 版新加入。

`socket.has_dualstack_ipv6()`

Return `True` if the platform supports creating a TCP socket which can handle both IPv4 and IPv6 connections.

在 3.8 版新加入。

`socket.fromfd(fd, family, type, proto=0)`

Duplicate the file descriptor *fd* (an integer as returned by a file object's `fileno()` method) and build a socket object from the result. Address family, socket type and protocol number are as for the `socket()` function above. The file descriptor should refer to a socket, but this is not checked --- subsequent operations on the object may fail if the file descriptor is invalid. This function is rarely needed, but can be used to get or set socket options on a socket passed to a program as standard input or output (such as a server started by the Unix `inetd` daemon). The socket is assumed to be in blocking mode.

The newly created socket is *non-inheritable*.

在 3.4 版的變更: The returned socket is now non-inheritable.

`socket.fromshare(data)`

Instantiate a socket from data obtained from the `socket.share()` method. The socket is assumed to be in blocking mode.

適用: Windows。

在 3.3 版新加入。

`socket.SocketType`

This is a Python type object that represents the socket object type. It is the same as `type(socket(...))`.

其他函式

The `socket` module also offers various network-related services:

`socket.close(fd)`

Close a socket file descriptor. This is like `os.close()`, but for sockets. On some platforms (most noticeable Windows) `os.close()` does not work for socket file descriptors.

在 3.7 版新加入。

`socket.getaddrinfo(host, port, family=0, type=0, proto=0, flags=0)`

Translate the *host/port* argument into a sequence of 5-tuples that contain all the necessary arguments for creating a socket connected to that service. *host* is a domain name, a string representation of an IPv4/v6 address or `None`. *port* is a string service name such as `'http'`, a numeric port number or `None`. By passing `None` as the value of *host* and *port*, you can pass `NULL` to the underlying C API.

The *family*, *type* and *proto* arguments can be optionally specified in order to narrow the list of addresses returned. Passing zero as a value for each of these arguments selects the full range of results. The *flags* argument can be one or several of the `AI_*` constants, and will influence how results are computed and returned. For

example, `AI_NUMERICHOST` will disable domain name resolution and will raise an error if *host* is a domain name.

The function returns a list of 5-tuples with the following structure:

```
(family, type, proto, canonname, sockaddr)
```

In these tuples, *family*, *type*, *proto* are all integers and are meant to be passed to the `socket()` function. *canonname* will be a string representing the canonical name of the *host* if `AI_CANONNAME` is part of the *flags* argument; else *canonname* will be empty. *sockaddr* is a tuple describing a socket address, whose format depends on the returned *family* (a (address, port) 2-tuple for `AF_INET`, a (address, port, flowinfo, scope_id) 4-tuple for `AF_INET6`), and is meant to be passed to the `socket.connect()` method.

引發一個附帶引數 *host*、*port*、*family*、*type*、*protocol* 的稽核事件 `socket.getaddrinfo`。

The following example fetches address information for a hypothetical TCP connection to `example.org` on port 80 (results may differ on your system if IPv6 isn't enabled):

```
>>> socket.getaddrinfo("example.org", 80, proto=socket.IPPROTO_TCP)
[(socket.AF_INET6, socket.SOCK_STREAM,
 6, '', ('2606:2800:220:1:248:1893:25c8:1946', 80, 0, 0)),
 (socket.AF_INET, socket.SOCK_STREAM,
 6, '', ('93.184.216.34', 80))]
```

在 3.2 版的變更: parameters can now be passed using keyword arguments.

在 3.7 版的變更: for IPv6 multicast addresses, string representing an address will not contain `%scope_id` part.

`socket.getfqdn([name])`

Return a fully qualified domain name for *name*. If *name* is omitted or empty, it is interpreted as the local host. To find the fully qualified name, the hostname returned by `gethostbyaddr()` is checked, followed by aliases for the host, if available. The first name which includes a period is selected. In case no fully qualified domain name is available and *name* was provided, it is returned unchanged. If *name* was empty or equal to `'0.0.0.0'`, the hostname from `gethostname()` is returned.

`socket.gethostbyname(hostname)`

Translate a host name to IPv4 address format. The IPv4 address is returned as a string, such as `'100.50.200.5'`. If the host name is an IPv4 address itself it is returned unchanged. See `gethostbyname_ex()` for a more complete interface. `gethostbyname()` does not support IPv6 name resolution, and `getaddrinfo()` should be used instead for IPv4/v6 dual stack support.

引發一個附帶引數 *hostname* 的稽核事件 `socket.gethostbyname`。

適用: 非 WASI。

`socket.gethostbyname_ex(hostname)`

Translate a host name to IPv4 address format, extended interface. Return a 3-tuple (*hostname*, *aliaslist*, *ipaddrlist*) where *hostname* is the host's primary host name, *aliaslist* is a (possibly empty) list of alternative host names for the same address, and *ipaddrlist* is a list of IPv4 addresses for the same interface on the same host (often but not always a single address). `gethostbyname_ex()` does not support IPv6 name resolution, and `getaddrinfo()` should be used instead for IPv4/v6 dual stack support.

引發一個附帶引數 *hostname* 的稽核事件 `socket.gethostbyname`。

適用: 非 WASI。

`socket.gethostname()`

Return a string containing the hostname of the machine where the Python interpreter is currently executing.

引發一個不附帶引數的稽核事件 `socket.gethostname`。

Note: `gethostname()` doesn't always return the fully qualified domain name; use `getfqdn()` for that.

適用: 非 WASI。

`socket.gethostbyaddr(ip_address)`

Return a 3-tuple (*hostname*, *aliaslist*, *ipaddrlist*) where *hostname* is the primary host name responding to the given *ip_address*, *aliaslist* is a (possibly empty) list of alternative host names for the same address, and *ipaddrlist* is a list of IPv4/v6 addresses for the same interface on the same host (most likely containing only a single address). To find the fully qualified domain name, use the function `getfqdn()`. `gethostbyaddr()` supports both IPv4 and IPv6.

引發一個附帶引數 *ip_address* 的稽核事件 `socket.gethostbyaddr`。

適用：非 WASI。

`socket.getnameinfo(sockaddr, flags)`

Translate a socket address *sockaddr* into a 2-tuple (*host*, *port*). Depending on the settings of *flags*, the result can contain a fully qualified domain name or numeric address representation in *host*. Similarly, *port* can contain a string port name or a numeric port number.

For IPv6 addresses, *%scope_id* is appended to the host part if *sockaddr* contains meaningful *scope_id*. Usually this happens for multicast addresses.

For more information about *flags* you can consult `getnameinfo(3)`.

引發一個附帶引數 *sockaddr* 的稽核事件 `socket.getnameinfo`。

適用：非 WASI。

`socket.getprotobyne(protocolname)`

Translate an internet protocol name (for example, 'icmp') to a constant suitable for passing as the (optional) third argument to the `socket()` function. This is usually only needed for sockets opened in "raw" mode (`SOCK_RAW`); for the normal socket modes, the correct protocol is chosen automatically if the protocol is omitted or zero.

適用：非 WASI。

`socket.getservbyname(servicename[, protocolname])`

Translate an internet service name and protocol name to a port number for that service. The optional protocol name, if given, should be 'tcp' or 'udp', otherwise any protocol will match.

引發一個附帶引數 *sockaddr*、*protocolname* 的稽核事件 `socket.getservbyname`。

適用：非 WASI。

`socket.getservbyport(port[, protocolname])`

Translate an internet port number and protocol name to a service name for that service. The optional protocol name, if given, should be 'tcp' or 'udp', otherwise any protocol will match.

引發一個附帶引數 *port*、*protocolname* 的稽核事件 `socket.getservbyport`。

適用：非 WASI。

`socket.ntohl(x)`

Convert 32-bit positive integers from network to host byte order. On machines where the host byte order is the same as network byte order, this is a no-op; otherwise, it performs a 4-byte swap operation.

`socket.ntohs(x)`

Convert 16-bit positive integers from network to host byte order. On machines where the host byte order is the same as network byte order, this is a no-op; otherwise, it performs a 2-byte swap operation.

在 3.10 版的變更: Raises `OverflowError` if *x* does not fit in a 16-bit unsigned integer.

`socket.htonl(x)`

Convert 32-bit positive integers from host to network byte order. On machines where the host byte order is the same as network byte order, this is a no-op; otherwise, it performs a 4-byte swap operation.

`socket.htons(x)`

Convert 16-bit positive integers from host to network byte order. On machines where the host byte order is the same as network byte order, this is a no-op; otherwise, it performs a 2-byte swap operation.

在 3.10 版的變更: Raises *OverflowError* if *x* does not fit in a 16-bit unsigned integer.

`socket.inet_aton(ip_string)`

Convert an IPv4 address from dotted-quad string format (for example, '123.45.67.89') to 32-bit packed binary format, as a bytes object four characters in length. This is useful when conversing with a program that uses the standard C library and needs objects of type `in_addr`, which is the C type for the 32-bit packed binary this function returns.

`inet_aton()` also accepts strings with less than three dots; see the Unix manual page *inet(3)* for details.

If the IPv4 address string passed to this function is invalid, *OSError* will be raised. Note that exactly what is valid depends on the underlying C implementation of `inet_aton()`.

`inet_aton()` does not support IPv6, and `inet_pton()` should be used instead for IPv4/v6 dual stack support.

`socket.inet_ntoa(packed_ip)`

Convert a 32-bit packed IPv4 address (a *bytes-like object* four bytes in length) to its standard dotted-quad string representation (for example, '123.45.67.89'). This is useful when conversing with a program that uses the standard C library and needs objects of type `in_addr`, which is the C type for the 32-bit packed binary data this function takes as an argument.

If the byte sequence passed to this function is not exactly 4 bytes in length, *OSError* will be raised. `inet_ntoa()` does not support IPv6, and `inet_ntop()` should be used instead for IPv4/v6 dual stack support.

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

`socket.inet_pton(address_family, ip_string)`

Convert an IP address from its family-specific string format to a packed, binary format. `inet_pton()` is useful when a library or network protocol calls for an object of type `in_addr` (similar to `inet_aton()`) or `in6_addr`.

Supported values for *address_family* are currently `AF_INET` and `AF_INET6`. If the IP address string *ip_string* is invalid, *OSError* will be raised. Note that exactly what is valid depends on both the value of *address_family* and the underlying implementation of `inet_pton()`.

適用: Unix、Windows。

在 3.4 版的變更: Windows support added

`socket.inet_ntop(address_family, packed_ip)`

Convert a packed IP address (a *bytes-like object* of some number of bytes) to its standard, family-specific string representation (for example, '7.10.0.5' or '5aef:2b::8'). `inet_ntop()` is useful when a library or network protocol returns an object of type `in_addr` (similar to `inet_ntoa()`) or `in6_addr`.

Supported values for *address_family* are currently `AF_INET` and `AF_INET6`. If the bytes object *packed_ip* is not the correct length for the specified address family, *ValueError* will be raised. *OSError* is raised for errors from the call to `inet_ntop()`.

適用: Unix、Windows。

在 3.4 版的變更: Windows support added

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

`socket.CMSG_LEN(length)`

Return the total length, without trailing padding, of an ancillary data item with associated data of the given *length*. This value can often be used as the buffer size for `recvmsg()` to receive a single item of ancillary data, but **RFC 3542** requires portable applications to use `CMSG_SPACE()` and thus include space for padding, even when the item will be the last in the buffer. Raises *OverflowError* if *length* is outside the permissible range of values.

適用：Unix、非 Emscripten、非 WASI。

Most Unix platforms.

在 3.3 版新加入。

`socket.CMSG_SPACE (length)`

Return the buffer size needed for `recvmsg()` to receive an ancillary data item with associated data of the given *length*, along with any trailing padding. The buffer space needed to receive multiple items is the sum of the `CMSG_SPACE()` values for their associated data lengths. Raises `OverflowError` if *length* is outside the permissible range of values.

Note that some systems might support ancillary data without providing this function. Also note that setting the buffer size using the results of this function may not precisely limit the amount of ancillary data that can be received, since additional data may be able to fit into the padding area.

適用：Unix、非 Emscripten、非 WASI。

most Unix platforms.

在 3.3 版新加入。

`socket.getdefaulttimeout ()`

Return the default timeout in seconds (float) for new socket objects. A value of `None` indicates that new socket objects have no timeout. When the socket module is first imported, the default is `None`.

`socket.setdefaulttimeout (timeout)`

Set the default timeout in seconds (float) for new socket objects. When the socket module is first imported, the default is `None`. See `settimeout()` for possible values and their respective meanings.

`socket.sethostname (name)`

Set the machine's hostname to *name*. This will raise an `OSError` if you don't have enough rights.

引發一個附帶引數 *name* 的稽核事件 `socket.sethostname`。

適用：Unix。

在 3.3 版新加入。

`socket.if_nameindex ()`

Return a list of network interface information (index int, name string) tuples. `OSError` if the system call fails.

適用：Unix、Windows、非 Emscripten、非 WASI。

在 3.3 版新加入。

在 3.8 版的變更：增加對 Windows 的支援。

備註：On Windows network interfaces have different names in different contexts (all names are examples):

- `UUID`: {FB605B73-AAC2-49A6-9A2F-25416AEA0573}
- `name`: ethernet_32770
- `friendly name`: vEthernet (nat)
- `description`: Hyper-V Virtual Ethernet Adapter

This function returns names of the second form from the list, `ethernet_32770` in this example case.

`socket.if_nameindex (if_name)`

Return a network interface index number corresponding to an interface name. `OSError` if no interface with the given name exists.

適用：Unix、Windows、非 Emscripten、非 WASI。

在 3.3 版新加入。

在 3.8 版的變更: 增加對 Windows 的支援。

也參考:

”Interface name” is a name as documented in [if_nameindex\(\)](#).

`socket.if_indextoname` (*if_index*)

Return a network interface name corresponding to an interface index number. *OSError* if no interface with the given index exists.

適用: Unix、Windows、非 Emscripten、非 WASI。

在 3.3 版新加入。

在 3.8 版的變更: 增加對 Windows 的支援。

也參考:

”Interface name” is a name as documented in [if_nameindex\(\)](#).

`socket.send_fds` (*sock*, *buffers*, *fds*[, *flags*[, *address*]])

Send the list of file descriptors *fds* over an [AF_UNIX](#) socket *sock*. The *fds* parameter is a sequence of file descriptors. Consult [sendmsg\(\)](#) for the documentation of these parameters.

適用: Unix、Windows、非 Emscripten、非 WASI。

Unix platforms supporting [sendmsg\(\)](#) and SCM_RIGHTS mechanism.

在 3.9 版新加入。

`socket.recv_fds` (*sock*, *bufsize*, *maxfds*[, *flags*])

Receive up to *maxfds* file descriptors from an [AF_UNIX](#) socket *sock*. Return (*msg*, *list(fds)*, *flags*, *addr*). Consult [recvmsg\(\)](#) for the documentation of these parameters.

適用: Unix、Windows、非 Emscripten、非 WASI。

Unix platforms supporting [sendmsg\(\)](#) and SCM_RIGHTS mechanism.

在 3.9 版新加入。

備 F: Any truncated integers at the end of the list of file descriptors.

18.2.3 Socket 物件

Socket objects have the following methods. Except for [makefile\(\)](#), these correspond to Unix system calls applicable to sockets.

在 3.2 版的變更: Support for the [context manager](#) protocol was added. Exiting the context manager is equivalent to calling [close\(\)](#).

`socket.accept()`

Accept a connection. The socket must be bound to an address and listening for connections. The return value is a pair (*conn*, *address*) where *conn* is a new socket object usable to send and receive data on the connection, and *address* is the address bound to the socket on the other end of the connection.

The newly created socket is [non-inheritable](#).

在 3.4 版的變更: The socket is now non-inheritable.

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an [InterruptedError](#) exception (see [PEP 475](#) for the rationale).

`socket.bind(address)`

Bind the socket to *address*. The socket must not already be bound. (The format of *address* depends on the address family --- see above.)

引發一個附帶引數 `self`、`address` 的稽核事件 `socket.bind`。

適用：非 WASI。

`socket.close()`

Mark the socket closed. The underlying system resource (e.g. a file descriptor) is also closed when all file objects from `makefile()` are closed. Once that happens, all future operations on the socket object will fail. The remote end will receive no more data (after queued data is flushed).

Sockets are automatically closed when they are garbage-collected, but it is recommended to `close()` them explicitly, or to use a `with` statement around them.

在 3.6 版的變更: `OSError` is now raised if an error occurs when the underlying `close()` call is made.

備註: `close()` releases the resource associated with a connection but does not necessarily close the connection immediately. If you want to close the connection in a timely fashion, call `shutdown()` before `close()`.

`socket.connect(address)`

Connect to a remote socket at *address*. (The format of *address* depends on the address family --- see above.)

If the connection is interrupted by a signal, the method waits until the connection completes, or raise a `TimeoutError` on timeout, if the signal handler doesn't raise an exception and the socket is blocking or has a timeout. For non-blocking sockets, the method raises an `InterruptedError` exception if the connection is interrupted by a signal (or the exception raised by the signal handler).

引發一個附帶引數 `self`、`address` 的稽核事件 `socket.connect`。

在 3.5 版的變更: The method now waits until the connection completes instead of raising an `InterruptedError` exception if the connection is interrupted by a signal, the signal handler doesn't raise an exception and the socket is blocking or has a timeout (see the [PEP 475](#) for the rationale).

適用：非 WASI。

`socket.connect_ex(address)`

Like `connect(address)`, but return an error indicator instead of raising an exception for errors returned by the C-level `connect()` call (other problems, such as "host not found," can still raise exceptions). The error indicator is 0 if the operation succeeded, otherwise the value of the `errno` variable. This is useful to support, for example, asynchronous connects.

引發一個附帶引數 `self`、`address` 的稽核事件 `socket.connect`。

適用：非 WASI。

`socket.detach()`

Put the socket object into closed state without actually closing the underlying file descriptor. The file descriptor is returned, and can be reused for other purposes.

在 3.2 版新加入。

`socket.dup()`

Duplicate the socket.

The newly created socket is *non-inheritable*.

在 3.4 版的變更: The socket is now non-inheritable.

適用：非 WASI。

`socket.fileno()`

Return the socket's file descriptor (a small integer), or -1 on failure. This is useful with `select.select()`.

Under Windows the small integer returned by this method cannot be used where a file descriptor can be used (such as `os.fdopen()`). Unix does not have this limitation.

`socket.get_inheritable()`

Get the *inheritable flag* of the socket's file descriptor or socket's handle: `True` if the socket can be inherited in child processes, `False` if it cannot.

在 3.4 版新加入。

`socket.getpeername()`

Return the remote address to which the socket is connected. This is useful to find out the port number of a remote IPv4/v6 socket, for instance. (The format of the address returned depends on the address family --- see above.) On some systems this function is not supported.

`socket.getsockname()`

Return the socket's own address. This is useful to find out the port number of an IPv4/v6 socket, for instance. (The format of the address returned depends on the address family --- see above.)

`socket.getsockopt(level, optname[, buflen])`

Return the value of the given socket option (see the Unix man page *getsockopt(2)*). The needed symbolic constants (*SO_* etc.*) are defined in this module. If *buflen* is absent, an integer option is assumed and its integer value is returned by the function. If *buflen* is present, it specifies the maximum length of the buffer used to receive the option in, and this buffer is returned as a bytes object. It is up to the caller to decode the contents of the buffer (see the optional built-in module *struct* for a way to decode C structures encoded as byte strings).

適用：非 WASI。

`socket.getblocking()`

Return `True` if socket is in blocking mode, `False` if in non-blocking.

這等同於檢查 `socket.gettimeout() != 0`。

在 3.7 版新加入。

`socket.gettimeout()`

Return the timeout in seconds (float) associated with socket operations, or `None` if no timeout is set. This reflects the last call to `setblocking()` or `settimeout()`.

`socket.ioctl(control, option)`

平台

Windows

The *ioctl()* method is a limited interface to the *WSAIoctl* system interface. Please refer to the [Win32 documentation](#) for more information.

On other platforms, the generic *fcntl.fcntl()* and *fcntl.ioctl()* functions may be used; they accept a socket object as their first argument.

Currently only the following control codes are supported: *SIO_RCVALL*, *SIO_KEEPA_LIVE_VALS*, and *SIO_LOOPBACK_FAST_PATH*.

在 3.6 版的變更：加入 *SIO_LOOPBACK_FAST_PATH*。

`socket.listen([backlog])`

Enable a server to accept connections. If *backlog* is specified, it must be at least 0 (if it is lower, it is set to 0); it specifies the number of unaccepted connections that the system will allow before refusing new connections. If not specified, a default reasonable value is chosen.

適用：非 WASI。

在 3.5 版的變更：The *backlog* parameter is now optional.

`socket.makefile(mode='r', buffering=None, *, encoding=None, errors=None, newline=None)`

Return a *file object* associated with the socket. The exact returned type depends on the arguments given to `makefile()`. These arguments are interpreted the same way as by the built-in `open()` function, except the only supported *mode* values are 'r' (default), 'w' and 'b'.

The socket must be in blocking mode; it can have a timeout, but the file object's internal buffer may end up in an inconsistent state if a timeout occurs.

Closing the file object returned by `makefile()` won't close the original socket unless all other file objects have been closed and `socket.close()` has been called on the socket object.

備註: On Windows, the file-like object created by `makefile()` cannot be used where a file object with a file descriptor is expected, such as the stream arguments of `subprocess.Popen()`.

`socket.recv(bufsize[, flags])`

Receive data from the socket. The return value is a bytes object representing the data received. The maximum amount of data to be received at once is specified by *bufsize*. A returned empty bytes object indicates that the client has disconnected. See the Unix manual page `recv(2)` for the meaning of the optional argument *flags*; it defaults to zero.

備註: For best match with hardware and network realities, the value of *bufsize* should be a relatively small power of 2, for example, 4096.

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an `InterruptedError` exception (see [PEP 475](#) for the rationale).

`socket.recvfrom(bufsize[, flags])`

Receive data from the socket. The return value is a pair (*bytes*, *address*) where *bytes* is a bytes object representing the data received and *address* is the address of the socket sending the data. See the Unix manual page `recv(2)` for the meaning of the optional argument *flags*; it defaults to zero. (The format of *address* depends on the address family --- see above.)

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an `InterruptedError` exception (see [PEP 475](#) for the rationale).

在 3.7 版的變更: For multicast IPv6 address, first item of *address* does not contain `%scope_id` part anymore. In order to get full IPv6 address use `getnameinfo()`.

`socket.recvmsg(bufsize[, ancbufsize[, flags]])`

Receive normal data (up to *bufsize* bytes) and ancillary data from the socket. The *ancbufsize* argument sets the size in bytes of the internal buffer used to receive the ancillary data; it defaults to 0, meaning that no ancillary data will be received. Appropriate buffer sizes for ancillary data can be calculated using `CMSG_SPACE()` or `CMSG_LEN()`, and items which do not fit into the buffer might be truncated or discarded. The *flags* argument defaults to 0 and has the same meaning as for `recv()`.

The return value is a 4-tuple: (*data*, *ancdata*, *msg_flags*, *address*). The *data* item is a *bytes* object holding the non-ancillary data received. The *ancdata* item is a list of zero or more tuples (*cmsg_level*, *cmsg_type*, *cmsg_data*) representing the ancillary data (control messages) received: *cmsg_level* and *cmsg_type* are integers specifying the protocol level and protocol-specific type respectively, and *cmsg_data* is a *bytes* object holding the associated data. The *msg_flags* item is the bitwise OR of various flags indicating conditions on the received message; see your system documentation for details. If the receiving socket is unconnected, *address* is the address of the sending socket, if available; otherwise, its value is unspecified.

On some systems, `sendmsg()` and `recvmsg()` can be used to pass file descriptors between processes over an `AF_UNIX` socket. When this facility is used (it is often restricted to `SOCK_STREAM` sockets),

`recvmsg()` will return, in its ancillary data, items of the form `(socket.SOL_SOCKET, socket.SCM_RIGHTS, fds)`, where `fds` is a *bytes* object representing the new file descriptors as a binary array of the native C `int` type. If `recvmsg()` raises an exception after the system call returns, it will first attempt to close any file descriptors received via this mechanism.

Some systems do not indicate the truncated length of ancillary data items which have been only partially received. If an item appears to extend beyond the end of the buffer, `recvmsg()` will issue a *RuntimeWarning*, and will return the part of it which is inside the buffer provided it has not been truncated before the start of its associated data.

On systems which support the `SCM_RIGHTS` mechanism, the following function will receive up to `maxfds` file descriptors, returning the message data and a list containing the descriptors (while ignoring unexpected conditions such as unrelated control messages being received). See also `sendmsg()`.

```
import socket, array

def recv_fds(sock, msglen, maxfds):
    fds = array.array("i")    # Array of ints
    msg, ancdata, flags, addr = sock.recvmsg(msglen, socket.CMSG_LEN(maxfds *
→fds.itemsize))
    for cmsg_level, cmsg_type, cmsg_data in ancdata:
        if cmsg_level == socket.SOL_SOCKET and cmsg_type == socket.SCM_RIGHTS:
            # Append data, ignoring any truncated integers at the end.
            fds.frombytes(cmsg_data[:len(cmsg_data) - (len(cmsg_data) % fds.
→itemsize)])
    return msg, list(fds)
```

適用：Unix。

Most Unix platforms.

在 3.3 版新加入。

在 3.5 版的變更：If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an *InterruptedError* exception (see **PEP 475** for the rationale).

`socket.recvmsg_into(buffers[, ancbufsize[, flags]])`

Receive normal data and ancillary data from the socket, behaving as `recvmsg()` would, but scatter the non-ancillary data into a series of buffers instead of returning a new bytes object. The *buffers* argument must be an iterable of objects that export writable buffers (e.g. *bytearray* objects); these will be filled with successive chunks of the non-ancillary data until it has all been written or there are no more buffers. The operating system may set a limit (`sysconf()` value `SC_IOV_MAX`) on the number of buffers that can be used. The *ancbufsize* and *flags* arguments have the same meaning as for `recvmsg()`.

The return value is a 4-tuple: `(nbytes, ancdata, msg_flags, address)`, where *nbytes* is the total number of bytes of non-ancillary data written into the buffers, and *ancdata*, *msg_flags* and *address* are the same as for `recvmsg()`.

範例：

```
>>> import socket
>>> s1, s2 = socket.socketpair()
>>> b1 = bytearray(b'----')
>>> b2 = bytearray(b'0123456789')
>>> b3 = bytearray(b'-----')
>>> s1.send(b'Mary had a little lamb')
22
>>> s2.recvmsg_into([b1, memoryview(b2)[2:9], b3])
(22, [], 0, None)
>>> [b1, b2, b3]
[bytearray(b'Mary'), bytearray(b'01 had a 9'), bytearray(b'little lamb---')]
```

適用：Unix。

Most Unix platforms.

在 3.3 版新加入。

```
socket.recvfrom_into(buffer[, nbytes[, flags]])
```

Receive data from the socket, writing it into *buffer* instead of creating a new bytestring. The return value is a pair (*nbytes*, *address*) where *nbytes* is the number of bytes received and *address* is the address of the socket sending the data. See the Unix manual page *recv(2)* for the meaning of the optional argument *flags*; it defaults to zero. (The format of *address* depends on the address family --- see above.)

```
socket.recv_into(buffer[, nbytes[, flags]])
```

Receive up to *nbytes* bytes from the socket, storing the data into a buffer rather than creating a new bytestring. If *nbytes* is not specified (or 0), receive up to the size available in the given buffer. Returns the number of bytes received. See the Unix manual page *recv(2)* for the meaning of the optional argument *flags*; it defaults to zero.

```
socket.send(bytes[, flags])
```

Send data to the socket. The socket must be connected to a remote socket. The optional *flags* argument has the same meaning as for *recv()* above. Returns the number of bytes sent. Applications are responsible for checking that all data has been sent; if only some of the data was transmitted, the application needs to attempt delivery of the remaining data. For further information on this topic, consult the socket-howto.

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an *InterruptedError* exception (see [PEP 475](#) for the rationale).

```
socket.sendall(bytes[, flags])
```

Send data to the socket. The socket must be connected to a remote socket. The optional *flags* argument has the same meaning as for *recv()* above. Unlike *send()*, this method continues to send data from *bytes* until either all data has been sent or an error occurs. None is returned on success. On error, an exception is raised, and there is no way to determine how much data, if any, was successfully sent.

在 3.5 版的變更: The socket timeout is no longer reset each time data is sent successfully. The socket timeout is now the maximum total duration to send all data.

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an *InterruptedError* exception (see [PEP 475](#) for the rationale).

```
socket.sendto(bytes, address)
```

```
socket.sendto(bytes, flags, address)
```

Send data to the socket. The socket should not be connected to a remote socket, since the destination socket is specified by *address*. The optional *flags* argument has the same meaning as for *recv()* above. Return the number of bytes sent. (The format of *address* depends on the address family --- see above.)

引發一個附帶引數 *self*、*address* 的稽核事件 `socket.sendto`。

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an *InterruptedError* exception (see [PEP 475](#) for the rationale).

```
socket.sendmsg(buffers[, ancdata[, flags[, address]]])
```

Send normal and ancillary data to the socket, gathering the non-ancillary data from a series of buffers and concatenating it into a single message. The *buffers* argument specifies the non-ancillary data as an iterable of *bytes-like objects* (e.g. *bytes* objects); the operating system may set a limit (*sysconf()* value *SC_IOV_MAX*) on the number of buffers that can be used. The *ancdata* argument specifies the ancillary data (control messages) as an iterable of zero or more tuples (*cmsg_level*, *cmsg_type*, *cmsg_data*), where *cmsg_level* and *cmsg_type* are integers specifying the protocol level and protocol-specific type respectively, and *cmsg_data* is a bytes-like object holding the associated data. Note that some systems (in particular, systems without *MSG_SPACE()*) might support sending only one control message per call. The *flags* argument defaults to 0 and has the same meaning as for *send()*. If *address* is supplied and not None, it sets a destination address for the message. The return value is the number of bytes of non-ancillary data sent.

The following function sends the list of file descriptors *fds* over an *AF_UNIX* socket, on systems which support the *SCM_RIGHTS* mechanism. See also *recvmsg()*.

```
import socket, array

def send_fds(sock, msg, fds):
    return sock.sendmsg([msg], [(socket.SOL_SOCKET, socket.SCM_RIGHTS, array.
    ↪array("i", fds))])
```

適用：Unix、非 WASI。

Most Unix platforms.

引發一個附帶引數 *self*、*address* 的稽核事件 *socket.sendmsg*。

在 3.3 版新加入。

在 3.5 版的變更: If the system call is interrupted and the signal handler does not raise an exception, the method now retries the system call instead of raising an *InterruptedError* exception (see **PEP 475** for the rationale).

socket.sendmsg_afalg (*[msg,]**, *op*[, *iv*[, *assoclen*[, *flags*]]])

Specialized version of *sendmsg()* for *AF_ALG* socket. Set mode, IV, AEAD associated data length and flags for *AF_ALG* socket.

適用：Linux >= 2.6.38。

在 3.6 版新加入。

socket.sendfile (*file*, *offset*=0, *count*=None)

Send a file until EOF is reached by using high-performance *os.sendfile* and return the total number of bytes which were sent. *file* must be a regular file object opened in binary mode. If *os.sendfile* is not available (e.g. Windows) or *file* is not a regular file *send()* will be used instead. *offset* tells from where to start reading the file. If specified, *count* is the total number of bytes to transmit as opposed to sending the file until EOF is reached. File position is updated on return or also in case of error in which case *file.tell()* can be used to figure out the number of bytes which were sent. The socket must be of *SOCK_STREAM* type. Non-blocking sockets are not supported.

在 3.5 版新加入。

socket.set_inheritable (*inheritable*)

Set the *inheritable* flag of the socket's file descriptor or socket's handle.

在 3.4 版新加入。

socket.setblocking (*flag*)

Set blocking or non-blocking mode of the socket: if *flag* is false, the socket is set to non-blocking, else to blocking mode.

This method is a shorthand for certain *settimeout()* calls:

- *sock.setblocking*(True) 等價於 *sock.settimeout*(None)
- *sock.setblocking*(False) 等價於 *sock.settimeout*(0.0)

在 3.7 版的變更: The method no longer applies *SOCK_NONBLOCK* flag on *socket.type*.

socket.settimeout (*value*)

Set a timeout on blocking socket operations. The *value* argument can be a nonnegative floating point number expressing seconds, or None. If a non-zero value is given, subsequent socket operations will raise a *timeout* exception if the timeout period *value* has elapsed before the operation has completed. If zero is given, the socket is put in non-blocking mode. If None is given, the socket is put in blocking mode.

For further information, please consult the *notes on socket timeouts*.

在 3.7 版的變更: The method no longer toggles *SOCK_NONBLOCK* flag on *socket.type*.

`socket.setsockopt (level, optname, value: int)`

`socket.setsockopt (level, optname, value: buffer)`

`socket.setsockopt (level, optname, None, optlen: int)`

Set the value of the given socket option (see the Unix manual page *setsockopt(2)*). The needed symbolic constants are defined in this module (`SO_*` etc. <socket-unix-constants>). The value can be an integer, `None` or a *bytes-like object* representing a buffer. In the later case it is up to the caller to ensure that the bytestring contains the proper bits (see the optional built-in module *struct* for a way to encode C structures as bytestrings). When *value* is set to `None`, *optlen* argument is required. It's equivalent to call `setsockopt()` C function with `optval=NULL` and `optlen=optlen`.

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

在 3.6 版的變更: `setsockopt(level, optname, None, optlen: int)` form added.

適用: 非 WASI。

`socket.shutdown (how)`

Shut down one or both halves of the connection. If *how* is `SHUT_RD`, further receives are disallowed. If *how* is `SHUT_WR`, further sends are disallowed. If *how* is `SHUT_RDWR`, further sends and receives are disallowed.

適用: 非 WASI。

`socket.share (process_id)`

Duplicate a socket and prepare it for sharing with a target process. The target process must be provided with *process_id*. The resulting bytes object can then be passed to the target process using some form of interprocess communication and the socket can be recreated there using *fromshare()*. Once this method has been called, it is safe to close the socket since the operating system has already duplicated it for the target process.

適用: Windows。

在 3.3 版新加入。

Note that there are no methods `read()` or `write()`; use *recv()* and *send()* without *flags* argument instead.

Socket objects also have these (read-only) attributes that correspond to the values given to the *socket* constructor.

`socket.family`

The socket family.

`socket.type`

The socket type.

`socket.proto`

The socket protocol.

18.2.4 Notes on socket timeouts

A socket object can be in one of three modes: blocking, non-blocking, or timeout. Sockets are by default always created in blocking mode, but this can be changed by calling *setdefaulttimeout()*.

- In *blocking mode*, operations block until complete or the system returns an error (such as connection timed out).
- In *non-blocking mode*, operations fail (with an error that is unfortunately system-dependent) if they cannot be completed immediately; functions from the *select* module can be used to know when and whether a socket is available for reading or writing.
- In *timeout mode*, operations fail if they cannot be completed within the timeout specified for the socket (they raise a *timeout* exception) or if the system returns an error.

備註: At the operating system level, sockets in *timeout mode* are internally set in non-blocking mode. Also, the blocking and timeout modes are shared between file descriptors and socket objects that refer to the same network

endpoint. This implementation detail can have visible consequences if e.g. you decide to use the `fileno()` of a socket.

Timeouts and the `connect` method

The `connect()` operation is also subject to the timeout setting, and in general it is recommended to call `settimeout()` before calling `connect()` or pass a timeout parameter to `create_connection()`. However, the system network stack may also return a connection timeout error of its own regardless of any Python socket timeout setting.

Timeouts and the `accept` method

If `getdefaulttimeout()` is not `None`, sockets returned by the `accept()` method inherit that timeout. Otherwise, the behaviour depends on settings of the listening socket:

- if the listening socket is in *blocking mode* or in *timeout mode*, the socket returned by `accept()` is in *blocking mode*;
- if the listening socket is in *non-blocking mode*, whether the socket returned by `accept()` is in blocking or non-blocking mode is operating system-dependent. If you want to ensure cross-platform behaviour, it is recommended you manually override this setting.

18.2.5 范例

Here are four minimal example programs using the TCP/IP protocol: a server that echoes all data that it receives back (servicing only one client), and a client using it. Note that a server must perform the sequence `socket()`, `bind()`, `listen()`, `accept()` (possibly repeating the `accept()` to service more than one client), while a client only needs the sequence `socket()`, `connect()`. Also note that the server does not `sendall()/recv()` on the socket it is listening on but on the new socket returned by `accept()`.

前兩個範例只支援 IPv4:

```
# Echo server program
import socket

HOST = ''                    # Symbolic name meaning all available interfaces
PORT = 50007                 # Arbitrary non-privileged port
with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
    s.bind((HOST, PORT))
    s.listen(1)
    conn, addr = s.accept()
    with conn:
        print('Connected by', addr)
        while True:
            data = conn.recv(1024)
            if not data: break
            conn.sendall(data)
```

```
# Echo client program
import socket

HOST = 'daring.cwi.nl'      # The remote host
PORT = 50007                # The same port as used by the server
with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
    s.connect((HOST, PORT))
    s.sendall(b'Hello, world')
    data = s.recv(1024)
print('Received', repr(data))
```


The next two examples are identical to the above two, but support both IPv4 and IPv6. The server side will listen to the first address family available (it should listen to both instead). On most of IPv6-ready systems, IPv6 will take precedence and the server may not accept IPv4 traffic. The client side will try to connect to all the addresses returned as a result of the name resolution, and sends traffic to the first one connected successfully.

```
# Echo server program
import socket
import sys

HOST = None           # Symbolic name meaning all available interfaces
PORT = 50007          # Arbitrary non-privileged port
s = None
for res in socket.getaddrinfo(HOST, PORT, socket.AF_UNSPEC,
                              socket.SOCK_STREAM, 0, socket.AI_PASSIVE):
    af, socktype, proto, canonname, sa = res
    try:
        s = socket.socket(af, socktype, proto)
    except OSError as msg:
        s = None
        continue
    try:
        s.bind(sa)
        s.listen(1)
    except OSError as msg:
        s.close()
        s = None
        continue
    break
if s is None:
    print('could not open socket')
    sys.exit(1)
conn, addr = s.accept()
with conn:
    print('Connected by', addr)
    while True:
        data = conn.recv(1024)
        if not data: break
        conn.send(data)
```

```
# Echo client program
import socket
import sys

HOST = 'daring.cwi.nl' # The remote host
PORT = 50007           # The same port as used by the server
s = None
for res in socket.getaddrinfo(HOST, PORT, socket.AF_UNSPEC, socket.SOCK_STREAM):
    af, socktype, proto, canonname, sa = res
    try:
        s = socket.socket(af, socktype, proto)
    except OSError as msg:
        s = None
        continue
    try:
        s.connect(sa)
    except OSError as msg:
        s.close()
        s = None
        continue
    break
if s is None:
    print('could not open socket')
```

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```

    sys.exit(1)
with s:
    s.sendall(b'Hello, world')
    data = s.recv(1024)
print('Received', repr(data))

```

The next example shows how to write a very simple network sniffer with raw sockets on Windows. The example requires administrator privileges to modify the interface:

```

import socket

# the public network interface
HOST = socket.gethostbyname(socket.gethostname())

# create a raw socket and bind it to the public interface
s = socket.socket(socket.AF_INET, socket.SOCK_RAW, socket.IPPROTO_IP)
s.bind((HOST, 0))

# Include IP headers
s.setsockopt(socket.IPPROTO_IP, socket.IP_HDRINCL, 1)

# receive all packets
s.ioctl(socket.SIO_RCVALL, socket.RCVALL_ON)

# receive a packet
print(s.recvfrom(65565))

# disabled promiscuous mode
s.ioctl(socket.SIO_RCVALL, socket.RCVALL_OFF)

```

The next example shows how to use the socket interface to communicate to a CAN network using the raw socket protocol. To use CAN with the broadcast manager protocol instead, open a socket with:

```
socket.socket(socket.AF_CAN, socket.SOCK_DGRAM, socket.CAN_BCM)
```

After binding (`CAN_RAW`) or connecting (`CAN_BCM`) the socket, you can use the `socket.send()` and `socket.recv()` operations (and their counterparts) on the socket object as usual.

This last example might require special privileges:

```

import socket
import struct

# CAN frame packing/unpacking (see 'struct can_frame' in <linux/can.h>)

can_frame_fmt = "=IB3x8s"
can_frame_size = struct.calcsize(can_frame_fmt)

def build_can_frame(can_id, data):
    can_dlc = len(data)
    data = data.ljust(8, b'\x00')
    return struct.pack(can_frame_fmt, can_id, can_dlc, data)

def dissect_can_frame(frame):
    can_id, can_dlc, data = struct.unpack(can_frame_fmt, frame)
    return (can_id, can_dlc, data[:can_dlc])

# create a raw socket and bind it to the 'vcan0' interface
s = socket.socket(socket.AF_CAN, socket.SOCK_RAW, socket.CAN_RAW)

```

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```
s.bind(('vcan0',))

while True:
    cf, addr = s.recvfrom(can_frame_size)

    print('Received: can_id=%x, can_dlc=%x, data=%s' % dissect_can_frame(cf))

    try:
        s.send(cf)
    except OSError:
        print('Error sending CAN frame')

    try:
        s.send(build_can_frame(0x01, b'\x01\x02\x03'))
    except OSError:
        print('Error sending CAN frame')
```

Running an example several times with too small delay between executions, could lead to this error:

```
OSError: [Errno 98] Address already in use
```

This is because the previous execution has left the socket in a `TIME_WAIT` state, and can't be immediately reused.

There is a `socket` flag to set, in order to prevent this, `socket.SO_REUSEADDR`:

```
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
s.bind((HOST, PORT))
```

the `SO_REUSEADDR` flag tells the kernel to reuse a local socket in `TIME_WAIT` state, without waiting for its natural timeout to expire.

也參考:

For an introduction to socket programming (in C), see the following papers:

- *An Introductory 4.3BSD Interprocess Communication Tutorial*, by Stuart Sechrest
- *An Advanced 4.3BSD Interprocess Communication Tutorial*, by Samuel J. Leffler et al,

both in the UNIX Programmer's Manual, Supplementary Documents 1 (sections PS1:7 and PS1:8). The platform-specific reference material for the various socket-related system calls are also a valuable source of information on the details of socket semantics. For Unix, refer to the manual pages; for Windows, see the WinSock (or Winsock 2) specification. For IPv6-ready APIs, readers may want to refer to [RFC 3493](#) titled Basic Socket Interface Extensions for IPv6.

18.3 `ssl` --- TLS/SSL wrapper for socket objects

原始碼: [Lib/ssl.py](#)

This module provides access to Transport Layer Security (often known as "Secure Sockets Layer") encryption and peer authentication facilities for network sockets, both client-side and server-side. This module uses the OpenSSL library. It is available on all modern Unix systems, Windows, macOS, and probably additional platforms, as long as OpenSSL is installed on that platform.

備 F: Some behavior may be platform dependent, since calls are made to the operating system socket APIs. The installed version of OpenSSL may also cause variations in behavior. For example, TLSv1.3 comes with OpenSSL version 1.1.1.

警告: Don't use this module without reading the *Security considerations*. Doing so may lead to a false sense of security, as the default settings of the `ssl` module are not necessarily appropriate for your application.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See *WebAssembly 平台* for more information.

This section documents the objects and functions in the `ssl` module; for more general information about TLS, SSL, and certificates, the reader is referred to the documents in the "See Also" section at the bottom.

This module provides a class, `ssl.SSLSocket`, which is derived from the `socket.socket` type, and provides a socket-like wrapper that also encrypts and decrypts the data going over the socket with SSL. It supports additional methods such as `getpeercert()`, which retrieves the certificate of the other side of the connection, and `cipher()`, which retrieves the cipher being used for the secure connection.

For more sophisticated applications, the `ssl.SSLContext` class helps manage settings and certificates, which can then be inherited by SSL sockets created through the `SSLContext.wrap_socket()` method.

在 3.5.3 版的變更: Updated to support linking with OpenSSL 1.1.0

在 3.6 版的變更: OpenSSL 0.9.8, 1.0.0 and 1.0.1 are deprecated and no longer supported. In the future the `ssl` module will require at least OpenSSL 1.0.2 or 1.1.0.

在 3.10 版的變更: **PEP 644** has been implemented. The `ssl` module requires OpenSSL 1.1.1 or newer.

Use of deprecated constants and functions result in deprecation warnings.

18.3.1 函式、常數與例外

Socket creation

Since Python 3.2 and 2.7.9, it is recommended to use the `SSLContext.wrap_socket()` of an `SSLContext` instance to wrap sockets as `SSLSocket` objects. The helper functions `create_default_context()` returns a new context with secure default settings. The old `wrap_socket()` function is deprecated since it is both inefficient and has no support for server name indication (SNI) and hostname matching.

Client socket example with default context and IPv4/IPv6 dual stack:

```
import socket
import ssl

hostname = 'www.python.org'
context = ssl.create_default_context()

with socket.create_connection((hostname, 443)) as sock:
    with context.wrap_socket(sock, server_hostname=hostname) as ssock:
        print(ssock.version())
```

Client socket example with custom context and IPv4:

```
hostname = 'www.python.org'
# PROTOCOL_TLS_CLIENT requires valid cert chain and hostname
context = ssl.SSLContext(ssl.PROTOCOL_TLS_CLIENT)
context.load_verify_locations('path/to/cabundle.pem')

with socket.socket(socket.AF_INET, socket.SOCK_STREAM, 0) as sock:
    with context.wrap_socket(sock, server_hostname=hostname) as ssock:
        print(ssock.version())
```

Server socket example listening on localhost IPv4:

```
context = ssl.SSLContext(ssl.PROTOCOL_TLS_SERVER)
context.load_cert_chain('/path/to/certchain.pem', '/path/to/private.key')

with socket.socket(socket.AF_INET, socket.SOCK_STREAM, 0) as sock:
    sock.bind(('127.0.0.1', 8443))
    sock.listen(5)
    with context.wrap_socket(sock, server_side=True) as ssock:
        conn, addr = ssock.accept()
    ...
```

Context creation

A convenience function helps create *SSLContext* objects for common purposes.

`ssl.create_default_context` (*purpose*=*Purpose.SERVER_AUTH*, *cafile*=*None*, *capath*=*None*, *cadata*=*None*)

Return a new *SSLContext* object with default settings for the given *purpose*. The settings are chosen by the *ssl* module, and usually represent a higher security level than when calling the *SSLContext* constructor directly.

cafile, *capath*, *cadata* represent optional CA certificates to trust for certificate verification, as in *SSLContext.load_verify_locations()*. If all three are *None*, this function can choose to trust the system's default CA certificates instead.

The settings are: *PROTOCOL_TLS_CLIENT* or *PROTOCOL_TLS_SERVER*, *OP_NO_SSLv2*, and *OP_NO_SSLv3* with high encryption cipher suites without RC4 and without unauthenticated cipher suites. Passing *SERVER_AUTH* as *purpose* sets *verify_mode* to *CERT_REQUIRED* and either loads CA certificates (when at least one of *cafile*, *capath* or *cadata* is given) or uses *SSLContext.load_default_certs()* to load default CA certificates.

When *keylog_filename* is supported and the environment variable *SSLKEYLOGFILE* is set, *create_default_context()* enables key logging.

備 注: The protocol, options, cipher and other settings may change to more restrictive values anytime without prior deprecation. The values represent a fair balance between compatibility and security.

If your application needs specific settings, you should create a *SSLContext* and apply the settings yourself.

備 注: If you find that when certain older clients or servers attempt to connect with a *SSLContext* created by this function that they get an error stating "Protocol or cipher suite mismatch", it may be that they only support SSL3.0 which this function excludes using the *OP_NO_SSLv3*. SSL3.0 is widely considered to be **completely broken**. If you still wish to continue to use this function but still allow SSL 3.0 connections you can re-enable them using:

```
ctx = ssl.create_default_context(Purpose.CLIENT_AUTH)
ctx.options |= ~ssl.OP_NO_SSLv3
```

在 3.4 版新加入.

在 3.4.4 版的變更: RC4 was dropped from the default cipher string.

在 3.6 版的變更: ChaCha20/Poly1305 was added to the default cipher string.

3DES was dropped from the default cipher string.

在 3.8 版的變更: Support for key logging to *SSLKEYLOGFILE* was added.

在 3.10 版的變更: The context now uses *PROTOCOL_TLS_CLIENT* or *PROTOCOL_TLS_SERVER* protocol instead of generic *PROTOCOL_TLS*.

例外

exception `ssl.SSLError`

Raised to signal an error from the underlying SSL implementation (currently provided by the OpenSSL library). This signifies some problem in the higher-level encryption and authentication layer that's superimposed on the underlying network connection. This error is a subtype of *OSError*. The error code and message of *SSLError* instances are provided by the OpenSSL library.

在 3.3 版的變更: *SSLError* used to be a subtype of *socket.error*.

library

A string mnemonic designating the OpenSSL submodule in which the error occurred, such as *SSL*, *PEM* or *X509*. The range of possible values depends on the OpenSSL version.

在 3.3 版新加入.

reason

A string mnemonic designating the reason this error occurred, for example *CERTIFICATE_VERIFY_FAILED*. The range of possible values depends on the OpenSSL version.

在 3.3 版新加入.

exception `ssl.SSLZeroReturnError`

A subclass of *SSLError* raised when trying to read or write and the SSL connection has been closed cleanly. Note that this doesn't mean that the underlying transport (read TCP) has been closed.

在 3.3 版新加入.

exception `ssl.SSLWantReadError`

A subclass of *SSLError* raised by a *non-blocking SSL socket* when trying to read or write data, but more data needs to be received on the underlying TCP transport before the request can be fulfilled.

在 3.3 版新加入.

exception `ssl.SSLWantWriteError`

A subclass of *SSLError* raised by a *non-blocking SSL socket* when trying to read or write data, but more data needs to be sent on the underlying TCP transport before the request can be fulfilled.

在 3.3 版新加入.

exception `ssl.SSLSyscallError`

A subclass of *SSLError* raised when a system error was encountered while trying to fulfill an operation on a SSL socket. Unfortunately, there is no easy way to inspect the original *errno* number.

在 3.3 版新加入.

exception `ssl.SSLEOFError`

A subclass of *SSLError* raised when the SSL connection has been terminated abruptly. Generally, you shouldn't try to reuse the underlying transport when this error is encountered.

在 3.3 版新加入.

exception `ssl.SSLCertVerificationError`

A subclass of *SSLError* raised when certificate validation has failed.

在 3.7 版新加入.

verify_code

A numeric error number that denotes the verification error.

verify_message

A human readable string of the verification error.

exception `ssl.CertificateError`

An alias for `SSLCertVerificationError`.

在 3.7 版的變更: The exception is now an alias for `SSLCertVerificationError`.

Random generation`ssl.RAND_bytes(num)`

Return *num* cryptographically strong pseudo-random bytes. Raises an `SSL_ERROR` if the PRNG has not been seeded with enough data or if the operation is not supported by the current RAND method. `RAND_status()` can be used to check the status of the PRNG and `RAND_add()` can be used to seed the PRNG.

For almost all applications `os.urandom()` is preferable.

Read the Wikipedia article, [Cryptographically secure pseudorandom number generator \(CSPRNG\)](#), to get the requirements of a cryptographically strong generator.

在 3.3 版新加入.

`ssl.RAND_pseudo_bytes(num)`

Return (bytes, is_cryptographic): bytes are *num* pseudo-random bytes, is_cryptographic is `True` if the bytes generated are cryptographically strong. Raises an `SSL_ERROR` if the operation is not supported by the current RAND method.

Generated pseudo-random byte sequences will be unique if they are of sufficient length, but are not necessarily unpredictable. They can be used for non-cryptographic purposes and for certain purposes in cryptographic protocols, but usually not for key generation etc.

For almost all applications `os.urandom()` is preferable.

在 3.3 版新加入.

在 3.6 版之後被 用: OpenSSL has deprecated `ssl.RAND_pseudo_bytes()`, use `ssl.RAND_bytes()` instead.

`ssl.RAND_status()`

Return `True` if the SSL pseudo-random number generator has been seeded with 'enough' randomness, and `False` otherwise. You can use `ssl.RAND_egd()` and `ssl.RAND_add()` to increase the randomness of the pseudo-random number generator.

`ssl.RAND_add(bytes, entropy)`

Mix the given *bytes* into the SSL pseudo-random number generator. The parameter *entropy* (a float) is a lower bound on the entropy contained in string (so you can always use `0.0`). See [RFC 1750](#) for more information on sources of entropy.

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

Certificate handling`ssl.match_hostname(cert, hostname)`

Verify that *cert* (in decoded format as returned by `SSLSocket.getpeercert()`) matches the given *hostname*. The rules applied are those for checking the identity of HTTPS servers as outlined in [RFC 2818](#), [RFC 5280](#) and [RFC 6125](#). In addition to HTTPS, this function should be suitable for checking the identity of servers in various SSL-based protocols such as FTPS, IMAPS, POPS and others.

`CertificateError` is raised on failure. On success, the function returns nothing:

```
>>> cert = {'subject': (('commonName', 'example.com'),),)}
>>> ssl.match_hostname(cert, "example.com")
>>> ssl.match_hostname(cert, "example.org")
Traceback (most recent call last):
```

(繼續下一頁)

(繼續上一頁)

```
File "<stdin>", line 1, in <module>
File "/home/py3k/Lib/ssl.py", line 130, in match_hostname
ssl.CertificateError: hostname 'example.org' doesn't match 'example.com'
```

在 3.2 版新加入。

在 3.3.3 版的變更: The function now follows [RFC 6125](#), section 6.4.3 and does neither match multiple wildcards (e.g. `*.*.com` or `*a*.example.org`) nor a wildcard inside an internationalized domain names (IDN) fragment. IDN A-labels such as `www*.xn--python-kva.org` are still supported, but `x*.python.org` no longer matches `xn--tda.python.org`.

在 3.5 版的變更: Matching of IP addresses, when present in the `subjectAltName` field of the certificate, is now supported.

在 3.7 版的變更: The function is no longer used to TLS connections. Hostname matching is now performed by OpenSSL.

Allow wildcard when it is the leftmost and the only character in that segment. Partial wildcards like `www*.example.com` are no longer supported.

在 3.7 版之後被禁用。

`ssl.cert_time_to_seconds(cert_time)`

Return the time in seconds since the Epoch, given the `cert_time` string representing the "notBefore" or "notAfter" date from a certificate in `"%b %d %H:%M:%S %Y %Z"` `strptime` format (C locale).

Here's an example:

```
>>> import ssl
>>> timestamp = ssl.cert_time_to_seconds("Jan  5 09:34:43 2018 GMT")
>>> timestamp
1515144883
>>> from datetime import datetime
>>> print(datetime.utcfromtimestamp(timestamp))
2018-01-05 09:34:43
```

"notBefore" or "notAfter" dates must use GMT ([RFC 5280](#)).

在 3.5 版的變更: Interpret the input time as a time in UTC as specified by 'GMT' timezone in the input string. Local timezone was used previously. Return an integer (no fractions of a second in the input format)

`ssl.get_server_certificate(addr, ssl_version=PROTOCOL_TLS_CLIENT, ca_certs=None[, timeout])`

Given the address `addr` of an SSL-protected server, as a *(hostname, port-number)* pair, fetches the server's certificate, and returns it as a PEM-encoded string. If `ssl_version` is specified, uses that version of the SSL protocol to attempt to connect to the server. If `ca_certs` is specified, it should be a file containing a list of root certificates, the same format as used for the same parameter in `SSLContext.wrap_socket()`. The call will attempt to validate the server certificate against that set of root certificates, and will fail if the validation attempt fails. A timeout can be specified with the `timeout` parameter.

在 3.3 版的變更: This function is now IPv6-compatible.

在 3.5 版的變更: The default `ssl_version` is changed from `PROTOCOL_SSLv3` to `PROTOCOL_TLS` for maximum compatibility with modern servers.

在 3.10 版的變更: 新增 `timeout` 參數。

`ssl.DER_cert_to_PEM_cert(DER_cert_bytes)`

Given a certificate as a DER-encoded blob of bytes, returns a PEM-encoded string version of the same certificate.

`ssl.PEM_cert_to_DER_cert(PEM_cert_string)`

Given a certificate as an ASCII PEM string, returns a DER-encoded sequence of bytes for that same certificate.

ssl.get_default_verify_paths()

Returns a named tuple with paths to OpenSSL's default cafile and capath. The paths are the same as used by `SSLContext.set_default_verify_paths()`. The return value is a *named tuple* `DefaultVerifyPaths`:

- `cafile` - resolved path to cafile or `None` if the file doesn't exist,
- `capath` - resolved path to capath or `None` if the directory doesn't exist,
- `openssl_cafile_env` - OpenSSL's environment key that points to a cafile,
- `openssl_cafile` - hard coded path to a cafile,
- `openssl_capath_env` - OpenSSL's environment key that points to a capath,
- `openssl_capath` - hard coded path to a capath directory

在 3.4 版新加入。

ssl.enum_certificates(store_name)

Retrieve certificates from Windows' system cert store. `store_name` may be one of `CA`, `ROOT` or `MY`. Windows may provide additional cert stores, too.

The function returns a list of (cert_bytes, encoding_type, trust) tuples. The `encoding_type` specifies the encoding of `cert_bytes`. It is either `x509_asn` for X.509 ASN.1 data or `pkcs_7_asn` for PKCS#7 ASN.1 data. Trust specifies the purpose of the certificate as a set of OIDS or exactly `True` if the certificate is trustworthy for all purposes.

範例：

```
>>> ssl.enum_certificates("CA")
[(b'data...', 'x509_asn', {'1.3.6.1.5.5.7.3.1', '1.3.6.1.5.5.7.3.2'}),
 (b'data...', 'x509_asn', True)]
```

適用：只有 Windows。

在 3.4 版新加入。

ssl.enum_crls(store_name)

Retrieve CRLs from Windows' system cert store. `store_name` may be one of `CA`, `ROOT` or `MY`. Windows may provide additional cert stores, too.

The function returns a list of (cert_bytes, encoding_type, trust) tuples. The `encoding_type` specifies the encoding of `cert_bytes`. It is either `x509_asn` for X.509 ASN.1 data or `pkcs_7_asn` for PKCS#7 ASN.1 data.

適用：只有 Windows。

在 3.4 版新加入。

ssl.wrap_socket(sock, keyfile=None, certfile=None, server_side=False, cert_reqs=CERT_NONE, ssl_version=PROTOCOL_TLS, ca_certs=None, do_handshake_on_connect=True, suppress_ragged_eofs=True, ciphers=None)

Takes an instance `sock` of `socket.socket`, and returns an instance of `ssl.SSLSocket`, a subtype of `socket.socket`, which wraps the underlying socket in an SSL context. `sock` must be a `SOCK_STREAM` socket; other socket types are unsupported.

Internally, function creates a `SSLContext` with protocol `ssl_version` and `SSLContext.options` set to `cert_reqs`. If parameters `keyfile`, `certfile`, `ca_certs` or `ciphers` are set, then the values are passed to `SSLContext.load_cert_chain()`, `SSLContext.load_verify_locations()`, and `SSLContext.set_ciphers()`.

The arguments `server_side`, `do_handshake_on_connect`, and `suppress_ragged_eofs` have the same meaning as `SSLContext.wrap_socket()`.

在 3.7 版之後被 用: Since Python 3.2 and 2.7.9, it is recommended to use the `SSLContext.wrap_socket()` instead of `wrap_socket()`. The top-level function is limited and creates an insecure client socket without server name indication or hostname matching.

常數

All constants are now `enum.IntEnum` or `enum.IntFlag` collections.

在 3.6 版新加入.

`ssl.CERT_NONE`

Possible value for `SSLContext.verify_mode`, or the `cert_reqs` parameter to `wrap_socket()`. Except for `PROTOCOL_TLS_CLIENT`, it is the default mode. With client-side sockets, just about any cert is accepted. Validation errors, such as untrusted or expired cert, are ignored and do not abort the TLS/SSL handshake.

In server mode, no certificate is requested from the client, so the client does not send any for client cert authentication.

參 下方 *Security considerations* 的討論。

`ssl.CERT_OPTIONAL`

Possible value for `SSLContext.verify_mode`, or the `cert_reqs` parameter to `wrap_socket()`. In client mode, `CERT_OPTIONAL` has the same meaning as `CERT_REQUIRED`. It is recommended to use `CERT_REQUIRED` for client-side sockets instead.

In server mode, a client certificate request is sent to the client. The client may either ignore the request or send a certificate in order perform TLS client cert authentication. If the client chooses to send a certificate, it is verified. Any verification error immediately aborts the TLS handshake.

Use of this setting requires a valid set of CA certificates to be passed, either to `SSLContext.load_verify_locations()` or as a value of the `ca_certs` parameter to `wrap_socket()`.

`ssl.CERT_REQUIRED`

Possible value for `SSLContext.verify_mode`, or the `cert_reqs` parameter to `wrap_socket()`. In this mode, certificates are required from the other side of the socket connection; an `SSLError` will be raised if no certificate is provided, or if its validation fails. This mode is **not** sufficient to verify a certificate in client mode as it does not match hostnames. `check_hostname` must be enabled as well to verify the authenticity of a cert. `PROTOCOL_TLS_CLIENT` uses `CERT_REQUIRED` and enables `check_hostname` by default.

With server socket, this mode provides mandatory TLS client cert authentication. A client certificate request is sent to the client and the client must provide a valid and trusted certificate.

Use of this setting requires a valid set of CA certificates to be passed, either to `SSLContext.load_verify_locations()` or as a value of the `ca_certs` parameter to `wrap_socket()`.

`class ssl.VerifyMode`

`enum.IntEnum` collection of `CERT_*` constants.

在 3.6 版新加入.

`ssl.VERIFY_DEFAULT`

Possible value for `SSLContext.verify_flags`. In this mode, certificate revocation lists (CRLs) are not checked. By default OpenSSL does neither require nor verify CRLs.

在 3.4 版新加入.

`ssl.VERIFY_CRL_CHECK_LEAF`

Possible value for `SSLContext.verify_flags`. In this mode, only the peer cert is checked but none of the intermediate CA certificates. The mode requires a valid CRL that is signed by the peer cert's issuer (its direct ancestor CA). If no proper CRL has been loaded with `SSLContext.load_verify_locations`, validation will fail.

在 3.4 版新加入.

ssl.VERIFY_CRL_CHECK_CHAIN

Possible value for `SSLContext.verify_flags`. In this mode, CRLs of all certificates in the peer cert chain are checked.

在 3.4 版新加入。

ssl.VERIFY_X509_STRICT

Possible value for `SSLContext.verify_flags` to disable workarounds for broken X.509 certificates.

在 3.4 版新加入。

ssl.VERIFY_ALLOW_PROXY_CERTS

Possible value for `SSLContext.verify_flags` to enables proxy certificate verification.

在 3.10 版新加入。

ssl.VERIFY_X509_TRUSTED_FIRST

Possible value for `SSLContext.verify_flags`. It instructs OpenSSL to prefer trusted certificates when building the trust chain to validate a certificate. This flag is enabled by default.

在 3.4.4 版新加入。

ssl.VERIFY_X509_PARTIAL_CHAIN

Possible value for `SSLContext.verify_flags`. It instructs OpenSSL to accept intermediate CAs in the trust store to be treated as trust-anchors, in the same way as the self-signed root CA certificates. This makes it possible to trust certificates issued by an intermediate CA without having to trust its ancestor root CA.

在 3.10 版新加入。

class ssl.VerifyFlags

`enum.IntFlag` collection of VERIFY_* constants.

在 3.6 版新加入。

ssl.PROTOCOL_TLS

Selects the highest protocol version that both the client and server support. Despite the name, this option can select both "SSL" and "TLS" protocols.

在 3.6 版新加入。

在 3.10 版之後被 用: TLS clients and servers require different default settings for secure communication. The generic TLS protocol constant is deprecated in favor of `PROTOCOL_TLS_CLIENT` and `PROTOCOL_TLS_SERVER`.

ssl.PROTOCOL_TLS_CLIENT

Auto-negotiate the highest protocol version that both the client and server support, and configure the context client-side connections. The protocol enables `CERT_REQUIRED` and `check_hostname` by default.

在 3.6 版新加入。

ssl.PROTOCOL_TLS_SERVER

Auto-negotiate the highest protocol version that both the client and server support, and configure the context server-side connections.

在 3.6 版新加入。

ssl.PROTOCOL_SSLv23

Alias for `PROTOCOL_TLS`.

在 3.6 版之後被 用: Use `PROTOCOL_TLS` instead.

ssl.PROTOCOL_SSLv2

Selects SSL version 2 as the channel encryption protocol.

This protocol is not available if OpenSSL is compiled with the `no-ssl2` option.

警告: SSL version 2 is insecure. Its use is highly discouraged.

在 3.6 版之後被~~用~~: OpenSSL has removed support for SSLv2.

ssl.PROTOCOL_SSLv3

Selects SSL version 3 as the channel encryption protocol.

This protocol is not available if OpenSSL is compiled with the `no-ssl3` option.

警告: SSL version 3 is insecure. Its use is highly discouraged.

在 3.6 版之後被~~用~~: OpenSSL has deprecated all version specific protocols. Use the default protocol `PROTOCOL_TLS_SERVER` or `PROTOCOL_TLS_CLIENT` with `SSLContext.minimum_version` and `SSLContext.maximum_version` instead.

ssl.PROTOCOL_TLSv1

Selects TLS version 1.0 as the channel encryption protocol.

在 3.6 版之後被~~用~~: OpenSSL has deprecated all version specific protocols.

ssl.PROTOCOL_TLSv1_1

Selects TLS version 1.1 as the channel encryption protocol. Available only with openssl version 1.0.1+.

在 3.4 版新加入.

在 3.6 版之後被~~用~~: OpenSSL has deprecated all version specific protocols.

ssl.PROTOCOL_TLSv1_2

Selects TLS version 1.2 as the channel encryption protocol. Available only with openssl version 1.0.1+.

在 3.4 版新加入.

在 3.6 版之後被~~用~~: OpenSSL has deprecated all version specific protocols.

ssl.OP_ALL

Enables workarounds for various bugs present in other SSL implementations. This option is set by default. It does not necessarily set the same flags as OpenSSL's `SSL_OP_ALL` constant.

在 3.2 版新加入.

ssl.OP_NO_SSLv2

Prevents an SSLv2 connection. This option is only applicable in conjunction with `PROTOCOL_TLS`. It prevents the peers from choosing SSLv2 as the protocol version.

在 3.2 版新加入.

在 3.6 版之後被~~用~~: SSLv2 is deprecated

ssl.OP_NO_SSLv3

Prevents an SSLv3 connection. This option is only applicable in conjunction with `PROTOCOL_TLS`. It prevents the peers from choosing SSLv3 as the protocol version.

在 3.2 版新加入.

在 3.6 版之後被~~用~~: SSLv3 is deprecated

ssl.OP_NO_TLSv1

Prevents a TLSv1 connection. This option is only applicable in conjunction with `PROTOCOL_TLS`. It prevents the peers from choosing TLSv1 as the protocol version.

在 3.2 版新加入.

在 3.7 版之後被~~用~~: The option is deprecated since OpenSSL 1.1.0, use the new `SSLContext.minimum_version` and `SSLContext.maximum_version` instead.

ssl.OP_NO_TLSv1_1

Prevents a TLSv1.1 connection. This option is only applicable in conjunction with *PROTOCOL_TLS*. It prevents the peers from choosing TLSv1.1 as the protocol version. Available only with openssl version 1.0.1+.

在 3.4 版新加入。

在 3.7 版之後被廢用: The option is deprecated since OpenSSL 1.1.0.

ssl.OP_NO_TLSv1_2

Prevents a TLSv1.2 connection. This option is only applicable in conjunction with *PROTOCOL_TLS*. It prevents the peers from choosing TLSv1.2 as the protocol version. Available only with openssl version 1.0.1+.

在 3.4 版新加入。

在 3.7 版之後被廢用: The option is deprecated since OpenSSL 1.1.0.

ssl.OP_NO_TLSv1_3

Prevents a TLSv1.3 connection. This option is only applicable in conjunction with *PROTOCOL_TLS*. It prevents the peers from choosing TLSv1.3 as the protocol version. TLS 1.3 is available with OpenSSL 1.1.1 or later. When Python has been compiled against an older version of OpenSSL, the flag defaults to 0.

在 3.6.3 版新加入。

在 3.7 版之後被廢用: The option is deprecated since OpenSSL 1.1.0. It was added to 2.7.15 and 3.6.3 for backwards compatibility with OpenSSL 1.0.2.

ssl.OP_NO_RENEGOTIATION

Disable all renegotiation in TLSv1.2 and earlier. Do not send HelloRequest messages, and ignore renegotiation requests via ClientHello.

This option is only available with OpenSSL 1.1.0h and later.

在 3.7 版新加入。

ssl.OP_CIPHER_SERVER_PREFERENCE

Use the server's cipher ordering preference, rather than the client's. This option has no effect on client sockets and SSLv2 server sockets.

在 3.3 版新加入。

ssl.OP_SINGLE_DH_USE

Prevents re-use of the same DH key for distinct SSL sessions. This improves forward secrecy but requires more computational resources. This option only applies to server sockets.

在 3.3 版新加入。

ssl.OP_SINGLE_ECDH_USE

Prevents re-use of the same ECDH key for distinct SSL sessions. This improves forward secrecy but requires more computational resources. This option only applies to server sockets.

在 3.3 版新加入。

ssl.OP_ENABLE_MIDDLEBOX_COMPAT

Send dummy Change Cipher Spec (CCS) messages in TLS 1.3 handshake to make a TLS 1.3 connection look more like a TLS 1.2 connection.

This option is only available with OpenSSL 1.1.1 and later.

在 3.8 版新加入。

ssl.OP_NO_COMPRESSION

Disable compression on the SSL channel. This is useful if the application protocol supports its own compression scheme.

在 3.3 版新加入。

class `ssl.Options`

enum.IntFlag collection of `OP_*` constants.

ssl.OP_NO_TICKET

Prevent client side from requesting a session ticket.

在 3.6 版新加入.

ssl.OP_IGNORE_UNEXPECTED_EOF

Ignore unexpected shutdown of TLS connections.

This option is only available with OpenSSL 3.0.0 and later.

在 3.10 版新加入.

ssl.HAS_ALPN

Whether the OpenSSL library has built-in support for the *Application-Layer Protocol Negotiation* TLS extension as described in [RFC 7301](#).

在 3.5 版新加入.

ssl.HAS_NEVER_CHECK_COMMON_NAME

Whether the OpenSSL library has built-in support not checking subject common name and `SSLContext.hostname_checks_common_name` is writeable.

在 3.7 版新加入.

ssl.HAS_ECDH

Whether the OpenSSL library has built-in support for the Elliptic Curve-based Diffie-Hellman key exchange. This should be true unless the feature was explicitly disabled by the distributor.

在 3.3 版新加入.

ssl.HAS_SNI

Whether the OpenSSL library has built-in support for the *Server Name Indication* extension (as defined in [RFC 6066](#)).

在 3.2 版新加入.

ssl.HAS_NPN

Whether the OpenSSL library has built-in support for the *Next Protocol Negotiation* as described in the [Application Layer Protocol Negotiation](#). When true, you can use the `SSLContext.set_npn_protocols()` method to advertise which protocols you want to support.

在 3.3 版新加入.

ssl.HAS_SSLv2

Whether the OpenSSL library has built-in support for the SSL 2.0 protocol.

在 3.7 版新加入.

ssl.HAS_SSLv3

Whether the OpenSSL library has built-in support for the SSL 3.0 protocol.

在 3.7 版新加入.

ssl.HAS_TLSv1

Whether the OpenSSL library has built-in support for the TLS 1.0 protocol.

在 3.7 版新加入.

ssl.HAS_TLSv1_1

Whether the OpenSSL library has built-in support for the TLS 1.1 protocol.

在 3.7 版新加入.

ssl.HAS_TLSv1_2

Whether the OpenSSL library has built-in support for the TLS 1.2 protocol.

在 3.7 版新加入。

ssl.HAS_TLSv1_3

Whether the OpenSSL library has built-in support for the TLS 1.3 protocol.

在 3.7 版新加入。

ssl.CHANNEL_BINDING_TYPES

List of supported TLS channel binding types. Strings in this list can be used as arguments to *SSLSocket.get_channel_binding()*.

在 3.3 版新加入。

ssl.OPENSSSL_VERSION

The version string of the OpenSSL library loaded by the interpreter:

```
>>> ssl.OPENSSSL_VERSION
'OpenSSL 1.0.2k  26 Jan 2017'
```

在 3.2 版新加入。

ssl.OPENSSSL_VERSION_INFO

A tuple of five integers representing version information about the OpenSSL library:

```
>>> ssl.OPENSSSL_VERSION_INFO
(1, 0, 2, 11, 15)
```

在 3.2 版新加入。

ssl.OPENSSSL_VERSION_NUMBER

The raw version number of the OpenSSL library, as a single integer:

```
>>> ssl.OPENSSSL_VERSION_NUMBER
268443839
>>> hex(ssl.OPENSSSL_VERSION_NUMBER)
'0x100020bf'
```

在 3.2 版新加入。

ssl.ALERT_DESCRIPTION_HANDSHAKE_FAILURE**ssl.ALERT_DESCRIPTION_INTERNAL_ERROR****ALERT_DESCRIPTION_***

Alert Descriptions from [RFC 5246](#) and others. The [IANA TLS Alert Registry](#) contains this list and references to the RFCs where their meaning is defined.

Used as the return value of the callback function in *SSLContext.set_servername_callback()*.

在 3.4 版新加入。

class ssl.AlertDescription

enum.IntEnum collection of **ALERT_DESCRIPTION_*** constants.

在 3.6 版新加入。

Purpose.SERVER_AUTH

Option for *create_default_context()* and *SSLContext.load_default_certs()*. This value indicates that the context may be used to authenticate web servers (therefore, it will be used to create client-side sockets).

在 3.4 版新加入。

`Purpose.CLIENT_AUTH`

Option for `create_default_context()` and `SSLContext.load_default_certs()`. This value indicates that the context may be used to authenticate web clients (therefore, it will be used to create server-side sockets).

在 3.4 版新加入.

class `ssl.SSLErrorNumber`

enum.IntEnum collection of `SSL_ERROR_*` constants.

在 3.6 版新加入.

class `ssl.TLSVersion`

enum.IntEnum collection of SSL and TLS versions for `SSLContext.maximum_version` and `SSLContext.minimum_version`.

在 3.7 版新加入.

`TLSVersion.MINIMUM_SUPPORTED`

`TLSVersion.MAXIMUM_SUPPORTED`

The minimum or maximum supported SSL or TLS version. These are magic constants. Their values don't reflect the lowest and highest available TLS/SSL versions.

`TLSVersion.SSLv3`

`TLSVersion.TLSv1`

`TLSVersion.TLSv1_1`

`TLSVersion.TLSv1_2`

`TLSVersion.TLSv1_3`

SSL 3.0 to TLS 1.3.

在 3.10 版之後被 用: All `TLSVersion` members except `TLSVersion.TLSv1_2` and `TLSVersion.TLSv1_3` are deprecated.

18.3.2 SSL Sockets

class `ssl.SSLSocket` (*socket.socket*)

SSL sockets provide the following methods of *Socket* 物件:

- `accept()`
- `bind()`
- `close()`
- `connect()`
- `detach()`
- `fileno()`
- `getpeername()`, `getsockname()`
- `getsockopt()`, `setsockopt()`
- `gettimeout()`, `settimeout()`, `setblocking()`
- `listen()`
- `makefile()`
- `recv()`, `recv_into()` (but passing a non-zero `flags` argument is not allowed)

- `send()`, `sendall()` (with the same limitation)
- `sendfile()` (but `os.sendfile` will be used for plain-text sockets only, else `send()` will be used)
- `shutdown()`

However, since the SSL (and TLS) protocol has its own framing atop of TCP, the SSL sockets abstraction can, in certain respects, diverge from the specification of normal, OS-level sockets. See especially the *notes on non-blocking sockets*.

Instances of `SSLSocket` must be created using the `SSLContext.wrap_socket()` method.

在 3.5 版的變更: The `sendfile()` method was added.

在 3.5 版的變更: The `shutdown()` does not reset the socket timeout each time bytes are received or sent. The socket timeout is now the maximum total duration of the shutdown.

在 3.6 版之後被 用: It is deprecated to create a `SSLSocket` instance directly, use `SSLContext.wrap_socket()` to wrap a socket.

在 3.7 版的變更: `SSLSocket` instances must be created with `wrap_socket()`. In earlier versions, it was possible to create instances directly. This was never documented or officially supported.

在 3.10 版的變更: Python now uses `SSL_read_ex` and `SSL_write_ex` internally. The functions support reading and writing of data larger than 2 GB. Writing zero-length data no longer fails with a protocol violation error.

SSL sockets also have the following additional methods and attributes:

`SSLSocket.read(len=1024, buffer=None)`

Read up to `len` bytes of data from the SSL socket and return the result as a `bytes` instance. If `buffer` is specified, then read into the buffer instead, and return the number of bytes read.

Raise `SSLWantReadError` or `SSLWantWriteError` if the socket is *non-blocking* and the read would block.

As at any time a re-negotiation is possible, a call to `read()` can also cause write operations.

在 3.5 版的變更: The socket timeout is no longer reset each time bytes are received or sent. The socket timeout is now the maximum total duration to read up to `len` bytes.

在 3.6 版之後被 用: Use `recv()` instead of `read()`.

`SSLSocket.write(buf)`

Write `buf` to the SSL socket and return the number of bytes written. The `buf` argument must be an object supporting the buffer interface.

Raise `SSLWantReadError` or `SSLWantWriteError` if the socket is *non-blocking* and the write would block.

As at any time a re-negotiation is possible, a call to `write()` can also cause read operations.

在 3.5 版的變更: The socket timeout is no longer reset each time bytes are received or sent. The socket timeout is now the maximum total duration to write `buf`.

在 3.6 版之後被 用: Use `send()` instead of `write()`.

備 用: The `read()` and `write()` methods are the low-level methods that read and write unencrypted, application-level data and decrypt/encrypt it to encrypted, wire-level data. These methods require an active SSL connection, i.e. the handshake was completed and `SSLSocket.unwrap()` was not called.

Normally you should use the socket API methods like `recv()` and `send()` instead of these methods.

`SSLSocket.do_handshake()`

Perform the SSL setup handshake.

在 3.4 版的變更: The handshake method also performs `match_hostname()` when the `check_hostname` attribute of the socket's `context` is true.

在 3.5 版的變更: The socket timeout is no longer reset each time bytes are received or sent. The socket timeout is now the maximum total duration of the handshake.

在 3.7 版的變更: Hostname or IP address is matched by OpenSSL during handshake. The function `match_hostname()` is no longer used. In case OpenSSL refuses a hostname or IP address, the handshake is aborted early and a TLS alert message is sent to the peer.

`SSLSocket.getpeercert (binary_form=False)`

If there is no certificate for the peer on the other end of the connection, return `None`. If the SSL handshake hasn't been done yet, raise `ValueError`.

If the `binary_form` parameter is `False`, and a certificate was received from the peer, this method returns a `dict` instance. If the certificate was not validated, the dict is empty. If the certificate was validated, it returns a dict with several keys, amongst them `subject` (the principal for which the certificate was issued) and `issuer` (the principal issuing the certificate). If a certificate contains an instance of the *Subject Alternative Name* extension (see [RFC 3280](#)), there will also be a `subjectAltName` key in the dictionary.

The `subject` and `issuer` fields are tuples containing the sequence of relative distinguished names (RDNs) given in the certificate's data structure for the respective fields, and each RDN is a sequence of name-value pairs. Here is a real-world example:

```
{'issuer': (((('countryName', 'IL'),),
              (('organizationName', 'StartCom Ltd.'),),
              (('organizationalUnitName',
               'Secure Digital Certificate Signing'),),
              (('commonName',
               'StartCom Class 2 Primary Intermediate Server CA'),)),
 'notAfter': 'Nov 22 08:15:19 2013 GMT',
 'notBefore': 'Nov 21 03:09:52 2011 GMT',
 'serialNumber': '95F0',
 'subject': (((('description', '571208-SLe257oHY9fVQ07Z'),),
               (('countryName', 'US'),),
               (('stateOrProvinceName', 'California'),),
               (('localityName', 'San Francisco'),),
               (('organizationName', 'Electronic Frontier Foundation, Inc.'),),
               (('commonName', '*.eff.org'),),
               (('emailAddress', 'hostmaster@eff.org'),)),
 'subjectAltName': (('DNS', '*.eff.org'), ('DNS', 'eff.org')),
 'version': 3}
```

備註: To validate a certificate for a particular service, you can use the `match_hostname()` function.

If the `binary_form` parameter is `True`, and a certificate was provided, this method returns the DER-encoded form of the entire certificate as a sequence of bytes, or `None` if the peer did not provide a certificate. Whether the peer provides a certificate depends on the SSL socket's role:

- for a client SSL socket, the server will always provide a certificate, regardless of whether validation was required;
- for a server SSL socket, the client will only provide a certificate when requested by the server; therefore `getpeercert()` will return `None` if you used `CERT_NONE` (rather than `CERT_OPTIONAL` or `CERT_REQUIRED`).

在 3.2 版的變更: The returned dictionary includes additional items such as `issuer` and `notBefore`.

在 3.4 版的變更: `ValueError` is raised when the handshake isn't done. The returned dictionary includes additional X509v3 extension items such as `crlDistributionPoints`, `caIssuers` and `OCSP URIs`.

在 3.9 版的變更: IPv6 address strings no longer have a trailing new line.

`SSLSocket.cipher()`

Returns a three-value tuple containing the name of the cipher being used, the version of the SSL protocol that defines its use, and the number of secret bits being used. If no connection has been established, returns `None`.

`SSLSocket.shared_ciphers()`

Return the list of ciphers available in both the client and server. Each entry of the returned list is a three-value tuple containing the name of the cipher, the version of the SSL protocol that defines its use, and the number of secret bits the cipher uses. `shared_ciphers()` returns `None` if no connection has been established or the socket is a client socket.

在 3.5 版新加入。

`SSLSocket.compression()`

Return the compression algorithm being used as a string, or `None` if the connection isn't compressed.

If the higher-level protocol supports its own compression mechanism, you can use `OP_NO_COMPRESSION` to disable SSL-level compression.

在 3.3 版新加入。

`SSLSocket.get_channel_binding(cb_type='tls-unique')`

Get channel binding data for current connection, as a bytes object. Returns `None` if not connected or the handshake has not been completed.

The `cb_type` parameter allow selection of the desired channel binding type. Valid channel binding types are listed in the `CHANNEL_BINDING_TYPES` list. Currently only the 'tls-unique' channel binding, defined by [RFC 5929](#), is supported. `ValueError` will be raised if an unsupported channel binding type is requested.

在 3.3 版新加入。

`SSLSocket.selected_alpn_protocol()`

Return the protocol that was selected during the TLS handshake. If `SSLContext.set_alpn_protocols()` was not called, if the other party does not support ALPN, if this socket does not support any of the client's proposed protocols, or if the handshake has not happened yet, `None` is returned.

在 3.5 版新加入。

`SSLSocket.selected_npn_protocol()`

Return the higher-level protocol that was selected during the TLS/SSL handshake. If `SSLContext.set_npn_protocols()` was not called, or if the other party does not support NPN, or if the handshake has not yet happened, this will return `None`.

在 3.3 版新加入。

在 3.10 版之後被^①用: NPN has been superseded by ALPN

`SSLSocket.unwrap()`

Performs the SSL shutdown handshake, which removes the TLS layer from the underlying socket, and returns the underlying socket object. This can be used to go from encrypted operation over a connection to unencrypted. The returned socket should always be used for further communication with the other side of the connection, rather than the original socket.

`SSLSocket.verify_client_post_handshake()`

Requests post-handshake authentication (PHA) from a TLS 1.3 client. PHA can only be initiated for a TLS 1.3 connection from a server-side socket, after the initial TLS handshake and with PHA enabled on both sides, see `SSLContext.post_handshake_auth`.

The method does not perform a cert exchange immediately. The server-side sends a `CertificateRequest` during the next write event and expects the client to respond with a certificate on the next read event.

If any precondition isn't met (e.g. not TLS 1.3, PHA not enabled), an `SSL_ERROR` is raised.

備 F: Only available with OpenSSL 1.1.1 and TLS 1.3 enabled. Without TLS 1.3 support, the method raises *NotImplementedError*.

在 3.8 版新加入.

`SSLSocket.version()`

Return the actual SSL protocol version negotiated by the connection as a string, or `None` if no secure connection is established. As of this writing, possible return values include `"SSLv2"`, `"SSLv3"`, `"TLSv1"`, `"TLSv1.1"` and `"TLSv1.2"`. Recent OpenSSL versions may define more return values.

在 3.5 版新加入.

`SSLSocket.pending()`

Returns the number of already decrypted bytes available for read, pending on the connection.

`SSLSocket.context`

The *SSLContext* object this SSL socket is tied to. If the SSL socket was created using the deprecated *wrap_socket()* function (rather than *SSLContext.wrap_socket()*), this is a custom context object created for this SSL socket.

在 3.2 版新加入.

`SSLSocket.server_side`

A boolean which is `True` for server-side sockets and `False` for client-side sockets.

在 3.2 版新加入.

`SSLSocket.server_hostname`

Hostname of the server: *str* type, or `None` for server-side socket or if the hostname was not specified in the constructor.

在 3.2 版新加入.

在 3.7 版的變更: The attribute is now always ASCII text. When `server_hostname` is an internationalized domain name (IDN), this attribute now stores the A-label form (`"xn--pythn-mua.org"`), rather than the U-label form (`"pythön.org"`).

`SSLSocket.session`

The *SSLSession* for this SSL connection. The session is available for client and server side sockets after the TLS handshake has been performed. For client sockets the session can be set before *do_handshake()* has been called to reuse a session.

在 3.6 版新加入.

`SSLSocket.session_reused`

在 3.6 版新加入.

18.3.3 SSL Contexts

在 3.2 版新加入.

An SSL context holds various data longer-lived than single SSL connections, such as SSL configuration options, certificate(s) and private key(s). It also manages a cache of SSL sessions for server-side sockets, in order to speed up repeated connections from the same clients.

class `ssl.SSLContext` (*protocol=None*)

Create a new SSL context. You may pass *protocol* which must be one of the `PROTOCOL_*` constants defined in this module. The parameter specifies which version of the SSL protocol to use. Typically, the server chooses a particular protocol version, and the client must adapt to the server's choice. Most of the versions are not interoperable with the other versions. If not specified, the default is *PROTOCOL_TLS*; it provides the most compatibility with other versions.

Here's a table showing which versions in a client (down the side) can connect to which versions in a server (along the top):

<i>client / server</i>	SSLv2	SSLv3	TLS ³	TLSv1	TLSv1.1	TLSv1.2
SSLv2	yes	no	no ¹	no	no	no
SSLv3	no	yes	no ²	no	no	no
TLS (SSLv23) ³	no ¹	no ²	yes	yes	yes	yes
TLSv1	no	no	yes	yes	no	no
TLSv1.1	no	no	yes	no	yes	no
TLSv1.2	no	no	yes	no	no	yes

解

也參考:

`create_default_context()` lets the `ssl` module choose security settings for a given purpose.

在 3.6 版的變更: The context is created with secure default values. The options `OP_NO_COMPRESSION`, `OP_CIPHER_SERVER_PREFERENCE`, `OP_SINGLE_DH_USE`, `OP_SINGLE_ECDH_USE`, `OP_NO_SSLv2` (except for `PROTOCOL_SSLv2`), and `OP_NO_SSLv3` (except for `PROTOCOL_SSLv3`) are set by default. The initial cipher suite list contains only HIGH ciphers, no NULL ciphers and no MD5 ciphers (except for `PROTOCOL_SSLv2`).

在 3.10 版之後被用: `SSLContext` without protocol argument is deprecated. The context class will either require `PROTOCOL_TLS_CLIENT` or `PROTOCOL_TLS_SERVER` protocol in the future.

在 3.10 版的變更: The default cipher suites now include only secure AES and ChaCha20 ciphers with forward secrecy and security level 2. RSA and DH keys with less than 2048 bits and ECC keys with less than 224 bits are prohibited. `PROTOCOL_TLS`, `PROTOCOL_TLS_CLIENT`, and `PROTOCOL_TLS_SERVER` use TLS 1.2 as minimum TLS version.

`SSLContext` objects have the following methods and attributes:

`SSLContext.cert_store_stats()`

Get statistics about quantities of loaded X.509 certificates, count of X.509 certificates flagged as CA certificates and certificate revocation lists as dictionary.

Example for a context with one CA cert and one other cert:

```
>>> context.cert_store_stats()
{'crl': 0, 'x509_ca': 1, 'x509': 2}
```

在 3.4 版新加入.

`SSLContext.load_cert_chain(certfile, keyfile=None, password=None)`

Load a private key and the corresponding certificate. The `certfile` string must be the path to a single file in PEM format containing the certificate as well as any number of CA certificates needed to establish the certificate's authenticity. The `keyfile` string, if present, must point to a file containing the private key. Otherwise the private key will be taken from `certfile` as well. See the discussion of [Certificates](#) for more information on how the certificate is stored in the `certfile`.

The `password` argument may be a function to call to get the password for decrypting the private key. It will only be called if the private key is encrypted and a password is necessary. It will be called with no arguments, and it should return a string, bytes, or bytearray. If the return value is a string it will be encoded as UTF-8 before using it to decrypt the key. Alternatively a string, bytes, or bytearray value may be supplied directly as the `password` argument. It will be ignored if the private key is not encrypted and no password is needed.

³ TLS 1.3 protocol will be available with `PROTOCOL_TLS` in OpenSSL \geq 1.1.1. There is no dedicated PROTOCOL constant for just TLS 1.3.

¹ `SSLContext` disables SSLv2 with `OP_NO_SSLv2` by default.

² `SSLContext` disables SSLv3 with `OP_NO_SSLv3` by default.

If the *password* argument is not specified and a password is required, OpenSSL's built-in password prompting mechanism will be used to interactively prompt the user for a password.

An *SSL**Error* is raised if the private key doesn't match with the certificate.

在 3.3 版的變更: New optional argument *password*.

`SSLContext.load_default_certs (purpose=Purpose.SERVER_AUTH)`

Load a set of default "certification authority" (CA) certificates from default locations. On Windows it loads CA certs from the CA and ROOT system stores. On all systems it calls `SSLContext.set_default_verify_paths()`. In the future the method may load CA certificates from other locations, too.

The *purpose* flag specifies what kind of CA certificates are loaded. The default settings *Purpose.SERVER_AUTH* loads certificates, that are flagged and trusted for TLS web server authentication (client side sockets). *Purpose.CLIENT_AUTH* loads CA certificates for client certificate verification on the server side.

在 3.4 版新加入.

`SSLContext.load_verify_locations (cafile=None, capath=None, cadata=None)`

Load a set of "certification authority" (CA) certificates used to validate other peers' certificates when *verify_mode* is other than *CERT_NONE*. At least one of *cafile* or *capath* must be specified.

This method can also load certification revocation lists (CRLs) in PEM or DER format. In order to make use of CRLs, `SSLContext.verify_flags` must be configured properly.

The *cafile* string, if present, is the path to a file of concatenated CA certificates in PEM format. See the discussion of *Certificates* for more information about how to arrange the certificates in this file.

The *capath* string, if present, is the path to a directory containing several CA certificates in PEM format, following an *OpenSSL specific layout*.

The *cadata* object, if present, is either an ASCII string of one or more PEM-encoded certificates or a *bytes-like object* of DER-encoded certificates. Like with *capath* extra lines around PEM-encoded certificates are ignored but at least one certificate must be present.

在 3.4 版的變更: New optional argument *cadata*

`SSLContext.get_ca_certs (binary_form=False)`

Get a list of loaded "certification authority" (CA) certificates. If the *binary_form* parameter is *False* each list entry is a dict like the output of `SSLSocket.getpeercert()`. Otherwise the method returns a list of DER-encoded certificates. The returned list does not contain certificates from *capath* unless a certificate was requested and loaded by a SSL connection.

備 註: Certificates in a *capath* directory aren't loaded unless they have been used at least once.

在 3.4 版新加入.

`SSLContext.get_ciphers ()`

Get a list of enabled ciphers. The list is in order of cipher priority. See `SSLContext.set_ciphers()`.

範例:

```
>>> ctx = ssl.SSLContext(ssl.PROTOCOL_SSLv23)
>>> ctx.set_ciphers('ECDHE+AESGCM:!ECDSA')
>>> ctx.get_ciphers()
[{'aead': True,
  'alg_bits': 256,
  'auth': 'auth-rsa',
  'description': 'ECDHE-RSA-AES256-GCM-SHA384 TLSv1.2 Kx=ECDH      Au=RSA      '
                  'Enc=AESGCM(256) Mac=AEAD',
  'digest': None,
```

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```

'id': 50380848,
'kea': 'kx-ecdhe',
'name': 'ECDHE-RSA-AES256-GCM-SHA384',
'protocol': 'TLSv1.2',
'strength_bits': 256,
'symmetric': 'aes-256-gcm'},
{'aead': True,
'alg_bits': 128,
'auth': 'auth-rsa',
'description': 'ECDHE-RSA-AES128-GCM-SHA256 TLSv1.2 Kx=ECDH      Au=RSA      '
                'Enc=AESGCM(128) Mac=AEAD',
'digest': None,
'id': 50380847,
'kea': 'kx-ecdhe',
'name': 'ECDHE-RSA-AES128-GCM-SHA256',
'protocol': 'TLSv1.2',
'strength_bits': 128,
'symmetric': 'aes-128-gcm'}]]

```

在 3.6 版新加入。

`SSLContext.set_default_verify_paths()`

Load a set of default “certification authority” (CA) certificates from a filesystem path defined when building the OpenSSL library. Unfortunately, there’s no easy way to know whether this method succeeds: no error is returned if no certificates are to be found. When the OpenSSL library is provided as part of the operating system, though, it is likely to be configured properly.

`SSLContext.set_ciphers(ciphers)`

Set the available ciphers for sockets created with this context. It should be a string in the [OpenSSL cipher list format](#). If no cipher can be selected (because compile-time options or other configuration forbids use of all the specified ciphers), an `SSL_ERROR` will be raised.

備註: when connected, the `SSLSocket.cipher()` method of SSL sockets will give the currently selected cipher.

TLS 1.3 cipher suites cannot be disabled with `set_ciphers()`.

`SSLContext.set_alpn_protocols(protocols)`

Specify which protocols the socket should advertise during the SSL/TLS handshake. It should be a list of ASCII strings, like `['http/1.1', 'spdy/2']`, ordered by preference. The selection of a protocol will happen during the handshake, and will play out according to [RFC 7301](#). After a successful handshake, the `SSLSocket.selected_alpn_protocol()` method will return the agreed-upon protocol.

This method will raise `NotImplementedError` if `HAS_ALPN` is False.

在 3.5 版新加入。

`SSLContext.set_npn_protocols(protocols)`

Specify which protocols the socket should advertise during the SSL/TLS handshake. It should be a list of strings, like `['http/1.1', 'spdy/2']`, ordered by preference. The selection of a protocol will happen during the handshake, and will play out according to the [Application Layer Protocol Negotiation](#). After a successful handshake, the `SSLSocket.selected_npn_protocol()` method will return the agreed-upon protocol.

This method will raise `NotImplementedError` if `HAS_NPN` is False.

在 3.3 版新加入。

在 3.10 版之後被註用: NPN has been superseded by ALPN

SSLContext.sni_callback

Register a callback function that will be called after the TLS Client Hello handshake message has been received by the SSL/TLS server when the TLS client specifies a server name indication. The server name indication mechanism is specified in [RFC 6066](#) section 3 - Server Name Indication.

Only one callback can be set per `SSLContext`. If `sni_callback` is set to `None` then the callback is disabled. Calling this function a subsequent time will disable the previously registered callback.

The callback function will be called with three arguments; the first being the `ssl.SSLSocket`, the second is a string that represents the server name that the client is intending to communicate (or `None` if the TLS Client Hello does not contain a server name) and the third argument is the original `SSLContext`. The server name argument is text. For internationalized domain name, the server name is an IDN A-label ("`xn--pythn-mua.org`").

A typical use of this callback is to change the `ssl.SSLSocket`'s `SSLSocket.context` attribute to a new object of type `SSLContext` representing a certificate chain that matches the server name.

Due to the early negotiation phase of the TLS connection, only limited methods and attributes are usable like `SSLSocket.selected_alpn_protocol()` and `SSLSocket.context`. The `SSLSocket.getpeercert()`, `SSLSocket.cipher()` and `SSLSocket.compression()` methods require that the TLS connection has progressed beyond the TLS Client Hello and therefore will not return meaningful values nor can they be called safely.

The `sni_callback` function must return `None` to allow the TLS negotiation to continue. If a TLS failure is required, a constant `ALERT_DESCRIPTION_*` can be returned. Other return values will result in a TLS fatal error with `ALERT_DESCRIPTION_INTERNAL_ERROR`.

If an exception is raised from the `sni_callback` function the TLS connection will terminate with a fatal TLS alert message `ALERT_DESCRIPTION_HANDSHAKE_FAILURE`.

This method will raise `NotImplementedError` if the OpenSSL library had `OPENSSL_NO_TLSEXT` defined when it was built.

在 3.7 版新加入。

SSLContext.set_servername_callback(server_name_callback)

This is a legacy API retained for backwards compatibility. When possible, you should use `sni_callback` instead. The given `server_name_callback` is similar to `sni_callback`, except that when the server hostname is an IDN-encoded internationalized domain name, the `server_name_callback` receives a decoded U-label ("`python.org`").

If there is an decoding error on the server name, the TLS connection will terminate with an `ALERT_DESCRIPTION_INTERNAL_ERROR` fatal TLS alert message to the client.

在 3.4 版新加入。

SSLContext.load_dh_params(dhfile)

Load the key generation parameters for Diffie-Hellman (DH) key exchange. Using DH key exchange improves forward secrecy at the expense of computational resources (both on the server and on the client). The `dhfile` parameter should be the path to a file containing DH parameters in PEM format.

This setting doesn't apply to client sockets. You can also use the `OP_SINGLE_DH_USE` option to further improve security.

在 3.3 版新加入。

SSLContext.set_ecdh_curve(curve_name)

Set the curve name for Elliptic Curve-based Diffie-Hellman (ECDH) key exchange. ECDH is significantly faster than regular DH while arguably as secure. The `curve_name` parameter should be a string describing a well-known elliptic curve, for example `prime256v1` for a widely supported curve.

This setting doesn't apply to client sockets. You can also use the `OP_SINGLE_ECDH_USE` option to further improve security.

This method is not available if `HAS_ECDH` is `False`.

在 3.3 版新加入。

也参考：

SSL/TLS & Perfect Forward Secrecy

Vincent Bernat.

`SSLContext.wrap_socket(sock, server_side=False, do_handshake_on_connect=True, suppress_ragged_eofs=True, server_hostname=None, session=None)`

Wrap an existing Python socket *sock* and return an instance of `SSLContext.sslsocket_class` (default `SSLSocket`). The returned SSL socket is tied to the context, its settings and certificates. *sock* must be a `SOCK_STREAM` socket; other socket types are unsupported.

The parameter *server_side* is a boolean which identifies whether server-side or client-side behavior is desired from this socket.

For client-side sockets, the context construction is lazy; if the underlying socket isn't connected yet, the context construction will be performed after `connect()` is called on the socket. For server-side sockets, if the socket has no remote peer, it is assumed to be a listening socket, and the server-side SSL wrapping is automatically performed on client connections accepted via the `accept()` method. The method may raise `SSL_ERROR`.

On client connections, the optional parameter *server_hostname* specifies the hostname of the service which we are connecting to. This allows a single server to host multiple SSL-based services with distinct certificates, quite similarly to HTTP virtual hosts. Specifying *server_hostname* will raise a `ValueError` if *server_side* is true.

The parameter *do_handshake_on_connect* specifies whether to do the SSL handshake automatically after doing a `socket.connect()`, or whether the application program will call it explicitly, by invoking the `SSLSocket.do_handshake()` method. Calling `SSLSocket.do_handshake()` explicitly gives the program control over the blocking behavior of the socket I/O involved in the handshake.

The parameter *suppress_ragged_eofs* specifies how the `SSLSocket.recv()` method should signal unexpected EOF from the other end of the connection. If specified as `True` (the default), it returns a normal EOF (an empty bytes object) in response to unexpected EOF errors raised from the underlying socket; if `False`, it will raise the exceptions back to the caller.

session, see *session*.

To wrap an `SSLSocket` in another `SSLSocket`, use `SSLContext.wrap_bio()`.

在 3.5 版的變更: Always allow a *server_hostname* to be passed, even if OpenSSL does not have SNI.

在 3.6 版的變更: 新增 *session* 引數。

在 3.7 版的變更: The method returns an instance of `SSLContext.sslsocket_class` instead of hard-coded `SSLSocket`.

`SSLContext.sslsocket_class`

The return type of `SSLContext.wrap_socket()`, defaults to `SSLSocket`. The attribute can be overridden on instance of class in order to return a custom subclass of `SSLSocket`.

在 3.7 版新加入。

`SSLContext.wrap_bio(incoming, outgoing, server_side=False, server_hostname=None, session=None)`

Wrap the BIO objects *incoming* and *outgoing* and return an instance of `SSLContext.sslobject_class` (default `SSLObject`). The SSL routines will read input data from the incoming BIO and write data to the outgoing BIO.

The *server_side*, *server_hostname* and *session* parameters have the same meaning as in `SSLContext.wrap_socket()`.

在 3.6 版的變更: 新增 *session* 引數。

在 3.7 版的變更: The method returns an instance of `SSLContext.sslobject_class` instead of hard-coded `SSLObject`.

SSLContext.sslobject_class

The return type of `SSLContext.wrap_bio()`, defaults to `SSLObject`. The attribute can be overridden on instance of class in order to return a custom subclass of `SSLObject`.

在 3.7 版新加入。

SSLContext.session_stats()

Get statistics about the SSL sessions created or managed by this context. A dictionary is returned which maps the names of each *piece of information* to their numeric values. For example, here is the total number of hits and misses in the session cache since the context was created:

```
>>> stats = context.session_stats()
>>> stats['hits'], stats['misses']
(0, 0)
```

SSLContext.check_hostname

Whether to match the peer cert's hostname in `SSLSocket.do_handshake()`. The context's `verify_mode` must be set to `CERT_OPTIONAL` or `CERT_REQUIRED`, and you must pass `server_hostname` to `wrap_socket()` in order to match the hostname. Enabling hostname checking automatically sets `verify_mode` from `CERT_NONE` to `CERT_REQUIRED`. It cannot be set back to `CERT_NONE` as long as hostname checking is enabled. The `PROTOCOL_TLS_CLIENT` protocol enables hostname checking by default. With other protocols, hostname checking must be enabled explicitly.

範例：

```
import socket, ssl

context = ssl.SSLContext(ssl.PROTOCOL_TLSv1_2)
context.verify_mode = ssl.CERT_REQUIRED
context.check_hostname = True
context.load_default_certs()

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
ssl_sock = context.wrap_socket(s, server_hostname='www.verisign.com')
ssl_sock.connect(('www.verisign.com', 443))
```

在 3.4 版新加入。

在 3.7 版的變更: `verify_mode` is now automatically changed to `CERT_REQUIRED` when hostname checking is enabled and `verify_mode` is `CERT_NONE`. Previously the same operation would have failed with a `ValueError`.

SSLContext.keylog_filename

Write TLS keys to a keylog file, whenever key material is generated or received. The keylog file is designed for debugging purposes only. The file format is specified by NSS and used by many traffic analyzers such as Wireshark. The log file is opened in append-only mode. Writes are synchronized between threads, but not between processes.

在 3.8 版新加入。

SSLContext.maximum_version

A `TLSVersion` enum member representing the highest supported TLS version. The value defaults to `TLSVersion.MAXIMUM_SUPPORTED`. The attribute is read-only for protocols other than `PROTOCOL_TLS`, `PROTOCOL_TLS_CLIENT`, and `PROTOCOL_TLS_SERVER`.

The attributes `maximum_version`, `minimum_version` and `SSLContext.options` all affect the supported SSL and TLS versions of the context. The implementation does not prevent invalid combination. For example a context with `OP_NO_TLSv1_2` in `options` and `maximum_version` set to `TLSVersion.TLSv1_2` will not be able to establish a TLS 1.2 connection.

在 3.7 版新加入。

SSLContext.minimum_version

Like *SSLContext.maximum_version* except it is the lowest supported version or *TLSVersion.MINIMUM_SUPPORTED*.

在 3.7 版新加入。

SSLContext.num_tickets

Control the number of TLS 1.3 session tickets of a *PROTOCOL_TLS_SERVER* context. The setting has no impact on TLS 1.0 to 1.2 connections.

在 3.8 版新加入。

SSLContext.options

An integer representing the set of SSL options enabled on this context. The default value is *OP_ALL*, but you can specify other options such as *OP_NO_SSLv2* by ORing them together.

在 3.6 版的變更: *SSLContext.options* returns *Options* flags:

```
>>> ssl.create_default_context().options
<Options.OP_ALL|OP_NO_SSLv3|OP_NO_SSLv2|OP_NO_COMPRESSION: 2197947391>
```

在 3.7 版之後被⌘用: All *OP_NO_SSL** and *OP_NO_TLS** options have been deprecated since Python 3.7. Use *SSLContext.minimum_version* and *SSLContext.maximum_version* instead.

SSLContext.post_handshake_auth

Enable TLS 1.3 post-handshake client authentication. Post-handshake auth is disabled by default and a server can only request a TLS client certificate during the initial handshake. When enabled, a server may request a TLS client certificate at any time after the handshake.

When enabled on client-side sockets, the client signals the server that it supports post-handshake authentication.

When enabled on server-side sockets, *SSLContext.verify_mode* must be set to *CERT_OPTIONAL* or *CERT_REQUIRED*, too. The actual client cert exchange is delayed until *SSLSocket.verify_client_post_handshake()* is called and some I/O is performed.

在 3.8 版新加入。

SSLContext.protocol

The protocol version chosen when constructing the context. This attribute is read-only.

SSLContext.hostname_checks_common_name

Whether *check_hostname* falls back to verify the cert's subject common name in the absence of a subject alternative name extension (default: true).

在 3.7 版新加入。

在 3.10 版的變更: The flag had no effect with OpenSSL before version 1.1.1l. Python 3.8.9, 3.9.3, and 3.10 include workarounds for previous versions.

SSLContext.security_level

An integer representing the security level for the context. This attribute is read-only.

在 3.10 版新加入。

SSLContext.verify_flags

The flags for certificate verification operations. You can set flags like *VERIFY_CRL_CHECK_LEAF* by ORing them together. By default OpenSSL does neither require nor verify certificate revocation lists (CRLs).

在 3.4 版新加入。

在 3.6 版的變更: *SSLContext.verify_flags* returns *VerifyFlags* flags:

```
>>> ssl.create_default_context().verify_flags
<VerifyFlags.VERIFY_X509_TRUSTED_FIRST: 32768>
```

`SSLContext.verify_mode`

Whether to try to verify other peers' certificates and how to behave if verification fails. This attribute must be one of `CERT_NONE`, `CERT_OPTIONAL` or `CERT_REQUIRED`.

在 3.6 版的變更: `SSLContext.verify_mode` returns `VerifyMode` enum:

```
>>> ssl.create_default_context().verify_mode
<VerifyMode.CERT_REQUIRED: 2>
```

18.3.4 Certificates

Certificates in general are part of a public-key / private-key system. In this system, each *principal*, (which may be a machine, or a person, or an organization) is assigned a unique two-part encryption key. One part of the key is public, and is called the *public key*; the other part is kept secret, and is called the *private key*. The two parts are related, in that if you encrypt a message with one of the parts, you can decrypt it with the other part, and **only** with the other part.

A certificate contains information about two principals. It contains the name of a *subject*, and the subject's public key. It also contains a statement by a second principal, the *issuer*, that the subject is who they claim to be, and that this is indeed the subject's public key. The issuer's statement is signed with the issuer's private key, which only the issuer knows. However, anyone can verify the issuer's statement by finding the issuer's public key, decrypting the statement with it, and comparing it to the other information in the certificate. The certificate also contains information about the time period over which it is valid. This is expressed as two fields, called "notBefore" and "notAfter".

In the Python use of certificates, a client or server can use a certificate to prove who they are. The other side of a network connection can also be required to produce a certificate, and that certificate can be validated to the satisfaction of the client or server that requires such validation. The connection attempt can be set to raise an exception if the validation fails. Validation is done automatically, by the underlying OpenSSL framework; the application need not concern itself with its mechanics. But the application does usually need to provide sets of certificates to allow this process to take place.

Python uses files to contain certificates. They should be formatted as "PEM" (see [RFC 1422](#)), which is a base-64 encoded form wrapped with a header line and a footer line:

```
-----BEGIN CERTIFICATE-----
... (certificate in base64 PEM encoding) ...
-----END CERTIFICATE-----
```

Certificate chains

The Python files which contain certificates can contain a sequence of certificates, sometimes called a *certificate chain*. This chain should start with the specific certificate for the principal who "is" the client or server, and then the certificate for the issuer of that certificate, and then the certificate for the issuer of *that* certificate, and so on up the chain till you get to a certificate which is *self-signed*, that is, a certificate which has the same subject and issuer, sometimes called a *root certificate*. The certificates should just be concatenated together in the certificate file. For example, suppose we had a three certificate chain, from our server certificate to the certificate of the certification authority that signed our server certificate, to the root certificate of the agency which issued the certification authority's certificate:

```
-----BEGIN CERTIFICATE-----
... (certificate for your server)...
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
... (the certificate for the CA)...
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
... (the root certificate for the CA's issuer)...
-----END CERTIFICATE-----
```

CA certificates

If you are going to require validation of the other side of the connection's certificate, you need to provide a "CA certs" file, filled with the certificate chains for each issuer you are willing to trust. Again, this file just contains these chains concatenated together. For validation, Python will use the first chain it finds in the file which matches. The platform's certificates file can be used by calling `SSLContext.load_default_certs()`, this is done automatically with `create_default_context()`.

Combined key and certificate

Often the private key is stored in the same file as the certificate; in this case, only the `certfile` parameter to `SSLContext.load_cert_chain()` and `wrap_socket()` needs to be passed. If the private key is stored with the certificate, it should come before the first certificate in the certificate chain:

```
-----BEGIN RSA PRIVATE KEY-----
... (private key in base64 encoding) ...
-----END RSA PRIVATE KEY-----
-----BEGIN CERTIFICATE-----
... (certificate in base64 PEM encoding) ...
-----END CERTIFICATE-----
```

Self-signed certificates

If you are going to create a server that provides SSL-encrypted connection services, you will need to acquire a certificate for that service. There are many ways of acquiring appropriate certificates, such as buying one from a certification authority. Another common practice is to generate a self-signed certificate. The simplest way to do this is with the OpenSSL package, using something like the following:

```
% openssl req -new -x509 -days 365 -nodes -out cert.pem -keyout cert.pem
Generating a 1024 bit RSA private key
.....++++++
.....++++++
writing new private key to 'cert.pem'
-----
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:US
State or Province Name (full name) [Some-State]:MyState
Locality Name (eg, city) []:Some City
Organization Name (eg, company) [Internet Widgits Pty Ltd]:My Organization, Inc.
Organizational Unit Name (eg, section) []:My Group
Common Name (eg, YOUR name) []:myserver.mygroup.myorganization.com
Email Address []:ops@myserver.mygroup.myorganization.com
%
```

The disadvantage of a self-signed certificate is that it is its own root certificate, and no one else will have it in their cache of known (and trusted) root certificates.

18.3.5 范例

Testing for SSL support

To test for the presence of SSL support in a Python installation, user code should use the following idiom:

```
try:
    import ssl
except ImportError:
    pass
else:
    ... # do something that requires SSL support
```

Client-side operation

This example creates a SSL context with the recommended security settings for client sockets, including automatic certificate verification:

```
>>> context = ssl.create_default_context()
```

If you prefer to tune security settings yourself, you might create a context from scratch (but beware that you might not get the settings right):

```
>>> context = ssl.SSLContext(ssl.PROTOCOL_TLS_CLIENT)
>>> context.load_verify_locations("/etc/ssl/certs/ca-bundle.crt")
```

(this snippet assumes your operating system places a bundle of all CA certificates in `/etc/ssl/certs/ca-bundle.crt`; if not, you'll get an error and have to adjust the location)

The `PROTOCOL_TLS_CLIENT` protocol configures the context for cert validation and hostname verification. `verify_mode` is set to `CERT_REQUIRED` and `check_hostname` is set to `True`. All other protocols create SSL contexts with insecure defaults.

When you use the context to connect to a server, `CERT_REQUIRED` and `check_hostname` validate the server certificate: it ensures that the server certificate was signed with one of the CA certificates, checks the signature for correctness, and verifies other properties like validity and identity of the hostname:

```
>>> conn = context.wrap_socket(socket.socket(socket.AF_INET),
...                             server_hostname="www.python.org")
>>> conn.connect(("www.python.org", 443))
```

You may then fetch the certificate:

```
>>> cert = conn.getpeercert()
```

Visual inspection shows that the certificate does identify the desired service (that is, the HTTPS host `www.python.org`):

```
>>> pprint.pprint(cert)
{'OCSP': ('http://ocsp.digicert.com',),
 'caIssuers': ('http://cacerts.digicert.com/DigiCertSHA2ExtendedValidationServerCA.
→crt',),
 'crlDistributionPoints': ('http://crl3.digicert.com/sha2-ev-server-g1.crl',
                           'http://crl4.digicert.com/sha2-ev-server-g1.crl'),
 'issuer': (((('countryName', 'US'),),
               (('organizationName', 'DigiCert Inc'),),
               (('organizationalUnitName', 'www.digicert.com'),),
               (('commonName', 'DigiCert SHA2 Extended Validation Server CA'),)),
 'notAfter': 'Sep  9 12:00:00 2016 GMT',
 'notBefore': 'Sep  5 00:00:00 2014 GMT',
```

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```

'serialNumber': '01BB6F00122B177F36CAB49CEA8B6B26',
'subject': (((('businessCategory', 'Private Organization'),),
              (('1.3.6.1.4.1.311.60.2.1.3', 'US'),),
              (('1.3.6.1.4.1.311.60.2.1.2', 'Delaware'),),
              (('serialNumber', '3359300'),),
              (('streetAddress', '16 Allen Rd'),),
              (('postalCode', '03894-4801'),),
              (('countryName', 'US'),),
              (('stateOrProvinceName', 'NH'),),
              (('localityName', 'Wolfeboro'),),
              (('organizationName', 'Python Software Foundation'),),
              (('commonName', 'www.python.org'),)),
'subjectAltName': (('DNS', 'www.python.org'),
                  ('DNS', 'python.org'),
                  ('DNS', 'pypi.org'),
                  ('DNS', 'docs.python.org'),
                  ('DNS', 'testpypi.org'),
                  ('DNS', 'bugs.python.org'),
                  ('DNS', 'wiki.python.org'),
                  ('DNS', 'hg.python.org'),
                  ('DNS', 'mail.python.org'),
                  ('DNS', 'packaging.python.org'),
                  ('DNS', 'pythonhosted.org'),
                  ('DNS', 'www.pythonhosted.org'),
                  ('DNS', 'test.pythonhosted.org'),
                  ('DNS', 'us.pycon.org'),
                  ('DNS', 'id.python.org')),
'version': 3}

```

Now the SSL channel is established and the certificate verified, you can proceed to talk with the server:

```

>>> conn.sendall(b"HEAD / HTTP/1.0\r\nHost: linuxfr.org\r\n\r\n")
>>> pprint.pprint(conn.recv(1024).split(b"\r\n"))
[b'HTTP/1.1 200 OK',
 b'Date: Sat, 18 Oct 2014 18:27:20 GMT',
 b'Server: nginx',
 b'Content-Type: text/html; charset=utf-8',
 b'X-Frame-Options: SAMEORIGIN',
 b'Content-Length: 45679',
 b'Accept-Ranges: bytes',
 b'Via: 1.1 varnish',
 b'Age: 2188',
 b'X-Served-By: cache-lcy1134-LCY',
 b'X-Cache: HIT',
 b'X-Cache-Hits: 11',
 b'Vary: Cookie',
 b'Strict-Transport-Security: max-age=63072000; includeSubDomains',
 b'Connection: close',
 b'',
 b'']

```

參閱下方 *Security considerations* 的討論。

Server-side operation

For server operation, typically you'll need to have a server certificate, and private key, each in a file. You'll first create a context holding the key and the certificate, so that clients can check your authenticity. Then you'll open a socket, bind it to a port, call `listen()` on it, and start waiting for clients to connect:

```
import socket, ssl

context = ssl.create_default_context(ssl.Purpose.CLIENT_AUTH)
context.load_cert_chain(certfile="mycertfile", keyfile="mykeyfile")

bindsocket = socket.socket()
bindsocket.bind(('myaddr.example.com', 10023))
bindsocket.listen(5)
```

When a client connects, you'll call `accept()` on the socket to get the new socket from the other end, and use the context's `SSLContext.wrap_socket()` method to create a server-side SSL socket for the connection:

```
while True:
    newsocket, fromaddr = bindsocket.accept()
    connstream = context.wrap_socket(newsocket, server_side=True)
    try:
        deal_with_client(connstream)
    finally:
        connstream.shutdown(socket.SHUT_RDWR)
        connstream.close()
```

Then you'll read data from the `connstream` and do something with it till you are finished with the client (or the client is finished with you):

```
def deal_with_client(connstream):
    data = connstream.recv(1024)
    # empty data means the client is finished with us
    while data:
        if not do_something(connstream, data):
            # we'll assume do_something returns False
            # when we're finished with client
            break
        data = connstream.recv(1024)
    # finished with client
```

And go back to listening for new client connections (of course, a real server would probably handle each client connection in a separate thread, or put the sockets in *non-blocking mode* and use an event loop).

18.3.6 Notes on non-blocking sockets

SSL sockets behave slightly different than regular sockets in non-blocking mode. When working with non-blocking sockets, there are thus several things you need to be aware of:

- Most `SSLSocket` methods will raise either `SSLWantWriteError` or `SSLWantReadError` instead of `BlockingIOError` if an I/O operation would block. `SSLWantReadError` will be raised if a read operation on the underlying socket is necessary, and `SSLWantWriteError` for a write operation on the underlying socket. Note that attempts to *write* to an SSL socket may require *reading* from the underlying socket first, and attempts to *read* from the SSL socket may require a prior *write* to the underlying socket.

在 3.5 版的變更: In earlier Python versions, the `SSLSocket.send()` method returned zero instead of raising `SSLWantWriteError` or `SSLWantReadError`.

- Calling `select()` tells you that the OS-level socket can be read from (or written to), but it does not imply that there is sufficient data at the upper SSL layer. For example, only part of an SSL frame might have arrived. Therefore, you must be ready to handle `SSLSocket.recv()` and `SSLSocket.send()` failures, and retry after another call to `select()`.

- Conversely, since the SSL layer has its own framing, a SSL socket may still have data available for reading without `select()` being aware of it. Therefore, you should first call `SSLSocket.recv()` to drain any potentially available data, and then only block on a `select()` call if still necessary.

(of course, similar provisions apply when using other primitives such as `poll()`, or those in the `selectors` module)

- The SSL handshake itself will be non-blocking: the `SSLSocket.do_handshake()` method has to be retried until it returns successfully. Here is a synopsis using `select()` to wait for the socket's readiness:

```
while True:
    try:
        sock.do_handshake()
        break
    except ssl.SSLWantReadError:
        select.select([sock], [], [])
    except ssl.SSLWantWriteError:
        select.select([], [sock], [])
```

也参考:

The `asyncio` module supports *non-blocking SSL sockets* and provides a higher level API. It polls for events using the `selectors` module and handles `SSLWantWriteError`, `SSLWantReadError` and `BlockingIOError` exceptions. It runs the SSL handshake asynchronously as well.

18.3.7 Memory BIO Support

在 3.5 版新加入.

Ever since the SSL module was introduced in Python 2.6, the `SSLSocket` class has provided two related but distinct areas of functionality:

- SSL protocol handling
- Network IO

The network IO API is identical to that provided by `socket.socket`, from which `SSLSocket` also inherits. This allows an SSL socket to be used as a drop-in replacement for a regular socket, making it very easy to add SSL support to an existing application.

Combining SSL protocol handling and network IO usually works well, but there are some cases where it doesn't. An example is async IO frameworks that want to use a different IO multiplexing model than the "select/poll on a file descriptor" (readiness based) model that is assumed by `socket.socket` and by the internal OpenSSL socket IO routines. This is mostly relevant for platforms like Windows where this model is not efficient. For this purpose, a reduced scope variant of `SSLSocket` called `SSLObject` is provided.

class `ssl.SSLObject`

A reduced-scope variant of `SSLSocket` representing an SSL protocol instance that does not contain any network IO methods. This class is typically used by framework authors that want to implement asynchronous IO for SSL through memory buffers.

This class implements an interface on top of a low-level SSL object as implemented by OpenSSL. This object captures the state of an SSL connection but does not provide any network IO itself. IO needs to be performed through separate "BIO" objects which are OpenSSL's IO abstraction layer.

This class has no public constructor. An `SSLObject` instance must be created using the `wrap_bio()` method. This method will create the `SSLObject` instance and bind it to a pair of BIOs. The *incoming* BIO is used to pass data from Python to the SSL protocol instance, while the *outgoing* BIO is used to pass data the other way around.

The following methods are available:

- `context`
- `server_side`

- `server_hostname`
- `session`
- `session_reused`
- `read()`
- `write()`
- `getpeercert()`
- `selected_alpn_protocol()`
- `selected_npn_protocol()`
- `cipher()`
- `shared_ciphers()`
- `compression()`
- `pending()`
- `do_handshake()`
- `verify_client_post_handshake()`
- `unwrap()`
- `get_channel_binding()`
- `version()`

When compared to `SSLSocket`, this object lacks the following features:

- Any form of network IO; `recv()` and `send()` read and write only to the underlying `MemoryBIO` buffers.
- There is no `do_handshake_on_connect` machinery. You must always manually call `do_handshake()` to start the handshake.
- There is no handling of `suppress_ragged_eofs`. All end-of-file conditions that are in violation of the protocol are reported via the `SSLEOFError` exception.
- The method `unwrap()` call does not return anything, unlike for an SSL socket where it returns the underlying socket.
- The `server_name_callback` callback passed to `SSLContext.set_servername_callback()` will get an `SSLObject` instance instead of a `SSLSocket` instance as its first parameter.

Some notes related to the use of `SSLObject`:

- All IO on an `SSLObject` is *non-blocking*. This means that for example `read()` will raise an `SSLWantReadError` if it needs more data than the incoming BIO has available.
- There is no module-level `wrap_bio()` call like there is for `wrap_socket()`. An `SSLObject` is always created via an `SSLContext`.

在 3.7 版的變更: `SSLObject` instances must to created with `wrap_bio()`. In earlier versions, it was possible to create instances directly. This was never documented or officially supported.

An `SSLObject` communicates with the outside world using memory buffers. The class `MemoryBIO` provides a memory buffer that can be used for this purpose. It wraps an OpenSSL memory BIO (Basic IO) object:

class `ssl.MemoryBIO`

A memory buffer that can be used to pass data between Python and an SSL protocol instance.

pending

Return the number of bytes currently in the memory buffer.

eof

A boolean indicating whether the memory BIO is current at the end-of-file position.

read (*n=-1*)

Read up to *n* bytes from the memory buffer. If *n* is not specified or negative, all bytes are returned.

write (*buf*)

Write the bytes from *buf* to the memory BIO. The *buf* argument must be an object supporting the buffer protocol.

The return value is the number of bytes written, which is always equal to the length of *buf*.

write_eof ()

Write an EOF marker to the memory BIO. After this method has been called, it is illegal to call *write* (). The attribute *eof* will become true after all data currently in the buffer has been read.

18.3.8 SSL session

在 3.6 版新加入.

class `ssl.SSLSession`

Session object used by *session*.

id**time****timeout****ticket_lifetime_hint****has_ticket**

18.3.9 Security considerations

Best defaults

For **client use**, if you don't have any special requirements for your security policy, it is highly recommended that you use the `create_default_context()` function to create your SSL context. It will load the system's trusted CA certificates, enable certificate validation and hostname checking, and try to choose reasonably secure protocol and cipher settings.

For example, here is how you would use the `smtplib.SMTP` class to create a trusted, secure connection to a SMTP server:

```
>>> import ssl, smtplib
>>> smtp = smtplib.SMTP("mail.python.org", port=587)
>>> context = ssl.create_default_context()
>>> smtp.starttls(context=context)
(220, b'2.0.0 Ready to start TLS')
```

If a client certificate is needed for the connection, it can be added with `SSLContext.load_cert_chain()`.

By contrast, if you create the SSL context by calling the `SSLContext` constructor yourself, it will not have certificate validation nor hostname checking enabled by default. If you do so, please read the paragraphs below to achieve a good security level.

Manual settings

Verifying certificates

When calling the `SSLContext` constructor directly, `CERT_NONE` is the default. Since it does not authenticate the other peer, it can be insecure, especially in client mode where most of time you would like to ensure the authenticity of the server you're talking to. Therefore, when in client mode, it is highly recommended to use `CERT_REQUIRED`. However, it is in itself not sufficient; you also have to check that the server certificate, which can be obtained by calling `SSLSocket.getpeercert()`, matches the desired service. For many protocols and applications, the service can be identified by the hostname; in this case, the `match_hostname()` function can be used. This common check is automatically performed when `SSLContext.check_hostname` is enabled.

在 3.7 版的變更: Hostname matchings is now performed by OpenSSL. Python no longer uses `match_hostname()`.

In server mode, if you want to authenticate your clients using the SSL layer (rather than using a higher-level authentication mechanism), you'll also have to specify `CERT_REQUIRED` and similarly check the client certificate.

Protocol versions

SSL versions 2 and 3 are considered insecure and are therefore dangerous to use. If you want maximum compatibility between clients and servers, it is recommended to use `PROTOCOL_TLS_CLIENT` or `PROTOCOL_TLS_SERVER` as the protocol version. SSLv2 and SSLv3 are disabled by default.

```
>>> client_context = ssl.SSLContext(ssl.PROTOCOL_TLS_CLIENT)
>>> client_context.minimum_version = ssl.TLSVersion.TLSv1_3
>>> client_context.maximum_version = ssl.TLSVersion.TLSv1_3
```

The SSL context created above will only allow TLSv1.3 and later (if supported by your system) connections to a server. `PROTOCOL_TLS_CLIENT` implies certificate validation and hostname checks by default. You have to load certificates into the context.

Cipher selection

If you have advanced security requirements, fine-tuning of the ciphers enabled when negotiating a SSL session is possible through the `SSLContext.set_ciphers()` method. Starting from Python 3.2.3, the ssl module disables certain weak ciphers by default, but you may want to further restrict the cipher choice. Be sure to read OpenSSL's documentation about the [cipher list format](#). If you want to check which ciphers are enabled by a given cipher list, use `SSLContext.get_ciphers()` or the `openssl ciphers` command on your system.

Multi-processing

If using this module as part of a multi-processed application (using, for example the `multiprocessing` or `concurrent.futures` modules), be aware that OpenSSL's internal random number generator does not properly handle forked processes. Applications must change the PRNG state of the parent process if they use any SSL feature with `os.fork()`. Any successful call of `RAND_add()`, `RAND_bytes()` or `RAND_pseudo_bytes()` is sufficient.

18.3.10 TLS 1.3

在 3.7 版新加入.

The TLS 1.3 protocol behaves slightly differently than previous version of TLS/SSL. Some new TLS 1.3 features are not yet available.

- TLS 1.3 uses a disjunct set of cipher suites. All AES-GCM and ChaCha20 cipher suites are enabled by default. The method `SSLContext.set_ciphers()` cannot enable or disable any TLS 1.3 ciphers yet, but `SSLContext.get_ciphers()` returns them.
- Session tickets are no longer sent as part of the initial handshake and are handled differently. `SSLSocket.session` and `SSLSession` are not compatible with TLS 1.3.
- Client-side certificates are also no longer verified during the initial handshake. A server can request a certificate at any time. Clients process certificate requests while they send or receive application data from the server.
- TLS 1.3 features like early data, deferred TLS client cert request, signature algorithm configuration, and rekeying are not supported yet.

也参考:

Class `socket.socket`

Documentation of underlying `socket` class

SSL/TLS Strong Encryption: An Introduction

Intro from the Apache HTTP Server documentation

RFC 1422: Privacy Enhancement for Internet Electronic Mail: Part II: Certificate-Based Key Management

Steve Kent

RFC 4086: Randomness Requirements for Security

Donald E., Jeffrey I. Schiller

RFC 5280: Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile

D. Cooper

RFC 5246: The Transport Layer Security (TLS) Protocol Version 1.2

T. Dierks et. al.

RFC 6066: Transport Layer Security (TLS) Extensions

D. Eastlake

IANA TLS: Transport Layer Security (TLS) Parameters

IANA

RFC 7525: Recommendations for Secure Use of Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS)

IETF

Mozilla's Server Side TLS recommendations

Mozilla

18.4 select --- Waiting for I/O completion

This module provides access to the `select()` and `poll()` functions available in most operating systems, `devpoll()` available on Solaris and derivatives, `epoll()` available on Linux 2.5+ and `kqueue()` available on most BSD. Note that on Windows, it only works for sockets; on other operating systems, it also works for other file types (in particular, on Unix, it works on pipes). It cannot be used on regular files to determine whether a file has grown since it was last read.

備 F: The `selectors` module allows high-level and efficient I/O multiplexing, built upon the `select` module primitives. Users are encouraged to use the `selectors` module instead, unless they want precise control over the OS-level primitives used.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

The module defines the following:

exception `select.error`

A deprecated alias of `OSError`.

在 3.3 版的變更: Following [PEP 3151](#), this class was made an alias of `OSError`.

`select.devpoll()`

(Only supported on Solaris and derivatives.) Returns a `/dev/poll` polling object; see section [/dev/poll Polling Objects](#) below for the methods supported by `devpoll` objects.

`devpoll()` objects are linked to the number of file descriptors allowed at the time of instantiation. If your program reduces this value, `devpoll()` will fail. If your program increases this value, `devpoll()` may return an incomplete list of active file descriptors.

The new file descriptor is *non-inheritable*.

在 3.3 版新加入.

在 3.4 版的變更: The new file descriptor is now non-inheritable.

`select.epoll(sizehint=-1, flags=0)`

(Only supported on Linux 2.5.44 and newer.) Return an edge polling object, which can be used as Edge or Level Triggered interface for I/O events.

sizehint informs `epoll` about the expected number of events to be registered. It must be positive, or `-1` to use the default. It is only used on older systems where `epoll_create1()` is not available; otherwise it has no effect (though its value is still checked).

flags is deprecated and completely ignored. However, when supplied, its value must be `0` or `select.EPOLL_CLOEXEC`, otherwise `OSError` is raised.

See the [Edge and Level Trigger Polling \(epoll\) Objects](#) section below for the methods supported by `epoll` objects.

`epoll` objects support the context management protocol: when used in a `with` statement, the new file descriptor is automatically closed at the end of the block.

The new file descriptor is *non-inheritable*.

在 3.3 版的變更: 新增 *flags* 參數。

在 3.4 版的變更: Support for the `with` statement was added. The new file descriptor is now non-inheritable.

在 3.4 版之後被 F 用: The *flags* parameter. `select.EPOLL_CLOEXEC` is used by default now. Use `os.set_inheritable()` to make the file descriptor inheritable.

`select.poll()`

(Not supported by all operating systems.) Returns a polling object, which supports registering and unregistering file descriptors, and then polling them for I/O events; see section [Polling Objects](#) below for the methods supported by polling objects.

`select.kqueue()`

(Only supported on BSD.) Returns a kernel queue object; see section [Kqueue Objects](#) below for the methods supported by `kqueue` objects.

The new file descriptor is *non-inheritable*.

在 3.4 版的變更: The new file descriptor is now non-inheritable.

`select.kevent(ident, filter=KQ_FILTER_READ, flags=KQ_EV_ADD, fflags=0, data=0, udata=0)`

(Only supported on BSD.) Returns a kernel event object; see section [Kevent Objects](#) below for the methods supported by kevent objects.

`select.select(rlist, wlist, xlist[, timeout])`

This is a straightforward interface to the Unix `select()` system call. The first three arguments are iterables of 'waitable objects': either integers representing file descriptors or objects with a parameterless method named `fileno()` returning such an integer:

- *rlist*: wait until ready for reading
- *wlist*: wait until ready for writing
- *xlist*: wait for an "exceptional condition" (see the manual page for what your system considers such a condition)

Empty iterables are allowed, but acceptance of three empty iterables is platform-dependent. (It is known to work on Unix but not on Windows.) The optional *timeout* argument specifies a time-out as a floating point number in seconds. When the *timeout* argument is omitted the function blocks until at least one file descriptor is ready. A time-out value of zero specifies a poll and never blocks.

The return value is a triple of lists of objects that are ready: subsets of the first three arguments. When the time-out is reached without a file descriptor becoming ready, three empty lists are returned.

Among the acceptable object types in the iterables are Python *file objects* (e.g. `sys.stdin`, or objects returned by `open()` or `os.popen()`), socket objects returned by `socket.socket()`. You may also define a *wrapper* class yourself, as long as it has an appropriate `fileno()` method (that really returns a file descriptor, not just a random integer).

備註: File objects on Windows are not acceptable, but sockets are. On Windows, the underlying `select()` function is provided by the WinSock library, and does not handle file descriptors that don't originate from WinSock.

在 3.5 版的變更: The function is now retried with a recomputed timeout when interrupted by a signal, except if the signal handler raises an exception (see [PEP 475](#) for the rationale), instead of raising `InterruptedError`.

`select.PIPE_BUF`

The minimum number of bytes which can be written without blocking to a pipe when the pipe has been reported as ready for writing by `select()`, `poll()` or another interface in this module. This doesn't apply to other kind of file-like objects such as sockets.

This value is guaranteed by POSIX to be at least 512.

適用: Unix。

在 3.2 版新加入。

18.4.1 /dev/poll Polling Objects

Solaris and derivatives have `/dev/poll`. While `select()` is $O(\text{highest file descriptor})$ and `poll()` is $O(\text{number of file descriptors})$, `/dev/poll` is $O(\text{active file descriptors})$.

`/dev/poll` behaviour is very close to the standard `poll()` object.

`devpoll.close()`

Close the file descriptor of the polling object.

在 3.4 版新加入。

`devpoll.closed`

True if the polling object is closed.

在 3.4 版新加入。

`devpoll.fileno()`

Return the file descriptor number of the polling object.

在 3.4 版新加入。

`devpoll.register(fd[, eventmask])`

Register a file descriptor with the polling object. Future calls to the `poll()` method will then check whether the file descriptor has any pending I/O events. `fd` can be either an integer, or an object with a `fileno()` method that returns an integer. File objects implement `fileno()`, so they can also be used as the argument.

`eventmask` is an optional bitmask describing the type of events you want to check for. The constants are the same that with `poll()` object. The default value is a combination of the constants `POLLIN`, `POLLPRI`, and `POLLOUT`.

警告: Registering a file descriptor that's already registered is not an error, but the result is undefined. The appropriate action is to unregister or modify it first. This is an important difference compared with `poll()`.

`devpoll.modify(fd[, eventmask])`

This method does an `unregister()` followed by a `register()`. It is (a bit) more efficient than doing the same explicitly.

`devpoll.unregister(fd)`

Remove a file descriptor being tracked by a polling object. Just like the `register()` method, `fd` can be an integer or an object with a `fileno()` method that returns an integer.

Attempting to remove a file descriptor that was never registered is safely ignored.

`devpoll.poll([timeout])`

Polls the set of registered file descriptors, and returns a possibly empty list containing `(fd, event)` 2-tuples for the descriptors that have events or errors to report. `fd` is the file descriptor, and `event` is a bitmask with bits set for the reported events for that descriptor --- `POLLIN` for waiting input, `POLLOUT` to indicate that the descriptor can be written to, and so forth. An empty list indicates that the call timed out and no file descriptors had any events to report. If `timeout` is given, it specifies the length of time in milliseconds which the system will wait for events before returning. If `timeout` is omitted, `-1`, or `None`, the call will block until there is an event for this poll object.

在 3.5 版的變更: The function is now retried with a recomputed timeout when interrupted by a signal, except if the signal handler raises an exception (see [PEP 475](#) for the rationale), instead of raising `InterruptedError`.

18.4.2 Edge and Level Trigger Polling (epoll) Objects

<https://linux.die.net/man/4/epoll>

`eventmask`

常數	Meaning
<code>EPOLLIN</code>	Available for read
<code>EPOLLOUT</code>	Available for write
<code>EPOLLPRI</code>	Urgent data for read
<code>EPOLLERR</code>	Error condition happened on the assoc. fd
<code>EPOLLHUP</code>	Hang up happened on the assoc. fd
<code>EPOLLET</code>	Set Edge Trigger behavior, the default is Level Trigger behavior
<code>EPOLLONESHO</code>	Set one-shot behavior. After one event is pulled out, the fd is internally disabled
<code>EPOLLEXCLU</code>	Wake only one epoll object when the associated fd has an event. The default (if this flag is not set) is to wake all epoll objects polling on a fd.
<code>EPOLLRDHUP</code>	Stream socket peer closed connection or shut down writing half of connection.
<code>EPOLLRDNOI</code>	等價於 <code>EPOLLIN</code>
<code>EPOLLRDBAI</code>	Priority data band can be read.
<code>EPOLLWRNOI</code>	等價於 <code>EPOLLOUT</code>
<code>EPOLLWRBAI</code>	Priority data may be written.
<code>EPOLMSG</code>	Ignored.

在 3.6 版新加入: `EPOLLEXCLUSIVE` was added. It's only supported by Linux Kernel 4.5 or later.

`epoll.close()`

Close the control file descriptor of the epoll object.

`epoll.closed`

True if the epoll object is closed.

`epoll.fileno()`

Return the file descriptor number of the control fd.

`epoll.fromfd(fd)`

Create an epoll object from a given file descriptor.

`epoll.register(fd[, eventmask])`

Register a fd descriptor with the epoll object.

`epoll.modify(fd, eventmask)`

Modify a registered file descriptor.

`epoll.unregister(fd)`

Remove a registered file descriptor from the epoll object.

在 3.9 版的變更: The method no longer ignores the `EBADF` error.

`epoll.poll(timeout=None, maxevents=-1)`

Wait for events. timeout in seconds (float)

在 3.5 版的變更: The function is now retried with a recomputed timeout when interrupted by a signal, except if the signal handler raises an exception (see [PEP 475](#) for the rationale), instead of raising `InterruptedError`.

18.4.3 Polling Objects

The `poll()` system call, supported on most Unix systems, provides better scalability for network servers that service many, many clients at the same time. `poll()` scales better because the system call only requires listing the file descriptors of interest, while `select()` builds a bitmap, turns on bits for the fds of interest, and then afterward the whole bitmap has to be linearly scanned again. `select()` is $O(\text{highest file descriptor})$, while `poll()` is $O(\text{number of file descriptors})$.

`poll.register(fd[, eventmask])`

Register a file descriptor with the polling object. Future calls to the `poll()` method will then check whether the file descriptor has any pending I/O events. `fd` can be either an integer, or an object with a `fileno()` method that returns an integer. File objects implement `fileno()`, so they can also be used as the argument.

`eventmask` is an optional bitmask describing the type of events you want to check for, and can be a combination of the constants `POLLIN`, `POLLPRI`, and `POLLOUT`, described in the table below. If not specified, the default value used will check for all 3 types of events.

常數	Meaning
<code>POLLIN</code>	There is data to read
<code>POLLPRI</code>	There is urgent data to read
<code>POLLOUT</code>	Ready for output: writing will not block
<code>POLLERR</code>	Error condition of some sort
<code>POLLHUP</code>	Hung up
<code>POLLRDHUP</code>	Stream socket peer closed connection, or shut down writing half of connection
<code>POLLNVAL</code>	Invalid request: descriptor not open

Registering a file descriptor that's already registered is not an error, and has the same effect as registering the descriptor exactly once.

`poll.modify(fd, eventmask)`

Modifies an already registered `fd`. This has the same effect as `register(fd, eventmask)`. Attempting to modify a file descriptor that was never registered causes an `OSError` exception with `errno ENOENT` to be raised.

`poll.unregister(fd)`

Remove a file descriptor being tracked by a polling object. Just like the `register()` method, `fd` can be an integer or an object with a `fileno()` method that returns an integer.

Attempting to remove a file descriptor that was never registered causes a `KeyError` exception to be raised.

`poll.poll([timeout])`

Polls the set of registered file descriptors, and returns a possibly empty list containing `(fd, event)` 2-tuples for the descriptors that have events or errors to report. `fd` is the file descriptor, and `event` is a bitmask with bits set for the reported events for that descriptor --- `POLLIN` for waiting input, `POLLOUT` to indicate that the descriptor can be written to, and so forth. An empty list indicates that the call timed out and no file descriptors had any events to report. If `timeout` is given, it specifies the length of time in milliseconds which the system will wait for events before returning. If `timeout` is omitted, negative, or `None`, the call will block until there is an event for this poll object.

在 3.5 版的變更: The function is now retried with a recomputed timeout when interrupted by a signal, except if the signal handler raises an exception (see [PEP 475](#) for the rationale), instead of raising `InterruptedError`.

18.4.4 Kqueue Objects

- `kqueue.close()`
Close the control file descriptor of the kqueue object.
- `kqueue.closed`
True if the kqueue object is closed.
- `kqueue.fileno()`
Return the file descriptor number of the control fd.
- `kqueue.fromfd(fd)`
Create a kqueue object from a given file descriptor.
- `kqueue.control(changelist, max_events[, timeout])` → eventlist
Low level interface to kevent
 - changelist must be an iterable of kevent objects or None
 - max_events must be 0 or a positive integer
 - timeout in seconds (floats possible); the default is None, to wait forever

在 3.5 版的變更: The function is now retried with a recomputed timeout when interrupted by a signal, except if the signal handler raises an exception (see [PEP 475](#) for the rationale), instead of raising `InterruptedError`.

18.4.5 Kevent Objects

<https://man.freebsd.org/cgi/man.cgi?query=kqueue&sektion=2>

- `kevent.ident`
Value used to identify the event. The interpretation depends on the filter but it's usually the file descriptor. In the constructor ident can either be an int or an object with a `fileno()` method. kevent stores the integer internally.
- `kevent.filter`
Name of the kernel filter.

常數	Meaning
<code>KQ_FILTER_READ</code>	Takes a descriptor and returns whenever there is data available to read
<code>KQ_FILTER_WRITE</code>	Takes a descriptor and returns whenever there is data available to write
<code>KQ_FILTER_AIO</code>	AIO requests
<code>KQ_FILTER_VNODE</code>	Returns when one or more of the requested events watched in <i>fflag</i> occurs
<code>KQ_FILTER_PROC</code>	Watch for events on a process id
<code>KQ_FILTER_NETDEV</code>	Watch for events on a network device [not available on macOS]
<code>KQ_FILTER_SIGNAL</code>	Returns whenever the watched signal is delivered to the process
<code>KQ_FILTER_TIMER</code>	Establishes an arbitrary timer

- `kevent.flags`
Filter action.

常數	Meaning
KQ_EV_ADD	Adds or modifies an event
KQ_EV_DELETE	Removes an event from the queue
KQ_EV_ENABLE	Permits <code>control()</code> to return the event
KQ_EV_DISABLE	Disables event
KQ_EV_ONESHOT	Removes event after first occurrence
KQ_EV_CLEAR	Reset the state after an event is retrieved
KQ_EV_SYSFLAGS	internal event
KQ_EV_FLAG1	internal event
KQ_EV_EOF	Filter specific EOF condition
KQ_EV_ERROR	See return values

`kevent.fflags`

Filter specific flags.

`KQ_FILTER_READ` and `KQ_FILTER_WRITE` filter flags:

常數	Meaning
KQ_NOTE_LOWAT	low water mark of a socket buffer

`KQ_FILTER_VNODE` filter flags:

常數	Meaning
KQ_NOTE_DELETE	<code>unlink()</code> was called
KQ_NOTE_WRITE	a write occurred
KQ_NOTE_EXTEND	the file was extended
KQ_NOTE_ATTRIB	an attribute was changed
KQ_NOTE_LINK	the link count has changed
KQ_NOTE_RENAME	the file was renamed
KQ_NOTE_REVOKE	access to the file was revoked

`KQ_FILTER_PROC` filter flags:

常數	Meaning
KQ_NOTE_EXIT	the process has exited
KQ_NOTE_FORK	the process has called <code>fork()</code>
KQ_NOTE_EXEC	the process has executed a new process
KQ_NOTE_PCTRLMASK	internal filter flag
KQ_NOTE_PDATAMASK	internal filter flag
KQ_NOTE_TRACK	follow a process across <code>fork()</code>
KQ_NOTE_CHILD	returned on the child process for <code>NOTE_TRACK</code>
KQ_NOTE_TRACKERR	unable to attach to a child

`KQ_FILTER_NETDEV` filter flags (not available on macOS):

常數	Meaning
KQ_NOTE_LINKUP	link is up
KQ_NOTE_LINKDOWN	link is down
KQ_NOTE_LINKINV	link state is invalid

`kevent.data`

Filter specific data.

`kevent.udata`

User defined value.

18.5 selectors --- High-level I/O multiplexing

在 3.4 版新加入.

原始碼: [Lib/selectors.py](#)

18.5.1 簡介

This module allows high-level and efficient I/O multiplexing, built upon the *select* module primitives. Users are encouraged to use this module instead, unless they want precise control over the OS-level primitives used.

It defines a *BaseSelector* abstract base class, along with several concrete implementations (*KqueueSelector*, *EpollSelector*...), that can be used to wait for I/O readiness notification on multiple file objects. In the following, “file object” refers to any object with a *fileno()* method, or a raw file descriptor. See *file object*.

DefaultSelector is an alias to the most efficient implementation available on the current platform: this should be the default choice for most users.

備註: The type of file objects supported depends on the platform: on Windows, sockets are supported, but not pipes, whereas on Unix, both are supported (some other types may be supported as well, such as fifos or special file devices).

也參考:

select

Low-level I/O multiplexing module.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

18.5.2 Classes

Classes hierarchy:

```
BaseSelector
+-- SelectSelector
+-- PollSelector
+-- EpollSelector
+-- DevpollSelector
+-- KqueueSelector
```

In the following, *events* is a bitwise mask indicating which I/O events should be waited for on a given file object. It can be a combination of the modules constants below:

Constant	Meaning
<code>selectors.EVENT_READ</code>	Available for read
<code>selectors.EVENT_WRITE</code>	Available for write

class `selectors.SelectorKey`

A *SelectorKey* is a *namedtuple* used to associate a file object to its underlying file descriptor, selected event mask and attached data. It is returned by several *BaseSelector* methods.

fileobj

File object registered.

fd

Underlying file descriptor.

events

Events that must be waited for on this file object.

data

Optional opaque data associated to this file object: for example, this could be used to store a per-client session ID.

class `selectors.BaseSelector`

A *BaseSelector* is used to wait for I/O event readiness on multiple file objects. It supports file stream registration, unregistration, and a method to wait for I/O events on those streams, with an optional time-out. It's an abstract base class, so cannot be instantiated. Use *DefaultSelector* instead, or one of *SelectSelector*, *KqueueSelector* etc. if you want to specifically use an implementation, and your platform supports it. *BaseSelector* and its concrete implementations support the *context manager* protocol.

abstractmethod `register(fileobj, events, data=None)`

Register a file object for selection, monitoring it for I/O events.

fileobj is the file object to monitor. It may either be an integer file descriptor or an object with a `fileno()` method. *events* is a bitwise mask of events to monitor. *data* is an opaque object.

This returns a new *SelectorKey* instance, or raises a *ValueError* in case of invalid event mask or file descriptor, or *KeyError* if the file object is already registered.

abstractmethod `unregister(fileobj)`

Unregister a file object from selection, removing it from monitoring. A file object shall be unregistered prior to being closed.

fileobj must be a file object previously registered.

This returns the associated *SelectorKey* instance, or raises a *KeyError* if *fileobj* is not registered. It will raise *ValueError* if *fileobj* is invalid (e.g. it has no `fileno()` method or its `fileno()` method has an invalid return value).

modify `(fileobj, events, data=None)`

Change a registered file object's monitored events or attached data.

This is equivalent to `BaseSelector.unregister(fileobj)` followed by `BaseSelector.register(fileobj, events, data)`, except that it can be implemented more efficiently.

This returns a new *SelectorKey* instance, or raises a *ValueError* in case of invalid event mask or file descriptor, or *KeyError* if the file object is not registered.

abstractmethod select (*timeout=None*)

Wait until some registered file objects become ready, or the timeout expires.

If *timeout* > 0, this specifies the maximum wait time, in seconds. If *timeout* ≤ 0, the call won't block, and will report the currently ready file objects. If *timeout* is None, the call will block until a monitored file object becomes ready.

This returns a list of (*key*, *events*) tuples, one for each ready file object.

key is the [SelectorKey](#) instance corresponding to a ready file object. *events* is a bitmask of events ready on this file object.

備 F: This method can return before any file object becomes ready or the timeout has elapsed if the current process receives a signal: in this case, an empty list will be returned.

在 3.5 版的變更: The selector is now retried with a recomputed timeout when interrupted by a signal if the signal handler did not raise an exception (see [PEP 475](#) for the rationale), instead of returning an empty list of events before the timeout.

close ()

Close the selector.

This must be called to make sure that any underlying resource is freed. The selector shall not be used once it has been closed.

get_key (*fileobj*)

Return the key associated with a registered file object.

This returns the [SelectorKey](#) instance associated to this file object, or raises [KeyError](#) if the file object is not registered.

abstractmethod get_map ()

Return a mapping of file objects to selector keys.

This returns a [Mapping](#) instance mapping registered file objects to their associated [SelectorKey](#) instance.

class selectors.DefaultSelector

The default selector class, using the most efficient implementation available on the current platform. This should be the default choice for most users.

class selectors.SelectSelector

[select.select\(\)](#)-based selector.

class selectors.PollSelector

[select.poll\(\)](#)-based selector.

class selectors.EpollSelector

[select.epoll\(\)](#)-based selector.

fileno ()

This returns the file descriptor used by the underlying [select.epoll\(\)](#) object.

class selectors.DevpollSelector

[select.devpoll\(\)](#)-based selector.

fileno ()

This returns the file descriptor used by the underlying [select.devpoll\(\)](#) object.

在 3.5 版新加入.

class selectors.KqueueSelector

[select.kqueue\(\)](#)-based selector.

`fileno()`

This returns the file descriptor used by the underlying `select.kqueue()` object.

18.5.3 范例

Here is a simple echo server implementation:

```
import selectors
import socket

sel = selectors.DefaultSelector()

def accept(sock, mask):
    conn, addr = sock.accept() # Should be ready
    print('accepted', conn, 'from', addr)
    conn.setblocking(False)
    sel.register(conn, selectors.EVENT_READ, read)

def read(conn, mask):
    data = conn.recv(1000) # Should be ready
    if data:
        print('echoing', repr(data), 'to', conn)
        conn.send(data) # Hope it won't block
    else:
        print('closing', conn)
        sel.unregister(conn)
        conn.close()

sock = socket.socket()
sock.bind(('localhost', 1234))
sock.listen(100)
sock.setblocking(False)
sel.register(sock, selectors.EVENT_READ, accept)

while True:
    events = sel.select()
    for key, mask in events:
        callback = key.data
        callback(key.fileobj, mask)
```

18.6 signal --- Set handlers for asynchronous events

原始碼: [Lib/signal.py](#)

This module provides mechanisms to use signal handlers in Python.

18.6.1 General rules

The `signal.signal()` function allows defining custom handlers to be executed when a signal is received. A small number of default handlers are installed: `SIGPIPE` is ignored (so write errors on pipes and sockets can be reported as ordinary Python exceptions) and `SIGINT` is translated into a `KeyboardInterrupt` exception if the parent process has not changed it.

A handler for a particular signal, once set, remains installed until it is explicitly reset (Python emulates the BSD style interface regardless of the underlying implementation), with the exception of the handler for `SIGCHLD`, which follows the underlying implementation.

On WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`, signals are emulated and therefore behave differently. Several functions and signals are not available on these platforms.

Execution of Python signal handlers

A Python signal handler does not get executed inside the low-level (C) signal handler. Instead, the low-level signal handler sets a flag which tells the *virtual machine* to execute the corresponding Python signal handler at a later point (for example at the next *bytecode* instruction). This has consequences:

- It makes little sense to catch synchronous errors like `SIGFPE` or `SIGSEGV` that are caused by an invalid operation in C code. Python will return from the signal handler to the C code, which is likely to raise the same signal again, causing Python to apparently hang. From Python 3.3 onwards, you can use the `faulthandler` module to report on synchronous errors.
- A long-running calculation implemented purely in C (such as regular expression matching on a large body of text) may run uninterrupted for an arbitrary amount of time, regardless of any signals received. The Python signal handlers will be called when the calculation finishes.
- If the handler raises an exception, it will be raised "out of thin air" in the main thread. See the *note below* for a discussion.

Signals and threads

Python signal handlers are always executed in the main Python thread of the main interpreter, even if the signal was received in another thread. This means that signals can't be used as a means of inter-thread communication. You can use the synchronization primitives from the `threading` module instead.

Besides, only the main thread of the main interpreter is allowed to set a new signal handler.

18.6.2 模組內容

在 3.5 版的變更: `signal` (`SIG*`), `handler` (`SIG_DFL`, `SIG_IGN`) and `sigmask` (`SIG_BLOCK`, `SIG_UNBLOCK`, `SIG_SETMASK`) related constants listed below were turned into `enums` (`Signals`, `Handlers` and `Sigmask` respectively). `getsignal()`, `pthread_sigmask()`, `sigpending()` and `sigwait()` functions return human-readable `enums` as `Signals` objects.

The `signal` module defines three `enums`:

class `signal.Signals`

`enum.IntEnum` collection of `SIG*` constants and the `CTRL_*` constants.

在 3.5 版新加入.

class `signal.Handlers`

`enum.IntEnum` collection the constants `SIG_DFL` and `SIG_IGN`.

在 3.5 版新加入.

class `signal.Sigmask`

`enum.IntEnum` collection the constants `SIG_BLOCK`, `SIG_UNBLOCK` and `SIG_SETMASK`.

適用：Unix。

更多資訊請見 `sigprocmask(2)` 與 `pthread_sigmask(3)` 手冊頁。

在 3.5 版新加入。

The variables defined in the `signal` module are:

`signal.SIG_DFL`

This is one of two standard signal handling options; it will simply perform the default function for the signal. For example, on most systems the default action for `SIGQUIT` is to dump core and exit, while the default action for `SIGCHLD` is to simply ignore it.

`signal.SIG_IGN`

This is another standard signal handler, which will simply ignore the given signal.

`signal.SIGABRT`

Abort signal from `abort(3)`.

`signal.SIGALRM`

Timer signal from `alarm(2)`.

適用：Unix。

`signal.SIGBREAK`

Interrupt from keyboard (CTRL + BREAK).

適用：Windows。

`signal.SIGBUS`

Bus error (bad memory access).

適用：Unix。

`signal.SIGCHLD`

Child process stopped or terminated.

適用：Unix。

`signal.SIGCLD`

Alias to `SIGCHLD`.

Availability: not macOS.

`signal.SIGCONT`

Continue the process if it is currently stopped

適用：Unix。

`signal.SIGFPE`

Floating-point exception. For example, division by zero.

也參考：

`ZeroDivisionError` is raised when the second argument of a division or modulo operation is zero.

`signal.SIGHUP`

Hangup detected on controlling terminal or death of controlling process.

適用：Unix。

`signal.SIGILL`

Illegal instruction.

signal.SIGINT

Interrupt from keyboard (CTRL + C).

Default action is to raise *KeyboardInterrupt*.

signal.SIGKILL

Kill signal.

It cannot be caught, blocked, or ignored.

適用：Unix。

signal.SIGPIPE

Broken pipe: write to pipe with no readers.

Default action is to ignore the signal.

適用：Unix。

signal.SIGSEGV

Segmentation fault: invalid memory reference.

signal.SIGSTKFLT

Stack fault on coprocessor. The Linux kernel does not raise this signal: it can only be raised in user space.

適用：Linux。

On architectures where the signal is available. See the man page *signal(7)* for further information.

在 3.11 版新加入。

signal.SIGTERM

Termination signal.

signal.SIGUSR1

User-defined signal 1.

適用：Unix。

signal.SIGUSR2

User-defined signal 2.

適用：Unix。

signal.SIGWINCH

Window resize signal.

適用：Unix。

SIG*

All the signal numbers are defined symbolically. For example, the hangup signal is defined as *signal.SIGHUP*; the variable names are identical to the names used in C programs, as found in `<signal.h>`. The Unix man page for `signal()` lists the existing signals (on some systems this is *signal(2)*, on others the list is in *signal(7)*). Note that not all systems define the same set of signal names; only those names defined by the system are defined by this module.

signal.CTRL_C_EVENT

The signal corresponding to the Ctrl+C keystroke event. This signal can only be used with *os.kill()*.

適用：Windows。

在 3.2 版新加入。

signal.CTRL_BREAK_EVENT

The signal corresponding to the Ctrl+Break keystroke event. This signal can only be used with `os.kill()`.

適用：Windows。

在 3.2 版新加入。

signal.NSIG

One more than the number of the highest signal number. Use `valid_signals()` to get valid signal numbers.

signal.ITIMER_REAL

Decrements interval timer in real time, and delivers `SIGALRM` upon expiration.

signal.ITIMER_VIRTUAL

Decrements interval timer only when the process is executing, and delivers `SIGVTALRM` upon expiration.

signal.ITIMER_PROF

Decrements interval timer both when the process executes and when the system is executing on behalf of the process. Coupled with `ITIMER_VIRTUAL`, this timer is usually used to profile the time spent by the application in user and kernel space. `SIGPROF` is delivered upon expiration.

signal.SIG_BLOCK

A possible value for the *how* parameter to `pthread_sigmask()` indicating that signals are to be blocked.

在 3.3 版新加入。

signal.SIG_UNBLOCK

A possible value for the *how* parameter to `pthread_sigmask()` indicating that signals are to be unblocked.

在 3.3 版新加入。

signal.SIG_SETMASK

A possible value for the *how* parameter to `pthread_sigmask()` indicating that the signal mask is to be replaced.

在 3.3 版新加入。

The `signal` module defines one exception:

exception signal.ItimerError

Raised to signal an error from the underlying `setitimer()` or `getitimer()` implementation. Expect this error if an invalid interval timer or a negative time is passed to `setitimer()`. This error is a subtype of `OSError`.

在 3.3 版新加入：This error used to be a subtype of `IOError`, which is now an alias of `OSError`.

The `signal` module defines the following functions:

signal.alarm(time)

If *time* is non-zero, this function requests that a `SIGALRM` signal be sent to the process in *time* seconds. Any previously scheduled alarm is canceled (only one alarm can be scheduled at any time). The returned value is then the number of seconds before any previously set alarm was to have been delivered. If *time* is zero, no alarm is scheduled, and any scheduled alarm is canceled. If the return value is zero, no alarm is currently scheduled.

適用：Unix。

更多資訊請見 `alarm(2)` 手冊頁。

signal.getsignal(signalnum)

Return the current signal handler for the signal *signalnum*. The returned value may be a callable Python object, or one of the special values `signal.SIG_IGN`, `signal.SIG_DFL` or `None`. Here, `signal.SIG_IGN` means that the signal was previously ignored, `signal.SIG_DFL` means that the default way of handling the signal was previously in use, and `None` means that the previous signal handler was not installed from Python.

`signal.strsignal(signalnum)`

Returns the description of signal *signalnum*, such as "Interrupt" for *SIGINT*. Returns *None* if *signalnum* has no description. Raises *ValueError* if *signalnum* is invalid.

在 3.8 版新加入。

`signal.valid_signals()`

Return the set of valid signal numbers on this platform. This can be less than `range(1, NSIG)` if some signals are reserved by the system for internal use.

在 3.8 版新加入。

`signal.pause()`

Cause the process to sleep until a signal is received; the appropriate handler will then be called. Returns nothing.

適用：Unix。

更多資訊請見 *signal(2)* 手冊頁。

See also *sigwait()*, *sigwaitinfo()*, *sigtimedwait()* and *sigpending()*.

`signal.raise_signal(signum)`

Sends a signal to the calling process. Returns nothing.

在 3.8 版新加入。

`signal.pidfd_send_signal(pidfd, sig, siginfo=None, flags=0)`

Send signal *sig* to the process referred to by file descriptor *pidfd*. Python does not currently support the *siginfo* parameter; it must be *None*. The *flags* argument is provided for future extensions; no flag values are currently defined.

更多資訊請見 *pidfd_send_signal(2)* 手冊頁。

適用：Linux 5.1 以上

在 3.9 版新加入。

`signal.thread_kill(thread_id, signalnum)`

Send the signal *signalnum* to the thread *thread_id*, another thread in the same process as the caller. The target thread can be executing any code (Python or not). However, if the target thread is executing the Python interpreter, the Python signal handlers will be *executed by the main thread of the main interpreter*. Therefore, the only point of sending a signal to a particular Python thread would be to force a running system call to fail with *InterruptedError*.

Use *threading.get_ident()* or the *ident* attribute of *threading.Thread* objects to get a suitable value for *thread_id*.

If *signalnum* is 0, then no signal is sent, but error checking is still performed; this can be used to check if the target thread is still running.

引發一個附帶引數 *thread_id*、*signalnum* 的稽核事件 *signal.thread_kill*。

適用：Unix。

更多資訊請見 *pthread_kill(3)* 手冊頁。

另請參閱 *os.kill()*。

在 3.3 版新加入。

`signal.thread_sigmask(how, mask)`

Fetch and/or change the signal mask of the calling thread. The signal mask is the set of signals whose delivery is currently blocked for the caller. Return the old signal mask as a set of signals.

The behavior of the call is dependent on the value of *how*, as follows.

- *SIG_BLOCK*: The set of blocked signals is the union of the current set and the *mask* argument.

- `SIG_UNBLOCK`: The signals in *mask* are removed from the current set of blocked signals. It is permissible to attempt to unblock a signal which is not blocked.
- `SIG_SETMASK`: The set of blocked signals is set to the *mask* argument.

mask is a set of signal numbers (e.g. `{signal.SIGINT, signal.SIGTERM}`). Use `valid_signals()` for a full mask including all signals.

For example, `signal.pthread_sigmask(signal.SIG_BLOCK, [])` reads the signal mask of the calling thread.

`SIGKILL` and `SIGSTOP` cannot be blocked.

適用：Unix。

更多資訊請見 `sigprocmask(2)` 與 `pthread_sigmask(3)` 手冊頁。

另請參閱 `pause()`、`sigpending()` 與 `sigwait()`。

在 3.3 版新加入。

`signal.setitimer(which, seconds, interval=0.0)`

Sets given interval timer (one of `signal.ITIMER_REAL`, `signal.ITIMER_VIRTUAL` or `signal.ITIMER_PROF`) specified by *which* to fire after *seconds* (float is accepted, different from `alarm()`) and after that every *interval* seconds (if *interval* is non-zero). The interval timer specified by *which* can be cleared by setting *seconds* to zero.

When an interval timer fires, a signal is sent to the process. The signal sent is dependent on the timer being used; `signal.ITIMER_REAL` will deliver `SIGALRM`, `signal.ITIMER_VIRTUAL` sends `SIGVTALRM`, and `signal.ITIMER_PROF` will deliver `SIGPROF`.

The old values are returned as a tuple: (delay, interval).

Attempting to pass an invalid interval timer will cause an `ItimerError`.

適用：Unix。

`signal.getitimer(which)`

Returns current value of a given interval timer specified by *which*.

適用：Unix。

`signal.set_wakeup_fd(fd, *, warn_on_full_buffer=True)`

Set the wakeup file descriptor to *fd*. When a signal is received, the signal number is written as a single byte into the fd. This can be used by a library to wakeup a poll or select call, allowing the signal to be fully processed.

The old wakeup fd is returned (or -1 if file descriptor wakeup was not enabled). If *fd* is -1, file descriptor wakeup is disabled. If not -1, *fd* must be non-blocking. It is up to the library to remove any bytes from *fd* before calling poll or select again.

When threads are enabled, this function can only be called from *the main thread of the main interpreter*; attempting to call it from other threads will cause a `ValueError` exception to be raised.

There are two common ways to use this function. In both approaches, you use the fd to wake up when a signal arrives, but then they differ in how they determine *which* signal or signals have arrived.

In the first approach, we read the data out of the fd's buffer, and the byte values give you the signal numbers. This is simple, but in rare cases it can run into a problem: generally the fd will have a limited amount of buffer space, and if too many signals arrive too quickly, then the buffer may become full, and some signals may be lost. If you use this approach, then you should set `warn_on_full_buffer=True`, which will at least cause a warning to be printed to stderr when signals are lost.

In the second approach, we use the wakeup fd *only* for wakeups, and ignore the actual byte values. In this case, all we care about is whether the fd's buffer is empty or non-empty; a full buffer doesn't indicate a problem at all. If you use this approach, then you should set `warn_on_full_buffer=False`, so that your users are not confused by spurious warning messages.

在 3.5 版的變更: On Windows, the function now also supports socket handles.

在 3.7 版的變更: 新增 `warn_on_full_buffer` 參數。

`signal.siginterrupt (signalnum, flag)`

Change system call restart behaviour: if *flag* is *False*, system calls will be restarted when interrupted by signal *signalnum*, otherwise system calls will be interrupted. Returns nothing.

適用: Unix。

更多資訊請見 `siginterrupt(3)` 手冊頁。

Note that installing a signal handler with `signal()` will reset the restart behaviour to interruptible by implicitly calling `siginterrupt()` with a true *flag* value for the given signal.

`signal.signal (signalnum, handler)`

Set the handler for signal *signalnum* to the function *handler*. *handler* can be a callable Python object taking two arguments (see below), or one of the special values `signal.SIG_IGN` or `signal.SIG_DFL`. The previous signal handler will be returned (see the description of `getsignal()` above). (See the Unix man page `signal(2)` for further information.)

When threads are enabled, this function can only be called from *the main thread of the main interpreter*; attempting to call it from other threads will cause a *ValueError* exception to be raised.

The *handler* is called with two arguments: the signal number and the current stack frame (None or a frame object; for a description of frame objects, see the description in the type hierarchy or see the attribute descriptions in the `inspect` module).

On Windows, `signal()` can only be called with `SIGABRT`, `SIGFPE`, `SIGILL`, `SIGINT`, `SIGSEGV`, `SIGTERM`, or `SIGBREAK`. A *ValueError* will be raised in any other case. Note that not all systems define the same set of signal names; an *AttributeError* will be raised if a signal name is not defined as `SIG*` module level constant.

`signal.sigpending ()`

Examine the set of signals that are pending for delivery to the calling thread (i.e., the signals which have been raised while blocked). Return the set of the pending signals.

適用: Unix。

更多資訊請見 `sigpending(2)` 手冊頁。

另請參閱 `pause()`、`pthread_sigmask()` 與 `sigwait()`。

在 3.3 版新加入。

`signal.sigwait (sigset)`

Suspend execution of the calling thread until the delivery of one of the signals specified in the signal set *sigset*. The function accepts the signal (removes it from the pending list of signals), and returns the signal number.

適用: Unix。

更多資訊請見 `sigwait(3)` 手冊頁。

See also `pause()`, `pthread_sigmask()`, `sigpending()`, `sigwaitinfo()` and `sigtimedwait()`.

在 3.3 版新加入。

`signal.sigwaitinfo (sigset)`

Suspend execution of the calling thread until the delivery of one of the signals specified in the signal set *sigset*. The function accepts the signal and removes it from the pending list of signals. If one of the signals in *sigset* is already pending for the calling thread, the function will return immediately with information about that signal. The signal handler is not called for the delivered signal. The function raises an *InterruptedError* if it is interrupted by a signal that is not in *sigset*.

The return value is an object representing the data contained in the `siginfo_t` structure, namely: `si_signo`, `si_code`, `si_errno`, `si_pid`, `si_uid`, `si_status`, `si_band`.

適用: Unix。

更多資訊請見 `sigwaitinfo(2)` 手冊頁。

另請參閱 `pause()`、`sigwait()` 與 `sigtimedwait()`。

在 3.3 版新加入。

在 3.5 版的變更: The function is now retried if interrupted by a signal not in *sigset* and the signal handler does not raise an exception (see [PEP 475](#) for the rationale).

`signal.sigtimedwait (sigset, timeout)`

Like `sigwaitinfo()`, but takes an additional *timeout* argument specifying a timeout. If *timeout* is specified as 0, a poll is performed. Returns *None* if a timeout occurs.

適用: Unix。

更多資訊請見 `sigtimedwait(2)` 手冊頁。

另請參閱 `pause()`、`sigwait()` 與 `sigwaitinfo()`。

在 3.3 版新加入。

在 3.5 版的變更: The function is now retried with the recomputed *timeout* if interrupted by a signal not in *sigset* and the signal handler does not raise an exception (see [PEP 475](#) for the rationale).

18.6.3 范例

Here is a minimal example program. It uses the `alarm()` function to limit the time spent waiting to open a file; this is useful if the file is for a serial device that may not be turned on, which would normally cause the `os.open()` to hang indefinitely. The solution is to set a 5-second alarm before opening the file; if the operation takes too long, the alarm signal will be sent, and the handler raises an exception.

```
import signal, os

def handler(signum, frame):
    signame = signal.Signals(signum).name
    print(f'Signal handler called with signal {signame} ({signum})')
    raise OSError("Couldn't open device!")

# Set the signal handler and a 5-second alarm
signal.signal(signal.SIGALRM, handler)
signal.alarm(5)

# This open() may hang indefinitely
fd = os.open('/dev/ttyS0', os.O_RDWR)

signal.alarm(0)          # Disable the alarm
```

18.6.4 Note on SIGPIPE

Piping output of your program to tools like `head(1)` will cause a `SIGPIPE` signal to be sent to your process when the receiver of its standard output closes early. This results in an exception like `BrokenPipeError: [Errno 32] Broken pipe`. To handle this case, wrap your entry point to catch this exception as follows:

```
import os
import sys

def main():
    try:
        # simulate large output (your code replaces this loop)
        for x in range(10000):
            print("y")
        # flush output here to force SIGPIPE to be triggered
```

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```

    # while inside this try block.
    sys.stdout.flush()
except BrokenPipeError:
    # Python flushes standard streams on exit; redirect remaining output
    # to devnull to avoid another BrokenPipeError at shutdown
    devnull = os.open(os.devnull, os.O_WRONLY)
    os.dup2(devnull, sys.stdout.fileno())
    sys.exit(1) # Python exits with error code 1 on EPIPE

if __name__ == '__main__':
    main()

```

Do not set `SIGPIPE`'s disposition to `SIG_DFL` in order to avoid `BrokenPipeError`. Doing that would cause your program to exit unexpectedly whenever any socket connection is interrupted while your program is still writing to it.

18.6.5 Note on Signal Handlers and Exceptions

If a signal handler raises an exception, the exception will be propagated to the main thread and may be raised after any *bytecode* instruction. Most notably, a `KeyboardInterrupt` may appear at any point during execution. Most Python code, including the standard library, cannot be made robust against this, and so a `KeyboardInterrupt` (or any other exception resulting from a signal handler) may on rare occasions put the program in an unexpected state.

To illustrate this issue, consider the following code:

```

class SpamContext:
    def __init__(self):
        self.lock = threading.Lock()

    def __enter__(self):
        # If KeyboardInterrupt occurs here, everything is fine
        self.lock.acquire()
        # If KeyboardInterrupt occurs here, __exit__ will not be called
        ...
        # KeyboardInterrupt could occur just before the function returns

    def __exit__(self, exc_type, exc_val, exc_tb):
        ...
        self.lock.release()

```

For many programs, especially those that merely want to exit on `KeyboardInterrupt`, this is not a problem, but applications that are complex or require high reliability should avoid raising exceptions from signal handlers. They should also avoid catching `KeyboardInterrupt` as a means of gracefully shutting down. Instead, they should install their own `SIGINT` handler. Below is an example of an HTTP server that avoids `KeyboardInterrupt`:

```

import signal
import socket
from selectors import DefaultSelector, EVENT_READ
from http.server import HTTPServer, SimpleHTTPRequestHandler

interrupt_read, interrupt_write = socket.socketpair()

def handler(signum, frame):
    print('Signal handler called with signal', signum)
    interrupt_write.send(b'\0')
signal.signal(signal.SIGINT, handler)

def serve_forever(httpd):
    sel = DefaultSelector()

```

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```

sel.register(interrupt_read, EVENT_READ)
sel.register(httpd, EVENT_READ)

while True:
    for key, _ in sel.select():
        if key.fileobj == interrupt_read:
            interrupt_read.recv(1)
            return
        if key.fileobj == httpd:
            httpd.handle_request()

print("Serving on port 8000")
httpd = HTTPServer(('', 8000), SimpleHTTPRequestHandler)
serve_forever(httpd)
print("Shutdown...")

```

18.7 mmap --- Memory-mapped file support

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

Memory-mapped file objects behave like both [bytearray](#) and like [file objects](#). You can use `mmap` objects in most places where [bytearray](#) are expected; for example, you can use the [re](#) module to search through a memory-mapped file. You can also change a single byte by doing `obj[index] = 97`, or change a subsequence by assigning to a slice: `obj[i1:i2] = b'...'`. You can also read and write data starting at the current file position, and `seek()` through the file to different positions.

A memory-mapped file is created by the [mmap](#) constructor, which is different on Unix and on Windows. In either case you must provide a file descriptor for a file opened for update. If you wish to map an existing Python file object, use its [fileno\(\)](#) method to obtain the correct value for the *fileno* parameter. Otherwise, you can open the file using the [os.open\(\)](#) function, which returns a file descriptor directly (the file still needs to be closed when done).

備 F: If you want to create a memory-mapping for a writable, buffered file, you should [flush\(\)](#) the file first. This is necessary to ensure that local modifications to the buffers are actually available to the mapping.

For both the Unix and Windows versions of the constructor, *access* may be specified as an optional keyword parameter. *access* accepts one of four values: `ACCESS_READ`, `ACCESS_WRITE`, or `ACCESS_COPY` to specify read-only, write-through or copy-on-write memory respectively, or `ACCESS_DEFAULT` to defer to *prot*. *access* can be used on both Unix and Windows. If *access* is not specified, Windows `mmap` returns a write-through mapping. The initial memory values for all three access types are taken from the specified file. Assignment to an `ACCESS_READ` memory map raises a [TypeError](#) exception. Assignment to an `ACCESS_WRITE` memory map affects both memory and the underlying file. Assignment to an `ACCESS_COPY` memory map affects memory but does not update the underlying file.

在 3.7 版的變更: 新增 `ACCESS_DEFAULT` 常數。

To map anonymous memory, `-1` should be passed as the *fileno* along with the *length*.

class `mmap.mmap` (*fileno*, *length*, *tagname*=None, *access*=`ACCESS_DEFAULT`[, *offset*])

(Windows version) Maps *length* bytes from the file specified by the file handle *fileno*, and creates a `mmap` object. If *length* is larger than the current size of the file, the file is extended to contain *length* bytes. If *length* is 0, the maximum length of the map is the current size of the file, except that if the file is empty Windows raises an exception (you cannot create an empty mapping on Windows).

tagname, if specified and not `None`, is a string giving a tag name for the mapping. Windows allows you to have many different mappings against the same file. If you specify the name of an existing tag, that tag is opened, otherwise a new tag of this name is created. If this parameter is omitted or `None`, the mapping is created without a name. Avoiding the use of the *tagname* parameter will assist in keeping your code portable between Unix and Windows.

offset may be specified as a non-negative integer offset. `mmap` references will be relative to the offset from the beginning of the file. *offset* defaults to 0. *offset* must be a multiple of the `ALLOCATIONGRANULARITY`.

引發一個附帶引數 `fileno`、`length`、`access`、`offset` 的稽核事件 `mmap.__new__`。

```
class mmap.mmap (fileno, length, flags=MAP_SHARED, prot=PROT_WRITE|PROT_READ,
                  access=ACCESS_DEFAULT[, offset])
```

(Unix version) Maps *length* bytes from the file specified by the file descriptor *fileno*, and returns a `mmap` object. If *length* is 0, the maximum length of the map will be the current size of the file when *mmap* is called.

flags specifies the nature of the mapping. `MAP_PRIVATE` creates a private copy-on-write mapping, so changes to the contents of the `mmap` object will be private to this process, and `MAP_SHARED` creates a mapping that's shared with all other processes mapping the same areas of the file. The default value is `MAP_SHARED`. Some systems have additional possible flags with the full list specified in `MAP_* constants`.

prot, if specified, gives the desired memory protection; the two most useful values are `PROT_READ` and `PROT_WRITE`, to specify that the pages may be read or written. *prot* defaults to `PROT_READ | PROT_WRITE`.

access may be specified in lieu of *flags* and *prot* as an optional keyword parameter. It is an error to specify both *flags*, *prot* and *access*. See the description of *access* above for information on how to use this parameter.

offset may be specified as a non-negative integer offset. `mmap` references will be relative to the offset from the beginning of the file. *offset* defaults to 0. *offset* must be a multiple of `ALLOCATIONGRANULARITY` which is equal to `PAGESIZE` on Unix systems.

To ensure validity of the created memory mapping the file specified by the descriptor *fileno* is internally automatically synchronized with the physical backing store on macOS.

This example shows a simple way of using *mmap*:

```
import mmap

# write a simple example file
with open("hello.txt", "wb") as f:
    f.write(b"Hello Python!\n")

with open("hello.txt", "r+b") as f:
    # memory-map the file, size 0 means whole file
    mm = mmap.mmap(f.fileno(), 0)
    # read content via standard file methods
    print(mm.readline()) # prints b"Hello Python!\n"
    # read content via slice notation
    print(mm[:5]) # prints b"Hello"
    # update content using slice notation;
    # note that new content must have same size
    mm[6:] = b" world!\n"
    # ... and read again using standard file methods
    mm.seek(0)
    print(mm.readline()) # prints b"Hello world!\n"
    # close the map
    mm.close()
```

mmap can also be used as a context manager in a `with` statement:

```
import mmap
```

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```
with mmap.mmap(-1, 13) as mm:
    mm.write(b"Hello world!")
```

在 3.2 版新加入: Context manager support.

The next example demonstrates how to create an anonymous map and exchange data between the parent and child processes:

```
import mmap
import os

mm = mmap.mmap(-1, 13)
mm.write(b"Hello world!")

pid = os.fork()

if pid == 0: # In a child process
    mm.seek(0)
    print(mm.readline())

    mm.close()
```

引發一個附帶引數 `fileno`、`length`、`access`、`offset` 的稽核事件 `mmap.__new__`。

Memory-mapped file objects support the following methods:

close()

Closes the mmap. Subsequent calls to other methods of the object will result in a `ValueError` exception being raised. This will not close the open file.

closed

True if the file is closed.

在 3.2 版新加入.

find(sub[, start[, end]])

Returns the lowest index in the object where the subsequence *sub* is found, such that *sub* is contained in the range *[start, end]*. Optional arguments *start* and *end* are interpreted as in slice notation. Returns `-1` on failure.

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

flush([offset[, size]])

Flushes changes made to the in-memory copy of a file back to disk. Without use of this call there is no guarantee that changes are written back before the object is destroyed. If *offset* and *size* are specified, only changes to the given range of bytes will be flushed to disk; otherwise, the whole extent of the mapping is flushed. *offset* must be a multiple of the `PAGESIZE` or `ALLOCATIONGRANULARITY`.

None is returned to indicate success. An exception is raised when the call failed.

在 3.8 版的變更: Previously, a nonzero value was returned on success; zero was returned on error under Windows. A zero value was returned on success; an exception was raised on error under Unix.

madvise(option[, start[, length]])

Send advice *option* to the kernel about the memory region beginning at *start* and extending *length* bytes. *option* must be one of the `MADV_*` constants available on the system. If *start* and *length* are omitted, the entire mapping is spanned. On some systems (including Linux), *start* must be a multiple of the `PAGESIZE`.

Availability: Systems with the `madvise()` system call.

在 3.8 版新加入.

move (*dest*, *src*, *count*)

Copy the *count* bytes starting at offset *src* to the destination index *dest*. If the mmap was created with `ACCESS_READ`, then calls to move will raise a `TypeError` exception.

read (*[n]*)

Return a `bytes` containing up to *n* bytes starting from the current file position. If the argument is omitted, `None` or negative, return all bytes from the current file position to the end of the mapping. The file position is updated to point after the bytes that were returned.

在 3.3 版的變更: Argument can be omitted or `None`.

read_byte ()

Returns a byte at the current file position as an integer, and advances the file position by 1.

readline ()

Returns a single line, starting at the current file position and up to the next newline. The file position is updated to point after the bytes that were returned.

resize (*newsize*)

Resizes the map and the underlying file, if any. If the mmap was created with `ACCESS_READ` or `ACCESS_COPY`, resizing the map will raise a `TypeError` exception.

On Windows: Resizing the map will raise an `OSError` if there are other maps against the same named file. Resizing an anonymous map (ie against the pagefile) will silently create a new map with the original data copied over up to the length of the new size.

在 3.11 版的變更: Correctly fails if attempting to resize when another map is held Allows resize against an anonymous map on Windows

rfind (*sub* [*, start* [*, end*]])

Returns the highest index in the object where the subsequence *sub* is found, such that *sub* is contained in the range [*start*, *end*]. Optional arguments *start* and *end* are interpreted as in slice notation. Returns `-1` on failure.

在 3.5 版的變更: Writable `bytes-like object` is now accepted.

seek (*pos* [*, whence*])

Set the file's current position. *whence* argument is optional and defaults to `os.SEEK_SET` or 0 (absolute file positioning); other values are `os.SEEK_CUR` or 1 (seek relative to the current position) and `os.SEEK_END` or 2 (seek relative to the file's end).

size ()

Return the length of the file, which can be larger than the size of the memory-mapped area.

tell ()

Returns the current position of the file pointer.

write (*bytes*)

Write the bytes in *bytes* into memory at the current position of the file pointer and return the number of bytes written (never less than `len(bytes)`, since if the write fails, a `ValueError` will be raised). The file position is updated to point after the bytes that were written. If the mmap was created with `ACCESS_READ`, then writing to it will raise a `TypeError` exception.

在 3.5 版的變更: Writable `bytes-like object` is now accepted.

在 3.6 版的變更: The number of bytes written is now returned.

write_byte (*byte*)

Write the integer *byte* into memory at the current position of the file pointer; the file position is advanced by 1. If the mmap was created with `ACCESS_READ`, then writing to it will raise a `TypeError` exception.

18.7.1 MADV_* Constants

```
mmap.MADV_NORMAL  
mmap.MADV_RANDOM  
mmap.MADV_SEQUENTIAL  
mmap.MADV_WILLNEED  
mmap.MADV_DONTNEED  
mmap.MADV_REMOVE  
mmap.MADV_DONTFORK  
mmap.MADV_DOFORK  
mmap.MADV_HWPOISON  
mmap.MADV_MERGEABLE  
mmap.MADV_UNMERGEABLE  
mmap.MADV_SOFT_OFFLINE  
mmap.MADV_HUGEPAGE  
mmap.MADV_NOHUGEPAGE  
mmap.MADV_DONTDUMP  
mmap.MADV_DODUMP  
mmap.MADV_FREE  
mmap.MADV_NOSYNC  
mmap.MADV_AUTOSYNC  
mmap.MADV_NOCORE  
mmap.MADV_CORE  
mmap.MADV_PROTECT  
mmap.MADV_FREE_REUSABLE  
mmap.MADV_FREE_REUSE
```

These options can be passed to `mmap.madvise()`. Not every option will be present on every system.

Availability: Systems with the `madvise()` system call.

在 3.8 版新加入.

18.7.2 MAP_* Constants

```
mmap.MAP_SHARED  
mmap.MAP_PRIVATE  
mmap.MAP_DENYWRITE  
mmap.MAP_EXECUTABLE  
mmap.MAP_ANON  
mmap.MAP_ANONYMOUS  
mmap.MAP_POPULATE  
mmap.MAP_STACK
```

These are the various flags that can be passed to `mmap.mmap()`. Note that some options might not be present on some systems.

在 3.10 版的變更: 新增 `MAP_POPULATE` 常數。

在 3.11 版新加入: 新增 `MAP_STACK` 常數。

本章描述了支援網際網路上處理常用資料格式的模組。

19.1 `email` --- An email and MIME handling package

原始碼: `Lib/email/__init__.py`

The `email` package is a library for managing email messages. It is specifically *not* designed to do any sending of email messages to SMTP ([RFC 2821](#)), NNTP, or other servers; those are functions of modules such as `smtplib` and `nntplib`. The `email` package attempts to be as RFC-compliant as possible, supporting [RFC 5322](#) and [RFC 6532](#), as well as such MIME-related RFCs as [RFC 2045](#), [RFC 2046](#), [RFC 2047](#), [RFC 2183](#), and [RFC 2231](#).

The overall structure of the email package can be divided into three major components, plus a fourth component that controls the behavior of the other components.

The central component of the package is an "object model" that represents email messages. An application interacts with the package primarily through the object model interface defined in the `message` sub-module. The application can use this API to ask questions about an existing email, to construct a new email, or to add or remove email subcomponents that themselves use the same object model interface. That is, following the nature of email messages and their MIME subcomponents, the email object model is a tree structure of objects that all provide the `EmailMessage` API.

The other two major components of the package are the `parser` and the `generator`. The parser takes the serialized version of an email message (a stream of bytes) and converts it into a tree of `EmailMessage` objects. The generator takes an `EmailMessage` and turns it back into a serialized byte stream. (The parser and generator also handle streams of text characters, but this usage is discouraged as it is too easy to end up with messages that are not valid in one way or another.)

The control component is the `policy` module. Every `EmailMessage`, every `generator`, and every `parser` has an associated `policy` object that controls its behavior. Usually an application only needs to specify the policy when an `EmailMessage` is created, either by directly instantiating an `EmailMessage` to create a new email, or by parsing an input stream using a `parser`. But the policy can be changed when the message is serialized using a `generator`. This allows, for example, a generic email message to be parsed from disk, but to serialize it using standard SMTP settings when sending it to an email server.

The email package does its best to hide the details of the various governing RFCs from the application. Conceptually the application should be able to treat the email message as a structured tree of unicode text and binary attachments,

without having to worry about how these are represented when serialized. In practice, however, it is often necessary to be aware of at least some of the rules governing MIME messages and their structure, specifically the names and nature of the MIME "content types" and how they identify multipart documents. For the most part this knowledge should only be required for more complex applications, and even then it should only be the high level structure in question, and not the details of how those structures are represented. Since MIME content types are used widely in modern internet software (not just email), this will be a familiar concept to many programmers.

The following sections describe the functionality of the `email` package. We start with the `message` object model, which is the primary interface an application will use, and follow that with the `parser` and `generator` components. Then we cover the `policy` controls, which completes the treatment of the main components of the library.

The next three sections cover the exceptions the package may raise and the defects (non-compliance with the RFCs) that the `parser` may detect. Then we cover the `headerregistry` and the `contentmanager` sub-components, which provide tools for doing more detailed manipulation of headers and payloads, respectively. Both of these components contain features relevant to consuming and producing non-trivial messages, but also document their extensibility APIs, which will be of interest to advanced applications.

Following those is a set of examples of using the fundamental parts of the APIs covered in the preceding sections.

The foregoing represent the modern (unicode friendly) API of the email package. The remaining sections, starting with the `Message` class, cover the legacy `compat32` API that deals much more directly with the details of how email messages are represented. The `compat32` API does *not* hide the details of the RFCs from the application, but for applications that need to operate at that level, they can be useful tools. This documentation is also relevant for applications that are still using the `compat32` API for backward compatibility reasons.

在 3.6 版的變更: Docs reorganized and rewritten to promote the new `EmailMessage/EmailPolicy` API.

Contents of the `email` package documentation:

19.1.1 `email.message`: Representing an email message

原始碼: `Lib/email/message.py`

在 3.6 版新加入:¹

The central class in the `email` package is the `EmailMessage` class, imported from the `email.message` module. It is the base class for the `email` object model. `EmailMessage` provides the core functionality for setting and querying header fields, for accessing message bodies, and for creating or modifying structured messages.

An email message consists of *headers* and a *payload* (which is also referred to as the *content*). Headers are **RFC 5322** or **RFC 6532** style field names and values, where the field name and value are separated by a colon. The colon is not part of either the field name or the field value. The payload may be a simple text message, or a binary object, or a structured sequence of sub-messages each with their own set of headers and their own payload. The latter type of payload is indicated by the message having a MIME type such as `multipart/*` or `message/rfc822`.

The conceptual model provided by an `EmailMessage` object is that of an ordered dictionary of headers coupled with a *payload* that represents the **RFC 5322** body of the message, which might be a list of sub-`EmailMessage` objects. In addition to the normal dictionary methods for accessing the header names and values, there are methods for accessing specialized information from the headers (for example the MIME content type), for operating on the payload, for generating a serialized version of the message, and for recursively walking over the object tree.

The `EmailMessage` dictionary-like interface is indexed by the header names, which must be ASCII values. The values of the dictionary are strings with some extra methods. Headers are stored and returned in case-preserving form, but field names are matched case-insensitively. The keys are ordered, but unlike a real dict, there can be duplicates. Additional methods are provided for working with headers that have duplicate keys.

The *payload* is either a string or bytes object, in the case of simple message objects, or a list of `EmailMessage` objects, for MIME container documents such as `multipart/*` and `message/rfc822` message objects.

¹ Originally added in 3.4 as a *provisional module*. Docs for legacy message class moved to `email.message.Message: Representing an email message using the compat32 API`.

class `email.message.EmailMessage` (*policy=default*)

If *policy* is specified use the rules it specifies to update and serialize the representation of the message. If *policy* is not set, use the *default* policy, which follows the rules of the email RFCs except for line endings (instead of the RFC mandated `\r\n`, it uses the Python standard `\n` line endings). For more information see the *policy* documentation.

as_string (*unixfrom=False, maxheaderlen=None, policy=None*)

Return the entire message flattened as a string. When optional *unixfrom* is true, the envelope header is included in the returned string. *unixfrom* defaults to `False`. For backward compatibility with the base *Message* class *maxheaderlen* is accepted, but defaults to `None`, which means that by default the line length is controlled by the *max_line_length* of the policy. The *policy* argument may be used to override the default policy obtained from the message instance. This can be used to control some of the formatting produced by the method, since the specified *policy* will be passed to the *Generator*.

Flattening the message may trigger changes to the *EmailMessage* if defaults need to be filled in to complete the transformation to a string (for example, MIME boundaries may be generated or modified).

Note that this method is provided as a convenience and may not be the most useful way to serialize messages in your application, especially if you are dealing with multiple messages. See *email.generator.Generator* for a more flexible API for serializing messages. Note also that this method is restricted to producing messages serialized as "7 bit clean" when *utf8* is `False`, which is the default.

在 3.6 版的變更: the default behavior when *maxheaderlen* is not specified was changed from defaulting to 0 to defaulting to the value of *max_line_length* from the policy.

__str__ ()

Equivalent to `as_string(policy=self.policy.clone(utf8=True))`. Allows `str(msg)` to produce a string containing the serialized message in a readable format.

在 3.4 版的變更: the method was changed to use `utf8=True`, thus producing an **RFC 6531**-like message representation, instead of being a direct alias for *as_string* ().

as_bytes (*unixfrom=False, policy=None*)

Return the entire message flattened as a bytes object. When optional *unixfrom* is true, the envelope header is included in the returned string. *unixfrom* defaults to `False`. The *policy* argument may be used to override the default policy obtained from the message instance. This can be used to control some of the formatting produced by the method, since the specified *policy* will be passed to the *BytesGenerator*.

Flattening the message may trigger changes to the *EmailMessage* if defaults need to be filled in to complete the transformation to a string (for example, MIME boundaries may be generated or modified).

Note that this method is provided as a convenience and may not be the most useful way to serialize messages in your application, especially if you are dealing with multiple messages. See *email.generator.BytesGenerator* for a more flexible API for serializing messages.

__bytes__ ()

Equivalent to `as_bytes()`. Allows `bytes(msg)` to produce a bytes object containing the serialized message.

is_multipart ()

Return `True` if the message's payload is a list of sub-*EmailMessage* objects, otherwise return `False`. When *is_multipart* () returns `False`, the payload should be a string object (which might be a CTE encoded binary payload). Note that *is_multipart* () returning `True` does not necessarily mean that `"msg.get_content_maintype() == 'multipart'"` will return the `True`. For example, *is_multipart* will return `True` when the *EmailMessage* is of type *message/rfc822*.

set_unixfrom (*unixfrom*)

Set the message's envelope header to *unixfrom*, which should be a string. (See *mbxMessage* for a brief description of this header.)

get_unixfrom ()

Return the message's envelope header. Defaults to `None` if the envelope header was never set.

The following methods implement the mapping-like interface for accessing the message's headers. Note that there are some semantic differences between these methods and a normal mapping (i.e. dictionary) interface. For example, in a dictionary there are no duplicate keys, but here there may be duplicate message headers. Also, in dictionaries there is no guaranteed order to the keys returned by `keys()`, but in an `EmailMessage` object, headers are always returned in the order they appeared in the original message, or in which they were added to the message later. Any header deleted and then re-added is always appended to the end of the header list.

These semantic differences are intentional and are biased toward convenience in the most common use cases.

Note that in all cases, any envelope header present in the message is not included in the mapping interface.

`__len__()`

Return the total number of headers, including duplicates.

`__contains__(name)`

Return `True` if the message object has a field named *name*. Matching is done without regard to case and *name* does not include the trailing colon. Used for the `in` operator. For example:

```
if 'message-id' in myMessage:
    print('Message-ID:', myMessage['message-id'])
```

`__getitem__(name)`

Return the value of the named header field. *name* does not include the colon field separator. If the header is missing, `None` is returned; a `KeyError` is never raised.

Note that if the named field appears more than once in the message's headers, exactly which of those field values will be returned is undefined. Use the `get_all()` method to get the values of all the extant headers named *name*.

Using the standard (non-compat32) policies, the returned value is an instance of a subclass of `email.headerregistry.BaseHeader`.

`__setitem__(name, val)`

Add a header to the message with field name *name* and value *val*. The field is appended to the end of the message's existing headers.

Note that this does *not* overwrite or delete any existing header with the same name. If you want to ensure that the new header is the only one present in the message with field name *name*, delete the field first, e.g.:

```
del msg['subject']
msg['subject'] = 'Python roolz!'
```

If the *policy* defines certain headers to be unique (as the standard policies do), this method may raise a `ValueError` when an attempt is made to assign a value to such a header when one already exists. This behavior is intentional for consistency's sake, but do not depend on it as we may choose to make such assignments do an automatic deletion of the existing header in the future.

`__delitem__(name)`

Delete all occurrences of the field with name *name* from the message's headers. No exception is raised if the named field isn't present in the headers.

`keys()`

Return a list of all the message's header field names.

`values()`

Return a list of all the message's field values.

`items()`

Return a list of 2-tuples containing all the message's field headers and values.

get (*name*, *failobj*=None)

Return the value of the named header field. This is identical to `__getitem__()` except that optional *failobj* is returned if the named header is missing (*failobj* defaults to None).

Here are some additional useful header related methods:

get_all (*name*, *failobj*=None)

Return a list of all the values for the field named *name*. If there are no such named headers in the message, *failobj* is returned (defaults to None).

add_header (*_name*, *_value*, ***_params*)

Extended header setting. This method is similar to `__setitem__()` except that additional header parameters can be provided as keyword arguments. *_name* is the header field to add and *_value* is the *primary* value for the header.

For each item in the keyword argument dictionary *_params*, the key is taken as the parameter name, with underscores converted to dashes (since dashes are illegal in Python identifiers). Normally, the parameter will be added as `key="value"` unless the value is None, in which case only the key will be added.

If the value contains non-ASCII characters, the charset and language may be explicitly controlled by specifying the value as a three tuple in the format (CHARSET, LANGUAGE, VALUE), where CHARSET is a string naming the charset to be used to encode the value, LANGUAGE can usually be set to None or the empty string (see [RFC 2231](#) for other possibilities), and VALUE is the string value containing non-ASCII code points. If a three tuple is not passed and the value contains non-ASCII characters, it is automatically encoded in [RFC 2231](#) format using a CHARSET of `utf-8` and a LANGUAGE of None.

以下是個範例：

```
msg.add_header('Content-Disposition', 'attachment', filename='bud.gif')
```

This will add a header that looks like

```
Content-Disposition: attachment; filename="bud.gif"
```

An example of the extended interface with non-ASCII characters:

```
msg.add_header('Content-Disposition', 'attachment',
               filename=('iso-8859-1', '', 'Fußballer.ppt'))
```

replace_header (*_name*, *_value*)

Replace a header. Replace the first header found in the message that matches *_name*, retaining header order and field name case of the original header. If no matching header is found, raise a `KeyError`.

get_content_type ()

Return the message's content type, coerced to lower case of the form *maintype/subtype*. If there is no *Content-Type* header in the message return the value returned by `get_default_type()`. If the *Content-Type* header is invalid, return `text/plain`.

(According to [RFC 2045](#), messages always have a default type, `get_content_type()` will always return a value. [RFC 2045](#) defines a message's default type to be `text/plain` unless it appears inside a *multipart/digest* container, in which case it would be `message/rfc822`. If the *Content-Type* header has an invalid type specification, [RFC 2045](#) mandates that the default type be `text/plain`.)

get_content_maintype ()

Return the message's main content type. This is the *maintype* part of the string returned by `get_content_type()`.

get_content_subtype ()

Return the message's sub-content type. This is the *subtype* part of the string returned by `get_content_type()`.

get_default_type()

Return the default content type. Most messages have a default content type of *text/plain*, except for messages that are subparts of *multipart/digest* containers. Such subparts have a default content type of *message/rfc822*.

set_default_type(ctype)

Set the default content type. *ctype* should either be *text/plain* or *message/rfc822*, although this is not enforced. The default content type is not stored in the *Content-Type* header, so it only affects the return value of the *get_content_type* methods when no *Content-Type* header is present in the message.

set_param(param, value, header='Content-Type', requote=True, charset=None, language="", replace=False)

Set a parameter in the *Content-Type* header. If the parameter already exists in the header, replace its value with *value*. When *header* is *Content-Type* (the default) and the header does not yet exist in the message, add it, set its value to *text/plain*, and append the new parameter value. Optional *header* specifies an alternative header to *Content-Type*.

If the value contains non-ASCII characters, the *charset* and *language* may be explicitly specified using the optional *charset* and *language* parameters. Optional *language* specifies the [RFC 2231](#) language, defaulting to the empty string. Both *charset* and *language* should be strings. The default is to use the *utf8* *charset* and *None* for the *language*.

If *replace* is *False* (the default) the header is moved to the end of the list of headers. If *replace* is *True*, the header will be updated in place.

Use of the *requote* parameter with *EmailMessage* objects is deprecated.

Note that existing parameter values of headers may be accessed through the *params* attribute of the header value (for example, `msg['Content-Type'].params['charset']`).

在 3.4 版的變更: *replace* keyword was added.

del_param(param, header='content-type', requote=True)

Remove the given parameter completely from the *Content-Type* header. The header will be re-written in place without the parameter or its value. Optional *header* specifies an alternative to *Content-Type*.

Use of the *requote* parameter with *EmailMessage* objects is deprecated.

get_filename(failobj=None)

Return the value of the *filename* parameter of the *Content-Disposition* header of the message. If the header does not have a *filename* parameter, this method falls back to looking for the *name* parameter on the *Content-Type* header. If neither is found, or the header is missing, then *failobj* is returned. The returned string will always be unquoted as per `email.utils.unquote()`.

get_boundary(failobj=None)

Return the value of the *boundary* parameter of the *Content-Type* header of the message, or *failobj* if either the header is missing, or has no *boundary* parameter. The returned string will always be unquoted as per `email.utils.unquote()`.

set_boundary(boundary)

Set the *boundary* parameter of the *Content-Type* header to *boundary*. `set_boundary()` will always quote *boundary* if necessary. A *HeaderParseError* is raised if the message object has no *Content-Type* header.

Note that using this method is subtly different from deleting the old *Content-Type* header and adding a new one with the new *boundary* via `add_header()`, because `set_boundary()` preserves the order of the *Content-Type* header in the list of headers.

get_content_charset(failobj=None)

Return the *charset* parameter of the *Content-Type* header, coerced to lower case. If there is no *Content-Type* header, or if that header has no *charset* parameter, *failobj* is returned.

get_charsets (*failobj=None*)

Return a list containing the character set names in the message. If the message is a *multipart*, then the list will contain one element for each subpart in the payload, otherwise, it will be a list of length 1.

Each item in the list will be a string which is the value of the *charset* parameter in the *Content-Type* header for the represented subpart. If the subpart has no *Content-Type* header, no *charset* parameter, or is not of the *text* main MIME type, then that item in the returned list will be *failobj*.

is_attachment ()

Return True if there is a *Content-Disposition* header and its (case insensitive) value is attachment, False otherwise.

在 3.4.2 版的變更: *is_attachment* is now a method instead of a property, for consistency with *is_multipart* ().

get_content_disposition ()

Return the lowercased value (without parameters) of the message's *Content-Disposition* header if it has one, or None. The possible values for this method are *inline*, *attachment* or None if the message follows **RFC 2183**.

在 3.5 版新加入.

The following methods relate to interrogating and manipulating the content (payload) of the message.

walk ()

The *walk* () method is an all-purpose generator which can be used to iterate over all the parts and subparts of a message object tree, in depth-first traversal order. You will typically use *walk* () as the iterator in a *for* loop; each iteration returns the next subpart.

Here's an example that prints the MIME type of every part of a multipart message structure:

```
>>> for part in msg.walk():
...     print(part.get_content_type())
multipart/report
text/plain
message/delivery-status
text/plain
text/plain
message/rfc822
text/plain
```

walk iterates over the subparts of any part where *is_multipart* () returns True, even though *msg.get_content_maintype* () == 'multipart' may return False. We can see this in our example by making use of the *_structure* debug helper function:

```
>>> from email.iterators import _structure
>>> for part in msg.walk():
...     print(part.get_content_maintype() == 'multipart',
...           part.is_multipart())
True True
False False
False True
False False
False False
False False
False True
False False
>>> _structure(msg)
multipart/report
  text/plain
  message/delivery-status
    text/plain
    text/plain
```

(繼續下一頁)

(繼續上一頁)

```
message/rfc822
text/plain
```

Here the message parts are not multipart, but they do contain subparts. `is_multipart()` returns True and `walk` descends into the subparts.

get_body (*preferencelist*=('related', 'html', 'plain'))

Return the MIME part that is the best candidate to be the "body" of the message.

preferencelist must be a sequence of strings from the set `related`, `html`, and `plain`, and indicates the order of preference for the content type of the part returned.

Start looking for candidate matches with the object on which the `get_body` method is called.

If `related` is not included in *preferencelist*, consider the root part (or subpart of the root part) of any related encountered as a candidate if the (sub-)part matches a preference.

When encountering a `multipart/related`, check the `start` parameter and if a part with a matching *Content-ID* is found, consider only it when looking for candidate matches. Otherwise consider only the first (default root) part of the `multipart/related`.

If a part has a *Content-Disposition* header, only consider the part a candidate match if the value of the header is `inline`.

If none of the candidates matches any of the preferences in *preferencelist*, return `None`.

Notes: (1) For most applications the only *preferencelist* combinations that really make sense are ('plain',), ('html', 'plain'), and the default ('related', 'html', 'plain'). (2) Because matching starts with the object on which `get_body` is called, calling `get_body` on a `multipart/related` will return the object itself unless *preferencelist* has a non-default value. (3) Messages (or message parts) that do not specify a *Content-Type* or whose *Content-Type* header is invalid will be treated as if they are of type `text/plain`, which may occasionally cause `get_body` to return unexpected results.

iter_attachments ()

Return an iterator over all of the immediate sub-parts of the message that are not candidate "body" parts. That is, skip the first occurrence of each of `text/plain`, `text/html`, `multipart/related`, or `multipart/alternative` (unless they are explicitly marked as attachments via *Content-Disposition: attachment*), and return all remaining parts. When applied directly to a `multipart/related`, return an iterator over the all the related parts except the root part (ie: the part pointed to by the `start` parameter, or the first part if there is no `start` parameter or the `start` parameter doesn't match the *Content-ID* of any of the parts). When applied directly to a `multipart/alternative` or a non-multipart, return an empty iterator.

iter_parts ()

Return an iterator over all of the immediate sub-parts of the message, which will be empty for a non-multipart. (See also `walk()`.)

get_content (*args, *content_manager*=None, **kw)

Call the `get_content()` method of the *content_manager*, passing self as the message object, and passing along any other arguments or keywords as additional arguments. If *content_manager* is not specified, use the *content_manager* specified by the current *policy*.

set_content (*args, *content_manager*=None, **kw)

Call the `set_content()` method of the *content_manager*, passing self as the message object, and passing along any other arguments or keywords as additional arguments. If *content_manager* is not specified, use the *content_manager* specified by the current *policy*.

make_related (*boundary*=None)

Convert a non-multipart message into a `multipart/related` message, moving any existing *Content-* headers and payload into a (new) first part of the multipart. If *boundary* is specified,

use it as the boundary string in the multipart, otherwise leave the boundary to be automatically created when it is needed (for example, when the message is serialized).

make_alternative (*boundary=None*)

Convert a non-multipart or a multipart/related into a multipart/alternative, moving any existing *Content-* headers and payload into a (new) first part of the multipart. If *boundary* is specified, use it as the boundary string in the multipart, otherwise leave the boundary to be automatically created when it is needed (for example, when the message is serialized).

make_mixed (*boundary=None*)

Convert a non-multipart, a multipart/related, or a multipart-alternative into a multipart/mixed, moving any existing *Content-* headers and payload into a (new) first part of the multipart. If *boundary* is specified, use it as the boundary string in the multipart, otherwise leave the boundary to be automatically created when it is needed (for example, when the message is serialized).

add_related (**args, content_manager=None, **kw*)

If the message is a multipart/related, create a new message object, pass all of the arguments to its *set_content()* method, and *attach()* it to the multipart. If the message is a non-multipart, call *make_related()* and then proceed as above. If the message is any other type of multipart, raise a *TypeError*. If *content_manager* is not specified, use the *content_manager* specified by the current *policy*. If the added part has no *Content-Disposition* header, add one with the value *inline*.

add_alternative (**args, content_manager=None, **kw*)

If the message is a multipart/alternative, create a new message object, pass all of the arguments to its *set_content()* method, and *attach()* it to the multipart. If the message is a non-multipart or multipart/related, call *make_alternative()* and then proceed as above. If the message is any other type of multipart, raise a *TypeError*. If *content_manager* is not specified, use the *content_manager* specified by the current *policy*.

add_attachment (**args, content_manager=None, **kw*)

If the message is a multipart/mixed, create a new message object, pass all of the arguments to its *set_content()* method, and *attach()* it to the multipart. If the message is a non-multipart, multipart/related, or multipart/alternative, call *make_mixed()* and then proceed as above. If *content_manager* is not specified, use the *content_manager* specified by the current *policy*. If the added part has no *Content-Disposition* header, add one with the value *attachment*. This method can be used both for explicit attachments (*Content-Disposition: attachment*) and inline attachments (*Content-Disposition: inline*), by passing appropriate options to the *content_manager*.

clear()

Remove the payload and all of the headers.

clear_content()

Remove the payload and all of the *!Content-* headers, leaving all other headers intact and in their original order.

EmailMessage objects have the following instance attributes:

preamble

The format of a MIME document allows for some text between the blank line following the headers, and the first multipart boundary string. Normally, this text is never visible in a MIME-aware mail reader because it falls outside the standard MIME armor. However, when viewing the raw text of the message, or when viewing the message in a non-MIME aware reader, this text can become visible.

The *preamble* attribute contains this leading extra-armor text for MIME documents. When the *Parser* discovers some text after the headers but before the first boundary string, it assigns this text to the message's *preamble* attribute. When the *Generator* is writing out the plain text representation of a MIME message, and it finds the message has a *preamble* attribute, it will write this text in the area between the headers and the first boundary. See *email.parser* and *email.generator* for details.

Note that if the message object has no preamble, the *preamble* attribute will be `None`.

epilogue

The *epilogue* attribute acts the same way as the *preamble* attribute, except that it contains text that appears between the last boundary and the end of the message. As with the *preamble*, if there is no epilog text this attribute will be `None`.

defects

The *defects* attribute contains a list of all the problems found when parsing this message. See *email.errors* for a detailed description of the possible parsing defects.

class `email.message.MIMEPart` (*policy=default*)

This class represents a subpart of a MIME message. It is identical to *EmailMessage*, except that no *MIME-Version* headers are added when *set_content()* is called, since sub-parts do not need their own *MIME-Version* headers.

解

19.1.2 email.parser: Parsing email messages

原始碼: [Lib/email/parser.py](#)

Message object structures can be created in one of two ways: they can be created from whole cloth by creating an *EmailMessage* object, adding headers using the dictionary interface, and adding payload(s) using *set_content()* and related methods, or they can be created by parsing a serialized representation of the email message.

The *email* package provides a standard parser that understands most email document structures, including MIME documents. You can pass the parser a bytes, string or file object, and the parser will return to you the root *EmailMessage* instance of the object structure. For simple, non-MIME messages the payload of this root object will likely be a string containing the text of the message. For MIME messages, the root object will return `True` from its *is_multipart()* method, and the subparts can be accessed via the payload manipulation methods, such as *get_body()*, *iter_parts()*, and *walk()*.

There are actually two parser interfaces available for use, the *Parser* API and the incremental *FeedParser* API. The *Parser* API is most useful if you have the entire text of the message in memory, or if the entire message lives in a file on the file system. *FeedParser* is more appropriate when you are reading the message from a stream which might block waiting for more input (such as reading an email message from a socket). The *FeedParser* can consume and parse the message incrementally, and only returns the root object when you close the parser.

Note that the parser can be extended in limited ways, and of course you can implement your own parser completely from scratch. All of the logic that connects the *email* package's bundled parser and the *EmailMessage* class is embodied in the *Policy* class, so a custom parser can create message object trees any way it finds necessary by implementing custom versions of the appropriate *Policy* methods.

FeedParser API

The *BytesFeedParser*, imported from the *email.feedparser* module, provides an API that is conducive to incremental parsing of email messages, such as would be necessary when reading the text of an email message from a source that can block (such as a socket). The *BytesFeedParser* can of course be used to parse an email message fully contained in a *bytes-like object*, string, or file, but the *BytesParser* API may be more convenient for such use cases. The semantics and results of the two parser APIs are identical.

The *BytesFeedParser*'s API is simple; you create an instance, feed it a bunch of bytes until there's no more to feed it, then close the parser to retrieve the root message object. The *BytesFeedParser* is extremely accurate when parsing standards-compliant messages, and it does a very good job of parsing non-compliant messages, providing information about how a message was deemed broken. It will populate a message object's *defects* attribute

with a list of any problems it found in a message. See the `email.errors` module for the list of defects that it can find.

Here is the API for the `BytesFeedParser`:

class `email.parser.BytesFeedParser` (`_factory=None`, *, `policy=policy.compat32`)

Create a `BytesFeedParser` instance. Optional `_factory` is a no-argument callable; if not specified use the `message_factory` from the `policy`. Call `_factory` whenever a new message object is needed.

If `policy` is specified use the rules it specifies to update the representation of the message. If `policy` is not set, use the `compat32` policy, which maintains backward compatibility with the Python 3.2 version of the email package and provides `Message` as the default factory. All other policies provide `EmailMessage` as the default `_factory`. For more information on what else `policy` controls, see the `policy` documentation.

Note: The `policy` keyword should always be specified; The default will change to `email.policy.default` in a future version of Python.

在 3.2 版新加入。

在 3.3 版的變更: 新增 `policy` 關鍵字。

在 3.6 版的變更: `_factory` defaults to the `policy.message_factory`.

feed (`data`)

Feed the parser some more data. `data` should be a *bytes-like object* containing one or more lines. The lines can be partial and the parser will stitch such partial lines together properly. The lines can have any of the three common line endings: carriage return, newline, or carriage return and newline (they can even be mixed).

close ()

Complete the parsing of all previously fed data and return the root message object. It is undefined what happens if `feed()` is called after this method has been called.

class `email.parser.FeedParser` (`_factory=None`, *, `policy=policy.compat32`)

Works like `BytesFeedParser` except that the input to the `feed()` method must be a string. This is of limited utility, since the only way for such a message to be valid is for it to contain only ASCII text or, if `utf8` is True, no binary attachments.

在 3.3 版的變更: 新增 `policy` 關鍵字。

Parser API

The `BytesParser` class, imported from the `email.parser` module, provides an API that can be used to parse a message when the complete contents of the message are available in a *bytes-like object* or file. The `email.parser` module also provides `Parser` for parsing strings, and header-only parsers, `BytesHeaderParser` and `HeaderParser`, which can be used if you're only interested in the headers of the message. `BytesHeaderParser` and `HeaderParser` can be much faster in these situations, since they do not attempt to parse the message body, instead setting the payload to the raw body.

class `email.parser.BytesParser` (`_class=None`, *, `policy=policy.compat32`)

Create a `BytesParser` instance. The `_class` and `policy` arguments have the same meaning and semantics as the `_factory` and `policy` arguments of `BytesFeedParser`.

Note: The `policy` keyword should always be specified; The default will change to `email.policy.default` in a future version of Python.

在 3.3 版的變更: Removed the `strict` argument that was deprecated in 2.4. Added the `policy` keyword.

在 3.6 版的變更: `_class` defaults to the `policy.message_factory`.

parse (`fp`, `headersonly=False`)

Read all the data from the binary file-like object `fp`, parse the resulting bytes, and return the message object. `fp` must support both the `readline()` and the `read()` methods.

The bytes contained in *fp* must be formatted as a block of [RFC 5322](#) (or, if `utf8` is `True`, [RFC 6532](#)) style headers and header continuation lines, optionally preceded by an envelope header. The header block is terminated either by the end of the data or by a blank line. Following the header block is the body of the message (which may contain MIME-encoded subparts, including subparts with a *Content-Transfer-Encoding* of 8bit).

Optional *headersonly* is a flag specifying whether to stop parsing after reading the headers or not. The default is `False`, meaning it parses the entire contents of the file.

parsebytes (*bytes*, *headersonly=False*)

Similar to the *parse()* method, except it takes a *bytes-like object* instead of a file-like object. Calling this method on a *bytes-like object* is equivalent to wrapping *bytes* in a *BytesIO* instance first and calling *parse()*.

Optional *headersonly* is as with the *parse()* method.

在 3.2 版新加入。

class `email.parser.BytesHeaderParser` (*_class=None*, *, *policy=policy.compat32*)

Exactly like *BytesParser*, except that *headersonly* defaults to `True`.

在 3.3 版新加入。

class `email.parser.Parser` (*_class=None*, *, *policy=policy.compat32*)

This class is parallel to *BytesParser*, but handles string input.

在 3.3 版的變更: Removed the *strict* argument. Added the *policy* keyword.

在 3.6 版的變更: *_class* defaults to the *policy* *message_factory*.

parse (*fp*, *headersonly=False*)

Read all the data from the text-mode file-like object *fp*, parse the resulting text, and return the root message object. *fp* must support both the *readline()* and the *read()* methods on file-like objects.

Other than the text mode requirement, this method operates like *BytesParser.parse()*.

parsestr (*text*, *headersonly=False*)

Similar to the *parse()* method, except it takes a string object instead of a file-like object. Calling this method on a string is equivalent to wrapping *text* in a *StringIO* instance first and calling *parse()*.

Optional *headersonly* is as with the *parse()* method.

class `email.parser.HeaderParser` (*_class=None*, *, *policy=policy.compat32*)

Exactly like *Parser*, except that *headersonly* defaults to `True`.

Since creating a message object structure from a string or a file object is such a common task, four functions are provided as a convenience. They are available in the top-level *email* package namespace.

`email.message_from_bytes` (*s*, *_class=None*, *, *policy=policy.compat32*)

Return a message object structure from a *bytes-like object*. This is equivalent to `BytesParser().parsebytes(s)`. Optional *_class* and *policy* are interpreted as with the *BytesParser* class constructor.

在 3.2 版新加入。

在 3.3 版的變更: Removed the *strict* argument. Added the *policy* keyword.

`email.message_from_binary_file` (*fp*, *_class=None*, *, *policy=policy.compat32*)

Return a message object structure tree from an open binary *file object*. This is equivalent to `BytesParser().parse(fp)`. *_class* and *policy* are interpreted as with the *BytesParser* class constructor.

在 3.2 版新加入。

在 3.3 版的變更: Removed the *strict* argument. Added the *policy* keyword.

`email.message_from_string(s, _class=None, *, policy=policy.compat32)`

Return a message object structure from a string. This is equivalent to `Parser().parsestr(s)`. `_class` and `policy` are interpreted as with the `Parser` class constructor.

在 3.3 版的變更: Removed the *strict* argument. Added the *policy* keyword.

`email.message_from_file(fp, _class=None, *, policy=policy.compat32)`

Return a message object structure tree from an open *file object*. This is equivalent to `Parser().parse(fp)`. `_class` and `policy` are interpreted as with the `Parser` class constructor.

在 3.3 版的變更: Removed the *strict* argument. Added the *policy* keyword.

在 3.6 版的變更: `_class` defaults to the `policy.message_factory`.

Here's an example of how you might use `message_from_bytes()` at an interactive Python prompt:

```
>>> import email
>>> msg = email.message_from_bytes(myBytes)
```

Additional notes

Here are some notes on the parsing semantics:

- Most non-*multipart* type messages are parsed as a single message object with a string payload. These objects will return `False` for `is_multipart()`, and `iter_parts()` will yield an empty list.
- All *multipart* type messages will be parsed as a container message object with a list of sub-message objects for their payload. The outer container message will return `True` for `is_multipart()`, and `iter_parts()` will yield a list of subparts.
- Most messages with a content type of *message/** (such as *message/delivery-status* and *message/rfc822*) will also be parsed as container object containing a list payload of length 1. Their `is_multipart()` method will return `True`. The single element yielded by `iter_parts()` will be a sub-message object.
- Some non-standards-compliant messages may not be internally consistent about their *multipart*-edness. Such messages may have a *Content-Type* header of type *multipart*, but their `is_multipart()` method may return `False`. If such messages were parsed with the `FeedParser`, they will have an instance of the `MultipartInvariantViolationDefect` class in their `defects` attribute list. See `email.errors` for details.

19.1.3 email.generator: Generating MIME documents

原始碼: `Lib/email/generator.py`

One of the most common tasks is to generate the flat (serialized) version of the email message represented by a message object structure. You will need to do this if you want to send your message via `smtplib.SMTP.sendmail()` or the `nntplib` module, or print the message on the console. Taking a message object structure and producing a serialized representation is the job of the generator classes.

As with the `email.parser` module, you aren't limited to the functionality of the bundled generator; you could write one from scratch yourself. However the bundled generator knows how to generate most email in a standards-compliant way, should handle MIME and non-MIME email messages just fine, and is designed so that the bytes-oriented parsing and generation operations are inverses, assuming the same non-transforming *policy* is used for both. That is, parsing the serialized byte stream via the `BytesParser` class and then regenerating the serialized byte stream using `BytesGenerator` should produce output identical to the input¹. (On the other hand, using the

¹ This statement assumes that you use the appropriate setting for `unixfrom`, and that there are no `email.policy` settings calling for automatic adjustments (for example, `refold_source` must be `none`, which is *not* the default). It is also not 100% true, since if the message does not conform to the RFC standards occasionally information about the exact original text is lost during parsing error recovery. It is a goal to fix these latter edge cases when possible.

generator on an *EmailMessage* constructed by program may result in changes to the *EmailMessage* object as defaults are filled in.)

The *Generator* class can be used to flatten a message into a text (as opposed to binary) serialized representation, but since Unicode cannot represent binary data directly, the message is of necessity transformed into something that contains only ASCII characters, using the standard email RFC Content Transfer Encoding techniques for encoding email messages for transport over channels that are not "8 bit clean".

To accommodate reproducible processing of SMIME-signed messages *Generator* disables header folding for message parts of type multipart/signed and all subparts.

```
class email.generator.BytesGenerator(outfp, mangle_from_=None, maxheaderlen=None, *,
                                     policy=None)
```

Return a *BytesGenerator* object that will write any message provided to the *flatten()* method, or any surrogateescape encoded text provided to the *write()* method, to the *file-like object outfp*. *outfp* must support a *write* method that accepts binary data.

If optional *mangle_from_* is *True*, put a > character in front of any line in the body that starts with the exact string "From ", that is From followed by a space at the beginning of a line. *mangle_from_* defaults to the value of the *mangle_from_* setting of the *policy* (which is *True* for the *compat32* policy and *False* for all others). *mangle_from_* is intended for use when messages are stored in Unix mbox format (see *mailbox* and **WHY THE CONTENT-LENGTH FORMAT IS BAD**).

If *maxheaderlen* is not *None*, refold any header lines that are longer than *maxheaderlen*, or if 0, do not rewrap any headers. If *manheaderlen* is *None* (the default), wrap headers and other message lines according to the *policy* settings.

If *policy* is specified, use that policy to control message generation. If *policy* is *None* (the default), use the policy associated with the *Message* or *EmailMessage* object passed to *flatten* to control the message generation. See *email.policy* for details on what *policy* controls.

在 3.2 版新加入。

在 3.3 版的變更: 新增關鍵字 *policy*。

在 3.6 版的變更: The default behavior of the *mangle_from_* and *maxheaderlen* parameters is to follow the *policy*.

```
flatten(msg, unixfrom=False, linesep=None)
```

Print the textual representation of the message object structure rooted at *msg* to the output file specified when the *BytesGenerator* instance was created.

If the *policy* option *cte_type* is 8bit (the default), copy any headers in the original parsed message that have not been modified to the output with any bytes with the high bit set reproduced as in the original, and preserve the non-ASCII *Content-Transfer-Encoding* of any body parts that have them. If *cte_type* is 7bit, convert the bytes with the high bit set as needed using an ASCII-compatible *Content-Transfer-Encoding*. That is, transform parts with non-ASCII *Content-Transfer-Encoding* (*Content-Transfer-Encoding: 8bit*) to an ASCII compatible *Content-Transfer-Encoding*, and encode RFC-invalid non-ASCII bytes in headers using the MIME unknown-8bit character set, thus rendering them RFC-compliant.

If *unixfrom* is *True*, print the envelope header delimiter used by the Unix mailbox format (see *mailbox*) before the first of the **RFC 5322** headers of the root message object. If the root object has no envelope header, craft a standard one. The default is *False*. Note that for subparts, no envelope header is ever printed.

If *linesep* is not *None*, use it as the separator character between all the lines of the flattened message. If *linesep* is *None* (the default), use the value specified in the *policy*.

```
clone(fp)
```

Return an independent clone of this *BytesGenerator* instance with the exact same option settings, and *fp* as the new *outfp*.

write (*s*)

Encode *s* using the ASCII codec and the surrogateescape error handler, and pass it to the *write* method of the *outfp* passed to the *BytesGenerator*'s constructor.

As a convenience, *EmailMessage* provides the methods *as_bytes()* and *bytes(aMessage)* (a.k.a. *__bytes__()*), which simplify the generation of a serialized binary representation of a message object. For more detail, see *email.message*.

Because strings cannot represent binary data, the *Generator* class must convert any binary data in any message it flattens to an ASCII compatible format, by converting them to an ASCII compatible *Content-Transfer-Encoding*. Using the terminology of the email RFCs, you can think of this as *Generator* serializing to an I/O stream that is not "8 bit clean". In other words, most applications will want to be using *BytesGenerator*, and not *Generator*.

class email.generator.**Generator** (*outfp*, *mangle_from_=None*, *maxheaderlen=None*, *, *policy=None*)

Return a *Generator* object that will write any message provided to the *flatten()* method, or any text provided to the *write()* method, to the *file-like object* *outfp*. *outfp* must support a *write* method that accepts string data.

If optional *mangle_from_* is *True*, put a > character in front of any line in the body that starts with the exact string "From ", that is From followed by a space at the beginning of a line. *mangle_from_* defaults to the value of the *mangle_from_* setting of the *policy* (which is *True* for the *compat32* policy and *False* for all others). *mangle_from_* is intended for use when messages are stored in Unix mbox format (see *mailbox* and [WHY THE CONTENT-LENGTH FORMAT IS BAD](#)).

If *maxheaderlen* is not *None*, refold any header lines that are longer than *maxheaderlen*, or if 0, do not rewrap any headers. If *manheaderlen* is *None* (the default), wrap headers and other message lines according to the *policy* settings.

If *policy* is specified, use that policy to control message generation. If *policy* is *None* (the default), use the policy associated with the *Message* or *EmailMessage* object passed to *flatten* to control the message generation. See *email.policy* for details on what *policy* controls.

在 3.3 版的變更: 新增關鍵字 *policy*。

在 3.6 版的變更: The default behavior of the *mangle_from_* and *maxheaderlen* parameters is to follow the *policy*.

flatten (*msg*, *unixfrom=False*, *linesep=None*)

Print the textual representation of the message object structure rooted at *msg* to the output file specified when the *Generator* instance was created.

If the *policy* option *cte_type* is 8bit, generate the message as if the option were set to 7bit. (This is required because strings cannot represent non-ASCII bytes.) Convert any bytes with the high bit set as needed using an ASCII-compatible *Content-Transfer-Encoding*. That is, transform parts with non-ASCII *Content-Transfer-Encoding* (*Content-Transfer-Encoding: 8bit*) to an ASCII compatible *Content-Transfer-Encoding*, and encode RFC-invalid non-ASCII bytes in headers using the MIME unknown-8bit character set, thus rendering them RFC-compliant.

If *unixfrom* is *True*, print the envelope header delimiter used by the Unix mailbox format (see *mailbox*) before the first of the [RFC 5322](#) headers of the root message object. If the root object has no envelope header, craft a standard one. The default is *False*. Note that for subparts, no envelope header is ever printed.

If *linesep* is not *None*, use it as the separator character between all the lines of the flattened message. If *linesep* is *None* (the default), use the value specified in the *policy*.

在 3.2 版的變更: Added support for re-encoding 8bit message bodies, and the *linesep* argument.

clone (*fp*)

Return an independent clone of this *Generator* instance with the exact same options, and *fp* as the new *outfp*.

write (*s*)

Write *s* to the *write* method of the *outfp* passed to the *Generator*'s constructor. This provides just enough file-like API for *Generator* instances to be used in the *print()* function.

As a convenience, *EmailMessage* provides the methods *as_string()* and *str(aMessage)* (a.k.a. *__str__()*), which simplify the generation of a formatted string representation of a message object. For more detail, see *email.message*.

The *email.generator* module also provides a derived class, *DecodedGenerator*, which is like the *Generator* base class, except that non-*text* parts are not serialized, but are instead represented in the output stream by a string derived from a template filled in with information about the part.

class *email.generator.DecodedGenerator* (*outfp*, *mangle_from_=None*, *maxheaderlen=None*, *fmt=None*, *, *policy=None*)

Act like *Generator*, except that for any subpart of the message passed to *Generator.flatten()*, if the subpart is of main type *text*, print the decoded payload of the subpart, and if the main type is not *text*, instead of printing it fill in the string *fmt* using information from the part and print the resulting filled-in string.

To fill in *fmt*, execute *fmt % part_info*, where *part_info* is a dictionary composed of the following keys and values:

- *type* -- Full MIME type of the non-*text* part
- *maintype* -- Main MIME type of the non-*text* part
- *subtype* -- Sub-MIME type of the non-*text* part
- *filename* -- Filename of the non-*text* part
- *description* -- Description associated with the non-*text* part
- *encoding* -- Content transfer encoding of the non-*text* part

If *fmt* is *None*, use the following default *fmt*:

”[Non-text (%(type)s) part of message omitted, filename %(filename)s]”

Optional *_mangle_from_* and *maxheaderlen* are as with the *Generator* base class.

解

19.1.4 email.policy: Policy Objects

在 3.3 版新加入.

原始碼: [Lib/email/policy.py](#)

The *email* package's prime focus is the handling of email messages as described by the various email and MIME RFCs. However, the general format of email messages (a block of header fields each consisting of a name followed by a colon followed by a value, the whole block followed by a blank line and an arbitrary 'body'), is a format that has found utility outside of the realm of email. Some of these uses conform fairly closely to the main email RFCs, some do not. Even when working with email, there are times when it is desirable to break strict compliance with the RFCs, such as generating emails that interoperate with email servers that do not themselves follow the standards, or that implement extensions you want to use in ways that violate the standards.

Policy objects give the email package the flexibility to handle all these disparate use cases.

A *Policy* object encapsulates a set of attributes and methods that control the behavior of various components of the email package during use. *Policy* instances can be passed to various classes and methods in the email package to alter the default behavior. The settable values and their defaults are described below.

There is a default policy used by all classes in the email package. For all of the *parser* classes and the related convenience functions, and for the *Message* class, this is the *Compat32* policy, via its corresponding pre-defined

instance `compat32`. This policy provides for complete backward compatibility (in some cases, including bug compatibility) with the pre-Python3.3 version of the email package.

This default value for the `policy` keyword to `EmailMessage` is the `EmailPolicy` policy, via its pre-defined instance `default`.

When a `Message` or `EmailMessage` object is created, it acquires a policy. If the message is created by a `parser`, a policy passed to the parser will be the policy used by the message it creates. If the message is created by the program, then the policy can be specified when it is created. When a message is passed to a `generator`, the generator uses the policy from the message by default, but you can also pass a specific policy to the generator that will override the one stored on the message object.

The default value for the `policy` keyword for the `email.parser` classes and the parser convenience functions **will be changing** in a future version of Python. Therefore you should **always specify explicitly which policy you want to use** when calling any of the classes and functions described in the `parser` module.

The first part of this documentation covers the features of `Policy`, an *abstract base class* that defines the features that are common to all policy objects, including `compat32`. This includes certain hook methods that are called internally by the email package, which a custom policy could override to obtain different behavior. The second part describes the concrete classes `EmailPolicy` and `Compat32`, which implement the hooks that provide the standard behavior and the backward compatible behavior and features, respectively.

`Policy` instances are immutable, but they can be cloned, accepting the same keyword arguments as the class constructor and returning a new `Policy` instance that is a copy of the original but with the specified attributes values changed.

As an example, the following code could be used to read an email message from a file on disk and pass it to the system `sendmail` program on a Unix system:

```
>>> from email import message_from_binary_file
>>> from email.generator import BytesGenerator
>>> from email import policy
>>> from subprocess import Popen, PIPE
>>> with open('mymsg.txt', 'rb') as f:
...     msg = message_from_binary_file(f, policy=policy.default)
>>> p = Popen(['sendmail', msg['To'].addresses[0]], stdin=PIPE)
>>> g = BytesGenerator(p.stdin, policy=msg.policy.clone(linesep='\r\n'))
>>> g.flatten(msg)
>>> p.stdin.close()
>>> rc = p.wait()
```

Here we are telling `BytesGenerator` to use the RFC correct line separator characters when creating the binary string to feed into `sendmail`'s `stdin`, where the default policy would use `\n` line separators.

Some email package methods accept a `policy` keyword argument, allowing the policy to be overridden for that method. For example, the following code uses the `as_bytes()` method of the `msg` object from the previous example and writes the message to a file using the native line separators for the platform on which it is running:

```
>>> import os
>>> with open('converted.txt', 'wb') as f:
...     f.write(msg.as_bytes(policy=msg.policy.clone(linesep=os.linesep)))
17
```

Policy objects can also be combined using the addition operator, producing a policy object whose settings are a combination of the non-default values of the summed objects:

```
>>> compat SMTP = policy.compat32.clone(linesep='\r\n')
>>> compat_strict = policy.compat32.clone(raise_on_defect=True)
>>> compat_strict SMTP = compat SMTP + compat_strict
```

This operation is not commutative; that is, the order in which the objects are added matters. To illustrate:

```

>>> policy100 = policy.compat32.clone(max_line_length=100)
>>> policy80 = policy.compat32.clone(max_line_length=80)
>>> apolicy = policy100 + policy80
>>> apolicy.max_line_length
80
>>> apolicy = policy80 + policy100
>>> apolicy.max_line_length
100

```

class email.policy.**Policy** (**kw)

This is the *abstract base class* for all policy classes. It provides default implementations for a couple of trivial methods, as well as the implementation of the immutability property, the *clone()* method, and the constructor semantics.

The constructor of a policy class can be passed various keyword arguments. The arguments that may be specified are any non-method properties on this class, plus any additional non-method properties on the concrete class. A value specified in the constructor will override the default value for the corresponding attribute.

This class defines the following properties, and thus values for the following may be passed in the constructor of any policy class:

max_line_length

The maximum length of any line in the serialized output, not counting the end of line character(s). Default is 78, per [RFC 5322](#). A value of 0 or *None* indicates that no line wrapping should be done at all.

linesep

The string to be used to terminate lines in serialized output. The default is `\n` because that's the internal end-of-line discipline used by Python, though `\r\n` is required by the RFCs.

cte_type

Controls the type of Content Transfer Encodings that may be or are required to be used. The possible values are:

7bit	all data must be "7 bit clean" (ASCII-only). This means that where necessary data will be encoded using either quoted-printable or base64 encoding.
8bit	data is not constrained to be 7 bit clean. Data in headers is still required to be ASCII-only and so will be encoded (see <i>fold_binary()</i> and <i>utf8</i> below for exceptions), but body parts may use the 8bit CTE.

A *cte_type* value of 8bit only works with *BytesGenerator*, not *Generator*, because strings cannot contain binary data. If a *Generator* is operating under a policy that specifies *cte_type=8bit*, it will act as if *cte_type* is 7bit.

raise_on_defect

If *True*, any defects encountered will be raised as errors. If *False* (the default), defects will be passed to the *register_defect()* method.

mangle_from_

If *True*, lines starting with "From " in the body are escaped by putting a > in front of them. This parameter is used when the message is being serialized by a generator. Default: *False*.

在 3.5 版新加入.

message_factory

A factory function for constructing a new empty message object. Used by the parser when building messages. Defaults to *None*, in which case *Message* is used.

在 3.6 版新加入.

The following *Policy* method is intended to be called by code using the email library to create policy instances with custom settings:

clone (***kw*)

Return a new *Policy* instance whose attributes have the same values as the current instance, except where those attributes are given new values by the keyword arguments.

The remaining *Policy* methods are called by the email package code, and are not intended to be called by an application using the email package. A custom policy must implement all of these methods.

handle_defect (*obj*, *defect*)

Handle a *defect* found on *obj*. When the email package calls this method, *defect* will always be a subclass of *Defect*.

The default implementation checks the *raise_on_defect* flag. If it is *True*, *defect* is raised as an exception. If it is *False* (the default), *obj* and *defect* are passed to *register_defect* ().

register_defect (*obj*, *defect*)

Register a *defect* on *obj*. In the email package, *defect* will always be a subclass of *Defect*.

The default implementation calls the *append* method of the *defects* attribute of *obj*. When the email package calls *handle_defect*, *obj* will normally have a *defects* attribute that has an *append* method. Custom object types used with the email package (for example, custom *Message* objects) should also provide such an attribute, otherwise defects in parsed messages will raise unexpected errors.

header_max_count (*name*)

Return the maximum allowed number of headers named *name*.

Called when a header is added to an *EmailMessage* or *Message* object. If the returned value is not 0 or *None*, and there are already a number of headers with the name *name* greater than or equal to the value returned, a *ValueError* is raised.

Because the default behavior of *Message*.*__setitem__* is to append the value to the list of headers, it is easy to create duplicate headers without realizing it. This method allows certain headers to be limited in the number of instances of that header that may be added to a *Message* programmatically. (The limit is not observed by the parser, which will faithfully produce as many headers as exist in the message being parsed.)

The default implementation returns *None* for all header names.

header_source_parse (*sourcelines*)

The email package calls this method with a list of strings, each string ending with the line separation characters found in the source being parsed. The first line includes the field header name and separator. All whitespace in the source is preserved. The method should return the (*name*, *value*) tuple that is to be stored in the *Message* to represent the parsed header.

If an implementation wishes to retain compatibility with the existing email package policies, *name* should be the case preserved name (all characters up to the ':' separator), while *value* should be the unfolded value (all line separator characters removed, but whitespace kept intact), stripped of leading whitespace.

sourcelines may contain surrogateescaped binary data.

There is no default implementation

header_store_parse (*name*, *value*)

The email package calls this method with the name and value provided by the application program when the application program is modifying a *Message* programmatically (as opposed to a *Message* created by a parser). The method should return the (*name*, *value*) tuple that is to be stored in the *Message* to represent the header.

If an implementation wishes to retain compatibility with the existing email package policies, the *name* and *value* should be strings or string subclasses that do not change the content of the passed in arguments.

There is no default implementation

header_fetch_parse (*name*, *value*)

The email package calls this method with the *name* and *value* currently stored in the *Message* when that header is requested by the application program, and whatever the method returns is what is passed

back to the application as the value of the header being retrieved. Note that there may be more than one header with the same name stored in the `Message`; the method is passed the specific name and value of the header destined to be returned to the application.

value may contain surrogateescaped binary data. There should be no surrogateescaped binary data in the value returned by the method.

There is no default implementation

fold (*name*, *value*)

The email package calls this method with the *name* and *value* currently stored in the `Message` for a given header. The method should return a string that represents that header “folded” correctly (according to the policy settings) by composing the *name* with the *value* and inserting *linesep* characters at the appropriate places. See [RFC 5322](#) for a discussion of the rules for folding email headers.

value may contain surrogateescaped binary data. There should be no surrogateescaped binary data in the string returned by the method.

fold_binary (*name*, *value*)

The same as `fold()`, except that the returned value should be a bytes object rather than a string.

value may contain surrogateescaped binary data. These could be converted back into binary data in the returned bytes object.

class `email.policy.EmailPolicy` (***kw*)

This concrete *Policy* provides behavior that is intended to be fully compliant with the current email RFCs. These include (but are not limited to) [RFC 5322](#), [RFC 2047](#), and the current MIME RFCs.

This policy adds new header parsing and folding algorithms. Instead of simple strings, headers are `str` subclasses with attributes that depend on the type of the field. The parsing and folding algorithm fully implement [RFC 2047](#) and [RFC 5322](#).

The default value for the *message_factory* attribute is *EmailMessage*.

In addition to the settable attributes listed above that apply to all policies, this policy adds the following additional attributes:

在 3.6 版新加入:¹

utf8

If `False`, follow [RFC 5322](#), supporting non-ASCII characters in headers by encoding them as “encoded words”. If `True`, follow [RFC 6532](#) and use `utf-8` encoding for headers. Messages formatted in this way may be passed to SMTP servers that support the `SMTPUTF8` extension ([RFC 6531](#)).

refold_source

If the value for a header in the `Message` object originated from a *parser* (as opposed to being set by a program), this attribute indicates whether or not a generator should refold that value when transforming the message back into serialized form. The possible values are:

<code>none</code>	all source values use original folding
<code>long</code>	source values that have any line that is longer than <code>max_line_length</code> will be refolded
<code>all</code>	all values are refolded.

預設 F `long`。

header_factory

A callable that takes two arguments, *name* and *value*, where *name* is a header field name and *value* is an unfolded header field value, and returns a string subclass that represents that header. A default *header_factory* (see *headerregistry*) is provided that supports custom parsing for the various address and date [RFC 5322](#) header field types, and the major MIME header field stypes. Support for additional custom parsing will be added in the future.

¹ Originally added in 3.3 as a *provisional feature*.

content_manager

An object with at least two methods: `get_content()` and `set_content()`. When the `get_content()` or `set_content()` method of an `EmailMessage` object is called, it calls the corresponding method of this object, passing it the message object as its first argument, and any arguments or keywords that were passed to it as additional arguments. By default `content_manager` is set to `raw_data_manager`.

在 3.4 版新加入.

The class provides the following concrete implementations of the abstract methods of `Policy`:

header_max_count (*name*)

Returns the value of the `max_count` attribute of the specialized class used to represent the header with the given name.

header_source_parse (*sourcelines*)

The name is parsed as everything up to the ':' and returned unmodified. The value is determined by stripping leading whitespace off the remainder of the first line, joining all subsequent lines together, and stripping any trailing carriage return or linefeed characters.

header_store_parse (*name*, *value*)

The name is returned unchanged. If the input value has a `name` attribute and it matches *name* ignoring case, the value is returned unchanged. Otherwise the *name* and *value* are passed to `header_factory`, and the resulting header object is returned as the value. In this case a `ValueError` is raised if the input value contains CR or LF characters.

header_fetch_parse (*name*, *value*)

If the value has a `name` attribute, it is returned to unmodified. Otherwise the *name*, and the *value* with any CR or LF characters removed, are passed to the `header_factory`, and the resulting header object is returned. Any surrogateescaped bytes get turned into the unicode unknown-character glyph.

fold (*name*, *value*)

Header folding is controlled by the `refold_source` policy setting. A value is considered to be a 'source value' if and only if it does not have a `name` attribute (having a `name` attribute means it is a header object of some sort). If a source value needs to be refolded according to the policy, it is converted into a header object by passing the *name* and the *value* with any CR and LF characters removed to the `header_factory`. Folding of a header object is done by calling its `fold` method with the current policy.

Source values are split into lines using `splitlines()`. If the value is not to be refolded, the lines are rejoined using the `linesep` from the policy and returned. The exception is lines containing non-ascii binary data. In that case the value is refolded regardless of the `refold_source` setting, which causes the binary data to be CTE encoded using the `unknown-8bit` charset.

fold_binary (*name*, *value*)

The same as `fold()` if `cte_type` is 7bit, except that the returned value is bytes.

If `cte_type` is 8bit, non-ASCII binary data is converted back into bytes. Headers with binary data are not refolded, regardless of the `refold_header` setting, since there is no way to know whether the binary data consists of single byte characters or multibyte characters.

The following instances of `EmailPolicy` provide defaults suitable for specific application domains. Note that in the future the behavior of these instances (in particular the HTTP instance) may be adjusted to conform even more closely to the RFCs relevant to their domains.

`email.policy.default`

An instance of `EmailPolicy` with all defaults unchanged. This policy uses the standard Python `\n` line endings rather than the RFC-correct `\r\n`.

`email.policy.SMTP`

Suitable for serializing messages in conformance with the email RFCs. Like `default`, but with `linesep` set to `\r\n`, which is RFC compliant.

`email.policy.SMTPUTF8`

The same as SMTP except that `utf8` is `True`. Useful for serializing messages to a message store without using encoded words in the headers. Should only be used for SMTP transmission if the sender or recipient addresses have non-ASCII characters (the `smtplib.SMTP.send_message()` method handles this automatically).

`email.policy.HTTP`

Suitable for serializing headers with for use in HTTP traffic. Like SMTP except that `max_line_length` is set to `None` (unlimited).

`email.policy.strict`

Convenience instance. The same as default except that `raise_on_defect` is set to `True`. This allows any policy to be made strict by writing:

```
somepolicy + policy.strict
```

With all of these *EmailPolicies*, the effective API of the email package is changed from the Python 3.2 API in the following ways:

- Setting a header on a *Message* results in that header being parsed and a header object created.
- Fetching a header value from a *Message* results in that header being parsed and a header object created and returned.
- Any header object, or any header that is refolded due to the policy settings, is folded using an algorithm that fully implements the RFC folding algorithms, including knowing where encoded words are required and allowed.

From the application view, this means that any header obtained through the *EmailMessage* is a header object with extra attributes, whose string value is the fully decoded unicode value of the header. Likewise, a header may be assigned a new value, or a new header created, using a unicode string, and the policy will take care of converting the unicode string into the correct RFC encoded form.

The header objects and their attributes are described in *headerregistry*.

class `email.policy.Compat32` (***kw*)

This concrete *Policy* is the backward compatibility policy. It replicates the behavior of the email package in Python 3.2. The *policy* module also defines an instance of this class, *compat32*, that is used as the default policy. Thus the default behavior of the email package is to maintain compatibility with Python 3.2.

The following attributes have values that are different from the *Policy* default:

mangle_from_

The default is `True`.

The class provides the following concrete implementations of the abstract methods of *Policy*:

header_source_parse (*sourcelines*)

The name is parsed as everything up to the `:` and returned unmodified. The value is determined by stripping leading whitespace off the remainder of the first line, joining all subsequent lines together, and stripping any trailing carriage return or linefeed characters.

header_store_parse (*name, value*)

The name and value are returned unmodified.

header_fetch_parse (*name, value*)

If the value contains binary data, it is converted into a *Header* object using the `unknown-8bit` charset. Otherwise it is returned unmodified.

fold (*name, value*)

Headers are folded using the *Header* folding algorithm, which preserves existing line breaks in the value, and wraps each resulting line to the `max_line_length`. Non-ASCII binary data are CTE encoded using the `unknown-8bit` charset.

fold_binary (*name, value*)

Headers are folded using the *Header* folding algorithm, which preserves existing line breaks in the value, and wraps each resulting line to the `max_line_length`. If `cte_type` is 7bit, non-ascii binary data is CTE encoded using the `unknown-8bit` charset. Otherwise the original source header is used, with its existing line breaks and any (RFC invalid) binary data it may contain.

`email.policy.compat32`

An instance of *Compat32*, providing backward compatibility with the behavior of the email package in Python 3.2.

解

19.1.5 email.errors: Exception and Defect classes

原始碼: [Lib/email/errors.py](#)

The following exception classes are defined in the `email.errors` module:

exception `email.errors.MessageError`

This is the base class for all exceptions that the *email* package can raise. It is derived from the standard *Exception* class and defines no additional methods.

exception `email.errors.MessageParseError`

This is the base class for exceptions raised by the *Parser* class. It is derived from *MessageError*. This class is also used internally by the parser used by *headerregistry*.

exception `email.errors.HeaderParseError`

Raised under some error conditions when parsing the **RFC 5322** headers of a message, this class is derived from *MessageParseError*. The *set_boundary()* method will raise this error if the content type is unknown when the method is called. *Header* may raise this error for certain base64 decoding errors, and when an attempt is made to create a header that appears to contain an embedded header (that is, there is what is supposed to be a continuation line that has no leading whitespace and looks like a header).

exception `email.errors.BoundaryError`

Deprecated and no longer used.

exception `email.errors.MultipartConversionError`

Raised when a payload is added to a *Message* object using *add_payload()*, but the payload is already a scalar and the message's *Content-Type* main type is not either *multipart* or missing. *MultipartConversionError* multiply inherits from *MessageError* and the built-in *TypeError*.

Since *Message.add_payload()* is deprecated, this exception is rarely raised in practice. However the exception may also be raised if the *attach()* method is called on an instance of a class derived from *MIMENonMultipart* (e.g. *MIMEImage*).

exception `email.errors.MessageDefect`

This is the base class for all defects found when parsing email messages. It is derived from *ValueError*.

exception `email.errors.HeaderDefect`

This is the base class for all defects found when parsing email headers. It is derived from *MessageDefect*.

Here is the list of the defects that the *FeedParser* can find while parsing messages. Note that the defects are added to the message where the problem was found, so for example, if a message nested inside a *multipart/alternative* had a malformed header, that nested message object would have a defect, but the containing messages would not.

All defect classes are subclassed from `email.errors.MessageDefect`.

- `NoBoundaryInMultipartDefect` -- A message claimed to be a multipart, but had no *boundary* parameter.

- `StartBoundaryNotFoundDefect` -- The start boundary claimed in the *Content-Type* header was never found.
- `CloseBoundaryNotFoundDefect` -- A start boundary was found, but no corresponding close boundary was ever found.
在 3.3 版新加入.
- `FirstHeaderLineIsContinuationDefect` -- The message had a continuation line as its first header line.
- `MisplacedEnvelopeHeaderDefect` - A "Unix From" header was found in the middle of a header block.
- `MissingHeaderBodySeparatorDefect` - A line was found while parsing headers that had no leading white space but contained no `'.'`. Parsing continues assuming that the line represents the first line of the body.
在 3.3 版新加入.
- `MalformedHeaderDefect` -- A header was found that was missing a colon, or was otherwise malformed.
在 3.3 版之後被^F用: This defect has not been used for several Python versions.
- `MultipartInvariantViolationDefect` -- A message claimed to be a *multipart*, but no subparts were found. Note that when a message has this defect, its `is_multipart()` method may return `False` even though its content type claims to be *multipart*.
- `InvalidBase64PaddingDefect` -- When decoding a block of base64 encoded bytes, the padding was not correct. Enough padding is added to perform the decode, but the resulting decoded bytes may be invalid.
- `InvalidBase64CharactersDefect` -- When decoding a block of base64 encoded bytes, characters outside the base64 alphabet were encountered. The characters are ignored, but the resulting decoded bytes may be invalid.
- `InvalidBase64LengthDefect` -- When decoding a block of base64 encoded bytes, the number of non-padding base64 characters was invalid (1 more than a multiple of 4). The encoded block was kept as-is.
- `InvalidDateDefect` -- When decoding an invalid or unparsable date field. The original value is kept as-is.

19.1.6 email.headerregistry: Custom Header Objects

原始碼: [Lib/email/headerregistry.py](#)

在 3.6 版新加入:¹

Headers are represented by customized subclasses of `str`. The particular class used to represent a given header is determined by the `header_factory` of the `policy` in effect when the headers are created. This section documents the particular `header_factory` implemented by the email package for handling **RFC 5322** compliant email messages, which not only provides customized header objects for various header types, but also provides an extension mechanism for applications to add their own custom header types.

When using any of the policy objects derived from `EmailPolicy`, all headers are produced by `HeaderRegistry` and have `BaseHeader` as their last base class. Each header class has an additional base class that is determined by the type of the header. For example, many headers have the class `UnstructuredHeader` as their other base class. The specialized second class for a header is determined by the name of the header, using a lookup table stored in the `HeaderRegistry`. All of this is managed transparently for the typical application program, but interfaces are provided for modifying the default behavior for use by more complex applications.

The sections below first document the header base classes and their attributes, followed by the API for modifying the behavior of `HeaderRegistry`, and finally the support classes used to represent the data parsed from structured headers.

¹ Originally added in 3.3 as a *provisional module*

class email.headerregistry.**BaseHeader** (*name*, *value*)

name and *value* are passed to `BaseHeader` from the `header_factory` call. The string value of any header object is the *value* fully decoded to unicode.

This base class defines the following read-only properties:

name

The name of the header (the portion of the field before the `:`). This is exactly the value passed in the `header_factory` call for *name*; that is, case is preserved.

defects

A tuple of `HeaderDefect` instances reporting any RFC compliance problems found during parsing. The email package tries to be complete about detecting compliance issues. See the `errors` module for a discussion of the types of defects that may be reported.

max_count

The maximum number of headers of this type that can have the same *name*. A value of `None` means unlimited. The `BaseHeader` value for this attribute is `None`; it is expected that specialized header classes will override this value as needed.

`BaseHeader` also provides the following method, which is called by the email library code and should not in general be called by application programs:

fold (***, *policy*)

Return a string containing `linesep` characters as required to correctly fold the header according to *policy*. A *cte_type* of 8bit will be treated as if it were 7bit, since headers may not contain arbitrary binary data. If *utf8* is `False`, non-ASCII data will be **RFC 2047** encoded.

`BaseHeader` by itself cannot be used to create a header object. It defines a protocol that each specialized header cooperates with in order to produce the header object. Specifically, `BaseHeader` requires that the specialized class provide a `classmethod()` named `parse`. This method is called as follows:

```
parse(string, kwds)
```

kwds is a dictionary containing one pre-initialized key, `defects`. `defects` is an empty list. The `parse` method should append any detected defects to this list. On return, the *kwds* dictionary *must* contain values for at least the keys `decoded` and `defects`. `decoded` should be the string value for the header (that is, the header value fully decoded to unicode). The `parse` method should assume that *string* may contain content-transfer-encoded parts, but should correctly handle all valid unicode characters as well so that it can parse un-encoded header values.

`BaseHeader`'s `__new__` then creates the header instance, and calls its `init` method. The specialized class only needs to provide an `init` method if it wishes to set additional attributes beyond those provided by `BaseHeader` itself. Such an `init` method should look like this:

```
def init(self, /, *args, **kw):
    self._myattr = kw.pop('myattr')
    super().init(*args, **kw)
```

That is, anything extra that the specialized class puts in to the *kwds* dictionary should be removed and handled, and the remaining contents of *kw* (and *args*) passed to the `BaseHeader` `init` method.

class email.headerregistry.**UnstructuredHeader**

An "unstructured" header is the default type of header in **RFC 5322**. Any header that does not have a specified syntax is treated as unstructured. The classic example of an unstructured header is the *Subject* header.

In **RFC 5322**, an unstructured header is a run of arbitrary text in the ASCII character set. **RFC 2047**, however, has an **RFC 5322** compatible mechanism for encoding non-ASCII text as ASCII characters within a header value. When a *value* containing encoded words is passed to the constructor, the `UnstructuredHeader` parser converts such encoded words into unicode, following the **RFC 2047** rules for unstructured text. The parser uses heuristics to attempt to decode certain non-compliant encoded words. Defects are registered in such cases, as well as defects for issues such as invalid characters within the encoded words or the non-encoded text.

This header type provides no additional attributes.

class email.headerregistry.DateHeader

RFC 5322 specifies a very specific format for dates within email headers. The `DateHeader` parser recognizes that date format, as well as recognizing a number of variant forms that are sometimes found “in the wild”.

This header type provides the following additional attributes:

datetime

If the header value can be recognized as a valid date of one form or another, this attribute will contain a `datetime` instance representing that date. If the timezone of the input date is specified as `-0000` (indicating it is in UTC but contains no information about the source timezone), then `datetime` will be a naive `datetime`. If a specific timezone offset is found (including `+0000`), then `datetime` will contain an aware `datetime` that uses `datetime.timezone` to record the timezone offset.

The decoded value of the header is determined by formatting the `datetime` according to the **RFC 5322** rules; that is, it is set to:

```
email.utils.format_datetime(self.datetime)
```

When creating a `DateHeader`, `value` may be `datetime` instance. This means, for example, that the following code is valid and does what one would expect:

```
msg['Date'] = datetime(2011, 7, 15, 21)
```

Because this is a naive `datetime` it will be interpreted as a UTC timestamp, and the resulting value will have a timezone of `-0000`. Much more useful is to use the `localtime()` function from the `utils` module:

```
msg['Date'] = utils.localtime()
```

This example sets the date header to the current time and date using the current timezone offset.

class email.headerregistry.AddressHeader

Address headers are one of the most complex structured header types. The `AddressHeader` class provides a generic interface to any address header.

This header type provides the following additional attributes:

groups

A tuple of `Group` objects encoding the addresses and groups found in the header value. Addresses that are not part of a group are represented in this list as single-address `Groups` whose `display_name` is `None`.

addresses

A tuple of `Address` objects encoding all of the individual addresses from the header value. If the header value contains any groups, the individual addresses from the group are included in the list at the point where the group occurs in the value (that is, the list of addresses is “flattened” into a one dimensional list).

The decoded value of the header will have all encoded words decoded to unicode. `idna` encoded domain names are also decoded to unicode. The decoded value is set by *joining* the `str` value of the elements of the `groups` attribute with `', '`.

A list of `Address` and `Group` objects in any combination may be used to set the value of an address header. `Group` objects whose `display_name` is `None` will be interpreted as single addresses, which allows an address list to be copied with groups intact by using the list obtained from the `groups` attribute of the source header.

class email.headerregistry.SingleAddressHeader

A subclass of `AddressHeader` that adds one additional attribute:

address

The single address encoded by the header value. If the header value actually contains more than one address (which would be a violation of the RFC under the default *policy*), accessing this attribute will result in a *ValueError*.

Many of the above classes also have a *Unique* variant (for example, *UniqueUnstructuredHeader*). The only difference is that in the *Unique* variant, *max_count* is set to 1.

class email.headerregistry.MIMEVersionHeader

There is really only one valid value for the *MIME-Version* header, and that is 1.0. For future proofing, this header class supports other valid version numbers. If a version number has a valid value per [RFC 2045](#), then the header object will have non-None values for the following attributes:

version

The version number as a string, with any whitespace and/or comments removed.

major

The major version number as an integer

minor

The minor version number as an integer

class email.headerregistry.ParameterizedMIMEHeader

MIME headers all start with the prefix 'Content-'. Each specific header has a certain value, described under the class for that header. Some can also take a list of supplemental parameters, which have a common format. This class serves as a base for all the MIME headers that take parameters.

params

A dictionary mapping parameter names to parameter values.

class email.headerregistry.ContentTypeHeader

A *ParameterizedMIMEHeader* class that handles the *Content-Type* header.

content_type

The content type string, in the form *maintype/subtype*.

maintype**subtype****class** email.headerregistry.ContentDispositionHeader

A *ParameterizedMIMEHeader* class that handles the *Content-Disposition* header.

content_disposition

inline and *attachment* are the only valid values in common use.

class email.headerregistry.ContentTransferEncoding

Handles the *Content-Transfer-Encoding* header.

cte

Valid values are *7bit*, *8bit*, *base64*, and *quoted-printable*. See [RFC 2045](#) for more information.

class email.headerregistry.HeaderRegistry (*base_class=BaseHeader*,
default_class=UnstructuredHeader,
use_default_map=True)

This is the factory used by *EmailPolicy* by default. *HeaderRegistry* builds the class used to create a header instance dynamically, using *base_class* and a specialized class retrieved from a registry that it holds. When a given header name does not appear in the registry, the class specified by *default_class* is used as the specialized class. When *use_default_map* is *True* (the default), the standard mapping of header names to classes is copied in to the registry during initialization. *base_class* is always the last class in the generated class's *__bases__* list.

The default mappings are:

subject
UniqueUnstructuredHeader

date
UniqueDateHeader

resent-date
DateHeader

orig-date
UniqueDateHeader

sender
UniqueSingleAddressHeader

resent-sender
SingleAddressHeader

to
UniqueAddressHeader

resent-to
AddressHeader

cc
UniqueAddressHeader

resent-cc
AddressHeader

bcc
UniqueAddressHeader

resent-bcc
AddressHeader

from
UniqueAddressHeader

resent-from
AddressHeader

reply-to
UniqueAddressHeader

mime-version
MIMEVersionHeader

content-type
ContentTypeHeader

content-disposition
ContentDispositionHeader

content-transfer-encoding
ContentTransferEncodingHeader

message-id
MessageIDHeader

HeaderRegistry has the following methods:

map_to_type (*self*, *name*, *cls*)

name is the name of the header to be mapped. It will be converted to lower case in the registry. *cls* is the specialized class to be used, along with *base_class*, to create the class used to instantiate headers that match *name*.

__getitem__ (*name*)

Construct and return a class to handle creating a *name* header.

__call__ (*name*, *value*)

Retrieves the specialized header associated with *name* from the registry (using *default_class* if *name* does not appear in the registry) and composes it with *base_class* to produce a class, calls the constructed class's constructor, passing it the same argument list, and finally returns the class instance created thereby.

The following classes are the classes used to represent data parsed from structured headers and can, in general, be used by an application program to construct structured values to assign to specific headers.

class email.headerregistry.**Address** (*display_name*=", *username*", *domain*", *addr_spec*=None)

The class used to represent an email address. The general form of an address is:

```
[display_name] <username@domain>
```

或是:

```
username@domain
```

where each part must conform to specific syntax rules spelled out in [RFC 5322](#).

As a convenience *addr_spec* can be specified instead of *username* and *domain*, in which case *username* and *domain* will be parsed from the *addr_spec*. An *addr_spec* must be a properly RFC quoted string; if it is not **Address** will raise an error. Unicode characters are allowed and will be property encoded when serialized. However, per the RFCs, unicode is *not* allowed in the username portion of the address.

display_name

The display name portion of the address, if any, with all quoting removed. If the address does not have a display name, this attribute will be an empty string.

username

The username portion of the address, with all quoting removed.

domain

The domain portion of the address.

addr_spec

The username@domain portion of the address, correctly quoted for use as a bare address (the second form shown above). This attribute is not mutable.

__str__ ()

The `str` value of the object is the address quoted according to [RFC 5322](#) rules, but with no Content Transfer Encoding of any non-ASCII characters.

To support SMTP ([RFC 5321](#)), **Address** handles one special case: if *username* and *domain* are both the empty string (or `None`), then the string value of the **Address** is `<>`.

class email.headerregistry.**Group** (*display_name*=None, *addresses*=None)

The class used to represent an address group. The general form of an address group is:

```
display_name: [address-list];
```

As a convenience for processing lists of addresses that consist of a mixture of groups and single addresses, a **Group** may also be used to represent single addresses that are not part of a group by setting *display_name* to `None` and providing a list of the single address as *addresses*.

display_name

The *display_name* of the group. If it is `None` and there is exactly one **Address** in *addresses*, then the **Group** represents a single address that is not in a group.

addresses

A possibly empty tuple of [Address](#) objects representing the addresses in the group.

`__str__()`

The `str` value of a `Group` is formatted according to [RFC 5322](#), but with no Content Transfer Encoding of any non-ASCII characters. If `display_name` is `None` and there is a single `Address` in the `addresses` list, the `str` value will be the same as the `str` of that single `Address`.

解

19.1.7 `email.contentmanager`: Managing MIME Content

原始碼: [Lib/email/contentmanager.py](#)

在 3.6 版新加入:¹

class `email.contentmanager.ContentManager`

Base class for content managers. Provides the standard registry mechanisms to register converters between MIME content and other representations, as well as the `get_content` and `set_content` dispatch methods.

get_content (*msg*, **args*, ***kw*)

Look up a handler function based on the `mimetype` of *msg* (see next paragraph), call it, passing through all arguments, and return the result of the call. The expectation is that the handler will extract the payload from *msg* and return an object that encodes information about the extracted data.

To find the handler, look for the following keys in the registry, stopping with the first one found:

- the string representing the full MIME type (`maintype/subtype`)
- the string representing the `maintype`
- the empty string

If none of these keys produce a handler, raise a [KeyError](#) for the full MIME type.

set_content (*msg*, *obj*, **args*, ***kw*)

If the `maintype` is `multipart`, raise a [TypeError](#); otherwise look up a handler function based on the type of *obj* (see next paragraph), call [clear_content\(\)](#) on the *msg*, and call the handler function, passing through all arguments. The expectation is that the handler will transform and store *obj* into *msg*, possibly making other changes to *msg* as well, such as adding various MIME headers to encode information needed to interpret the stored data.

To find the handler, obtain the type of *obj* (`typ = type(obj)`), and look for the following keys in the registry, stopping with the first one found:

- the type itself (`typ`)
- the type's fully qualified name (`typ.__module__ + '.' + typ.__qualname__`).
- the type's `qualname` (`typ.__qualname__`)
- the type's `name` (`typ.__name__`).

If none of the above match, repeat all of the checks above for each of the types in the [MRO](#) (`typ.__mro__`). Finally, if no other key yields a handler, check for a handler for the key `None`. If there is no handler for `None`, raise a [KeyError](#) for the fully qualified name of the type.

Also add a `MIME-Version` header if one is not present (see also [MIMEPart](#)).

add_get_handler (*key*, *handler*)

Record the function *handler* as the handler for *key*. For the possible values of *key*, see [get_content\(\)](#).

¹ Originally added in 3.4 as a [provisional module](#)

add_set_handler (*typekey*, *handler*)

Record *handler* as the function to call when an object of a type matching *typekey* is passed to *set_content()*. For the possible values of *typekey*, see *set_content()*.

Content Manager Instances

Currently the email package provides only one concrete content manager, *raw_data_manager*, although more may be added in the future. *raw_data_manager* is the *content_manager* provided by *EmailPolicy* and its derivatives.

`email.contentmanager.raw_data_manager`

This content manager provides only a minimum interface beyond that provided by *Message* itself: it deals only with text, raw byte strings, and *Message* objects. Nevertheless, it provides significant advantages compared to the base API: *get_content* on a text part will return a unicode string without the application needing to manually decode it, *set_content* provides a rich set of options for controlling the headers added to a part and controlling the content transfer encoding, and it enables the use of the various *add_* methods, thereby simplifying the creation of multipart messages.

`email.contentmanager.get_content` (*msg*, *errors*='replace')

Return the payload of the part as either a string (for text parts), an *EmailMessage* object (for message/rfc822 parts), or a bytes object (for all other non-multipart types). Raise a *KeyError* if called on a multipart. If the part is a text part and *errors* is specified, use it as the error handler when decoding the payload to unicode. The default error handler is *replace*.

`email.contentmanager.set_content` (*msg*, <'str'>, *subtype*='plain', *charset*='utf-8', *cte*=None, *disposition*=None, *filename*=None, *cid*=None, *params*=None, *headers*=None)

`email.contentmanager.set_content` (*msg*, <'bytes'>, *maintype*, *subtype*, *cte*='base64', *disposition*=None, *filename*=None, *cid*=None, *params*=None, *headers*=None)

`email.contentmanager.set_content` (*msg*, <'EmailMessage'>, *cte*=None, *disposition*=None, *filename*=None, *cid*=None, *params*=None, *headers*=None)

Add headers and payload to *msg*:

Add a *Content-Type* header with a *maintype*/*subtype* value.

- For *str*, set the MIME *maintype* to *text*, and set the *subtype* to *subtype* if it is specified, or *plain* if it is not.
- For *bytes*, use the specified *maintype* and *subtype*, or raise a *TypeError* if they are not specified.
- For *EmailMessage* objects, set the *maintype* to *message*, and set the *subtype* to *subtype* if it is specified or *rfc822* if it is not. If *subtype* is *partial*, raise an error (bytes objects must be used to construct *message/partial* parts).

If *charset* is provided (which is valid only for *str*), encode the string to bytes using the specified character set. The default is *utf-8*. If the specified *charset* is a known alias for a standard MIME charset name, use the standard charset instead.

If *cte* is set, encode the payload using the specified content transfer encoding, and set the *Content-Transfer-Encoding* header to that value. Possible values for *cte* are *quoted-printable*, *base64*, *7bit*, *8bit*, and *binary*. If the input cannot be encoded in the specified encoding (for example, specifying a *cte* of *7bit* for an input that contains non-ASCII values), raise a *ValueError*.

- For *str* objects, if *cte* is not set use heuristics to determine the most compact encoding.
- For *EmailMessage*, per [RFC 2046](#), raise an error if a *cte* of *quoted-printable* or *base64* is requested for *subtype* *rfc822*, and for any *cte* other than *7bit* for *subtype* *external-body*. For *message/rfc822*, use *8bit* if *cte* is not specified. For all other values of *subtype*, use *7bit*.

備 F: A *cte* of *binary* does not actually work correctly yet. The `EmailMessage` object as modified by `set_content` is correct, but `BytesGenerator` does not serialize it correctly.

If *disposition* is set, use it as the value of the *Content-Disposition* header. If not specified, and *filename* is specified, add the header with the value `attachment`. If *disposition* is not specified and *filename* is also not specified, do not add the header. The only valid values for *disposition* are `attachment` and `inline`.

If *filename* is specified, use it as the value of the *filename* parameter of the *Content-Disposition* header.

If *cid* is specified, add a *Content-ID* header with *cid* as its value.

If *params* is specified, iterate its `items` method and use the resulting `(key, value)` pairs to set additional parameters on the *Content-Type* header.

If *headers* is specified and is a list of strings of the form `headername: headervalue` or a list of header objects (distinguished from strings by having a `name` attribute), add the headers to *msg*.

解

19.1.8 email: Examples

Here are a few examples of how to use the *email* package to read, write, and send simple email messages, as well as more complex MIME messages.

First, let's see how to create and send a simple text message (both the text content and the addresses may contain unicode characters):

```
# Import smtplib for the actual sending function
import smtplib

# Import the email modules we'll need
from email.message import EmailMessage

# Open the plain text file whose name is in textfile for reading.
with open(textfile) as fp:
    # Create a text/plain message
    msg = EmailMessage()
    msg.set_content(fp.read())

# me == the sender's email address
# you == the recipient's email address
msg['Subject'] = f'The contents of {textfile}'
msg['From'] = me
msg['To'] = you

# Send the message via our own SMTP server.
s = smtplib.SMTP('localhost')
s.send_message(msg)
s.quit()
```

Parsing RFC 822 headers can easily be done by the using the classes from the *parser* module:

```
# Import the email modules we'll need
from email.parser import BytesParser, Parser
from email.policy import default

# If the e-mail headers are in a file, uncomment these two lines:
# with open(messagefile, 'rb') as fp:
```

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```
# headers = BytesParser(policy=default).parse(fp)

# Or for parsing headers in a string (this is an uncommon operation), use:
headers = Parser(policy=default).parsestr(
    'From: Foo Bar <user@example.com>\n'
    'To: <someone_else@example.com>\n'
    'Subject: Test message\n'
    '\n'
    'Body would go here\n')

# Now the header items can be accessed as a dictionary:
print('To: {}'.format(headers['to']))
print('From: {}'.format(headers['from']))
print('Subject: {}'.format(headers['subject']))

# You can also access the parts of the addresses:
print('Recipient username: {}'.format(headers['to'].addresses[0].username))
print('Sender name: {}'.format(headers['from'].addresses[0].display_name))
```

Here's an example of how to send a MIME message containing a bunch of family pictures that may be residing in a directory:

```
# Import smtplib for the actual sending function.
import smtplib

# Here are the email package modules we'll need.
from email.message import EmailMessage

# Create the container email message.
msg = EmailMessage()
msg['Subject'] = 'Our family reunion'
# me == the sender's email address
# family = the list of all recipients' email addresses
msg['From'] = me
msg['To'] = ', '.join(family)
msg.preamble = 'You will not see this in a MIME-aware mail reader.\n'

# Open the files in binary mode. You can also omit the subtype
# if you want MIMEImage to guess it.
for file in pngfiles:
    with open(file, 'rb') as fp:
        img_data = fp.read()
        msg.add_attachment(img_data, maintype='image',
                           subtype='png')

# Send the email via our own SMTP server.
with smtplib.SMTP('localhost') as s:
    s.send_message(msg)
```

Here's an example of how to send the entire contents of a directory as an email message:¹

```
#!/usr/bin/env python3

"""Send the contents of a directory as a MIME message."""

import os
import smtplib
# For guessing MIME type based on file name extension
import mimetypes
```

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¹ Thanks to Matthew Dixon Cowles for the original inspiration and examples.

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```

from argparse import ArgumentParser

from email.message import EmailMessage
from email.policy import SMTP

def main():
    parser = ArgumentParser(description="""\
Send the contents of a directory as a MIME message.
Unless the -o option is given, the email is sent by forwarding to your local
SMTP server, which then does the normal delivery process. Your local machine
must be running an SMTP server.
""")
    parser.add_argument('-d', '--directory',
                        help="""Mail the contents of the specified directory,
otherwise use the current directory. Only the regular
files in the directory are sent, and we don't recurse to
subdirectories.""")
    parser.add_argument('-o', '--output',
                        metavar='FILE',
                        help="""Print the composed message to FILE instead of
sending the message to the SMTP server.""")
    parser.add_argument('-s', '--sender', required=True,
                        help='The value of the From: header (required)')
    parser.add_argument('-r', '--recipient', required=True,
                        action='append', metavar='RECIPIENT',
                        default=[], dest='recipients',
                        help='A To: header value (at least one required)')

    args = parser.parse_args()
    directory = args.directory
    if not directory:
        directory = '.'
    # Create the message
    msg = EmailMessage()
    msg['Subject'] = f'Contents of directory {os.path.abspath(directory)}'
    msg['To'] = ', '.join(args.recipients)
    msg['From'] = args.sender
    msg.preamble = 'You will not see this in a MIME-aware mail reader.\n'

    for filename in os.listdir(directory):
        path = os.path.join(directory, filename)
        if not os.path.isfile(path):
            continue
        # Guess the content type based on the file's extension. Encoding
        # will be ignored, although we should check for simple things like
        # gzip'd or compressed files.
        ctype, encoding = mimetypes.guess_type(path)
        if ctype is None or encoding is not None:
            # No guess could be made, or the file is encoded (compressed), so
            # use a generic bag-of-bits type.
            ctype = 'application/octet-stream'
        maintype, subtype = ctype.split('/', 1)
        with open(path, 'rb') as fp:
            msg.add_attachment(fp.read(),
                              maintype=maintype,
                              subtype=subtype,
                              filename=filename)

    # Now send or store the message
    if args.output:
        with open(args.output, 'wb') as fp:

```

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```

        fp.write(msg.as_bytes(policy=SMTP))
    else:
        with smtplib.SMTP('localhost') as s:
            s.send_message(msg)

if __name__ == '__main__':
    main()

```

Here's an example of how to unpack a MIME message like the one above, into a directory of files:

```

#!/usr/bin/env python3

"""Unpack a MIME message into a directory of files."""

import os
import email
import mimetypes

from email.policy import default

from argparse import ArgumentParser

def main():
    parser = ArgumentParser(description="""\
Unpack a MIME message into a directory of files.
""")
    parser.add_argument('-d', '--directory', required=True,
                        help="""Unpack the MIME message into the named
                        directory, which will be created if it doesn't already
                        exist.""")
    parser.add_argument('msgfile')
    args = parser.parse_args()

    with open(args.msgfile, 'rb') as fp:
        msg = email.message_from_binary_file(fp, policy=default)

    try:
        os.mkdir(args.directory)
    except FileExistsError:
        pass

    counter = 1
    for part in msg.walk():
        # multipart/* are just containers
        if part.get_content_maintype() == 'multipart':
            continue
        # Applications should really sanitize the given filename so that an
        # email message can't be used to overwrite important files
        filename = part.get_filename()
        if not filename:
            ext = mimetypes.guess_extension(part.get_content_type())
            if not ext:
                # Use a generic bag-of-bits extension
                ext = '.bin'
            filename = f'part-{counter:03d}{ext}'
        counter += 1
        with open(os.path.join(args.directory, filename), 'wb') as fp:
            fp.write(part.get_payload(decode=True))

```

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```
if __name__ == '__main__':
    main()
```

Here's an example of how to create an HTML message with an alternative plain text version. To make things a bit more interesting, we include a related image in the html part, and we save a copy of what we are going to send to disk, as well as sending it.

```
#!/usr/bin/env python3

import smtplib

from email.message import EmailMessage
from email.headerregistry import Address
from email.utils import make_msgid

# Create the base text message.
msg = EmailMessage()
msg['Subject'] = "Ayons asperges pour le déjeuner"
msg['From'] = Address("Pepé Le Pew", "pepe", "example.com")
msg['To'] = (Address("Penelope Pussycat", "penelope", "example.com"),
            Address("Fabrette Pussycat", "fabrette", "example.com"))
msg.set_content("""\
Salut!

Cela ressemble à un excellent recipie[1] déjeuner.

[1] http://www.yummly.com/recipe/Roasted-Asparagus-Epicurious-203718

--Pepé
""")

# Add the html version. This converts the message into a multipart/alternative
# container, with the original text message as the first part and the new html
# message as the second part.
asparagus_cid = make_msgid()
msg.add_alternative("""\
<html>
  <head></head>
  <body>
    <p>Salut!</p>
    <p>Cela ressemble à un excellent
      <a href="http://www.yummly.com/recipe/Roasted-Asparagus-Epicurious-203718">
        recipie
      </a> déjeuner.
    </p>
    
  </body>
</html>
""".format(asparagus_cid=asparagus_cid[1:-1]), subtype='html')
# note that we needed to peel the <> off the msgid for use in the html.

# Now add the related image to the html part.
with open("roasted-asparagus.jpg", 'rb') as img:
    msg.get_payload()[1].add_related(img.read(), 'image', 'jpeg',
                                     cid=asparagus_cid)

# Make a local copy of what we are going to send.
with open('outgoing.msg', 'wb') as f:
    f.write(bytes(msg))
```

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```
# Send the message via local SMTP server.
with smtplib.SMTP('localhost') as s:
    s.send_message(msg)
```

If we were sent the message from the last example, here is one way we could process it:

```
import os
import sys
import tempfile
import mimetypes
import webbrowser

# Import the email modules we'll need
from email import policy
from email.parser import BytesParser

def magic_html_parser(html_text, partfiles):
    """Return safety-sanitized html linked to partfiles.

    Rewrite the href="cid:..." attributes to point to the filenames in partfiles.
    Though not trivial, this should be possible using html.parser.
    """
    raise NotImplementedError("Add the magic needed")

# In a real program you'd get the filename from the arguments.
with open('outgoing.msg', 'rb') as fp:
    msg = BytesParser(policy=policy.default).parse(fp)

# Now the header items can be accessed as a dictionary, and any non-ASCII will
# be converted to unicode:
print('To:', msg['to'])
print('From:', msg['from'])
print('Subject:', msg['subject'])

# If we want to print a preview of the message content, we can extract whatever
# the least formatted payload is and print the first three lines. Of course,
# if the message has no plain text part printing the first three lines of html
# is probably useless, but this is just a conceptual example.
simplest = msg.get_body(preferencelist=('plain', 'html'))
print()
print(''.join(simplest.get_content().splitlines(keepends=True)[:3]))

ans = input("View full message?")
if ans.lower()[0] == 'n':
    sys.exit()

# We can extract the richest alternative in order to display it:
richest = msg.get_body()
partfiles = {}
if richest['content-type'].maintype == 'text':
    if richest['content-type'].subtype == 'plain':
        for line in richest.get_content().splitlines():
            print(line)
        sys.exit()
    elif richest['content-type'].subtype == 'html':
        body = richest
    else:
        print("Don't know how to display {}".format(richest.get_content_type()))
        sys.exit()
```

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```

elif richest['content-type'].content_type == 'multipart/related':
    body = richest.get_body(preferencelist=('html'))
    for part in richest.iter_attachments():
        fn = part.get_filename()
        if fn:
            extension = os.path.splitext(part.get_filename())[1]
        else:
            extension = mimetypes.guess_extension(part.get_content_type())
        with tempfile.NamedTemporaryFile(suffix=extension, delete=False) as f:
            f.write(part.get_content())
            # again strip the <> to go from email form of cid to html form.
            partfiles[part['content-id'][1:-1]] = f.name
    else:
        print("Don't know how to display {}".format(richest.get_content_type()))
        sys.exit()
with tempfile.NamedTemporaryFile(mode='w', delete=False) as f:
    f.write(magic_html_parser(body.get_content(), partfiles))
webbrowser.open(f.name)
os.remove(f.name)
for fn in partfiles.values():
    os.remove(fn)

# Of course, there are lots of email messages that could break this simple
# minded program, but it will handle the most common ones.

```

Up to the prompt, the output from the above is:

```

To: Penelope Pussycat <penelope@example.com>, Fabrette Pussycat <fabrette@example.
↪com>
From: Pepé Le Pew <pepe@example.com>
Subject: Ayons asperges pour le déjeuner

Salut!

Cela ressemble à un excellent recipie[1] déjeuner.

```

F解

Legacy API:

19.1.9 email.message.Message: Representing an email message using the compat32 API

The *Message* class is very similar to the *EmailMessage* class, without the methods added by that class, and with the default behavior of certain other methods being slightly different. We also document here some methods that, while supported by the *EmailMessage* class, are not recommended unless you are dealing with legacy code.

The philosophy and structure of the two classes is otherwise the same.

This document describes the behavior under the default (for *Message*) policy *Compat32*. If you are going to use another policy, you should be using the *EmailMessage* class instead.

An email message consists of *headers* and a *payload*. Headers must be **RFC 5322** style names and values, where the field name and value are separated by a colon. The colon is not part of either the field name or the field value. The payload may be a simple text message, or a binary object, or a structured sequence of sub-messages each with their own set of headers and their own payload. The latter type of payload is indicated by the message having a MIME type such as *multipart/** or *message/rfc822*.

The conceptual model provided by a *Message* object is that of an ordered dictionary of headers with additional methods for accessing both specialized information from the headers, for accessing the payload, for generating a serialized version of the message, and for recursively walking over the object tree. Note that duplicate headers are supported but special methods must be used to access them.

The *Message* pseudo-dictionary is indexed by the header names, which must be ASCII values. The values of the dictionary are strings that are supposed to contain only ASCII characters; there is some special handling for non-ASCII input, but it doesn't always produce the correct results. Headers are stored and returned in case-preserving form, but field names are matched case-insensitively. There may also be a single envelope header, also known as the *Unix-From* header or the *From_* header. The *payload* is either a string or bytes, in the case of simple message objects, or a list of *Message* objects, for MIME container documents (e.g. *multipart/** and *message/rfc822*).

Here are the methods of the *Message* class:

class email.message.*Message* (*policy=compat32*)

If *policy* is specified (it must be an instance of a *policy* class) use the rules it specifies to update and serialize the representation of the message. If *policy* is not set, use the *compat32* policy, which maintains backward compatibility with the Python 3.2 version of the email package. For more information see the *policy* documentation.

在 3.3 版的變更: 新增 *policy* 關鍵字引數。

as_string (*unixfrom=False*, *maxheaderlen=0*, *policy=None*)

Return the entire message flattened as a string. When optional *unixfrom* is true, the envelope header is included in the returned string. *unixfrom* defaults to *False*. For backward compatibility reasons, *maxheaderlen* defaults to 0, so if you want a different value you must override it explicitly (the value specified for *max_line_length* in the policy will be ignored by this method). The *policy* argument may be used to override the default policy obtained from the message instance. This can be used to control some of the formatting produced by the method, since the specified *policy* will be passed to the *Generator*.

Flattening the message may trigger changes to the *Message* if defaults need to be filled in to complete the transformation to a string (for example, MIME boundaries may be generated or modified).

Note that this method is provided as a convenience and may not always format the message the way you want. For example, by default it does not do the mangling of lines that begin with *From* that is required by the Unix mbox format. For more flexibility, instantiate a *Generator* instance and use its *flatten()* method directly. For example:

```
from io import StringIO
from email.generator import Generator
fp = StringIO()
g = Generator(fp, mangle_from_=True, maxheaderlen=60)
g.flatten(msg)
text = fp.getvalue()
```

If the message object contains binary data that is not encoded according to RFC standards, the non-compliant data will be replaced by unicode "unknown character" code points. (See also *as_bytes()* and *BytesGenerator*.)

在 3.4 版的變更: 新增 *policy* 關鍵字引數。

__str__ ()

Equivalent to *as_string()*. Allows *str(msg)* to produce a string containing the formatted message.

as_bytes (*unixfrom=False*, *policy=None*)

Return the entire message flattened as a bytes object. When optional *unixfrom* is true, the envelope header is included in the returned string. *unixfrom* defaults to *False*. The *policy* argument may be used to override the default policy obtained from the message instance. This can be used to control some of the formatting produced by the method, since the specified *policy* will be passed to the *BytesGenerator*.

Flattening the message may trigger changes to the *Message* if defaults need to be filled in to complete the transformation to a string (for example, MIME boundaries may be generated or modified).

Note that this method is provided as a convenience and may not always format the message the way you want. For example, by default it does not do the mangling of lines that begin with `From` that is required by the Unix mbox format. For more flexibility, instantiate a `BytesGenerator` instance and use its `flatten()` method directly. For example:

```
from io import BytesIO
from email.generator import BytesGenerator
fp = BytesIO()
g = BytesGenerator(fp, mangle_from_=True, maxheaderlen=60)
g.flatten(msg)
text = fp.getvalue()
```

在 3.4 版新加入。

`__bytes__()`

Equivalent to `as_bytes()`. Allows `bytes(msg)` to produce a bytes object containing the formatted message.

在 3.4 版新加入。

`is_multipart()`

Return `True` if the message's payload is a list of sub-`Message` objects, otherwise return `False`. When `is_multipart()` returns `False`, the payload should be a string object (which might be a CTE encoded binary payload). (Note that `is_multipart()` returning `True` does not necessarily mean that `"msg.get_content_maintype() == 'multipart'"` will return the `True`. For example, `is_multipart` will return `True` when the `Message` is of type `message/rfc822`.)

`set_unixfrom(unixfrom)`

Set the message's envelope header to `unixfrom`, which should be a string.

`get_unixfrom()`

Return the message's envelope header. Defaults to `None` if the envelope header was never set.

`attach(payload)`

Add the given `payload` to the current payload, which must be `None` or a list of `Message` objects before the call. After the call, the payload will always be a list of `Message` objects. If you want to set the payload to a scalar object (e.g. a string), use `set_payload()` instead.

This is a legacy method. On the `EmailMessage` class its functionality is replaced by `set_content()` and the related `make` and `add` methods.

`get_payload(i=None, decode=False)`

Return the current payload, which will be a list of `Message` objects when `is_multipart()` is `True`, or a string when `is_multipart()` is `False`. If the payload is a list and you mutate the list object, you modify the message's payload in place.

With optional argument `i`, `get_payload()` will return the `i`-th element of the payload, counting from zero, if `is_multipart()` is `True`. An `IndexError` will be raised if `i` is less than 0 or greater than or equal to the number of items in the payload. If the payload is a string (i.e. `is_multipart()` is `False`) and `i` is given, a `TypeError` is raised.

Optional `decode` is a flag indicating whether the payload should be decoded or not, according to the `Content-Transfer-Encoding` header. When `True` and the message is not a multipart, the payload will be decoded if this header's value is `quoted-printable` or `base64`. If some other encoding is used, or `Content-Transfer-Encoding` header is missing, the payload is returned as-is (undecoded). In all cases the returned value is binary data. If the message is a multipart and the `decode` flag is `True`, then `None` is returned. If the payload is `base64` and it was not perfectly formed (missing padding, characters outside the `base64` alphabet), then an appropriate defect will be added to the message's `defect` property (`InvalidBase64PaddingDefect` or `InvalidBase64CharactersDefect`, respectively).

When `decode` is `False` (the default) the body is returned as a string without decoding the `Content-Transfer-Encoding`. However, for a `Content-Transfer-Encoding` of `8bit`,

an attempt is made to decode the original bytes using the `charset` specified by the *Content-Type* header, using the `replace` error handler. If no `charset` is specified, or if the `charset` given is not recognized by the email package, the body is decoded using the default ASCII charset.

This is a legacy method. On the `EmailMessage` class its functionality is replaced by `get_content()` and `iter_parts()`.

set_payload(payload, charset=None)

Set the entire message object's payload to `payload`. It is the client's responsibility to ensure the payload invariants. Optional `charset` sets the message's default character set; see `set_charset()` for details.

This is a legacy method. On the `EmailMessage` class its functionality is replaced by `set_content()`.

set_charset(charset)

Set the character set of the payload to `charset`, which can either be a `Charset` instance (see `email.charset`), a string naming a character set, or `None`. If it is a string, it will be converted to a `Charset` instance. If `charset` is `None`, the `charset` parameter will be removed from the *Content-Type* header (the message will not be otherwise modified). Anything else will generate a `TypeError`.

If there is no existing *MIME-Version* header one will be added. If there is no existing *Content-Type* header, one will be added with a value of `text/plain`. Whether the *Content-Type* header already exists or not, its `charset` parameter will be set to `charset.output_charset`. If `charset.input_charset` and `charset.output_charset` differ, the payload will be re-encoded to the `output_charset`. If there is no existing *Content-Transfer-Encoding* header, then the payload will be transfer-encoded, if needed, using the specified `Charset`, and a header with the appropriate value will be added. If a *Content-Transfer-Encoding* header already exists, the payload is assumed to already be correctly encoded using that *Content-Transfer-Encoding* and is not modified.

This is a legacy method. On the `EmailMessage` class its functionality is replaced by the `charset` parameter of the `email.message.EmailMessage.set_content()` method.

get_charset()

Return the `Charset` instance associated with the message's payload.

This is a legacy method. On the `EmailMessage` class it always returns `None`.

The following methods implement a mapping-like interface for accessing the message's **RFC 2822** headers. Note that there are some semantic differences between these methods and a normal mapping (i.e. dictionary) interface. For example, in a dictionary there are no duplicate keys, but here there may be duplicate message headers. Also, in dictionaries there is no guaranteed order to the keys returned by `keys()`, but in a `Message` object, headers are always returned in the order they appeared in the original message, or were added to the message later. Any header deleted and then re-added are always appended to the end of the header list.

These semantic differences are intentional and are biased toward maximal convenience.

Note that in all cases, any envelope header present in the message is not included in the mapping interface.

In a model generated from bytes, any header values that (in contravention of the RFCs) contain non-ASCII bytes will, when retrieved through this interface, be represented as `Header` objects with a `charset` of `unknown-8bit`.

__len__()

Return the total number of headers, including duplicates.

__contains__(name)

Return `True` if the message object has a field named `name`. Matching is done case-insensitively and `name` should not include the trailing colon. Used for the `in` operator, e.g.:

```
if 'message-id' in myMessage:
    print('Message-ID:', myMessage['message-id'])
```


__getitem__ (*name*)

Return the value of the named header field. *name* should not include the colon field separator. If the header is missing, `None` is returned; a `KeyError` is never raised.

Note that if the named field appears more than once in the message's headers, exactly which of those field values will be returned is undefined. Use the `get_all()` method to get the values of all the extant named headers.

__setitem__ (*name*, *val*)

Add a header to the message with field name *name* and value *val*. The field is appended to the end of the message's existing fields.

Note that this does *not* overwrite or delete any existing header with the same name. If you want to ensure that the new header is the only one present in the message with field name *name*, delete the field first, e.g.:

```
del msg['subject']
msg['subject'] = 'Python roolz!'
```

__delitem__ (*name*)

Delete all occurrences of the field with name *name* from the message's headers. No exception is raised if the named field isn't present in the headers.

keys ()

Return a list of all the message's header field names.

values ()

Return a list of all the message's field values.

items ()

Return a list of 2-tuples containing all the message's field headers and values.

get (*name*, *failobj*=`None`)

Return the value of the named header field. This is identical to `__getitem__()` except that optional *failobj* is returned if the named header is missing (defaults to `None`).

Here are some additional useful methods:

get_all (*name*, *failobj*=`None`)

Return a list of all the values for the field named *name*. If there are no such named headers in the message, *failobj* is returned (defaults to `None`).

add_header (*_name*, *_value*, ****_params**)

Extended header setting. This method is similar to `__setitem__()` except that additional header parameters can be provided as keyword arguments. *_name* is the header field to add and *_value* is the *primary* value for the header.

For each item in the keyword argument dictionary *_params*, the key is taken as the parameter name, with underscores converted to dashes (since dashes are illegal in Python identifiers). Normally, the parameter will be added as `key="value"` unless the value is `None`, in which case only the key will be added. If the value contains non-ASCII characters, it can be specified as a three tuple in the format `(CHARSET, LANGUAGE, VALUE)`, where `CHARSET` is a string naming the charset to be used to encode the value, `LANGUAGE` can usually be set to `None` or the empty string (see [RFC 2231](#) for other possibilities), and `VALUE` is the string value containing non-ASCII code points. If a three tuple is not passed and the value contains non-ASCII characters, it is automatically encoded in [RFC 2231](#) format using a `CHARSET` of `utf-8` and a `LANGUAGE` of `None`.

以下是個範例：

```
msg.add_header('Content-Disposition', 'attachment', filename='bud.gif')
```

This will add a header that looks like


```
Content-Disposition: attachment; filename="bud.gif"
```

An example with non-ASCII characters:

```
msg.add_header('Content-Disposition', 'attachment',
               filename=('iso-8859-1', '', 'Fußballer.ppt'))
```

Which produces

```
Content-Disposition: attachment; filename*="iso-8859-1'Fu%DFballer.ppt"
```

replace_header (*_name*, *_value*)

Replace a header. Replace the first header found in the message that matches *_name*, retaining header order and field name case. If no matching header was found, a *KeyError* is raised.

get_content_type ()

Return the message's content type. The returned string is coerced to lower case of the form *maintype/subtype*. If there was no *Content-Type* header in the message the default type as given by *get_default_type* () will be returned. Since according to **RFC 2045**, messages always have a default type, *get_content_type* () will always return a value.

RFC 2045 defines a message's default type to be *text/plain* unless it appears inside a *multipart/digest* container, in which case it would be *message/rfc822*. If the *Content-Type* header has an invalid type specification, **RFC 2045** mandates that the default type be *text/plain*.

get_content_maintype ()

Return the message's main content type. This is the *maintype* part of the string returned by *get_content_type* ().

get_content_subtype ()

Return the message's sub-content type. This is the *subtype* part of the string returned by *get_content_type* ().

get_default_type ()

Return the default content type. Most messages have a default content type of *text/plain*, except for messages that are subparts of *multipart/digest* containers. Such subparts have a default content type of *message/rfc822*.

set_default_type (*ctype*)

Set the default content type. *ctype* should either be *text/plain* or *message/rfc822*, although this is not enforced. The default content type is not stored in the *Content-Type* header.

get_params (*failobj*=None, *header*='content-type', *unquote*=True)

Return the message's *Content-Type* parameters, as a list. The elements of the returned list are 2-tuples of key/value pairs, as split on the '=' sign. The left hand side of the '=' is the key, while the right hand side is the value. If there is no '=' sign in the parameter the value is the empty string, otherwise the value is as described in *get_param* () and is unquoted if optional *unquote* is True (the default).

Optional *failobj* is the object to return if there is no *Content-Type* header. Optional *header* is the header to search instead of *Content-Type*.

This is a legacy method. On the *EmailMessage* class its functionality is replaced by the *params* property of the individual header objects returned by the header access methods.

get_param (*param*, *failobj*=None, *header*='content-type', *unquote*=True)

Return the value of the *Content-Type* header's parameter *param* as a string. If the message has no *Content-Type* header or if there is no such parameter, then *failobj* is returned (defaults to None).

Optional *header* if given, specifies the message header to use instead of *Content-Type*.

Parameter keys are always compared case insensitively. The return value can either be a string, or a 3-tuple if the parameter was **RFC 2231** encoded. When it's a 3-tuple, the elements of the value are of the

form (CHARSET, LANGUAGE, VALUE). Note that both CHARSET and LANGUAGE can be None, in which case you should consider VALUE to be encoded in the `us-ascii` charset. You can usually ignore LANGUAGE.

If your application doesn't care whether the parameter was encoded as in [RFC 2231](#), you can collapse the parameter value by calling `email.utils.collapse_rfc2231_value()`, passing in the return value from `get_param()`. This will return a suitably decoded Unicode string when the value is a tuple, or the original string unquoted if it isn't. For example:

```
rawparam = msg.get_param('foo')
param = email.utils.collapse_rfc2231_value(rawparam)
```

In any case, the parameter value (either the returned string, or the VALUE item in the 3-tuple) is always unquoted, unless *unquote* is set to False.

This is a legacy method. On the `EmailMessage` class its functionality is replaced by the *params* property of the individual header objects returned by the header access methods.

set_param (param, value, header='Content-Type', requote=True, charset=None, language="", replace=False)

Set a parameter in the *Content-Type* header. If the parameter already exists in the header, its value will be replaced with *value*. If the *Content-Type* header has not yet been defined for this message, it will be set to *text/plain* and the new parameter value will be appended as per [RFC 2045](#).

Optional *header* specifies an alternative header to *Content-Type*, and all parameters will be quoted as necessary unless optional *requote* is False (the default is True).

If optional *charset* is specified, the parameter will be encoded according to [RFC 2231](#). Optional *language* specifies the RFC 2231 language, defaulting to the empty string. Both *charset* and *language* should be strings.

If *replace* is False (the default) the header is moved to the end of the list of headers. If *replace* is True, the header will be updated in place.

在 3.4 版的變更: *replace* keyword was added.

del_param (param, header='content-type', requote=True)

Remove the given parameter completely from the *Content-Type* header. The header will be rewritten in place without the parameter or its value. All values will be quoted as necessary unless *requote* is False (the default is True). Optional *header* specifies an alternative to *Content-Type*.

set_type (type, header='Content-Type', requote=True)

Set the main type and subtype for the *Content-Type* header. *type* must be a string in the form *maintype/subtype*, otherwise a *ValueError* is raised.

This method replaces the *Content-Type* header, keeping all the parameters in place. If *requote* is False, this leaves the existing header's quoting as is, otherwise the parameters will be quoted (the default).

An alternative header can be specified in the *header* argument. When the *Content-Type* header is set a *MIME-Version* header is also added.

This is a legacy method. On the `EmailMessage` class its functionality is replaced by the *make_* and *add_* methods.

get_filename (failobj=None)

Return the value of the *filename* parameter of the *Content-Disposition* header of the message. If the header does not have a *filename* parameter, this method falls back to looking for the *name* parameter on the *Content-Type* header. If neither is found, or the header is missing, then *failobj* is returned. The returned string will always be unquoted as per `email.utils.unquote()`.

get_boundary (failobj=None)

Return the value of the *boundary* parameter of the *Content-Type* header of the message, or *failobj*

if either the header is missing, or has no boundary parameter. The returned string will always be unquoted as per `email.utils.unquote()`.

set_boundary (*boundary*)

Set the boundary parameter of the *Content-Type* header to *boundary*. `set_boundary()` will always quote *boundary* if necessary. A `HeaderParseError` is raised if the message object has no *Content-Type* header.

Note that using this method is subtly different than deleting the old *Content-Type* header and adding a new one with the new boundary via `add_header()`, because `set_boundary()` preserves the order of the *Content-Type* header in the list of headers. However, it does *not* preserve any continuation lines which may have been present in the original *Content-Type* header.

get_content_charset (*failobj=None*)

Return the charset parameter of the *Content-Type* header, coerced to lower case. If there is no *Content-Type* header, or if that header has no charset parameter, *failobj* is returned.

Note that this method differs from `get_charset()` which returns the `Charset` instance for the default encoding of the message body.

get_charsets (*failobj=None*)

Return a list containing the character set names in the message. If the message is a *multipart*, then the list will contain one element for each subpart in the payload, otherwise, it will be a list of length 1.

Each item in the list will be a string which is the value of the charset parameter in the *Content-Type* header for the represented subpart. However, if the subpart has no *Content-Type* header, no charset parameter, or is not of the *text* main MIME type, then that item in the returned list will be *failobj*.

get_content_disposition ()

Return the lowercased value (without parameters) of the message's *Content-Disposition* header if it has one, or `None`. The possible values for this method are *inline*, *attachment* or `None` if the message follows **RFC 2183**.

在 3.5 版新加入。

walk ()

The `walk()` method is an all-purpose generator which can be used to iterate over all the parts and subparts of a message object tree, in depth-first traversal order. You will typically use `walk()` as the iterator in a `for` loop; each iteration returns the next subpart.

Here's an example that prints the MIME type of every part of a multipart message structure:

```
>>> for part in msg.walk():
...     print(part.get_content_type())
multipart/report
text/plain
message/delivery-status
text/plain
text/plain
message/rfc822
text/plain
```

`walk` iterates over the subparts of any part where `is_multipart()` returns `True`, even though `msg.get_content_maintype() == 'multipart'` may return `False`. We can see this in our example by making use of the `_structure` debug helper function:

```
>>> for part in msg.walk():
...     print(part.get_content_maintype() == 'multipart',
...           part.is_multipart())
True True
False False
False True
```

(繼續下一頁)

(繼續上一頁)

```
False False
False False
False True
False False
>>> _structure(msg)
multipart/report
  text/plain
  message/delivery-status
    text/plain
    text/plain
  message/rfc822
    text/plain
```

Here the message parts are not multipart, but they do contain subparts. `is_multipart()` returns `True` and `walk` descends into the subparts.

Message objects can also optionally contain two instance attributes, which can be used when generating the plain text of a MIME message.

preamble

The format of a MIME document allows for some text between the blank line following the headers, and the first multipart boundary string. Normally, this text is never visible in a MIME-aware mail reader because it falls outside the standard MIME armor. However, when viewing the raw text of the message, or when viewing the message in a non-MIME aware reader, this text can become visible.

The *preamble* attribute contains this leading extra-armor text for MIME documents. When the *Parser* discovers some text after the headers but before the first boundary string, it assigns this text to the message's *preamble* attribute. When the *Generator* is writing out the plain text representation of a MIME message, and it finds the message has a *preamble* attribute, it will write this text in the area between the headers and the first boundary. See *email.parser* and *email.generator* for details.

Note that if the message object has no preamble, the *preamble* attribute will be `None`.

epilogue

The *epilogue* attribute acts the same way as the *preamble* attribute, except that it contains text that appears between the last boundary and the end of the message.

You do not need to set the epilogue to the empty string in order for the *Generator* to print a newline at the end of the file.

defects

The *defects* attribute contains a list of all the problems found when parsing this message. See *email.errors* for a detailed description of the possible parsing defects.

19.1.10 email.mime: Creating email and MIME objects from scratch

原始碼: [Lib/email/mime/](#)

This module is part of the legacy (Compat32) email API. Its functionality is partially replaced by the *contentmanager* in the new API, but in certain applications these classes may still be useful, even in non-legacy code.

Ordinarily, you get a message object structure by passing a file or some text to a parser, which parses the text and returns the root message object. However you can also build a complete message structure from scratch, or even individual *Message* objects by hand. In fact, you can also take an existing structure and add new *Message* objects, move them around, etc. This makes a very convenient interface for slicing-and-dicing MIME messages.

You can create a new object structure by creating *Message* instances, adding attachments and all the appropriate headers manually. For MIME messages though, the *email* package provides some convenient subclasses to make things easier.

Here are the classes:

```
class email.mime.base.MIMEBase (_maintype, _subtype, *, policy=compat32, **_params)
```

模組: `email.mime.base`

This is the base class for all the MIME-specific subclasses of `Message`. Ordinarily you won't create instances specifically of `MIMEBase`, although you could. `MIMEBase` is provided primarily as a convenient base class for more specific MIME-aware subclasses.

`_maintype` is the *Content-Type* major type (e.g. `text` or `image`), and `_subtype` is the *Content-Type* minor type (e.g. `plain` or `gif`). `_params` is a parameter key/value dictionary and is passed directly to `Message.add_header`.

If `policy` is specified, (defaults to the `compat32` policy) it will be passed to `Message`.

The `MIMEBase` class always adds a *Content-Type* header (based on `_maintype`, `_subtype`, and `_params`), and a *MIME-Version* header (always set to 1.0).

在 3.6 版的變更: 新增僅限關鍵字參數 `policy`。

```
class email.mime.nonmultipart.MIMENonMultipart
```

模組: `email.mime.nonmultipart`

A subclass of `MIMEBase`, this is an intermediate base class for MIME messages that are not *multipart*. The primary purpose of this class is to prevent the use of the `attach()` method, which only makes sense for *multipart* messages. If `attach()` is called, a `MultipartConversionError` exception is raised.

```
class email.mime.multipart.MIMEMultipart (_subtype='mixed', boundary=None,
                                           _subparts=None, *, policy=compat32, **_params)
```

模組: `email.mime.multipart`

A subclass of `MIMEBase`, this is an intermediate base class for MIME messages that are *multipart*. Optional `_subtype` defaults to `mixed`, but can be used to specify the subtype of the message. A *Content-Type* header of `multipart/_subtype` will be added to the message object. A *MIME-Version* header will also be added.

Optional `boundary` is the multipart boundary string. When `None` (the default), the boundary is calculated when needed (for example, when the message is serialized).

`_subparts` is a sequence of initial subparts for the payload. It must be possible to convert this sequence to a list. You can always attach new subparts to the message by using the `Message.attach` method.

Optional `policy` argument defaults to `compat32`.

Additional parameters for the *Content-Type* header are taken from the keyword arguments, or passed into the `_params` argument, which is a keyword dictionary.

在 3.6 版的變更: 新增僅限關鍵字參數 `policy`。

```
class email.mime.application.MIMEApplication (_data, _subtype='octet-stream',
                                              _encoder=email.encoders.encode_base64, *,
                                              policy=compat32, **_params)
```

模組: `email.mime.application`

A subclass of `MIMENonMultipart`, the `MIMEApplication` class is used to represent MIME message objects of major type *application*. `_data` contains the bytes for the raw application data. Optional `_subtype` specifies the MIME subtype and defaults to `octet-stream`.

Optional `_encoder` is a callable (i.e. function) which will perform the actual encoding of the data for transport. This callable takes one argument, which is the `MIMEApplication` instance. It should use `get_payload()` and `set_payload()` to change the payload to encoded form. It should also add any *Content-Transfer-Encoding* or other headers to the message object as necessary. The default encoding is base64. See the `email.encoders` module for a list of the built-in encoders.

Optional `policy` argument defaults to `compat32`.

`_params` are passed straight through to the base class constructor.

在 3.6 版的變更: 新增僅限關鍵字參數 *policy*。

```
class email.mime.audio.MIMEAudio(_audiodata, _subtype=None,
                                   _encoder=email.encoders.encode_base64, *, policy=compat32,
                                   **_params)
```

模組: `email.mime.audio`

A subclass of *MIMENonMultipart*, the *MIMEAudio* class is used to create MIME message objects of major type *audio*. *_audiodata* contains the bytes for the raw audio data. If this data can be decoded as au, wav, aiff, or aifc, then the subtype will be automatically included in the *Content-Type* header. Otherwise you can explicitly specify the audio subtype via the *_subtype* argument. If the minor type could not be guessed and *_subtype* was not given, then *TypeError* is raised.

Optional *_encoder* is a callable (i.e. function) which will perform the actual encoding of the audio data for transport. This callable takes one argument, which is the *MIMEAudio* instance. It should use *get_payload()* and *set_payload()* to change the payload to encoded form. It should also add any *Content-Transfer-Encoding* or other headers to the message object as necessary. The default encoding is base64. See the *email.encoders* module for a list of the built-in encoders.

Optional *policy* argument defaults to *compat32*.

_params are passed straight through to the base class constructor.

在 3.6 版的變更: 新增僅限關鍵字參數 *policy*。

```
class email.mime.image.MIMEImage(_imagedata, _subtype=None,
                                   _encoder=email.encoders.encode_base64, *, policy=compat32,
                                   **_params)
```

模組: `email.mime.image`

A subclass of *MIMENonMultipart*, the *MIMEImage* class is used to create MIME message objects of major type *image*. *_imagedata* contains the bytes for the raw image data. If this data type can be detected (jpeg, png, gif, tiff, rgb, pbm, pgm, ppm, rast, xbm, bmp, webp, and exr attempted), then the subtype will be automatically included in the *Content-Type* header. Otherwise you can explicitly specify the image subtype via the *_subtype* argument. If the minor type could not be guessed and *_subtype* was not given, then *TypeError* is raised.

Optional *_encoder* is a callable (i.e. function) which will perform the actual encoding of the image data for transport. This callable takes one argument, which is the *MIMEImage* instance. It should use *get_payload()* and *set_payload()* to change the payload to encoded form. It should also add any *Content-Transfer-Encoding* or other headers to the message object as necessary. The default encoding is base64. See the *email.encoders* module for a list of the built-in encoders.

Optional *policy* argument defaults to *compat32*.

_params are passed straight through to the *MIMEBase* constructor.

在 3.6 版的變更: 新增僅限關鍵字參數 *policy*。

```
class email.mime.message.MIMEMessage(_msg, _subtype='rfc822', *, policy=compat32)
```

模組: `email.mime.message`

A subclass of *MIMENonMultipart*, the *MIMEMessage* class is used to create MIME objects of main type *message*. *_msg* is used as the payload, and must be an instance of class *Message* (or a subclass thereof), otherwise a *TypeError* is raised.

Optional *_subtype* sets the subtype of the message; it defaults to *rfc822*.

Optional *policy* argument defaults to *compat32*.

在 3.6 版的變更: 新增僅限關鍵字參數 *policy*。

```
class email.mime.text.MIMEText(_text, _subtype='plain', _charset=None, *, policy=compat32)
```

模組: `email.mime.text`

A subclass of *MIMENonMultipart*, the *MIMEText* class is used to create MIME objects of major type *text*. *_text* is the string for the payload. *_subtype* is the minor type and defaults to *plain*. *_charset* is the

character set of the text and is passed as an argument to the `MIMENonMultipart` constructor; it defaults to `us-ascii` if the string contains only `ascii` code points, and `utf-8` otherwise. The `_charset` parameter accepts either a string or a `Charset` instance.

Unless the `_charset` argument is explicitly set to `None`, the `MIMEText` object created will have both a `Content-Type` header with a `charset` parameter, and a `Content-Transfer-Encoding` header. This means that a subsequent `set_payload` call will not result in an encoded payload, even if a charset is passed in the `set_payload` command. You can “reset” this behavior by deleting the `Content-Transfer-Encoding` header, after which a `set_payload` call will automatically encode the new payload (and add a new `Content-Transfer-Encoding` header).

Optional `policy` argument defaults to `compat32`.

在 3.5 版的變更: `_charset` also accepts `Charset` instances.

在 3.6 版的變更: 新增僅限關鍵字參數 `policy`。

19.1.11 email.header: Internationalized headers

原始碼: [Lib/email/header.py](#)

This module is part of the legacy (Compat32) email API. In the current API encoding and decoding of headers is handled transparently by the dictionary-like API of the `EmailMessage` class. In addition to uses in legacy code, this module can be useful in applications that need to completely control the character sets used when encoding headers.

The remaining text in this section is the original documentation of the module.

RFC 2822 is the base standard that describes the format of email messages. It derives from the older **RFC 822** standard which came into widespread use at a time when most email was composed of ASCII characters only. **RFC 2822** is a specification written assuming email contains only 7-bit ASCII characters.

Of course, as email has been deployed worldwide, it has become internationalized, such that language specific character sets can now be used in email messages. The base standard still requires email messages to be transferred using only 7-bit ASCII characters, so a slew of RFCs have been written describing how to encode email containing non-ASCII characters into **RFC 2822**-compliant format. These RFCs include **RFC 2045**, **RFC 2046**, **RFC 2047**, and **RFC 2231**. The `email` package supports these standards in its `email.header` and `email.charset` modules.

If you want to include non-ASCII characters in your email headers, say in the `Subject` or `To` fields, you should use the `Header` class and assign the field in the `Message` object to an instance of `Header` instead of using a string for the header value. Import the `Header` class from the `email.header` module. For example:

```
>>> from email.message import Message
>>> from email.header import Header
>>> msg = Message()
>>> h = Header('p\xf6stal', 'iso-8859-1')
>>> msg['Subject'] = h
>>> msg.as_string()
'Subject: =?iso-8859-1?q?p=F6stal?=\n\n'
```

Notice here how we wanted the `Subject` field to contain a non-ASCII character? We did this by creating a `Header` instance and passing in the character set that the byte string was encoded in. When the subsequent `Message` instance was flattened, the `Subject` field was properly **RFC 2047** encoded. MIME-aware mail readers would show this header using the embedded ISO-8859-1 character.

Here is the `Header` class description:

```
class email.header.Header(s=None, charset=None, maxlinelen=None, header_name=None,
                          continuation_ws=' ', errors='strict')
```

Create a MIME-compliant header that can contain strings in different character sets.

Optional *s* is the initial header value. If `None` (the default), the initial header value is not set. You can later append to the header with `append()` method calls. *s* may be an instance of `bytes` or `str`, but see the `append()` documentation for semantics.

Optional *charset* serves two purposes: it has the same meaning as the *charset* argument to the `append()` method. It also sets the default character set for all subsequent `append()` calls that omit the *charset* argument. If *charset* is not provided in the constructor (the default), the `us-ascii` character set is used both as *s*'s initial charset and as the default for subsequent `append()` calls.

The maximum line length can be specified explicitly via *maxlinelen*. For splitting the first line to a shorter value (to account for the field header which isn't included in *s*, e.g. *Subject*) pass in the name of the field in *header_name*. The default *maxlinelen* is 76, and the default value for *header_name* is `None`, meaning it is not taken into account for the first line of a long, split header.

Optional *continuation_ws* must be **RFC 2822**-compliant folding whitespace, and is usually either a space or a hard tab character. This character will be prepended to continuation lines. *continuation_ws* defaults to a single space character.

Optional *errors* is passed straight through to the `append()` method.

append (*s*, *charset*=`None`, *errors*=`'strict'`)

Append the string *s* to the MIME header.

Optional *charset*, if given, should be a `Charset` instance (see `email.charset`) or the name of a character set, which will be converted to a `Charset` instance. A value of `None` (the default) means that the *charset* given in the constructor is used.

s may be an instance of `bytes` or `str`. If it is an instance of `bytes`, then *charset* is the encoding of that byte string, and a `UnicodeError` will be raised if the string cannot be decoded with that character set.

If *s* is an instance of `str`, then *charset* is a hint specifying the character set of the characters in the string.

In either case, when producing an **RFC 2822**-compliant header using **RFC 2047** rules, the string will be encoded using the output codec of the charset. If the string cannot be encoded using the output codec, a `UnicodeError` will be raised.

Optional *errors* is passed as the *errors* argument to the decode call if *s* is a byte string.

encode (*splitchars*=`','`, `\t`, *maxlinelen*=`None`, *linesep*=`\n`)

Encode a message header into an RFC-compliant format, possibly wrapping long lines and encapsulating non-ASCII parts in base64 or quoted-printable encodings.

Optional *splitchars* is a string containing characters which should be given extra weight by the splitting algorithm during normal header wrapping. This is in very rough support of **RFC 2822**'s 'higher level syntactic breaks': split points preceded by a splitchar are preferred during line splitting, with the characters preferred in the order in which they appear in the string. Space and tab may be included in the string to indicate whether preference should be given to one over the other as a split point when other split chars do not appear in the line being split. *Splitchars* does not affect **RFC 2047** encoded lines.

maxlinelen, if given, overrides the instance's value for the maximum line length.

linesep specifies the characters used to separate the lines of the folded header. It defaults to the most useful value for Python application code (`\n`), but `\r\n` can be specified in order to produce headers with RFC-compliant line separators.

在 3.2 版的變更: 新增引數 *linesep*。

The `Header` class also provides a number of methods to support standard operators and built-in functions.

__str__ ()

Returns an approximation of the `Header` as a string, using an unlimited line length. All pieces are converted to unicode using the specified encoding and joined together appropriately. Any pieces with a charset of `'unknown-8bit'` are decoded as ASCII using the `'replace'` error handler.

在 3.2 版的變更: Added handling for the `'unknown-8bit'` charset.

`__eq__(other)`

This method allows you to compare two *Header* instances for equality.

`__ne__(other)`

This method allows you to compare two *Header* instances for inequality.

The *email.header* module also provides the following convenient functions.

`email.header.decode_header(header)`

Decode a message header value without converting the character set. The header value is in *header*.

This function returns a list of (*decoded_string*, *charset*) pairs containing each of the decoded parts of the header. *charset* is *None* for non-encoded parts of the header, otherwise a lower case string containing the name of the character set specified in the encoded string.

以下是個範例：

```
>>> from email.header import decode_header
>>> decode_header('=?iso-8859-1?q?p=F6stal?='')
[(b'p\xF6stal', 'iso-8859-1')]
```

`email.header.make_header(decoded_seq, maxlinelen=None, header_name=None, continuation_ws='')`

Create a *Header* instance from a sequence of pairs as returned by *decode_header()*.

decode_header() takes a header value string and returns a sequence of pairs of the format (*decoded_string*, *charset*) where *charset* is the name of the character set.

This function takes one of those sequence of pairs and returns a *Header* instance. Optional *maxlinelen*, *header_name*, and *continuation_ws* are as in the *Header* constructor.

19.1.12 email.charset: Representing character sets

原始碼： [Lib/email/charset.py](#)

This module is part of the legacy (Compat32) email API. In the new API only the aliases table is used.

The remaining text in this section is the original documentation of the module.

This module provides a class *Charset* for representing character sets and character set conversions in email messages, as well as a character set registry and several convenience methods for manipulating this registry. Instances of *Charset* are used in several other modules within the *email* package.

Import this class from the *email.charset* module.

class `email.charset.Charset(input_charset=DEFAULT_CHARSET)`

Map character sets to their email properties.

This class provides information about the requirements imposed on email for a specific character set. It also provides convenience routines for converting between character sets, given the availability of the applicable codecs. Given a character set, it will do its best to provide information on how to use that character set in an email message in an RFC-compliant way.

Certain character sets must be encoded with quoted-printable or base64 when used in email headers or bodies. Certain character sets must be converted outright, and are not allowed in email.

Optional *input_charset* is as described below; it is always coerced to lower case. After being alias normalized it is also used as a lookup into the registry of character sets to find out the header encoding, body encoding, and output conversion codec to be used for the character set. For example, if *input_charset* is *iso-8859-1*, then headers and bodies will be encoded using quoted-printable and no output conversion codec is necessary. If *input_charset* is *eur-jp*, then headers will be encoded with base64, bodies will not be encoded, but output text will be converted from the *eur-jp* character set to the *iso-2022-jp* character set.

Charset instances have the following data attributes:

input_charset

The initial character set specified. Common aliases are converted to their *official* email names (e.g. `latin_1` is converted to `iso-8859-1`). Defaults to 7-bit `us-ascii`.

header_encoding

If the character set must be encoded before it can be used in an email header, this attribute will be set to `Charset.QP` (for quoted-printable), `Charset.BASE64` (for base64 encoding), or `Charset.SHORTEST` for the shortest of QP or BASE64 encoding. Otherwise, it will be `None`.

body_encoding

Same as `header_encoding`, but describes the encoding for the mail message's body, which indeed may be different than the header encoding. `Charset.SHORTEST` is not allowed for *body_encoding*.

output_charset

Some character sets must be converted before they can be used in email headers or bodies. If the *input_charset* is one of them, this attribute will contain the name of the character set output will be converted to. Otherwise, it will be `None`.

input_codec

The name of the Python codec used to convert the *input_charset* to Unicode. If no conversion codec is necessary, this attribute will be `None`.

output_codec

The name of the Python codec used to convert Unicode to the *output_charset*. If no conversion codec is necessary, this attribute will have the same value as the *input_codec*.

`Charset` instances also have the following methods:

get_body_encoding()

Return the content transfer encoding used for body encoding.

This is either the string `quoted-printable` or `base64` depending on the encoding used, or it is a function, in which case you should call the function with a single argument, the `Message` object being encoded. The function should then set the *Content-Transfer-Encoding* header itself to whatever is appropriate.

Returns the string `quoted-printable` if *body_encoding* is `QP`, returns the string `base64` if *body_encoding* is `BASE64`, and returns the string `7bit` otherwise.

get_output_charset()

Return the output character set.

This is the *output_charset* attribute if that is not `None`, otherwise it is *input_charset*.

header_encode(string)

Header-encode the string *string*.

The type of encoding (base64 or quoted-printable) will be based on the *header_encoding* attribute.

header_encode_lines(string, maxlengths)

Header-encode a *string* by converting it first to bytes.

This is similar to `header_encode()` except that the string is fit into maximum line lengths as given by the argument *maxlengths*, which must be an iterator: each element returned from this iterator will provide the next maximum line length.

body_encode(string)

Body-encode the string *string*.

The type of encoding (base64 or quoted-printable) will be based on the *body_encoding* attribute.

The `Charset` class also provides a number of methods to support standard operations and built-in functions.

`__str__()`

Returns `input_charset` as a string coerced to lower case. `__repr__()` is an alias for `__str__()`.

`__eq__(other)`

This method allows you to compare two `Charset` instances for equality.

`__ne__(other)`

This method allows you to compare two `Charset` instances for inequality.

The `email.charset` module also provides the following functions for adding new entries to the global character set, alias, and codec registries:

`email.charset.add_charset(charset, header_enc=None, body_enc=None, output_charset=None)`

Add character properties to the global registry.

`charset` is the input character set, and must be the canonical name of a character set.

Optional `header_enc` and `body_enc` is either `Charset.QP` for quoted-printable, `Charset.BASE64` for base64 encoding, `Charset.SHORTEST` for the shortest of quoted-printable or base64 encoding, or `None` for no encoding. `SHORTEST` is only valid for `header_enc`. The default is `None` for no encoding.

Optional `output_charset` is the character set that the output should be in. Conversions will proceed from input charset, to Unicode, to the output charset when the method `Charset.convert()` is called. The default is to output in the same character set as the input.

Both `input_charset` and `output_charset` must have Unicode codec entries in the module's character set-to-codec mapping; use `add_codec()` to add codecs the module does not know about. See the `codecs` module's documentation for more information.

The global character set registry is kept in the module global dictionary `CHARSETS`.

`email.charset.add_alias(alias, canonical)`

Add a character set alias. `alias` is the alias name, e.g. `latin-1`. `canonical` is the character set's canonical name, e.g. `iso-8859-1`.

The global charset alias registry is kept in the module global dictionary `ALIASES`.

`email.charset.add_codec(charset, codecname)`

Add a codec that map characters in the given character set to and from Unicode.

`charset` is the canonical name of a character set. `codecname` is the name of a Python codec, as appropriate for the second argument to the `str`'s `encode()` method.

19.1.13 email.encoders: Encoders

原始碼: [Lib/email/encoders.py](#)

This module is part of the legacy (Compat32) email API. In the new API the functionality is provided by the `cte` parameter of the `set_content()` method.

This module is deprecated in Python 3. The functions provided here should not be called explicitly since the `MIMEText` class sets the content type and CTE header using the `_subtype` and `_charset` values passed during the instantiation of that class.

The remaining text in this section is the original documentation of the module.

When creating `Message` objects from scratch, you often need to encode the payloads for transport through compliant mail servers. This is especially true for `image/*` and `text/*` type messages containing binary data.

The `email` package provides some convenient encoders in its `encoders` module. These encoders are actually used by the `MIMEAudio` and `MIMEImage` class constructors to provide default encodings. All encoder functions take exactly one argument, the message object to encode. They usually extract the payload, encode it, and reset the payload to this newly encoded value. They should also set the `Content-Transfer-Encoding` header as appropriate.

Note that these functions are not meaningful for a multipart message. They must be applied to individual subparts instead, and will raise a `TypeError` if passed a message whose type is multipart.

Here are the encoding functions provided:

`email.encoders.encode_quopri(msg)`

Encodes the payload into quoted-printable form and sets the *Content-Transfer-Encoding* header to *quoted-printable*¹. This is a good encoding to use when most of your payload is normal printable data, but contains a few unprintable characters.

`email.encoders.encode_base64(msg)`

Encodes the payload into base64 form and sets the *Content-Transfer-Encoding* header to *base64*. This is a good encoding to use when most of your payload is unprintable data since it is a more compact form than quoted-printable. The drawback of base64 encoding is that it renders the text non-human readable.

`email.encoders.encode_7or8bit(msg)`

This doesn't actually modify the message's payload, but it does set the *Content-Transfer-Encoding* header to either *7bit* or *8bit* as appropriate, based on the payload data.

`email.encoders.encode_noop(msg)`

This does nothing; it doesn't even set the *Content-Transfer-Encoding* header.

解

19.1.14 `email.utils`: Miscellaneous utilities

原始碼: [Lib/email/utils.py](#)

There are a couple of useful utilities provided in the `email.utils` module:

`email.utils.localtime(dt=None)`

Return local time as an aware datetime object. If called without arguments, return current time. Otherwise *dt* argument should be a *datetime* instance, and it is converted to the local time zone according to the system time zone database. If *dt* is naive (that is, *dt.tzinfo* is *None*), it is assumed to be in local time. In this case, a positive or zero value for *isdst* causes *localtime* to presume initially that summer time (for example, Daylight Saving Time) is or is not (respectively) in effect for the specified time. A negative value for *isdst* causes the *localtime* to attempt to divine whether summer time is in effect for the specified time.

在 3.3 版新加入。

`email.utils.make_msgid(idstring=None, domain=None)`

Returns a string suitable for an **RFC 2822**-compliant *Message-ID* header. Optional *idstring* if given, is a string used to strengthen the uniqueness of the message id. Optional *domain* if given provides the portion of the msgid after the '@'. The default is the local hostname. It is not normally necessary to override this default, but may be useful certain cases, such as a constructing distributed system that uses a consistent domain name across multiple hosts.

在 3.2 版的變更: 新增 *domain* 關鍵字。

The remaining functions are part of the legacy (Compat32) email API. There is no need to directly use these with the new API, since the parsing and formatting they provide is done automatically by the header parsing machinery of the new API.

`email.utils.quote(str)`

Return a new string with backslashes in *str* replaced by two backslashes, and double quotes replaced by backslash-double quote.

¹ Note that encoding with `encode_quopri()` also encodes all tabs and space characters in the data.

`email.utils.unquote(str)`

Return a new string which is an *unquoted* version of *str*. If *str* ends and begins with double quotes, they are stripped off. Likewise if *str* ends and begins with angle brackets, they are stripped off.

`email.utils.parseaddr(address)`

Parse address -- which should be the value of some address-containing field such as *To* or *Cc* -- into its constituent *realname* and *email address* parts. Returns a tuple of that information, unless the parse fails, in which case a 2-tuple of ('', '') is returned.

`email.utils.formataddr(pair, charset='utf-8')`

The inverse of `parseaddr()`, this takes a 2-tuple of the form (*realname*, *email_address*) and returns the string value suitable for a *To* or *Cc* header. If the first element of *pair* is false, then the second element is returned unmodified.

Optional *charset* is the character set that will be used in the [RFC 2047](#) encoding of the *realname* if the *realname* contains non-ASCII characters. Can be an instance of *str* or a *Charset*. Defaults to `utf-8`.

在 3.3 版的變更: 新增 *charset* 選項。

`email.utils.getaddresses(fieldvalues)`

This method returns a list of 2-tuples of the form returned by `parseaddr()`. *fieldvalues* is a sequence of header field values as might be returned by `Message.get_all`. Here's a simple example that gets all the recipients of a message:

```
from email.utils import getaddresses

tos = msg.get_all('to', [])
ccs = msg.get_all('cc', [])
resent_tos = msg.get_all('resent-to', [])
resent_ccs = msg.get_all('resent-cc', [])
all_recipients = getaddresses(tos + ccs + resent_tos + resent_ccs)
```

`email.utils.parsedate(date)`

Attempts to parse a date according to the rules in [RFC 2822](#). however, some mailers don't follow that format as specified, so `parsedate()` tries to guess correctly in such cases. *date* is a string containing an [RFC 2822](#) date, such as "Mon, 20 Nov 1995 19:12:08 -0500". If it succeeds in parsing the date, `parsedate()` returns a 9-tuple that can be passed directly to `time.mktime()`; otherwise `None` will be returned. Note that indexes 6, 7, and 8 of the result tuple are not usable.

`email.utils.parsedate_tz(date)`

Performs the same function as `parsedate()`, but returns either `None` or a 10-tuple; the first 9 elements make up a tuple that can be passed directly to `time.mktime()`, and the tenth is the offset of the date's timezone from UTC (which is the official term for Greenwich Mean Time)¹. If the input string has no timezone, the last element of the tuple returned is 0, which represents UTC. Note that indexes 6, 7, and 8 of the result tuple are not usable.

`email.utils.parsedate_to_datetime(date)`

The inverse of `format_datetime()`. Performs the same function as `parsedate()`, but on success returns a *datetime*; otherwise `ValueError` is raised if *date* contains an invalid value such as an hour greater than 23 or a timezone offset not between -24 and 24 hours. If the input date has a timezone of -0000, the *datetime* will be a naive *datetime*, and if the date is conforming to the RFCs it will represent a time in UTC but with no indication of the actual source timezone of the message the date comes from. If the input date has any other valid timezone offset, the *datetime* will be an aware *datetime* with the corresponding a *timezone tzinfo*.

在 3.3 版新加入。

`email.utils.mktime_tz(tuple)`

Turn a 10-tuple as returned by `parsedate_tz()` into a UTC timestamp (seconds since the Epoch). If the *timezone* item in the tuple is `None`, assume local time.

¹ Note that the sign of the timezone offset is the opposite of the sign of the `time.timezone` variable for the same timezone; the latter variable follows the POSIX standard while this module follows [RFC 2822](#).

`email.utils.formatdate (timeval=None, localtime=False, usegmt=False)`

Returns a date string as per [RFC 2822](#), e.g.:

```
Fri, 09 Nov 2001 01:08:47 -0000
```

Optional *timeval* if given is a floating point time value as accepted by `time.gmtime()` and `time.localtime()`, otherwise the current time is used.

Optional *localtime* is a flag that when `True`, interprets *timeval*, and returns a date relative to the local timezone instead of UTC, properly taking daylight savings time into account. The default is `False` meaning UTC is used.

Optional *usegmt* is a flag that when `True`, outputs a date string with the timezone as an ascii string GMT, rather than a numeric `-0000`. This is needed for some protocols (such as HTTP). This only applies when *localtime* is `False`. The default is `False`.

`email.utils.format_datetime (dt, usegmt=False)`

Like `formatdate`, but the input is a *datetime* instance. If it is a naive datetime, it is assumed to be "UTC with no information about the source timezone", and the conventional `-0000` is used for the timezone. If it is an aware datetime, then the numeric timezone offset is used. If it is an aware timezone with offset zero, then *usegmt* may be set to `True`, in which case the string GMT is used instead of the numeric timezone offset. This provides a way to generate standards conformant HTTP date headers.

在 3.3 版新加入。

`email.utils.decode_rfc2231 (s)`

Decode the string *s* according to [RFC 2231](#).

`email.utils.encode_rfc2231 (s, charset=None, language=None)`

Encode the string *s* according to [RFC 2231](#). Optional *charset* and *language*, if given is the character set name and language name to use. If neither is given, *s* is returned as-is. If *charset* is given but *language* is not, the string is encoded using the empty string for *language*.

`email.utils.collapse_rfc2231_value (value, errors='replace', fallback_charset='us-ascii')`

When a header parameter is encoded in [RFC 2231](#) format, `Message.get_param` may return a 3-tuple containing the character set, language, and value. `collapse_rfc2231_value()` turns this into a unicode string. Optional *errors* is passed to the *errors* argument of *str*'s `encode()` method; it defaults to `'replace'`. Optional *fallback_charset* specifies the character set to use if the one in the [RFC 2231](#) header is not known by Python; it defaults to `'us-ascii'`.

For convenience, if the *value* passed to `collapse_rfc2231_value()` is not a tuple, it should be a string and it is returned unquoted.

`email.utils.decode_params (params)`

Decode parameters list according to [RFC 2231](#). *params* is a sequence of 2-tuples containing elements of the form (content-type, string-value).

解

19.1.15 email.iterators: Iterators

原始碼: [Lib/email/iterators.py](#)

Iterating over a message object tree is fairly easy with the `Message.walk` method. The `email.iterators` module provides some useful higher level iterations over message object trees.

`email.iterators.body_line_iterator(msg, decode=False)`

This iterates over all the payloads in all the subparts of *msg*, returning the string payloads line-by-line. It skips over all the subpart headers, and it skips over any subpart with a payload that isn't a Python string. This is somewhat equivalent to reading the flat text representation of the message from a file using `readline()`, skipping over all the intervening headers.

Optional *decode* is passed through to `Message.get_payload()`.

`email.iterators.typed_subpart_iterator(msg, maintype='text', subtype=None)`

This iterates over all the subparts of *msg*, returning only those subparts that match the MIME type specified by *maintype* and *subtype*.

Note that *subtype* is optional; if omitted, then subpart MIME type matching is done only with the main type. *maintype* is optional too; it defaults to *text*.

Thus, by default `typed_subpart_iterator()` returns each subpart that has a MIME type of *text/**.

The following function has been added as a useful debugging tool. It should *not* be considered part of the supported public interface for the package.

`email.iterators._structure(msg, fp=None, level=0, include_default=False)`

Prints an indented representation of the content types of the message object structure. For example:

```
>>> msg = email.message_from_file(somefile)
>>> _structure(msg)
multipart/mixed
  text/plain
  text/plain
  multipart/digest
    message/rfc822
      text/plain
    message/rfc822
      text/plain
    message/rfc822
      text/plain
    message/rfc822
      text/plain
    message/rfc822
      text/plain
    message/rfc822
      text/plain
    message/rfc822
      text/plain
  text/plain
```

Optional *fp* is a file-like object to print the output to. It must be suitable for Python's `print()` function. *level* is used internally. *include_default*, if true, prints the default type as well.

也參考:

smtplib 模組

SMTP (Simple Mail Transport Protocol) client

poplib 模組

POP (Post Office Protocol) client

imaplib 模組

IMAP (Internet Message Access Protocol) client

nntplib 模組

NNTP (Net News Transport Protocol) client

mailbox 模組

Tools for creating, reading, and managing collections of messages on disk using a variety standard formats.

smtpd 模組

SMTP server framework (primarily useful for testing)

19.2 json --- JSON encoder and decoder

原始碼: `Lib/json/__init__.py`

JSON (JavaScript Object Notation), specified by [RFC 7159](#) (which obsoletes [RFC 4627](#)) and by [ECMA-404](#), is a lightweight data interchange format inspired by JavaScript object literal syntax (although it is not a strict subset of JavaScript¹).

警告: Be cautious when parsing JSON data from untrusted sources. A malicious JSON string may cause the decoder to consume considerable CPU and memory resources. Limiting the size of data to be parsed is recommended.

`json` exposes an API familiar to users of the standard library `marshal` and `pickle` modules.

Encoding basic Python object hierarchies:

```
>>> import json
>>> json.dumps(['foo', {'bar': ('baz', None, 1.0, 2)}])
'["foo", {"bar": ["baz", null, 1.0, 2]}]'
>>> print(json.dumps("\foo\bar"))
"\foo\bar"
>>> print(json.dumps('\u1234'))
"\u1234"
>>> print(json.dumps('\"'))
"\""
>>> print(json.dumps({'c': 0, 'b': 0, 'a': 0}, sort_keys=True))
{"a": 0, "b": 0, "c": 0}
>>> from io import StringIO
>>> io = StringIO()
>>> json.dump(['streaming API'], io)
>>> io.getvalue()
'["streaming API"]'
```

Compact encoding:

```
>>> import json
>>> json.dumps([1, 2, 3, {'4': 5, '6': 7}], separators=(',', ':'))
'[1,2,3,{"4":5,"6":7}]'
```

美化輸出:

```
>>> import json
>>> print(json.dumps({'4': 5, '6': 7}, sort_keys=True, indent=4))
{
    "4": 5,
    "6": 7
}
```

Decoding JSON:

```
>>> import json
>>> json.loads('["foo", {"bar":["baz", null, 1.0, 2]}]')
['foo', {'bar': ['baz', None, 1.0, 2]}]
>>> json.loads('\"\\foo\\bar\"')
'foo\x08ar'
>>> from io import StringIO
```

(繼續下一頁)

¹ As noted in the [errata for RFC 7159](#), JSON permits literal U+2028 (LINE SEPARATOR) and U+2029 (PARAGRAPH SEPARATOR) characters in strings, whereas JavaScript (as of ECMAScript Edition 5.1) does not.

(繼續上一頁)

```
>>> io = StringIO(['streaming API'])
>>> json.load(io)
['streaming API']
```

Specializing JSON object decoding:

```
>>> import json
>>> def as_complex(dct):
...     if '__complex__' in dct:
...         return complex(dct['real'], dct['imag'])
...     return dct
...
>>> json.loads('{ "__complex__": true, "real": 1, "imag": 2}',
...             object_hook=as_complex)
(1+2j)
>>> import decimal
>>> json.loads('1.1', parse_float=decimal.Decimal)
Decimal('1.1')
```

Extending *JSONEncoder*:

```
>>> import json
>>> class ComplexEncoder(json.JSONEncoder):
...     def default(self, obj):
...         if isinstance(obj, complex):
...             return [obj.real, obj.imag]
...         # Let the base class default method raise the TypeError
...         return super().default(obj)
...
>>> json.dumps(2 + 1j, cls=ComplexEncoder)
'[2.0, 1.0]'
>>> ComplexEncoder().encode(2 + 1j)
'[2.0, 1.0]'
>>> list(ComplexEncoder().iterencode(2 + 1j))
['[2.0', ', ', '1.0', ', ', ']'']
```

Using *json.tool* from the shell to validate and pretty-print:

```
$ echo '{"json":"obj"}' | python -m json.tool
{
    "json": "obj"
}
$ echo '{1.2:3.4}' | python -m json.tool
Expecting property name enclosed in double quotes: line 1 column 2 (char 1)
```

更詳盡的文件請見 *Command Line Interface*。

備註： JSON is a subset of **YAML 1.2**. The JSON produced by this module's default settings (in particular, the default *separators* value) is also a subset of **YAML 1.0** and **1.1**. This module can thus also be used as a **YAML** serializer.

備註： This module's encoders and decoders preserve input and output order by default. Order is only lost if the underlying containers are unordered.

19.2.1 基本用法

```
json.dump(obj, fp, *, skipkeys=False, ensure_ascii=True, check_circular=True, allow_nan=True, cls=None,
          indent=None, separators=None, default=None, sort_keys=False, **kw)
```

Serialize *obj* as a JSON formatted stream to *fp* (a `.write()`-supporting *file-like object*) using this *conversion table*.

If *skipkeys* is true (default: `False`), then dict keys that are not of a basic type (*str*, *int*, *float*, *bool*, *None*) will be skipped instead of raising a *TypeError*.

The *json* module always produces *str* objects, not *bytes* objects. Therefore, `fp.write()` must support *str* input.

If *ensure_ascii* is true (the default), the output is guaranteed to have all incoming non-ASCII characters escaped. If *ensure_ascii* is false, these characters will be output as-is.

If *check_circular* is false (default: `True`), then the circular reference check for container types will be skipped and a circular reference will result in a *RecursionError* (or worse).

If *allow_nan* is false (default: `True`), then it will be a *ValueError* to serialize out of range *float* values (*nan*, *inf*, *-inf*) in strict compliance of the JSON specification. If *allow_nan* is true, their JavaScript equivalents (*NaN*, *Infinity*, *-Infinity*) will be used.

If *indent* is a non-negative integer or string, then JSON array elements and object members will be pretty-printed with that indent level. An indent level of 0, negative, or "" will only insert newlines. *None* (the default) selects the most compact representation. Using a positive integer *indent* indents that many spaces per level. If *indent* is a string (such as "\t"), that string is used to indent each level.

在 3.2 版的變更: Allow strings for *indent* in addition to integers.

If specified, *separators* should be an (*item_separator*, *key_separator*) tuple. The default is (' ', ': ') if *indent* is *None* and ('', ': ') otherwise. To get the most compact JSON representation, you should specify ('', ': ') to eliminate whitespace.

在 3.4 版的變更: Use (' ', ': ') as default if *indent* is not *None*.

If specified, *default* should be a function that gets called for objects that can't otherwise be serialized. It should return a JSON encodable version of the object or raise a *TypeError*. If not specified, *TypeError* is raised.

If *sort_keys* is true (default: `False`), then the output of dictionaries will be sorted by key.

To use a custom *JSONEncoder* subclass (e.g. one that overrides the *default()* method to serialize additional types), specify it with the *cls* kwarg; otherwise *JSONEncoder* is used.

在 3.6 版的變更: All optional parameters are now *keyword-only*.

備註: Unlike *pickle* and *marshal*, JSON is not a framed protocol, so trying to serialize multiple objects with repeated calls to *dump()* using the same *fp* will result in an invalid JSON file.

```
json.dumps(obj, *, skipkeys=False, ensure_ascii=True, check_circular=True, allow_nan=True, cls=None,
           indent=None, separators=None, default=None, sort_keys=False, **kw)
```

Serialize *obj* to a JSON formatted *str* using this *conversion table*. The arguments have the same meaning as in *dump()*.

備註: Keys in key/value pairs of JSON are always of the type *str*. When a dictionary is converted into JSON, all the keys of the dictionary are coerced to strings. As a result of this, if a dictionary is converted into JSON and then back into a dictionary, the dictionary may not equal the original one. That is, `loads(dumps(x)) != x` if *x* has non-string keys.

```
json.load(fp, *, cls=None, object_hook=None, parse_float=None, parse_int=None, parse_constant=None,
          object_pairs_hook=None, **kw)
```

Deserialize *fp* (a `.read()`-supporting *text file* or *binary file* containing a JSON document) to a Python object using this *conversion table*.

object_hook is an optional function that will be called with the result of any object literal decoded (a *dict*). The return value of *object_hook* will be used instead of the *dict*. This feature can be used to implement custom decoders (e.g. *JSON-RPC* class hinting).

object_pairs_hook is an optional function that will be called with the result of any object literal decoded with an ordered list of pairs. The return value of *object_pairs_hook* will be used instead of the *dict*. This feature can be used to implement custom decoders. If *object_hook* is also defined, the *object_pairs_hook* takes priority.

在 3.1 版的變更: 新增對於 *object_pairs_hook* 的支援。

parse_float, if specified, will be called with the string of every JSON float to be decoded. By default, this is equivalent to `float(num_str)`. This can be used to use another datatype or parser for JSON floats (e.g. *decimal.Decimal*).

parse_int, if specified, will be called with the string of every JSON int to be decoded. By default, this is equivalent to `int(num_str)`. This can be used to use another datatype or parser for JSON integers (e.g. *float*).

在 3.11 版的變更: The default *parse_int* of *int()* now limits the maximum length of the integer string via the interpreter's *integer string conversion length limitation* to help avoid denial of service attacks.

parse_constant, if specified, will be called with one of the following strings: `'-Infinity'`, `'Infinity'`, `'NaN'`. This can be used to raise an exception if invalid JSON numbers are encountered.

在 3.1 版的變更: *parse_constant* doesn't get called on `'null'`, `'true'`, `'false'` anymore.

To use a custom *JSONDecoder* subclass, specify it with the `cls` kwarg; otherwise *JSONDecoder* is used. Additional keyword arguments will be passed to the constructor of the class.

If the data being deserialized is not a valid JSON document, a *JSONDecodeError* will be raised.

在 3.6 版的變更: All optional parameters are now *keyword-only*.

在 3.6 版的變更: *fp* can now be a *binary file*. The input encoding should be UTF-8, UTF-16 or UTF-32.

```
json.loads(s, *, cls=None, object_hook=None, parse_float=None, parse_int=None, parse_constant=None,
           object_pairs_hook=None, **kw)
```

Deserialize *s* (a *str*, *bytes* or *bytearray* instance containing a JSON document) to a Python object using this *conversion table*.

The other arguments have the same meaning as in *load()*.

If the data being deserialized is not a valid JSON document, a *JSONDecodeError* will be raised.

在 3.6 版的變更: *s* can now be of type *bytes* or *bytearray*. The input encoding should be UTF-8, UTF-16 or UTF-32.

在 3.9 版的變更: The keyword argument *encoding* has been removed.

19.2.2 Encoders and Decoders

```
class json.JSONDecoder(*, object_hook=None, parse_float=None, parse_int=None,
                       parse_constant=None, strict=True, object_pairs_hook=None)
```

Simple JSON decoder.

Performs the following translations in decoding by default:

JSON	Python
object	dict
array	list
string	str
number (int)	int
number (real)	float
true	True
false	False
null	None

It also understands `NaN`, `Infinity`, and `-Infinity` as their corresponding `float` values, which is outside the JSON spec.

object_hook, if specified, will be called with the result of every JSON object decoded and its return value will be used in place of the given *dict*. This can be used to provide custom deserializations (e.g. to support [JSON-RPC](#) class hinting).

object_pairs_hook, if specified will be called with the result of every JSON object decoded with an ordered list of pairs. The return value of *object_pairs_hook* will be used instead of the *dict*. This feature can be used to implement custom decoders. If *object_hook* is also defined, the *object_pairs_hook* takes priority.

在 3.1 版的變更: 新增對於 *object_pairs_hook* 的支援。

parse_float, if specified, will be called with the string of every JSON float to be decoded. By default, this is equivalent to `float(num_str)`. This can be used to use another datatype or parser for JSON floats (e.g. [decimal.Decimal](#)).

parse_int, if specified, will be called with the string of every JSON int to be decoded. By default, this is equivalent to `int(num_str)`. This can be used to use another datatype or parser for JSON integers (e.g. [float](#)).

parse_constant, if specified, will be called with one of the following strings: `'-Infinity'`, `'Infinity'`, `'NaN'`. This can be used to raise an exception if invalid JSON numbers are encountered.

If *strict* is false (`True` is the default), then control characters will be allowed inside strings. Control characters in this context are those with character codes in the 0--31 range, including `'\t'` (tab), `'\n'`, `'\r'` and `'\0'`.

If the data being deserialized is not a valid JSON document, a [JSONDecodeError](#) will be raised.

在 3.6 版的變更: All parameters are now *keyword-only*.

decode (*s*)

Return the Python representation of *s* (a *str* instance containing a JSON document).

[JSONDecodeError](#) will be raised if the given JSON document is not valid.

raw_decode (*s*)

Decode a JSON document from *s* (a *str* beginning with a JSON document) and return a 2-tuple of the Python representation and the index in *s* where the document ended.

This can be used to decode a JSON document from a string that may have extraneous data at the end.

```
class json.JSONEncoder (*, skipkeys=False, ensure_ascii=True, check_circular=True, allow_nan=True,
                        sort_keys=False, indent=None, separators=None, default=None)
```

Extensible JSON encoder for Python data structures.

Supports the following objects and types by default:

Python	JSON
dict	object
list, tuple	array
str	string
int, float, int- & float-derived Enums	number
True	true
False	false
None	null

在 3.4 版的變更: Added support for int- and float-derived Enum classes.

To extend this to recognize other objects, subclass and implement a `default()` method with another method that returns a serializable object for `o` if possible, otherwise it should call the superclass implementation (to raise `TypeError`).

If `skipkeys` is false (the default), a `TypeError` will be raised when trying to encode keys that are not `str`, `int`, `float` or `None`. If `skipkeys` is true, such items are simply skipped.

If `ensure_ascii` is true (the default), the output is guaranteed to have all incoming non-ASCII characters escaped. If `ensure_ascii` is false, these characters will be output as-is.

If `check_circular` is true (the default), then lists, dicts, and custom encoded objects will be checked for circular references during encoding to prevent an infinite recursion (which would cause a `RecursionError`). Otherwise, no such check takes place.

If `allow_nan` is true (the default), then NaN, Infinity, and -Infinity will be encoded as such. This behavior is not JSON specification compliant, but is consistent with most JavaScript based encoders and decoders. Otherwise, it will be a `ValueError` to encode such floats.

If `sort_keys` is true (default: False), then the output of dictionaries will be sorted by key; this is useful for regression tests to ensure that JSON serializations can be compared on a day-to-day basis.

If `indent` is a non-negative integer or string, then JSON array elements and object members will be pretty-printed with that indent level. An indent level of 0, negative, or "" will only insert newlines. `None` (the default) selects the most compact representation. Using a positive integer indent indents that many spaces per level. If `indent` is a string (such as "\t"), that string is used to indent each level.

在 3.2 版的變更: Allow strings for `indent` in addition to integers.

If specified, `separators` should be an (`item_separator`, `key_separator`) tuple. The default is (' ', ': ') if `indent` is `None` and ('', ': ') otherwise. To get the most compact JSON representation, you should specify ('', ': ') to eliminate whitespace.

在 3.4 版的變更: Use (' ', ': ') as default if `indent` is not `None`.

If specified, `default` should be a function that gets called for objects that can't otherwise be serialized. It should return a JSON encodable version of the object or raise a `TypeError`. If not specified, `TypeError` is raised.

在 3.6 版的變更: All parameters are now *keyword-only*.

default (*o*)

Implement this method in a subclass such that it returns a serializable object for *o*, or calls the base implementation (to raise a `TypeError`).

For example, to support arbitrary iterators, you could implement `default()` like this:

```
def default(self, o):
    try:
        iterable = iter(o)
    except TypeError:
        pass
    else:
        return list(iterable)
```

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```
# Let the base class default method raise the TypeError
return super().default(o)
```

encode(o)

Return a JSON string representation of a Python data structure, *o*. For example:

```
>>> json.JSONEncoder().encode({"foo": ["bar", "baz"]})
'{"foo": ["bar", "baz"]}'
```

iterencode(o)

Encode the given object, *o*, and yield each string representation as available. For example:

```
for chunk in json.JSONEncoder().iterencode(bigobject):
    mysocket.write(chunk)
```

19.2.3 例外

exception `json.JSONDecodeError(msg, doc, pos)`

Subclass of `ValueError` with the following additional attributes:

msg

The unformatted error message.

doc

The JSON document being parsed.

pos

The start index of *doc* where parsing failed.

lineno

The line corresponding to *pos*.

colno

The column corresponding to *pos*.

在 3.5 版新加入。

19.2.4 Standard Compliance and Interoperability

The JSON format is specified by [RFC 7159](#) and by [ECMA-404](#). This section details this module's level of compliance with the RFC. For simplicity, `JSONEncoder` and `JSONDecoder` subclasses, and parameters other than those explicitly mentioned, are not considered.

This module does not comply with the RFC in a strict fashion, implementing some extensions that are valid JavaScript but not valid JSON. In particular:

- Infinite and NaN number values are accepted and output;
- Repeated names within an object are accepted, and only the value of the last name-value pair is used.

Since the RFC permits RFC-compliant parsers to accept input texts that are not RFC-compliant, this module's de-serializer is technically RFC-compliant under default settings.

Character Encodings

The RFC requires that JSON be represented using either UTF-8, UTF-16, or UTF-32, with UTF-8 being the recommended default for maximum interoperability.

As permitted, though not required, by the RFC, this module's serializer sets `ensure_ascii=True` by default, thus escaping the output so that the resulting strings only contain ASCII characters.

Other than the `ensure_ascii` parameter, this module is defined strictly in terms of conversion between Python objects and *Unicode strings*, and thus does not otherwise directly address the issue of character encodings.

The RFC prohibits adding a byte order mark (BOM) to the start of a JSON text, and this module's serializer does not add a BOM to its output. The RFC permits, but does not require, JSON deserializers to ignore an initial BOM in their input. This module's deserializer raises a *ValueError* when an initial BOM is present.

The RFC does not explicitly forbid JSON strings which contain byte sequences that don't correspond to valid Unicode characters (e.g. unpaired UTF-16 surrogates), but it does note that they may cause interoperability problems. By default, this module accepts and outputs (when present in the original *str*) code points for such sequences.

Infinite and NaN Number Values

The RFC does not permit the representation of infinite or NaN number values. Despite that, by default, this module accepts and outputs Infinity, -Infinity, and NaN as if they were valid JSON number literal values:

```
>>> # Neither of these calls raises an exception, but the results are not valid_
↪JSON
>>> json.dumps(float('-inf'))
'-Infinity'
>>> json.dumps(float('nan'))
'NaN'
>>> # Same when deserializing
>>> json.loads('-Infinity')
-inf
>>> json.loads('NaN')
nan
```

In the serializer, the `allow_nan` parameter can be used to alter this behavior. In the deserializer, the `parse_constant` parameter can be used to alter this behavior.

Repeated Names Within an Object

The RFC specifies that the names within a JSON object should be unique, but does not mandate how repeated names in JSON objects should be handled. By default, this module does not raise an exception; instead, it ignores all but the last name-value pair for a given name:

```
>>> weird_json = '{"x": 1, "x": 2, "x": 3}'
>>> json.loads(weird_json)
{'x': 3}
```

The `object_pairs_hook` parameter can be used to alter this behavior.

Top-level Non-Object, Non-Array Values

The old version of JSON specified by the obsolete [RFC 4627](#) required that the top-level value of a JSON text must be either a JSON object or array (Python *dict* or *list*), and could not be a JSON null, boolean, number, or string value. [RFC 7159](#) removed that restriction, and this module does not and has never implemented that restriction in either its serializer or its deserializer.

Regardless, for maximum interoperability, you may wish to voluntarily adhere to the restriction yourself.

Implementation Limitations

Some JSON deserializer implementations may set limits on:

- the size of accepted JSON texts
- the maximum level of nesting of JSON objects and arrays
- the range and precision of JSON numbers
- the content and maximum length of JSON strings

This module does not impose any such limits beyond those of the relevant Python datatypes themselves or the Python interpreter itself.

When serializing to JSON, beware any such limitations in applications that may consume your JSON. In particular, it is common for JSON numbers to be deserialized into IEEE 754 double precision numbers and thus subject to that representation's range and precision limitations. This is especially relevant when serializing Python *int* values of extremely large magnitude, or when serializing instances of "exotic" numerical types such as *decimal.Decimal*.

19.2.5 Command Line Interface

原始碼: [Lib/json/tool.py](#)

The *json.tool* module provides a simple command line interface to validate and pretty-print JSON objects.

If the optional *infile* and *outfile* arguments are not specified, *sys.stdin* and *sys.stdout* will be used respectively:

```
$ echo '{"json": "obj"}' | python -m json.tool
{
  "json": "obj"
}
$ echo '{1.2:3.4}' | python -m json.tool
Expecting property name enclosed in double quotes: line 1 column 2 (char 1)
```

在 3.5 版的變更: The output is now in the same order as the input. Use the *--sort-keys* option to sort the output of dictionaries alphabetically by key.

Command line options

infile

The JSON file to be validated or pretty-printed:

```
$ python -m json.tool mp_films.json
[
  {
    "title": "And Now for Something Completely Different",
    "year": 1971
  },
  ...
]
```

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```
{
  "title": "Monty Python and the Holy Grail",
  "year": 1975
}
```

If *infile* is not specified, read from `sys.stdin`.

outfile

Write the output of the *infile* to the given *outfile*. Otherwise, write it to `sys.stdout`.

--sort-keys

Sort the output of dictionaries alphabetically by key.

在 3.5 版新加入。

--no-ensure-ascii

Disable escaping of non-ascii characters, see `json.dumps()` for more information.

在 3.9 版新加入。

--json-lines

Parse every input line as separate JSON object.

在 3.8 版新加入。

--indent, --tab, --no-indent, --compact

Mutually exclusive options for whitespace control.

在 3.9 版新加入。

-h, --help

Show the help message.

F解

19.3 mailbox --- Manipulate mailboxes in various formats

原始碼: [Lib/mailbox.py](#)

This module defines two classes, *Mailbox* and *Message*, for accessing and manipulating on-disk mailboxes and the messages they contain. *Mailbox* offers a dictionary-like mapping from keys to messages. *Message* extends the `email.message` module's *Message* class with format-specific state and behavior. Supported mailbox formats are Maildir, mbox, MH, Babyl, and MMDF.

也參考:**email 模組**

Represent and manipulate messages.

19.3.1 Mailbox objects

class mailbox.Mailbox

A mailbox, which may be inspected and modified.

The `Mailbox` class defines an interface and is not intended to be instantiated. Instead, format-specific subclasses should inherit from `Mailbox` and your code should instantiate a particular subclass.

The `Mailbox` interface is dictionary-like, with small keys corresponding to messages. Keys are issued by the `Mailbox` instance with which they will be used and are only meaningful to that `Mailbox` instance. A key continues to identify a message even if the corresponding message is modified, such as by replacing it with another message.

Messages may be added to a `Mailbox` instance using the set-like method `add()` and removed using a `del` statement or the set-like methods `remove()` and `discard()`.

`Mailbox` interface semantics differ from dictionary semantics in some noteworthy ways. Each time a message is requested, a new representation (typically a `Message` instance) is generated based upon the current state of the mailbox. Similarly, when a message is added to a `Mailbox` instance, the provided message representation's contents are copied. In neither case is a reference to the message representation kept by the `Mailbox` instance.

The default `Mailbox` iterator iterates over message representations, not keys as the default `dictionary` iterator does. Moreover, modification of a mailbox during iteration is safe and well-defined. Messages added to the mailbox after an iterator is created will not be seen by the iterator. Messages removed from the mailbox before the iterator yields them will be silently skipped, though using a key from an iterator may result in a `KeyError` exception if the corresponding message is subsequently removed.

警告： Be very cautious when modifying mailboxes that might be simultaneously changed by some other process. The safest mailbox format to use for such tasks is `Maildir`; try to avoid using single-file formats such as `mbx` for concurrent writing. If you're modifying a mailbox, you *must* lock it by calling the `lock()` and `unlock()` methods *before* reading any messages in the file or making any changes by adding or deleting a message. Failing to lock the mailbox runs the risk of losing messages or corrupting the entire mailbox.

`Mailbox` instances have the following methods:

add (*message*)

Add *message* to the mailbox and return the key that has been assigned to it.

Parameter *message* may be a `Message` instance, an `email.message.Message` instance, a string, a byte string, or a file-like object (which should be open in binary mode). If *message* is an instance of the appropriate format-specific `Message` subclass (e.g., if it's an `mbxMessage` instance and this is an `mbx` instance), its format-specific information is used. Otherwise, reasonable defaults for format-specific information are used.

在 3.2 版的變更: Support for binary input was added.

remove (*key*)

__delitem__ (*key*)

discard (*key*)

Delete the message corresponding to *key* from the mailbox.

If no such message exists, a `KeyError` exception is raised if the method was called as `remove()` or `__delitem__()` but no exception is raised if the method was called as `discard()`. The behavior of `discard()` may be preferred if the underlying mailbox format supports concurrent modification by other processes.

__setitem__ (*key*, *message*)

Replace the message corresponding to *key* with *message*. Raise a `KeyError` exception if no message already corresponds to *key*.

As with `add()`, parameter *message* may be a *Message* instance, an *email.message.Message* instance, a string, a byte string, or a file-like object (which should be open in binary mode). If *message* is an instance of the appropriate format-specific *Message* subclass (e.g., if it's an *mbxMessage* instance and this is an *mbx* instance), its format-specific information is used. Otherwise, the format-specific information of the message that currently corresponds to *key* is left unchanged.

iterkeys()

Return an *iterator* over all keys

keys()

The same as *iterkeys()*, except that a *list* is returned rather than an *iterator*

intervalues()

__iter__()

Return an *iterator* over representations of all messages. The messages are represented as instances of the appropriate format-specific *Message* subclass unless a custom message factory was specified when the *Mailbox* instance was initialized.

備註: The behavior of *__iter__()* is unlike that of dictionaries, which iterate over keys.

values()

The same as *intervalues()*, except that a *list* is returned rather than an *iterator*

iteritems()

Return an *iterator* over (*key*, *message*) pairs, where *key* is a key and *message* is a message representation. The messages are represented as instances of the appropriate format-specific *Message* subclass unless a custom message factory was specified when the *Mailbox* instance was initialized.

items()

The same as *iteritems()*, except that a *list* of pairs is returned rather than an *iterator* of pairs.

get(key, default=None)

__getitem__(key)

Return a representation of the message corresponding to *key*. If no such message exists, *default* is returned if the method was called as *get()* and a *KeyError* exception is raised if the method was called as *__getitem__()*. The message is represented as an instance of the appropriate format-specific *Message* subclass unless a custom message factory was specified when the *Mailbox* instance was initialized.

get_message(key)

Return a representation of the message corresponding to *key* as an instance of the appropriate format-specific *Message* subclass, or raise a *KeyError* exception if no such message exists.

get_bytes(key)

Return a byte representation of the message corresponding to *key*, or raise a *KeyError* exception if no such message exists.

在 3.2 版新加入.

get_string(key)

Return a string representation of the message corresponding to *key*, or raise a *KeyError* exception if no such message exists. The message is processed through *email.message.Message* to convert it to a 7bit clean representation.

get_file(key)

Return a *file-like* representation of the message corresponding to *key*, or raise a *KeyError* exception if no such message exists. The file-like object behaves as if open in binary mode. This file should be closed once it is no longer needed.

在 3.2 版的變更: The file object really is a *binary file*; previously it was incorrectly returned in text mode. Also, the *file-like object* now supports the *context manager* protocol: you can use a `with` statement to automatically close it.

備 F: Unlike other representations of messages, *file-like* representations are not necessarily independent of the `Mailbox` instance that created them or of the underlying mailbox. More specific documentation is provided by each subclass.

`__contains__` (*key*)

Return `True` if *key* corresponds to a message, `False` otherwise.

`__len__` ()

Return a count of messages in the mailbox.

`clear` ()

Delete all messages from the mailbox.

`pop` (*key*, *default=None*)

Return a representation of the message corresponding to *key* and delete the message. If no such message exists, return *default*. The message is represented as an instance of the appropriate format-specific *Message* subclass unless a custom message factory was specified when the `Mailbox` instance was initialized.

`popitem` ()

Return an arbitrary (*key*, *message*) pair, where *key* is a key and *message* is a message representation, and delete the corresponding message. If the mailbox is empty, raise a *KeyError* exception. The message is represented as an instance of the appropriate format-specific *Message* subclass unless a custom message factory was specified when the `Mailbox` instance was initialized.

`update` (*arg*)

Parameter *arg* should be a *key-to-message* mapping or an iterable of (*key*, *message*) pairs. Updates the mailbox so that, for each given *key* and *message*, the message corresponding to *key* is set to *message* as if by using `__setitem__` (). As with `__setitem__` (), each *key* must already correspond to a message in the mailbox or else a *KeyError* exception will be raised, so in general it is incorrect for *arg* to be a `Mailbox` instance.

備 F: Unlike with dictionaries, keyword arguments are not supported.

`flush` ()

Write any pending changes to the filesystem. For some *Mailbox* subclasses, changes are always written immediately and `flush` () does nothing, but you should still make a habit of calling this method.

`lock` ()

Acquire an exclusive advisory lock on the mailbox so that other processes know not to modify it. An *ExternalClashError* is raised if the lock is not available. The particular locking mechanisms used depend upon the mailbox format. You should *always* lock the mailbox before making any modifications to its contents.

`unlock` ()

Release the lock on the mailbox, if any.

`close` ()

Flush the mailbox, unlock it if necessary, and close any open files. For some `Mailbox` subclasses, this method does nothing.

Maildir objects

class mailbox.**Maildir** (*dirname*, *factory=None*, *create=True*)

A subclass of *Mailbox* for mailboxes in Maildir format. Parameter *factory* is a callable object that accepts a file-like message representation (which behaves as if opened in binary mode) and returns a custom representation. If *factory* is *None*, *MaildirMessage* is used as the default message representation. If *create* is *True*, the mailbox is created if it does not exist.

If *create* is *True* and the *dirname* path exists, it will be treated as an existing maildir without attempting to verify its directory layout.

It is for historical reasons that *dirname* is named as such rather than *path*.

Maildir is a directory-based mailbox format invented for the qmail mail transfer agent and now widely supported by other programs. Messages in a Maildir mailbox are stored in separate files within a common directory structure. This design allows Maildir mailboxes to be accessed and modified by multiple unrelated programs without data corruption, so file locking is unnecessary.

Maildir mailboxes contain three subdirectories, namely: *tmp*, *new*, and *cur*. Messages are created momentarily in the *tmp* subdirectory and then moved to the *new* subdirectory to finalize delivery. A mail user agent may subsequently move the message to the *cur* subdirectory and store information about the state of the message in a special "info" section appended to its file name.

Folders of the style introduced by the Courier mail transfer agent are also supported. Any subdirectory of the main mailbox is considered a folder if *'.'* is the first character in its name. Folder names are represented by *Maildir* without the leading *'.'*. Each folder is itself a *Maildir* mailbox but should not contain other folders. Instead, a logical nesting is indicated using *'.'* to delimit levels, e.g., "Archived.2005.07".

colon

The Maildir specification requires the use of a colon (*':'*) in certain message file names. However, some operating systems do not permit this character in file names. If you wish to use a Maildir-like format on such an operating system, you should specify another character to use instead. The exclamation point (*'!'*) is a popular choice. For example:

```
import mailbox
mailbox.Maildir.colon = '!'
```

The *colon* attribute may also be set on a per-instance basis.

Maildir instances have all of the methods of *Mailbox* in addition to the following:

list_folders ()

Return a list of the names of all folders.

get_folder (*folder*)

Return a *Maildir* instance representing the folder whose name is *folder*. A *NoSuchMailboxError* exception is raised if the folder does not exist.

add_folder (*folder*)

Create a folder whose name is *folder* and return a *Maildir* instance representing it.

remove_folder (*folder*)

Delete the folder whose name is *folder*. If the folder contains any messages, a *NotEmptyError* exception will be raised and the folder will not be deleted.

clean ()

Delete temporary files from the mailbox that have not been accessed in the last 36 hours. The Maildir specification says that mail-reading programs should do this occasionally.

Some *Mailbox* methods implemented by *Maildir* deserve special remarks:

add (*message*)

__setitem__ (*key*, *message*)

update (*arg*)

警告: These methods generate unique file names based upon the current process ID. When using multiple threads, undetected name clashes may occur and cause corruption of the mailbox unless threads are coordinated to avoid using these methods to manipulate the same mailbox simultaneously.

flush ()

All changes to Maildir mailboxes are immediately applied, so this method does nothing.

lock ()

unlock ()

Maildir mailboxes do not support (or require) locking, so these methods do nothing.

close ()

Maildir instances do not keep any open files and the underlying mailboxes do not support locking, so this method does nothing.

get_file (*key*)

Depending upon the host platform, it may not be possible to modify or remove the underlying message while the returned file remains open.

也参考:

maildir man page from Courier

A specification of the format. Describes a common extension for supporting folders.

Using maildir format

Notes on Maildir by its inventor. Includes an updated name-creation scheme and details on "info" semantics.

mbx objects

class mailbox.**mbx** (*path*, *factory=None*, *create=True*)

A subclass of *Mailbox* for mailboxes in mbox format. Parameter *factory* is a callable object that accepts a file-like message representation (which behaves as if opened in binary mode) and returns a custom representation. If *factory* is None, *mbxMessage* is used as the default message representation. If *create* is True, the mailbox is created if it does not exist.

The mbox format is the classic format for storing mail on Unix systems. All messages in an mbox mailbox are stored in a single file with the beginning of each message indicated by a line whose first five characters are "From ".

Several variations of the mbox format exist to address perceived shortcomings in the original. In the interest of compatibility, *mbx* implements the original format, which is sometimes referred to as *mbxo*. This means that the *Content-Length* header, if present, is ignored and that any occurrences of "From " at the beginning of a line in a message body are transformed to ">From " when storing the message, although occurrences of ">From " are not transformed to "From " when reading the message.

Some *Mailbox* methods implemented by *mbx* deserve special remarks:

get_file (*key*)

Using the file after calling *flush* () or *close* () on the *mbx* instance may yield unpredictable results or raise an exception.

lock ()

unlock ()

Three locking mechanisms are used---dot locking and, if available, the *flock* () and *lockf* () system calls.

也参考:

mbox man page from tin

A specification of the format, with details on locking.

Configuring Netscape Mail on Unix: Why The Content-Length Format is Bad

An argument for using the original mbox format rather than a variation.

”mbox” is a family of several mutually incompatible mailbox formats

A history of mbox variations.

MH objects

class mailbox.MH (*path*, *factory=None*, *create=True*)

A subclass of *Mailbox* for mailboxes in MH format. Parameter *factory* is a callable object that accepts a file-like message representation (which behaves as if opened in binary mode) and returns a custom representation. If *factory* is *None*, *MHMessage* is used as the default message representation. If *create* is *True*, the mailbox is created if it does not exist.

MH is a directory-based mailbox format invented for the MH Message Handling System, a mail user agent. Each message in an MH mailbox resides in its own file. An MH mailbox may contain other MH mailboxes (called *folders*) in addition to messages. Folders may be nested indefinitely. MH mailboxes also support *sequences*, which are named lists used to logically group messages without moving them to sub-folders. Sequences are defined in a file called *.mh_sequences* in each folder.

The MH class manipulates MH mailboxes, but it does not attempt to emulate all of *mh*’s behaviors. In particular, it does not modify and is not affected by the *context* or *.mh_profile* files that are used by *mh* to store its state and configuration.

MH instances have all of the methods of *Mailbox* in addition to the following:

list_folders ()

Return a list of the names of all folders.

get_folder (*folder*)

Return an MH instance representing the folder whose name is *folder*. A *NoSuchMailboxError* exception is raised if the folder does not exist.

add_folder (*folder*)

Create a folder whose name is *folder* and return an MH instance representing it.

remove_folder (*folder*)

Delete the folder whose name is *folder*. If the folder contains any messages, a *NotEmptyError* exception will be raised and the folder will not be deleted.

get_sequences ()

Return a dictionary of sequence names mapped to key lists. If there are no sequences, the empty dictionary is returned.

set_sequences (*sequences*)

Re-define the sequences that exist in the mailbox based upon *sequences*, a dictionary of names mapped to key lists, like returned by *get_sequences* ().

pack ()

Rename messages in the mailbox as necessary to eliminate gaps in numbering. Entries in the sequences list are updated correspondingly.

備F: Already-issued keys are invalidated by this operation and should not be subsequently used.

Some *Mailbox* methods implemented by MH deserve special remarks:

remove (*key*)

__delitem__ (*key*)

discard (*key*)

These methods immediately delete the message. The MH convention of marking a message for deletion by prepending a comma to its name is not used.

lock ()**unlock** ()

Three locking mechanisms are used---dot locking and, if available, the `flock()` and `lockf()` system calls. For MH mailboxes, locking the mailbox means locking the `.mh_sequences` file and, only for the duration of any operations that affect them, locking individual message files.

get_file (*key*)

Depending upon the host platform, it may not be possible to remove the underlying message while the returned file remains open.

flush ()

All changes to MH mailboxes are immediately applied, so this method does nothing.

close ()

MH instances do not keep any open files, so this method is equivalent to `unlock()`.

也參考:**nmh - Message Handling System**

Home page of **nmh**, an updated version of the original **mh**.

MH & nmh: Email for Users & Programmers

A GPL-licensed book on **mh** and **nmh**, with some information on the mailbox format.

Babyl objects**class** mailbox.**Babyl** (*path*, *factory*=None, *create*=True)

A subclass of *Mailbox* for mailboxes in Babyl format. Parameter *factory* is a callable object that accepts a file-like message representation (which behaves as if opened in binary mode) and returns a custom representation. If *factory* is None, *BabylMessage* is used as the default message representation. If *create* is True, the mailbox is created if it does not exist.

Babyl is a single-file mailbox format used by the Rmail mail user agent included with Emacs. The beginning of a message is indicated by a line containing the two characters Control-Underscore (`'\037'`) and Control-L (`'\014'`). The end of a message is indicated by the start of the next message or, in the case of the last message, a line containing a Control-Underscore (`'\037'`) character.

Messages in a Babyl mailbox have two sets of headers, original headers and so-called visible headers. Visible headers are typically a subset of the original headers that have been reformatted or abridged to be more attractive. Each message in a Babyl mailbox also has an accompanying list of *labels*, or short strings that record extra information about the message, and a list of all user-defined labels found in the mailbox is kept in the Babyl options section.

Babyl instances have all of the methods of *Mailbox* in addition to the following:

get_labels ()

Return a list of the names of all user-defined labels used in the mailbox.

備 F: The actual messages are inspected to determine which labels exist in the mailbox rather than consulting the list of labels in the Babyl options section, but the Babyl section is updated whenever the mailbox is modified.

Some *Mailbox* methods implemented by *Babyl* deserve special remarks:

get_file (*key*)

In Babyl mailboxes, the headers of a message are not stored contiguously with the body of the message. To generate a file-like representation, the headers and body are copied together into an *io.BytesIO* instance, which has an API identical to that of a file. As a result, the file-like object is truly independent of the underlying mailbox but does not save memory compared to a string representation.

lock ()**unlock** ()

Three locking mechanisms are used---dot locking and, if available, the *flock* () and *lockf* () system calls.

也参考:

Format of Version 5 Babyl Files

A specification of the Babyl format.

Reading Mail with Rmail

The Rmail manual, with some information on Babyl semantics.

MMDF objects

class mailbox.**MMDF** (*path*, *factory=None*, *create=True*)

A subclass of *Mailbox* for mailboxes in MMDF format. Parameter *factory* is a callable object that accepts a file-like message representation (which behaves as if opened in binary mode) and returns a custom representation. If *factory* is *None*, *MMDFMessage* is used as the default message representation. If *create* is *True*, the mailbox is created if it does not exist.

MMDF is a single-file mailbox format invented for the Multichannel Memorandum Distribution Facility, a mail transfer agent. Each message is in the same form as an mbox message but is bracketed before and after by lines containing four Control-A (' \001 ') characters. As with the mbox format, the beginning of each message is indicated by a line whose first five characters are "From ", but additional occurrences of "From " are not transformed to ">From " when storing messages because the extra message separator lines prevent mistaking such occurrences for the starts of subsequent messages.

Some *Mailbox* methods implemented by MMDF deserve special remarks:

get_file (*key*)

Using the file after calling *flush* () or *close* () on the MMDF instance may yield unpredictable results or raise an exception.

lock ()**unlock** ()

Three locking mechanisms are used---dot locking and, if available, the *flock* () and *lockf* () system calls.

也参考:

mmdf man page from tin

A specification of MMDF format from the documentation of tin, a newsreader.

MMDF

A Wikipedia article describing the Multichannel Memorandum Distribution Facility.

19.3.2 Message objects

class `mailbox.Message` (*message=None*)

A subclass of the `email.message` module's `Message`. Subclasses of `mailbox.Message` add mailbox-format-specific state and behavior.

If *message* is omitted, the new instance is created in a default, empty state. If *message* is an `email.message.Message` instance, its contents are copied; furthermore, any format-specific information is converted insofar as possible if *message* is a `Message` instance. If *message* is a string, a byte string, or a file, it should contain an **RFC 2822**-compliant message, which is read and parsed. Files should be open in binary mode, but text mode files are accepted for backward compatibility.

The format-specific state and behaviors offered by subclasses vary, but in general it is only the properties that are not specific to a particular mailbox that are supported (although presumably the properties are specific to a particular mailbox format). For example, file offsets for single-file mailbox formats and file names for directory-based mailbox formats are not retained, because they are only applicable to the original mailbox. But state such as whether a message has been read by the user or marked as important is retained, because it applies to the message itself.

There is no requirement that `Message` instances be used to represent messages retrieved using `Mailbox` instances. In some situations, the time and memory required to generate `Message` representations might not be acceptable. For such situations, `Mailbox` instances also offer string and file-like representations, and a custom message factory may be specified when a `Mailbox` instance is initialized.

MaildirMessage objects

class `mailbox.MaildirMessage` (*message=None*)

A message with Maildir-specific behaviors. Parameter *message* has the same meaning as with the `Message` constructor.

Typically, a mail user agent application moves all of the messages in the `new` subdirectory to the `cur` subdirectory after the first time the user opens and closes the mailbox, recording that the messages are old whether or not they've actually been read. Each message in `cur` has an "info" section added to its file name to store information about its state. (Some mail readers may also add an "info" section to messages in `new`.) The "info" section may take one of two forms: it may contain "2," followed by a list of standardized flags (e.g., "2,FR") or it may contain "1," followed by so-called experimental information. Standard flags for Maildir messages are as follows:

Flag	Meaning	Explanation
D	Draft	Under composition
F	Flagged	Marked as important
P	Passed	Forwarded, resent, or bounced
R	Replied	Replied to
S	Seen	Read
T	Trashed	Marked for subsequent deletion

`MaildirMessage` instances offer the following methods:

get_subdir()

Return either "new" (if the message should be stored in the `new` subdirectory) or "cur" (if the message should be stored in the `cur` subdirectory).

備註: A message is typically moved from `new` to `cur` after its mailbox has been accessed, whether or not the message is has been read. A message `msg` has been read if "S" in `msg.get_flags()` is `True`.

set_subdir (*subdir*)

Set the subdirectory the message should be stored in. Parameter *subdir* must be either "new" or "cur".

get_flags ()

Return a string specifying the flags that are currently set. If the message complies with the standard Maildir format, the result is the concatenation in alphabetical order of zero or one occurrence of each of 'D', 'F', 'P', 'R', 'S', and 'T'. The empty string is returned if no flags are set or if "info" contains experimental semantics.

set_flags (*flags*)

Set the flags specified by *flags* and unset all others.

add_flag (*flag*)

Set the flag(s) specified by *flag* without changing other flags. To add more than one flag at a time, *flag* may be a string of more than one character. The current "info" is overwritten whether or not it contains experimental information rather than flags.

remove_flag (*flag*)

Unset the flag(s) specified by *flag* without changing other flags. To remove more than one flag at a time, *flag* may be a string of more than one character. If "info" contains experimental information rather than flags, the current "info" is not modified.

get_date ()

Return the delivery date of the message as a floating-point number representing seconds since the epoch.

set_date (*date*)

Set the delivery date of the message to *date*, a floating-point number representing seconds since the epoch.

get_info ()

Return a string containing the "info" for a message. This is useful for accessing and modifying "info" that is experimental (i.e., not a list of flags).

set_info (*info*)

Set "info" to *info*, which should be a string.

When a MaildirMessage instance is created based upon an *mbboxMessage* or *MMDFMessage* instance, the *Status* and *X-Status* headers are omitted and the following conversions take place:

Resulting state	<i>mbboxMessage</i> or <i>MMDFMessage</i> state
"cur" subdirectory	O flag
F flag	F flag
R flag	A flag
S flag	R flag
T flag	D flag

When a MaildirMessage instance is created based upon an *MHMessage* instance, the following conversions take place:

Resulting state	<i>MHMessage</i> state
"cur" subdirectory	"unseen" sequence
"cur" subdirectory and S flag	no "unseen" sequence
F flag	"flagged" sequence
R flag	"replied" sequence

When a MaildirMessage instance is created based upon a *BabylMessage* instance, the following conversions take place:

Resulting state	<i>BabylMessage</i> state
"cur" subdirectory	"unseen" label
"cur" subdirectory and S flag	no "unseen" label
P flag	"forwarded" or "resent" label
R flag	"answered" label
T flag	"deleted" label

mailbox.Message objects

class mailbox.**Message** (*message=None*)

A message with mbox-specific behaviors. Parameter *message* has the same meaning as with the *Message* constructor.

Messages in an mbox mailbox are stored together in a single file. The sender's envelope address and the time of delivery are typically stored in a line beginning with "From " that is used to indicate the start of a message, though there is considerable variation in the exact format of this data among mbox implementations. Flags that indicate the state of the message, such as whether it has been read or marked as important, are typically stored in *Status* and *X-Status* headers.

Conventional flags for mbox messages are as follows:

Flag	Meaning	Explanation
R	Read	Read
O	Old	Previously detected by MUA
D	Deleted	Marked for subsequent deletion
F	Flagged	Marked as important
A	Answered	Replied to

The "R" and "O" flags are stored in the *Status* header, and the "D", "F", and "A" flags are stored in the *X-Status* header. The flags and headers typically appear in the order mentioned.

Message instances offer the following methods:

get_from()

Return a string representing the "From " line that marks the start of the message in an mbox mailbox. The leading "From " and the trailing newline are excluded.

set_from (*from_, time_=None*)

Set the "From " line to *from_*, which should be specified without a leading "From " or trailing newline. For convenience, *time_* may be specified and will be formatted appropriately and appended to *from_*. If *time_* is specified, it should be a *time.struct_time* instance, a tuple suitable for passing to *time.strftime()*, or True (to use *time.gmtime()*).

get_flags()

Return a string specifying the flags that are currently set. If the message complies with the conventional format, the result is the concatenation in the following order of zero or one occurrence of each of 'R', 'O', 'D', 'F', and 'A'.

set_flags (*flags*)

Set the flags specified by *flags* and unset all others. Parameter *flags* should be the concatenation in any order of zero or more occurrences of each of 'R', 'O', 'D', 'F', and 'A'.

add_flag (*flag*)

Set the flag(s) specified by *flag* without changing other flags. To add more than one flag at a time, *flag* may be a string of more than one character.

remove_flag(flag)

Unset the flag(s) specified by *flag* without changing other flags. To remove more than one flag at a time, *flag* maybe a string of more than one character.

When an `mboxMessage` instance is created based upon a `MaildirMessage` instance, a "From " line is generated based upon the `MaildirMessage` instance's delivery date, and the following conversions take place:

Resulting state	<code>MaildirMessage</code> state
R flag	S flag
O flag	"cur" subdirectory
D flag	T flag
F flag	F flag
A flag	R flag

When an `mboxMessage` instance is created based upon an `MHMessage` instance, the following conversions take place:

Resulting state	<code>MHMessage</code> state
R flag and O flag	no "unseen" sequence
O flag	"unseen" sequence
F flag	"flagged" sequence
A flag	"replied" sequence

When an `mboxMessage` instance is created based upon a `BabylMessage` instance, the following conversions take place:

Resulting state	<code>BabylMessage</code> state
R flag and O flag	no "unseen" label
O flag	"unseen" label
D flag	"deleted" label
A flag	"answered" label

When a `mboxMessage` instance is created based upon an `MMDFMessage` instance, the "From " line is copied and all flags directly correspond:

Resulting state	<code>MMDFMessage</code> state
R flag	R flag
O flag	O flag
D flag	D flag
F flag	F flag
A flag	A flag

MHMessage objects

class mailbox.**MHMessage** (*message=None*)

A message with MH-specific behaviors. Parameter *message* has the same meaning as with the *Message* constructor.

MH messages do not support marks or flags in the traditional sense, but they do support sequences, which are logical groupings of arbitrary messages. Some mail reading programs (although not the standard **mh** and **nmh**) use sequences in much the same way flags are used with other formats, as follows:

Sequence	Explanation
unseen	Not read, but previously detected by MUA
replied	Replied to
flagged	Marked as important

MHMessage instances offer the following methods:

get_sequences ()

Return a list of the names of sequences that include this message.

set_sequences (*sequences*)

Set the list of sequences that include this message.

add_sequence (*sequence*)

Add *sequence* to the list of sequences that include this message.

remove_sequence (*sequence*)

Remove *sequence* from the list of sequences that include this message.

When an MHMessage instance is created based upon a *MaildirMessage* instance, the following conversions take place:

Resulting state	<i>MaildirMessage</i> state
"unseen" sequence	no S flag
"replied" sequence	R flag
"flagged" sequence	F flag

When an MHMessage instance is created based upon an *mbxMessage* or *MMDFMessage* instance, the *Status* and *X-Status* headers are omitted and the following conversions take place:

Resulting state	<i>mbxMessage</i> or <i>MMDFMessage</i> state
"unseen" sequence	no R flag
"replied" sequence	A flag
"flagged" sequence	F flag

When an MHMessage instance is created based upon a *BabylMessage* instance, the following conversions take place:

Resulting state	<i>BabylMessage</i> state
"unseen" sequence	"unseen" label
"replied" sequence	"answered" label

BabylMessage objects

class mailbox.**BabylMessage** (*message=None*)

A message with Babyl-specific behaviors. Parameter *message* has the same meaning as with the *Message* constructor.

Certain message labels, called *attributes*, are defined by convention to have special meanings. The attributes are as follows:

Label	Explanation
unseen	Not read, but previously detected by MUA
deleted	Marked for subsequent deletion
filed	Copied to another file or mailbox
answered	Replied to
forwarded	Forwarded
edited	Modified by the user
resent	Resent

By default, Rmail displays only visible headers. The *BabylMessage* class, though, uses the original headers because they are more complete. Visible headers may be accessed explicitly if desired.

BabylMessage instances offer the following methods:

get_labels ()

Return a list of labels on the message.

set_labels (*labels*)

Set the list of labels on the message to *labels*.

add_label (*label*)

Add *label* to the list of labels on the message.

remove_label (*label*)

Remove *label* from the list of labels on the message.

get_visible ()

Return an *Message* instance whose headers are the message's visible headers and whose body is empty.

set_visible (*visible*)

Set the message's visible headers to be the same as the headers in *message*. Parameter *visible* should be a *Message* instance, an *email.message.Message* instance, a string, or a file-like object (which should be open in text mode).

update_visible ()

When a *BabylMessage* instance's original headers are modified, the visible headers are not automatically modified to correspond. This method updates the visible headers as follows: each visible header with a corresponding original header is set to the value of the original header, each visible header without a corresponding original header is removed, and any of *Date*, *From*, *Reply-To*, *To*, *CC*, and *Subject* that are present in the original headers but not the visible headers are added to the visible headers.

When a *BabylMessage* instance is created based upon a *MaildirMessage* instance, the following conversions take place:

Resulting state	<i>MaildirMessage</i> state
"unseen" label	no S flag
"deleted" label	T flag
"answered" label	R flag
"forwarded" label	P flag

When a `BabylMessage` instance is created based upon an `mboxMessage` or `MMDFMessage` instance, the `Status` and `X-Status` headers are omitted and the following conversions take place:

Resulting state	<code>mboxMessage</code> or <code>MMDFMessage</code> state
"unseen" label	no R flag
"deleted" label	D flag
"answered" label	A flag

When a `BabylMessage` instance is created based upon an `MHMessage` instance, the following conversions take place:

Resulting state	<code>MHMessage</code> state
"unseen" label	"unseen" sequence
"answered" label	"replied" sequence

MMDFMessage objects

class `mailbox.MMDFMessage` (*message=None*)

A message with MMDF-specific behaviors. Parameter *message* has the same meaning as with the `Message` constructor.

As with message in an mbox mailbox, MMDF messages are stored with the sender's address and the delivery date in an initial line beginning with "From ". Likewise, flags that indicate the state of the message are typically stored in `Status` and `X-Status` headers.

Conventional flags for MMDF messages are identical to those of mbox message and are as follows:

Flag	Meaning	Explanation
R	Read	Read
O	Old	Previously detected by MUA
D	Deleted	Marked for subsequent deletion
F	Flagged	Marked as important
A	Answered	Replied to

The "R" and "O" flags are stored in the `Status` header, and the "D", "F", and "A" flags are stored in the `X-Status` header. The flags and headers typically appear in the order mentioned.

`MMDFMessage` instances offer the following methods, which are identical to those offered by `mboxMessage`:

get_from()

Return a string representing the "From " line that marks the start of the message in an mbox mailbox. The leading "From " and the trailing newline are excluded.

set_from (*from_, time_=None*)

Set the "From " line to *from_*, which should be specified without a leading "From " or trailing newline. For convenience, *time_* may be specified and will be formatted appropriately and appended to *from_*. If *time_* is specified, it should be a `time.struct_time` instance, a tuple suitable for passing to `time.strftime()`, or `True` (to use `time.gmtime()`).

get_flags()

Return a string specifying the flags that are currently set. If the message complies with the conventional format, the result is the concatenation in the following order of zero or one occurrence of each of 'R', 'O', 'D', 'F', and 'A'.

set_flags (*flags*)

Set the flags specified by *flags* and unset all others. Parameter *flags* should be the concatenation in any order of zero or more occurrences of each of 'R', 'O', 'D', 'F', and 'A'.

add_flag (*flag*)

Set the flag(s) specified by *flag* without changing other flags. To add more than one flag at a time, *flag* may be a string of more than one character.

remove_flag (*flag*)

Unset the flag(s) specified by *flag* without changing other flags. To remove more than one flag at a time, *flag* may be a string of more than one character.

When an `MMDFMessage` instance is created based upon a `MaildirMessage` instance, a "From" line is generated based upon the `MaildirMessage` instance's delivery date, and the following conversions take place:

Resulting state	<code>MaildirMessage</code> state
R flag	S flag
O flag	"cur" subdirectory
D flag	T flag
F flag	F flag
A flag	R flag

When an `MMDFMessage` instance is created based upon an `MHMessage` instance, the following conversions take place:

Resulting state	<code>MHMessage</code> state
R flag and O flag	no "unseen" sequence
O flag	"unseen" sequence
F flag	"flagged" sequence
A flag	"replied" sequence

When an `MMDFMessage` instance is created based upon a `BabylMessage` instance, the following conversions take place:

Resulting state	<code>BabylMessage</code> state
R flag and O flag	no "unseen" label
O flag	"unseen" label
D flag	"deleted" label
A flag	"answered" label

When an `MMDFMessage` instance is created based upon an `mboxMessage` instance, the "From" line is copied and all flags directly correspond:

Resulting state	<code>mboxMessage</code> state
R flag	R flag
O flag	O flag
D flag	D flag
F flag	F flag
A flag	A flag

19.3.3 例外

The following exception classes are defined in the `mailbox` module:

exception `mailbox.Error`

The based class for all other module-specific exceptions.

exception `mailbox.NoSuchMailboxError`

Raised when a mailbox is expected but is not found, such as when instantiating a *Mailbox* subclass with a path that does not exist (and with the *create* parameter set to `False`), or when opening a folder that does not exist.

exception `mailbox.NotEmptyError`

Raised when a mailbox is not empty but is expected to be, such as when deleting a folder that contains messages.

exception `mailbox.ExternalClashError`

Raised when some mailbox-related condition beyond the control of the program causes it to be unable to proceed, such as when failing to acquire a lock that another program already holds a lock, or when a uniquely generated file name already exists.

exception `mailbox.FormatError`

Raised when the data in a file cannot be parsed, such as when an *MH* instance attempts to read a corrupted `.mh_sequences` file.

19.3.4 范例

A simple example of printing the subjects of all messages in a mailbox that seem interesting:

```
import mailbox
for message in mailbox.mbox('~/.mbox'):
    subject = message['subject']          # Could possibly be None.
    if subject and 'python' in subject.lower():
        print(subject)
```

To copy all mail from a Babyl mailbox to an MH mailbox, converting all of the format-specific information that can be converted:

```
import mailbox
destination = mailbox.MH('~/.Mail')
destination.lock()
for message in mailbox.Babyl('~/.RMAIL'):
    destination.add(mailbox.MHMessage(message))
destination.flush()
destination.unlock()
```

This example sorts mail from several mailing lists into different mailboxes, being careful to avoid mail corruption due to concurrent modification by other programs, mail loss due to interruption of the program, or premature termination due to malformed messages in the mailbox:

```
import mailbox
import email.errors

list_names = ('python-list', 'python-dev', 'python-bugs')

boxes = {name: mailbox.mbox('~/.email/%s' % name) for name in list_names}
inbox = mailbox.Maildir('~/.Maildir', factory=None)

for key in inbox.iterkeys():
    try:
        message = inbox[key]
```

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```

except email.errors.MessageParseError:
    continue          # The message is malformed. Just leave it.

for name in list_names:
    list_id = message['list-id']
    if list_id and name in list_id:
        # Get mailbox to use
        box = boxes[name]

        # Write copy to disk before removing original.
        # If there's a crash, you might duplicate a message, but
        # that's better than losing a message completely.
        box.lock()
        box.add(message)
        box.flush()
        box.unlock()

        # Remove original message
        inbox.lock()
        inbox.discard(key)
        inbox.flush()
        inbox.unlock()
        break          # Found destination, so stop looking.

for box in boxes.itervalues():
    box.close()

```

19.4 mimetypes --- Map filenames to MIME types

原始碼: [Lib/mimetypes.py](#)

The *mimetypes* module converts between a filename or URL and the MIME type associated with the filename extension. Conversions are provided from filename to MIME type and from MIME type to filename extension; encodings are not supported for the latter conversion.

The module provides one class and a number of convenience functions. The functions are the normal interface to this module, but some applications may be interested in the class as well.

The functions described below provide the primary interface for this module. If the module has not been initialized, they will call *init()* if they rely on the information *init()* sets up.

mimetypes.guess_type (*url*, *strict=True*)

Guess the type of a file based on its filename, path or URL, given by *url*. URL can be a string or a *path-like object*.

The return value is a tuple (*type*, *encoding*) where *type* is None if the type can't be guessed (missing or unknown suffix) or a string of the form 'type/subtype', usable for a MIME *content-type* header.

encoding is None for no encoding or the name of the program used to encode (e.g. **compress** or **gzip**). The encoding is suitable for use as a *Content-Encoding* header, **not** as a *Content-Transfer-Encoding* header. The mappings are table driven. Encoding suffixes are case sensitive; type suffixes are first tried case sensitively, then case insensitively.

The optional *strict* argument is a flag specifying whether the list of known MIME types is limited to only the official types registered with IANA. When *strict* is True (the default), only the IANA types are supported; when *strict* is False, some additional non-standard but commonly used MIME types are also recognized.

在 3.8 版的變更: Added support for url being a *path-like object*.

`mimetypes.guess_all_extensions (type, strict=True)`

Guess the extensions for a file based on its MIME type, given by *type*. The return value is a list of strings giving all possible filename extensions, including the leading dot ('.'). The extensions are not guaranteed to have been associated with any particular data stream, but would be mapped to the MIME type *type* by `guess_type()`.

The optional *strict* argument has the same meaning as with the `guess_type()` function.

`mimetypes.guess_extension (type, strict=True)`

Guess the extension for a file based on its MIME type, given by *type*. The return value is a string giving a filename extension, including the leading dot ('.'). The extension is not guaranteed to have been associated with any particular data stream, but would be mapped to the MIME type *type* by `guess_type()`. If no extension can be guessed for *type*, `None` is returned.

The optional *strict* argument has the same meaning as with the `guess_type()` function.

Some additional functions and data items are available for controlling the behavior of the module.

`mimetypes.init (files=None)`

Initialize the internal data structures. If given, *files* must be a sequence of file names which should be used to augment the default type map. If omitted, the file names to use are taken from `knownfiles`; on Windows, the current registry settings are loaded. Each file named in *files* or `knownfiles` takes precedence over those named before it. Calling `init()` repeatedly is allowed.

Specifying an empty list for *files* will prevent the system defaults from being applied: only the well-known values will be present from a built-in list.

If *files* is `None` the internal data structure is completely rebuilt to its initial default value. This is a stable operation and will produce the same results when called multiple times.

在 3.2 版的變更: Previously, Windows registry settings were ignored.

`mimetypes.read_mime_types (filename)`

Load the type map given in the file *filename*, if it exists. The type map is returned as a dictionary mapping filename extensions, including the leading dot ('.'), to strings of the form 'type/subtype'. If the file *filename* does not exist or cannot be read, `None` is returned.

`mimetypes.add_type (type, ext, strict=True)`

Add a mapping from the MIME type *type* to the extension *ext*. When the extension is already known, the new type will replace the old one. When the type is already known the extension will be added to the list of known extensions.

When *strict* is `True` (the default), the mapping will be added to the official MIME types, otherwise to the non-standard ones.

`mimetypes.inited`

Flag indicating whether or not the global data structures have been initialized. This is set to `True` by `init()`.

`mimetypes.knownfiles`

List of type map file names commonly installed. These files are typically named `mime.types` and are installed in different locations by different packages.

`mimetypes.suffix_map`

Dictionary mapping suffixes to suffixes. This is used to allow recognition of encoded files for which the encoding and the type are indicated by the same extension. For example, the `.tgz` extension is mapped to `.tar.gz` to allow the encoding and type to be recognized separately.

`mimetypes.encodings_map`

Dictionary mapping filename extensions to encoding types.

`mimetypes.types_map`

Dictionary mapping filename extensions to MIME types.

`mimetypes.common_types`

Dictionary mapping filename extensions to non-standard, but commonly found MIME types.

模組的使用範例：

```
>>> import mimetypes
>>> mimetypes.init()
>>> mimetypes.knownfiles
['/etc/mime.types', '/etc/httpd/mime.types', ... ]
>>> mimetypes.suffix_map['.tgz']
'.tar.gz'
>>> mimetypes.encodings_map['.gz']
'gzip'
>>> mimetypes.types_map['.tgz']
'application/x-tar-gz'
```

19.4.1 MimeTypes 物件

The *MimeTypes* class may be useful for applications which may want more than one MIME-type database; it provides an interface similar to the one of the *mimetypes* module.

class `mimetypes.MimeTypes` (*filenames=()*, *strict=True*)

This class represents a MIME-types database. By default, it provides access to the same database as the rest of this module. The initial database is a copy of that provided by the module, and may be extended by loading additional `mime.types`-style files into the database using the *read()* or *readfp()* methods. The mapping dictionaries may also be cleared before loading additional data if the default data is not desired.

The optional *filenames* parameter can be used to cause additional files to be loaded "on top" of the default database.

suffix_map

Dictionary mapping suffixes to suffixes. This is used to allow recognition of encoded files for which the encoding and the type are indicated by the same extension. For example, the `.tgz` extension is mapped to `.tar.gz` to allow the encoding and type to be recognized separately. This is initially a copy of the global *suffix_map* defined in the module.

encodings_map

Dictionary mapping filename extensions to encoding types. This is initially a copy of the global *encodings_map* defined in the module.

types_map

Tuple containing two dictionaries, mapping filename extensions to MIME types: the first dictionary is for the non-standards types and the second one is for the standard types. They are initialized by *common_types* and *types_map*.

types_map_inv

Tuple containing two dictionaries, mapping MIME types to a list of filename extensions: the first dictionary is for the non-standards types and the second one is for the standard types. They are initialized by *common_types* and *types_map*.

guess_extension (*type*, *strict=True*)

Similar to the *guess_extension()* function, using the tables stored as part of the object.

guess_type (*url*, *strict=True*)

Similar to the *guess_type()* function, using the tables stored as part of the object.

guess_all_extensions (*type*, *strict=True*)

Similar to the *guess_all_extensions()* function, using the tables stored as part of the object.

read (*filename*, *strict=True*)

Load MIME information from a file named *filename*. This uses `readfp()` to parse the file.

If *strict* is `True`, information will be added to list of standard types, else to the list of non-standard types.

readfp (*fp*, *strict=True*)

Load MIME type information from an open file *fp*. The file must have the format of the standard `mime.types` files.

If *strict* is `True`, information will be added to the list of standard types, else to the list of non-standard types.

read_windows_registry (*strict=True*)

Load MIME type information from the Windows registry.

適用：Windows。

If *strict* is `True`, information will be added to the list of standard types, else to the list of non-standard types.

在 3.2 版新加入。

19.5 base64 —— Base16、Base32、Base64、Base85 資料編碼

原始碼： [Lib/base64.py](#)

這個模組提供將二進位資料編碼成可顯示 ASCII 字元以及解碼回原始資料的功能，包括了 **RFC 4648** 中的 Base16、Base32、Base64 等編碼方式，以及標準 Ascii85、Base85 編碼等。

RFC 4648 標準編碼可以使電子郵件、URL，或是 HTTP POST 內容等傳輸管道安全地傳遞資料。這些編碼演算法與 **uuencode** 不相同。

There are two interfaces provided by this module. The modern interface supports encoding *bytes-like objects* to ASCII *bytes*, and decoding *bytes-like objects* or strings containing ASCII to *bytes*. Both base-64 alphabets defined in **RFC 4648** (normal, and URL- and filesystem-safe) are supported.

The legacy interface does not support decoding from strings, but it does provide functions for encoding and decoding to and from *file objects*. It only supports the Base64 standard alphabet, and it adds newlines every 76 characters as per **RFC 2045**. Note that if you are looking for **RFC 2045** support you probably want to be looking at the *email* package instead.

在 3.3 版的變更：ASCII-only Unicode strings are now accepted by the decoding functions of the modern interface.

在 3.4 版的變更：Any *bytes-like objects* are now accepted by all encoding and decoding functions in this module. Ascii85/Base85 support added.

The modern interface provides:

`base64.b64encode` (*s*, *altchars=None*)

Encode the *bytes-like object* *s* using Base64 and return the encoded *bytes*.

Optional *altchars* must be a *bytes-like object* of length 2 which specifies an alternative alphabet for the + and / characters. This allows an application to e.g. generate URL or filesystem safe Base64 strings. The default is `None`, for which the standard Base64 alphabet is used.

May assert or raise a *ValueError* if the length of *altchars* is not 2. Raises a *TypeError* if *altchars* is not a *bytes-like object*.

`base64.b64decode(s, altchars=None, validate=False)`

Decode the Base64 encoded *bytes-like object* or ASCII string *s* and return the decoded *bytes*.

Optional *altchars* must be a *bytes-like object* or ASCII string of length 2 which specifies the alternative alphabet used instead of the + and / characters.

A *binascii.Error* exception is raised if *s* is incorrectly padded.

If *validate* is `False` (the default), characters that are neither in the normal base-64 alphabet nor the alternative alphabet are discarded prior to the padding check. If *validate* is `True`, these non-alphabet characters in the input result in a *binascii.Error*.

For more information about the strict base64 check, see *binascii.a2b_base64()*

May assert or raise a *ValueError* if the length of *altchars* is not 2.

`base64.standard_b64encode(s)`

Encode *bytes-like object* *s* using the standard Base64 alphabet and return the encoded *bytes*.

`base64.standard_b64decode(s)`

Decode *bytes-like object* or ASCII string *s* using the standard Base64 alphabet and return the decoded *bytes*.

`base64.urlsafe_b64encode(s)`

Encode *bytes-like object* *s* using the URL- and filesystem-safe alphabet, which substitutes - instead of + and _ instead of / in the standard Base64 alphabet, and return the encoded *bytes*. The result can still contain =.

`base64.urlsafe_b64decode(s)`

Decode *bytes-like object* or ASCII string *s* using the URL- and filesystem-safe alphabet, which substitutes - instead of + and _ instead of / in the standard Base64 alphabet, and return the decoded *bytes*.

`base64.b32encode(s)`

Encode the *bytes-like object* *s* using Base32 and return the encoded *bytes*.

`base64.b32decode(s, casefold=False, map01=None)`

Decode the Base32 encoded *bytes-like object* or ASCII string *s* and return the decoded *bytes*.

Optional *casefold* is a flag specifying whether a lowercase alphabet is acceptable as input. For security purposes, the default is `False`.

RFC 4648 allows for optional mapping of the digit 0 (zero) to the letter O (oh), and for optional mapping of the digit 1 (one) to either the letter I (eye) or letter L (el). The optional argument *map01* when not `None`, specifies which letter the digit 1 should be mapped to (when *map01* is not `None`, the digit 0 is always mapped to the letter O). For security purposes the default is `None`, so that 0 and 1 are not allowed in the input.

A *binascii.Error* is raised if *s* is incorrectly padded or if there are non-alphabet characters present in the input.

`base64.b32hexencode(s)`

Similar to *b32encode()* but uses the Extended Hex Alphabet, as defined in **RFC 4648**.

在 3.10 版新加入。

`base64.b32hexdecode(s, casefold=False)`

Similar to *b32decode()* but uses the Extended Hex Alphabet, as defined in **RFC 4648**.

This version does not allow the digit 0 (zero) to the letter O (oh) and digit 1 (one) to either the letter I (eye) or letter L (el) mappings, all these characters are included in the Extended Hex Alphabet and are not interchangeable.

在 3.10 版新加入。

`base64.b16encode(s)`

Encode the *bytes-like object* *s* using Base16 and return the encoded *bytes*.

`base64.b16decode(s, casefold=False)`

Decode the Base16 encoded *bytes-like object* or ASCII string *s* and return the decoded *bytes*.

Optional *casefold* is a flag specifying whether a lowercase alphabet is acceptable as input. For security purposes, the default is `False`.

A *binascii.Error* is raised if *s* is incorrectly padded or if there are non-alphabet characters present in the input.

`base64.a85encode(b, *, foldspaces=False, wrapcol=0, pad=False, adobe=False)`

Encode the *bytes-like object* *b* using Ascii85 and return the encoded *bytes*.

foldspaces is an optional flag that uses the special short sequence 'y' instead of 4 consecutive spaces (ASCII 0x20) as supported by 'btoa'. This feature is not supported by the "standard" Ascii85 encoding.

wrapcol controls whether the output should have newline (b'\n') characters added to it. If this is non-zero, each output line will be at most this many characters long.

pad controls whether the input is padded to a multiple of 4 before encoding. Note that the `btoa` implementation always pads.

adobe controls whether the encoded byte sequence is framed with <~ and ~>, which is used by the Adobe implementation.

在 3.4 版新加入。

`base64.a85decode(b, *, foldspaces=False, adobe=False, ignorechars=b'\t\n\r\x0b')`

Decode the Ascii85 encoded *bytes-like object* or ASCII string *b* and return the decoded *bytes*.

foldspaces is a flag that specifies whether the 'y' short sequence should be accepted as shorthand for 4 consecutive spaces (ASCII 0x20). This feature is not supported by the "standard" Ascii85 encoding.

adobe controls whether the input sequence is in Adobe Ascii85 format (i.e. is framed with <~ and ~>).

ignorechars should be a *bytes-like object* or ASCII string containing characters to ignore from the input. This should only contain whitespace characters, and by default contains all whitespace characters in ASCII.

在 3.4 版新加入。

`base64.b85encode(b, pad=False)`

Encode the *bytes-like object* *b* using base85 (as used in e.g. git-style binary diffs) and return the encoded *bytes*.

If *pad* is true, the input is padded with b'\0' so its length is a multiple of 4 bytes before encoding.

在 3.4 版新加入。

`base64.b85decode(b)`

Decode the base85-encoded *bytes-like object* or ASCII string *b* and return the decoded *bytes*. Padding is implicitly removed, if necessary.

在 3.4 版新加入。

The legacy interface:

`base64.decode(input, output)`

Decode the contents of the binary *input* file and write the resulting binary data to the *output* file. *input* and *output* must be *file objects*. *input* will be read until `input.readline()` returns an empty bytes object.

`base64.decodebytes(s)`

Decode the *bytes-like object* *s*, which must contain one or more lines of base64 encoded data, and return the decoded *bytes*.

在 3.1 版新加入。

`base64.encode(input, output)`

Encode the contents of the binary *input* file and write the resulting base64 encoded data to the *output* file. *input* and *output* must be *file objects*. *input* will be read until `input.read()` returns an empty bytes object. `encode()` inserts a newline character (`b'\n'`) after every 76 bytes of the output, as well as ensuring that the output always ends with a newline, as per [RFC 2045](#) (MIME).

`base64.encodebytes(s)`

Encode the *bytes-like object* *s*, which can contain arbitrary binary data, and return *bytes* containing the base64-encoded data, with newlines (`b'\n'`) inserted after every 76 bytes of output, and ensuring that there is a trailing newline, as per [RFC 2045](#) (MIME).

在 3.1 版新加入。

An example usage of the module:

```
>>> import base64
>>> encoded = base64.b64encode(b'data to be encoded')
>>> encoded
b'ZGF0YSB0byBiZSB1bmNvZGVk'
>>> data = base64.b64decode(encoded)
>>> data
b'data to be encoded'
```

19.5.1 Security Considerations

A new security considerations section was added to [RFC 4648](#) (section 12); it's recommended to review the security section for any code deployed to production.

也參考:

[binascii](#) 模組

Support module containing ASCII-to-binary and binary-to-ASCII conversions.

[RFC 1521 - MIME \(Multipurpose Internet Mail Extensions\) Part One: Mechanisms for Specifying and Describing the Format of Internet Message Bodies](#)

Section 5.2, "Base64 Content-Transfer-Encoding," provides the definition of the base64 encoding.

19.6 binascii --- Convert between binary and ASCII

The *binascii* module contains a number of methods to convert between binary and various ASCII-encoded binary representations. Normally, you will not use these functions directly but use wrapper modules like *uu* or *base64* instead. The *binascii* module contains low-level functions written in C for greater speed that are used by the higher-level modules.

備註: `a2b_*` functions accept Unicode strings containing only ASCII characters. Other functions only accept *bytes-like objects* (such as *bytes*, *bytearray* and other objects that support the buffer protocol).

在 3.3 版的變更: ASCII-only unicode strings are now accepted by the `a2b_*` functions.

The *binascii* module defines the following functions:

`binascii.a2b_uu(string)`

Convert a single line of uuencoded data back to binary and return the binary data. Lines normally contain 45 (binary) bytes, except for the last line. Line data may be followed by whitespace.

`binascii.b2a_uu` (*data*, *, *backtick=False*)

Convert binary data to a line of ASCII characters, the return value is the converted line, including a newline char. The length of *data* should be at most 45. If *backtick* is true, zeros are represented by '``' instead of spaces.

在 3.7 版的變更: 新增 *backtick* 參數。

`binascii.a2b_base64` (*string*, /, *, *strict_mode=False*)

Convert a block of base64 data back to binary and return the binary data. More than one line may be passed at a time.

If *strict_mode* is true, only valid base64 data will be converted. Invalid base64 data will raise `binascii.Error`.

Valid base64:

- Conforms to [RFC 3548](#).
- Contains only characters from the base64 alphabet.
- Contains no excess data after padding (including excess padding, newlines, etc.).
- Does not start with a padding.

在 3.11 版的變更: 新增 *strict_mode* 參數。

`binascii.b2a_base64` (*data*, *, *newline=True*)

Convert binary data to a line of ASCII characters in base64 coding. The return value is the converted line, including a newline char if *newline* is true. The output of this function conforms to [RFC 3548](#).

在 3.6 版的變更: 新增 *newline* 參數。

`binascii.a2b_qp` (*data*, *header=False*)

Convert a block of quoted-printable data back to binary and return the binary data. More than one line may be passed at a time. If the optional argument *header* is present and true, underscores will be decoded as spaces.

`binascii.b2a_qp` (*data*, *quotetabs=False*, *istext=True*, *header=False*)

Convert binary data to a line(s) of ASCII characters in quoted-printable encoding. The return value is the converted line(s). If the optional argument *quotetabs* is present and true, all tabs and spaces will be encoded. If the optional argument *istext* is present and true, newlines are not encoded but trailing whitespace will be encoded. If the optional argument *header* is present and true, spaces will be encoded as underscores per [RFC 1522](#). If the optional argument *header* is present and false, newline characters will be encoded as well; otherwise linefeed conversion might corrupt the binary data stream.

`binascii.crc_hqx` (*data*, *value*)

Compute a 16-bit CRC value of *data*, starting with *value* as the initial CRC, and return the result. This uses the CRC-CCITT polynomial $x^{16} + x^{12} + x^5 + 1$, often represented as 0x1021. This CRC is used in the binhex4 format.

`binascii.crc32` (*data*[, *value*])

Compute CRC-32, the unsigned 32-bit checksum of *data*, starting with an initial CRC of *value*. The default initial CRC is zero. The algorithm is consistent with the ZIP file checksum. Since the algorithm is designed for use as a checksum algorithm, it is not suitable for use as a general hash algorithm. Use as follows:

```
print(binascii.crc32(b"hello world"))
# Or, in two pieces:
crc = binascii.crc32(b"hello")
crc = binascii.crc32(b" world", crc)
print('crc32 = {:#010x}'.format(crc))
```

在 3.0 版的變更: The result is always unsigned.

`binascii.b2a_hex` (*data*[, *sep*[, *bytes_per_sep=1*]])

`binascii.hexlify(data[, sep[, bytes_per_sep=1]])`

Return the hexadecimal representation of the binary *data*. Every byte of *data* is converted into the corresponding 2-digit hex representation. The returned bytes object is therefore twice as long as the length of *data*.

Similar functionality (but returning a text string) is also conveniently accessible using the `bytes.hex()` method.

If *sep* is specified, it must be a single character str or bytes object. It will be inserted in the output after every *bytes_per_sep* input bytes. Separator placement is counted from the right end of the output by default, if you wish to count from the left, supply a negative *bytes_per_sep* value.

```
>>> import binascii
>>> binascii.b2a_hex(b'\xb9\x01\xef')
b'b901ef'
>>> binascii.hexlify(b'\xb9\x01\xef', '-')
b'b9-01-ef'
>>> binascii.b2a_hex(b'\xb9\x01\xef', b'_', 2)
b'b9_01ef'
>>> binascii.b2a_hex(b'\xb9\x01\xef', b' ', -2)
b'b901 ef'
```

在 3.8 版的變更: 新增 *sep* 與 *bytes_per_sep* 參數。

`binascii.a2b_hex(hexstr)`

`binascii.unhexlify(hexstr)`

Return the binary data represented by the hexadecimal string *hexstr*. This function is the inverse of `b2a_hex()`. *hexstr* must contain an even number of hexadecimal digits (which can be upper or lower case), otherwise an `Error` exception is raised.

Similar functionality (accepting only text string arguments, but more liberal towards whitespace) is also accessible using the `bytes.fromhex()` class method.

exception `binascii.Error`

Exception raised on errors. These are usually programming errors.

exception `binascii.Incomplete`

Exception raised on incomplete data. These are usually not programming errors, but may be handled by reading a little more data and trying again.

也參考:

base64 模組

Support for RFC compliant base64-style encoding in base 16, 32, 64, and 85.

uu 模組

Support for UU encoding used on Unix.

quopri 模組

Support for quoted-printable encoding used in MIME email messages.

19.7 quopri --- 編碼和解碼 MIME 可列印字元資料

原始碼: [Lib/quopri.py](#)

該模組根據 **RFC 1521**: 「MIME (多功能網際網路郵件擴充) 第一部分: 指定和描述網際網路訊息正文格式的機制」中的定義來執行可列印字元 (quoted-printable) 傳輸編碼和解碼。可列印字元編碼是 不可列印字元相對較少的資料而設計的; 如果存在許多此類字元 (例如發送圖形檔案時), 則透過 **base64** 模組提供的 Base64 編碼方案會更加簡潔。

`quopri.decode(input, output, header=False)`

解碼 *input* 檔案的內容，並將解碼後的二進位資料寫入 *output* 檔案。*input* 和 *output* 必須是二進位檔案物件。如果可選參數 *header* 存在且為 `true`，則底層將被解碼的空格。這用於解碼如 [RFC 1522](#):「MIME (多功能網際網路郵件擴充) 第二部分: 非 ASCII 文字的訊息標頭擴充」中所述的“Q”編碼標頭。

`quopri.encode(input, output, quotetabs, header=False)`

對 *input* 檔案的內容進行編碼，並將生成的可列印字元資料寫入 *output* 檔案。*input* 和 *output* 必須是二進位檔案物件。*quotetabs*，一個非可選旗標，控制是否對嵌入的空格和表符號 (tab) 進行編碼；當 `true` 時，它將對此類嵌入的空白進行編碼，當 `false` 時，它將不對它們進行編碼。請注意，出現在列尾的空格和表符號都會按照 [RFC 1521](#) 進行編碼。*header* 是一個旗標，用於控制空格是否按照 [RFC 1522](#) 編碼到底。

`quopri.decodestring(s, header=False)`

與 `decode()` 類似，不同之處在於它接受來源的 *bytes* 並回傳相應的已解碼 *bytes*。

`quopri.encodestring(s, quotetabs=False, header=False)`

與 `encode()` 類似，不同之處在於它接受來源的 *bytes* 並回傳相應的已編碼 *bytes*。預設情況下，它向 `encode()` 函式的 *quotetabs* 參數發送一個 `False` 值。

也參考:

[base64](#) 模組

對 MIME Base64 資料進行編碼和解碼

Structured Markup Processing Tools

Python supports a variety of modules to work with various forms of structured data markup. This includes modules to work with the Standard Generalized Markup Language (SGML) and the Hypertext Markup Language (HTML), and several interfaces for working with the Extensible Markup Language (XML).

20.1 `html` --- HyperText Markup Language support

原始碼: [Lib/html/__init__.py](#)

This module defines utilities to manipulate HTML.

`html.escape(s, quote=True)`

Convert the characters `&`, `<` and `>` in string *s* to HTML-safe sequences. Use this if you need to display text that might contain such characters in HTML. If the optional flag *quote* is true, the characters `"` and `'` are also translated; this helps for inclusion in an HTML attribute value delimited by quotes, as in ``.

在 3.2 版新加入.

`html.unescape(s)`

Convert all named and numeric character references (e.g. `>`, `>`, `>`) in the string *s* to the corresponding Unicode characters. This function uses the rules defined by the HTML 5 standard for both valid and invalid character references, and the *list of HTML 5 named character references*.

在 3.4 版新加入.

Submodules in the `html` package are:

- `html.parser` -- HTML/XHTML parser with lenient parsing mode
- `html.entities` -- HTML entity definitions

20.2 `html.parser` --- 簡單的 HTML 和 XHTML 剖析器

原始碼: [Lib/html/parser.py](https://lib/html/parser.py)

該模組定義了一個類 `HTMLParser`，是剖析 (parse) HTML (HyperText Mark-up Language、超文本標記語言) 和 XHTML 格式文本檔案的基礎。

```
class html.parser.HTMLParser(*, convert_charrefs=True)
```

建立一個能剖析無效標記的剖析器實例。

如果 `convert_charrefs` 為 `True` (預設值)，所有字元參照 (reference) (script/style 元素中的參照除外) 將自動轉為相應的 Unicode 字元。

`HTMLParser` 實例被提供 HTML 資料，在遇到開始標、結束標、文本、解和其他標記元素時呼叫處理程式 (handler) 方法。使用者應該繼承 `HTMLParser` 並覆蓋其方法以實作所需的行。

此剖析器不檢查結束標是否與開始標匹配，也不會透過結束外部元素來隱晦地被結束的元素呼叫結束標處理程式。

在 3.4 版的變更: 新增關鍵字引數 `convert_charrefs`。

在 3.5 版的變更: 引數 `convert_charrefs` 的預設值現在是 `True`。

20.2.1 HTML 剖析器應用程式范例

以下的基礎範例是一個簡單的 HTML 剖析器，它使用 `HTMLParser` 類，當遇到開始標、結束標和資料時將它們印出：

```
from html.parser import HTMLParser

class MyHTMLParser(HTMLParser):
    def handle_starttag(self, tag, attrs):
        print("Encountered a start tag:", tag)

    def handle_endtag(self, tag):
        print("Encountered an end tag :", tag)

    def handle_data(self, data):
        print("Encountered some data  :", data)

parser = MyHTMLParser()
parser.feed('<html><head><title>Test</title></head>'
          '<body><h1>Parse me!</h1></body></html>')
```

輸出將是：

```
Encountered a start tag: html
Encountered a start tag: head
Encountered a start tag: title
Encountered some data  : Test
Encountered an end tag : title
Encountered an end tag : head
Encountered a start tag: body
Encountered a start tag: h1
Encountered some data  : Parse me!
Encountered an end tag : h1
Encountered an end tag : body
Encountered an end tag : html
```

20.2.2 HTMLParser 方法

`HTMLParser` 實例具有以下方法：

`HTMLParser.feed(data)`

向剖析器提供一些文本。只要它由完整的元素組成，它就會被處理；不完整的資料會被緩衝，直到輸入更多資料或呼叫 `close()`。`data` 必須是 `str`。

`HTMLParser.close()`

強制處理所有緩衝資料，如同它後面跟有文件結束標一樣。此方法可能有被衍生類重新定義，以在輸入末尾定義額外的處理，但重新定義的版本仍應要呼叫 `HTMLParser` 基底類方法 `close()`。

`HTMLParser.reset()`

重置實例。所有未處理的資料。這在實例化時被會隱晦地呼叫。

`HTMLParser.getpos()`

回傳當前列號 (line number) 和偏移量 (offset)。

`HTMLParser.get_starttag_text()`

回傳最近開 (open) 的開始標的文本。這對於結構化處理通常不必要，但在處理「已部署」的 HTML 或以最少的更改重新生成輸入（可以保留屬性之間的空白等）時可能很有用。

當遇到資料或標記元素時將呼叫以下方法，且它們應在子類中被覆蓋。基底類實作什麼都不做（除了 `handle_startendtag()`）：

`HTMLParser.handle_starttag(tag, attrs)`

呼叫此方法來處理元素的開始標（例如 `<div id="main">`）。

`tag` 引數是轉小寫的標名稱。`attrs` 引數是一個 (name, value) 對的列表，包含在標的 `<>` 括號找到的屬性。`name` 將被轉成小寫，`value` 中的引號會被除，字元和實體參照也會被替。

例如，對於標 ``，這個方法會以 `handle_starttag('a', [('href', 'https://www.cwi.nl/')])` 的形式被呼叫。

在屬性值中來自 `html.entities` 的所有實體參照都會被替。

`HTMLParser.handle_endtag(tag)`

呼叫此方法來處理元素的結束標（例如 `</div>`）。

`tag` 引數是轉小寫的標名稱。

`HTMLParser.handle_startendtag(tag, attrs)`

與 `handle_starttag()` 類似，但在剖析器遇到 XHTML 樣式的空標（``）時呼叫。這個方法可能被需要這個特定詞資訊 (lexical information) 的子類覆蓋；預設實作只是呼叫 `handle_starttag()` 和 `handle_endtag()`。

`HTMLParser.handle_data(data)`

呼叫此方法來處理任意資料（例如文本節點與 `<script>...</script>` 和 `<style>...</style>` 的內容）。

`HTMLParser.handle_entityref(name)`

呼叫此方法來處理形式 `&name;`（例如 `>`）的附名字元參照，其中 `name` 是一般實體參照（例如 `'gt'`）。如果 `convert_charrefs` 是 `True`，則永遠不會呼叫此方法。

`HTMLParser.handle_charref(name)`

This method is called to process decimal and hexadecimal numeric character references of the form `&#NNN;` and `&#xNNN;`. For example, the decimal equivalent for `>` is `>`, whereas the hexadecimal is `>`; in this case the method will receive `'62'` or `'x3E'`. This method is never called if `convert_charrefs` is `True`.

`HTMLParser.handle_comment(data)`

當遇到解時呼叫此方法（例如 `<!--comment-->`）。

舉例來，解 `<!-- comment -->` 會使得此方法被以引數 `'comment'` 來呼叫。

Internet Explorer 條件式解 (conditional comments, `condcoms`) 的內容也會被發送到這個方法，故以 `<!--[if IE 9]>IE9-specific content<![endif]-->` 為例，這個方法將會收到 `'[if IE 9]>IE9-specific content<![endif]'`。

`HTMLParser.handle_decl(decl)`

呼叫此方法來處理 HTML 文件類型聲明 (doctype declaration) (例如 `<!DOCTYPE html>`)。

`decl` 參數將是 `<![...>` 標記聲明部分的全部內容 (例如 `'DOCTYPE html'`)。

`HTMLParser.handle_pi(data)`

遇到處理指示 (processing instruction) 時會呼叫的方法。`data` 參數將包含整個處理指示。例如，對於處理指示 `<?proc color='red'>`，這個方法將以 `handle_pi("proc color='red'")` 形式被呼叫。它旨在被衍生類覆蓋；基底類實作中什麼都不做。

備註： `HTMLParser` 類使用 SGML 語法規則來處理指示。使用有？跟隨在後面的 XHTML 處理指示將導致？被包含在 `data` 中。

`HTMLParser.unknown_decl(data)`

當剖析器讀取無法識別的聲明時會呼叫此方法。

`data` 參數將是 `<![...]>` 標記聲明部分的全部內容。有時被衍生類被覆蓋會是好用的。在基底類實作中什麼都不做。

20.2.3 范例

以下類實作了一個剖析器，將用於解更多範例：

```
from html.parser import HTMLParser
from html.entities import name2codepoint

class MyHTMLParser(HTMLParser):
    def handle_starttag(self, tag, attrs):
        print("Start tag:", tag)
        for attr in attrs:
            print("    attr:", attr)

    def handle_endtag(self, tag):
        print("End tag :", tag)

    def handle_data(self, data):
        print("Data      :", data)

    def handle_comment(self, data):
        print("Comment  :", data)

    def handle_entityref(self, name):
        c = chr(name2codepoint[name])
        print("Named ent:", c)

    def handle_charref(self, name):
        if name.startswith('x'):
            c = chr(int(name[1:], 16))
        else:
            c = chr(int(name))
        print("Num ent  :", c)

    def handle_decl(self, data):
        print("Decl      :", data)

parser = MyHTMLParser()
```


剖析文件類型：

```
>>> parser.feed('<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN" '
...             '"http://www.w3.org/TR/html4/strict.dtd">')
Decl      : DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN" "http://www.w3.org/TR/
↳html4/strict.dtd"
```

剖析一個具有一些屬性和標題的元素：

```
>>> parser.feed('')
Start tag: img
  attr: ('src', 'python-logo.png')
  attr: ('alt', 'The Python logo')
>>>
>>> parser.feed('<h1>Python</h1>')
Start tag: h1
Data      : Python
End tag   : h1
```

script 和 style 元素的內容按原樣回傳，無需進一步剖析：

```
>>> parser.feed('<style type="text/css">#python { color: green }</style>')
Start tag: style
  attr: ('type', 'text/css')
Data      : #python { color: green }
End tag   : style

>>> parser.feed('<script type="text/javascript">'
...             'alert("<strong>hello!</strong>");</script>')
Start tag: script
  attr: ('type', 'text/javascript')
Data      : alert("<strong>hello!</strong>");
End tag   : script
```

剖析解：

```
>>> parser.feed('<!-- a comment -->'
...             '<!--[if IE 9]>IE-specific content<![endif]-->')
Comment   : a comment
Comment   : [if IE 9]>IE-specific content<![endif]
```

剖析附名 (named) 且數值的 (numeric) 字元參照，將它們轉為正確的字元（注意：這 3 個參照都等同於 '>'）：

```
>>> parser.feed('&gt;&#62;&#x3E;')
Named ent: >
Num ent   : >
Num ent   : >
```

將不完整的區塊提供給 `feed()` 是可行的，但是 `handle_data()` 可能會被多次呼叫（除非 `convert_charrefs` 設定為 `True`）：

```
>>> for chunk in ['<sp', 'an>buff', 'ered', 'text</s', 'pan>']:
...     parser.feed(chunk)
...
Start tag: span
Data      : buff
Data      : ered
Data      : text
End tag   : span
```

也能剖析無效的 HTML（例如未加引號的屬性）：

```
>>> parser.feed('<p><a class=link href=#main>tag soup</p>></a>')
Start tag: p
Start tag: a
      attr: ('class', 'link')
      attr: ('href', '#main')
Data      : tag soup
End tag   : p
End tag   : a
```

20.3 `html.entities` --- HTML 一般實體的定義

原始碼: [Lib/html/entities.py](#)

該 module (模組) 定義了四個字典: `html5`、`name2codepoint`、`codepoint2name` 以及 `entitydefs`。

`html.entities.html5`

將 HTML5 命名字元引用¹ 對映到同等 Unicode 字元的字典, 例如 `html5['gt;'] == '>'`。請注意, 後面的分號包含在名稱中 (例如 `'gt;'`), 但有些名稱即使有分號也會被此標準接受: 在這種情況下, 名稱可帶有或不帶有 `'>'`。請見 `html.unescape()`。

在 3.3 版新加入。

`html.entities.entitydefs`

將 XHTML 1.0 實體定義對映到 ISO Latin-1 中的替換文字的字典。

`html.entities.name2codepoint`

將 HTML 實體名稱對映到 Unicode 程式點的字典。

`html.entities.codepoint2name`

將 Unicode 程式點對映到 HTML 實體名稱的字典。

解

20.4 XML 處理模組

原始碼: [Lib/xml/](#)

Python's interfaces for processing XML are grouped in the `xml` package.

警告: The XML modules are not secure against erroneous or maliciously constructed data. If you need to parse untrusted or unauthenticated data see the [XML vulnerabilities](#) and [The defusedxml Package](#) sections.

It is important to note that modules in the `xml` package require that there be at least one SAX-compliant XML parser available. The Expat parser is included with Python, so the `xml.parsers.expat` module will always be available.

The documentation for the `xml.dom` and `xml.sax` packages are the definition of the Python bindings for the DOM and SAX interfaces.

The XML handling submodules are:

¹ 請見 <https://html.spec.whatwg.org/multipage/named-characters.html#named-character-references>

- `xml.etree.ElementTree`: the ElementTree API, a simple and lightweight XML processor
- `xml.dom`: the DOM API definition
- `xml.dom.minidom`: a minimal DOM implementation
- `xml.dom.pulldom`: support for building partial DOM trees
- `xml.sax`: SAX2 base classes and convenience functions
- `xml.parsers.expat`: the Expat parser binding

20.4.1 XML vulnerabilities

The XML processing modules are not secure against maliciously constructed data. An attacker can abuse XML features to carry out denial of service attacks, access local files, generate network connections to other machines, or circumvent firewalls.

The following table gives an overview of the known attacks and whether the various modules are vulnerable to them.

kind	sax	etree	minidom	pulldom	xmlrpc
billion laughs	Vulnerable (1)	Vulnerable (1)	Vulnerable (1)	Vulnerable (1)	Vulnerable (1)
quadratic blowup	Vulnerable (1)	Vulnerable (1)	Vulnerable (1)	Vulnerable (1)	Vulnerable (1)
external entity expansion	Safe (5)	Safe (2)	Safe (3)	Safe (5)	Safe (4)
DTD retrieval	Safe (5)	Safe	Safe	Safe (5)	Safe
decompression bomb	Safe	Safe	Safe	Safe	Vulnerable
large tokens	Vulnerable (6)	Vulnerable (6)	Vulnerable (6)	Vulnerable (6)	Vulnerable (6)

1. Expat 2.4.1 and newer is not vulnerable to the "billion laughs" and "quadratic blowup" vulnerabilities. Items still listed as vulnerable due to potential reliance on system-provided libraries. Check `pyexpat.EXPAT_VERSION`.
2. `xml.etree.ElementTree` doesn't expand external entities and raises a `ParseError` when an entity occurs.
3. `xml.dom.minidom` doesn't expand external entities and simply returns the unexpanded entity verbatim.
4. `xmlrpc.client` doesn't expand external entities and omits them.
5. Since Python 3.7.1, external general entities are no longer processed by default.
6. Expat 2.6.0 and newer is not vulnerable to denial of service through quadratic runtime caused by parsing large tokens. Items still listed as vulnerable due to potential reliance on system-provided libraries. Check `pyexpat.EXPAT_VERSION`.

billion laughs / exponential entity expansion

The **Billion Laughs** attack -- also known as exponential entity expansion -- uses multiple levels of nested entities. Each entity refers to another entity several times, and the final entity definition contains a small string. The exponential expansion results in several gigabytes of text and consumes lots of memory and CPU time.

quadratic blowup entity expansion

A quadratic blowup attack is similar to a **Billion Laughs** attack; it abuses entity expansion, too. Instead of nested entities it repeats one large entity with a couple of thousand chars over and over again. The attack isn't as efficient as the exponential case but it avoids triggering parser countermeasures that forbid deeply nested entities.

external entity expansion

Entity declarations can contain more than just text for replacement. They can also point to external resources or local files. The XML parser accesses the resource and embeds the content into the XML document.

DTD retrieval

Some XML libraries like Python's `xml.dom.pulldom` retrieve document type definitions from remote or local locations. The feature has similar implications as the external entity expansion issue.

decompression bomb

Decompression bombs (aka **ZIP bomb**) apply to all XML libraries that can parse compressed XML streams such as gzipped HTTP streams or LZMA-compressed files. For an attacker it can reduce the amount of transmitted data by three magnitudes or more.

large tokens

Expat needs to re-parse unfinished tokens; without the protection introduced in Expat 2.6.0, this can lead to quadratic runtime that can be used to cause denial of service in the application parsing XML. The issue is known as [CVE-2023-52425](#).

The documentation for [defusedxml](#) on PyPI has further information about all known attack vectors with examples and references.

20.4.2 The `defusedxml` Package

`defusedxml` is a pure Python package with modified subclasses of all stdlib XML parsers that prevent any potentially malicious operation. Use of this package is recommended for any server code that parses untrusted XML data. The package also ships with example exploits and extended documentation on more XML exploits such as XPath injection.

20.5 `xml.etree.ElementTree` --- The `ElementTree` XML API

原始碼: [Lib/xml/etree/ElementTree.py](#)

The `xml.etree.ElementTree` module implements a simple and efficient API for parsing and creating XML data.

在 3.3 版的變更: This module will use a fast implementation whenever available.

在 3.3 版之後被 用: The `xml.etree.cElementTree` module is deprecated.

警告: The `xml.etree.ElementTree` module is not secure against maliciously constructed data. If you need to parse untrusted or unauthenticated data see [XML vulnerabilities](#).

20.5.1 Tutorial

This is a short tutorial for using `xml.etree.ElementTree` (ET in short). The goal is to demonstrate some of the building blocks and basic concepts of the module.

XML tree and elements

XML is an inherently hierarchical data format, and the most natural way to represent it is with a tree. ET has two classes for this purpose - `ElementTree` represents the whole XML document as a tree, and `Element` represents a single node in this tree. Interactions with the whole document (reading and writing to/from files) are usually done on the `ElementTree` level. Interactions with a single XML element and its sub-elements are done on the `Element` level.

Parsing XML

We'll be using the fictive `country_data.xml` XML document as the sample data for this section:

```
<?xml version="1.0"?>
<data>
  <country name="Liechtenstein">
    <rank>1</rank>
    <year>2008</year>
    <gdppc>141100</gdppc>
    <neighbor name="Austria" direction="E"/>
    <neighbor name="Switzerland" direction="W"/>
  </country>
  <country name="Singapore">
    <rank>4</rank>
    <year>2011</year>
    <gdppc>59900</gdppc>
    <neighbor name="Malaysia" direction="N"/>
  </country>
  <country name="Panama">
    <rank>68</rank>
    <year>2011</year>
    <gdppc>13600</gdppc>
    <neighbor name="Costa Rica" direction="W"/>
    <neighbor name="Colombia" direction="E"/>
  </country>
</data>
```

We can import this data by reading from a file:

```
import xml.etree.ElementTree as ET
tree = ET.parse('country_data.xml')
root = tree.getroot()
```

Or directly from a string:

```
root = ET.fromstring(country_data_as_string)
```

`fromstring()` parses XML from a string directly into an *Element*, which is the root element of the parsed tree. Other parsing functions may create an *ElementTree*. Check the documentation to be sure.

As an *Element*, `root` has a tag and a dictionary of attributes:

```
>>> root.tag
'data'
>>> root.attrib
{}
```

It also has children nodes over which we can iterate:

```
>>> for child in root:
...     print(child.tag, child.attrib)
...
country {'name': 'Liechtenstein'}
country {'name': 'Singapore'}
country {'name': 'Panama'}
```

Children are nested, and we can access specific child nodes by index:

```
>>> root[0][1].text
'2008'
```

備: Not all elements of the XML input will end up as elements of the parsed tree. Currently, this module skips over any XML comments, processing instructions, and document type declarations in the input. Nevertheless, trees built using this module’s API rather than parsing from XML text can have comments and processing instructions in them; they will be included when generating XML output. A document type declaration may be accessed by passing a custom *TreeBuilder* instance to the *XMLParser* constructor.

Pull API for non-blocking parsing

Most parsing functions provided by this module require the whole document to be read at once before returning any result. It is possible to use an *XMLParser* and feed data into it incrementally, but it is a push API that calls methods on a callback target, which is too low-level and inconvenient for most needs. Sometimes what the user really wants is to be able to parse XML incrementally, without blocking operations, while enjoying the convenience of fully constructed *Element* objects.

The most powerful tool for doing this is *XMLPullParser*. It does not require a blocking read to obtain the XML data, and is instead fed with data incrementally with *XMLPullParser.feed()* calls. To get the parsed XML elements, call *XMLPullParser.read_events()*. Here is an example:

```
>>> parser = ET.XMLPullParser(['start', 'end'])
>>> parser.feed('<mytag>sometext')
>>> list(parser.read_events())
[('start', <Element 'mytag' at 0x7fa66db2be58>)]
>>> parser.feed(' more text</mytag>')
>>> for event, elem in parser.read_events():
...     print(event)
...     print(elem.tag, 'text=', elem.text)
...
end
mytag text= sometext more text
```

The obvious use case is applications that operate in a non-blocking fashion where the XML data is being received from a socket or read incrementally from some storage device. In such cases, blocking reads are unacceptable.

Because it’s so flexible, *XMLPullParser* can be inconvenient to use for simpler use-cases. If you don’t mind your application blocking on reading XML data but would still like to have incremental parsing capabilities, take a look at *iterparse()*. It can be useful when you’re reading a large XML document and don’t want to hold it wholly in memory.

Where *immediate* feedback through events is wanted, calling method *XMLPullParser.flush()* can help reduce delay; please make sure to study the related security notes.

Finding interesting elements

Element has some useful methods that help iterate recursively over all the sub-tree below it (its children, their children, and so on). For example, *Element.iter()*:

```
>>> for neighbor in root.iter('neighbor'):
...     print(neighbor.attrib)
...
{'name': 'Austria', 'direction': 'E'}
{'name': 'Switzerland', 'direction': 'W'}
{'name': 'Malaysia', 'direction': 'N'}
{'name': 'Costa Rica', 'direction': 'W'}
{'name': 'Colombia', 'direction': 'E'}
```

Element.findall() finds only elements with a tag which are direct children of the current element. *Element.find()* finds the *first* child with a particular tag, and *Element.text* accesses the element’s text content. *Element.get()* accesses the element’s attributes:

```
>>> for country in root.findall('country'):
...     rank = country.find('rank').text
...     name = country.get('name')
...     print(name, rank)
...
Liechtenstein 1
Singapore 4
Panama 68
```

More sophisticated specification of which elements to look for is possible by using *XPath*.

Modifying an XML File

ElementTree provides a simple way to build XML documents and write them to files. The *ElementTree.write()* method serves this purpose.

Once created, an *Element* object may be manipulated by directly changing its fields (such as *Element.text*), adding and modifying attributes (*Element.set()* method), as well as adding new children (for example with *Element.append()*).

Let's say we want to add one to each country's rank, and add an *updated* attribute to the rank element:

```
>>> for rank in root.iter('rank'):
...     new_rank = int(rank.text) + 1
...     rank.text = str(new_rank)
...     rank.set('updated', 'yes')
...
>>> tree.write('output.xml')
```

Our XML now looks like this:

```
<?xml version="1.0"?>
<data>
  <country name="Liechtenstein">
    <rank updated="yes">2</rank>
    <year>2008</year>
    <gdppc>141100</gdppc>
    <neighbor name="Austria" direction="E"/>
    <neighbor name="Switzerland" direction="W"/>
  </country>
  <country name="Singapore">
    <rank updated="yes">5</rank>
    <year>2011</year>
    <gdppc>59900</gdppc>
    <neighbor name="Malaysia" direction="N"/>
  </country>
  <country name="Panama">
    <rank updated="yes">69</rank>
    <year>2011</year>
    <gdppc>13600</gdppc>
    <neighbor name="Costa Rica" direction="W"/>
    <neighbor name="Colombia" direction="E"/>
  </country>
</data>
```

We can remove elements using *Element.remove()*. Let's say we want to remove all countries with a rank higher than 50:

```
>>> for country in root.findall('country'):
...     # using root.findall() to avoid removal during traversal
...     rank = int(country.find('rank').text)
```

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```
...     if rank > 50:
...         root.remove(country)
...
>>> tree.write('output.xml')
```

Note that concurrent modification while iterating can lead to problems, just like when iterating and modifying Python lists or dicts. Therefore, the example first collects all matching elements with `root.findall()`, and only then iterates over the list of matches.

Our XML now looks like this:

```
<?xml version="1.0"?>
<data>
  <country name="Liechtenstein">
    <rank updated="yes">2</rank>
    <year>2008</year>
    <gdppc>141100</gdppc>
    <neighbor name="Austria" direction="E"/>
    <neighbor name="Switzerland" direction="W"/>
  </country>
  <country name="Singapore">
    <rank updated="yes">5</rank>
    <year>2011</year>
    <gdppc>59900</gdppc>
    <neighbor name="Malaysia" direction="N"/>
  </country>
</data>
```

Building XML documents

The `SubElement()` function also provides a convenient way to create new sub-elements for a given element:

```
>>> a = ET.Element('a')
>>> b = ET.SubElement(a, 'b')
>>> c = ET.SubElement(a, 'c')
>>> d = ET.SubElement(c, 'd')
>>> ET.dump(a)
<a><b /><c><d /></c></a>
```

Parsing XML with Namespaces

If the XML input has `namespaces`, tags and attributes with prefixes in the form `prefix:sometag` get expanded to `{uri}sometag` where the *prefix* is replaced by the full *URI*. Also, if there is a `default namespace`, that full URI gets prepended to all of the non-prefixed tags.

Here is an XML example that incorporates two namespaces, one with the prefix "fictional" and the other serving as the default namespace:

```
<?xml version="1.0"?>
<actors xmlns:fictional="http://characters.example.com"
        xmlns="http://people.example.com">
  <actor>
    <name>John Cleese</name>
    <fictional:character>Lancelot</fictional:character>
    <fictional:character>Archie Leach</fictional:character>
  </actor>
  <actor>
    <name>Eric Idle</name>
```

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```

<fictional:character>Sir Robin</fictional:character>
<fictional:character>Gunther</fictional:character>
<fictional:character>Commander Clement</fictional:character>
</actor>
</actors>

```

One way to search and explore this XML example is to manually add the URI to every tag or attribute in the xpath of a `find()` or `findall()`:

```

root = fromstring(xml_text)
for actor in root.findall('{http://people.example.com}actor'):
    name = actor.find('{http://people.example.com}name')
    print(name.text)
    for char in actor.findall('{http://characters.example.com}character'):
        print(' |-->', char.text)

```

A better way to search the namespaced XML example is to create a dictionary with your own prefixes and use those in the search functions:

```

ns = {'real_person': 'http://people.example.com',
      'role': 'http://characters.example.com'}

for actor in root.findall('real_person:actor', ns):
    name = actor.find('real_person:name', ns)
    print(name.text)
    for char in actor.findall('role:character', ns):
        print(' |-->', char.text)

```

These two approaches both output:

```

John Cleese
|--> Lancelot
|--> Archie Leach
Eric Idle
|--> Sir Robin
|--> Gunther
|--> Commander Clement

```

20.5.2 XPath support

This module provides limited support for [XPath expressions](#) for locating elements in a tree. The goal is to support a small subset of the abbreviated syntax; a full XPath engine is outside the scope of the module.

范例

Here's an example that demonstrates some of the XPath capabilities of the module. We'll be using the `countrydata` XML document from the *Parsing XML* section:

```

import xml.etree.ElementTree as ET

root = ET.fromstring(countrydata)

# Top-level elements
root.findall(".")

# All 'neighbor' grand-children of 'country' children of the top-level
# elements
root.findall("./country/neighbor")

```

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```
# Nodes with name='Singapore' that have a 'year' child
root.findall("./year/..[@name='Singapore']")

# 'year' nodes that are children of nodes with name='Singapore'
root.findall("./*[@name='Singapore']/year")

# All 'neighbor' nodes that are the second child of their parent
root.findall("./neighbor[2]")
```

For XML with namespaces, use the usual qualified {namespace}tag notation:

```
# All dublin-core "title" tags in the document
root.findall("./{http://purl.org/dc/elements/1.1/}title")
```

Supported XPath syntax

Syntax	Meaning
tag	Selects all child elements with the given tag. For example, spam selects all child elements named spam, and spam/egg selects all grandchildren named egg in all children named spam. {namespace}* selects all tags in the given namespace, {*}spam selects tags named spam in any (or no) namespace, and {}* only selects tags that are not in a namespace. 在 3.8 版的變更: Support for star-wildcards was added.
*	Selects all child elements, including comments and processing instructions. For example, */egg selects all grandchildren named egg.
.	Selects the current node. This is mostly useful at the beginning of the path, to indicate that it's a relative path.
//	Selects all subelements, on all levels beneath the current element. For example, ././egg selects all egg elements in the entire tree.
..	Selects the parent element. Returns None if the path attempts to reach the ancestors of the start element (the element find was called on).
[@attrib]	Selects all elements that have the given attribute.
[@attrib='value']	Selects all elements for which the given attribute has the given value. The value cannot contain quotes.
[@attrib!='value']	Selects all elements for which the given attribute does not have the given value. The value cannot contain quotes. 在 3.10 版新加入.
[tag]	Selects all elements that have a child named tag. Only immediate children are supported.
[.='text']	Selects all elements whose complete text content, including descendants, equals the given text. 在 3.7 版新加入.
[.!='text']	Selects all elements whose complete text content, including descendants, does not equal the given text. 在 3.10 版新加入.
[tag='text']	Selects all elements that have a child named tag whose complete text content, including descendants, equals the given text.
[tag!='text']	Selects all elements that have a child named tag whose complete text content, including descendants, does not equal the given text. 在 3.10 版新加入.
[position]	Selects all elements that are located at the given position. The position can be either an integer (1 is the first position), the expression last() (for the last position), or a position relative to the last position (e.g. last()-1).

Predicates (expressions within square brackets) must be preceded by a tag name, an asterisk, or another predicate. `position` predicates must be preceded by a tag name.

20.5.3 Reference

函式

`xml.etree.ElementTree.canonicalize` (*xml_data=None*, *, *out=None*, *from_file=None*, ***options*)

C14N 2.0 transformation function.

Canonicalization is a way to normalise XML output in a way that allows byte-by-byte comparisons and digital signatures. It reduced the freedom that XML serializers have and instead generates a more constrained XML representation. The main restrictions regard the placement of namespace declarations, the ordering of attributes, and ignorable whitespace.

This function takes an XML data string (*xml_data*) or a file path or file-like object (*from_file*) as input, converts it to the canonical form, and writes it out using the *out* file(-like) object, if provided, or returns it as a text string if not. The output file receives text, not bytes. It should therefore be opened in text mode with `utf-8` encoding.

Typical uses:

```
xml_data = "<root>...</root>"
print(canonicalize(xml_data))

with open("c14n_output.xml", mode='w', encoding='utf-8') as out_file:
    canonicalize(xml_data, out=out_file)

with open("c14n_output.xml", mode='w', encoding='utf-8') as out_file:
    canonicalize(from_file="inputfile.xml", out=out_file)
```

The configuration *options* are as follows:

- *with_comments*: set to true to include comments (default: false)
- *strip_text*: set to true to strip whitespace before and after text content (default: false)
- *rewrite_prefixes*: set to true to replace namespace prefixes by "n{number}" (default: false)
- *qname_aware_tags*: a set of qname aware tag names in which prefixes should be replaced in text content (default: empty)
- *qname_aware_attrs*: a set of qname aware attribute names in which prefixes should be replaced in text content (default: empty)
- *exclude_attrs*: a set of attribute names that should not be serialised
- *exclude_tags*: a set of tag names that should not be serialised

In the option list above, "a set" refers to any collection or iterable of strings, no ordering is expected.

在 3.8 版新加入。

`xml.etree.ElementTree.Comment` (*text=None*)

Comment element factory. This factory function creates a special element that will be serialized as an XML comment by the standard serializer. The comment string can be either a bytestring or a Unicode string. *text* is a string containing the comment string. Returns an element instance representing a comment.

Note that `XMLParser` skips over comments in the input instead of creating comment objects for them. An `ElementTree` will only contain comment nodes if they have been inserted into to the tree using one of the `Element` methods.

`xml.etree.ElementTree.dump(elem)`

Writes an element tree or element structure to `sys.stdout`. This function should be used for debugging only.

The exact output format is implementation dependent. In this version, it's written as an ordinary XML file.

elem is an element tree or an individual element.

在 3.8 版的變更: The `dump()` function now preserves the attribute order specified by the user.

`xml.etree.ElementTree.fromstring(text, parser=None)`

Parses an XML section from a string constant. Same as `XML()`. *text* is a string containing XML data. *parser* is an optional parser instance. If not given, the standard `XMLParser` parser is used. Returns an *Element* instance.

`xml.etree.ElementTree.fromstringlist(sequence, parser=None)`

Parses an XML document from a sequence of string fragments. *sequence* is a list or other sequence containing XML data fragments. *parser* is an optional parser instance. If not given, the standard `XMLParser` parser is used. Returns an *Element* instance.

在 3.2 版新加入。

`xml.etree.ElementTree.indent(tree, space=' ', level=0)`

Appends whitespace to the subtree to indent the tree visually. This can be used to generate pretty-printed XML output. *tree* can be an *Element* or *ElementTree*. *space* is the whitespace string that will be inserted for each indentation level, two space characters by default. For indenting partial subtrees inside of an already indented tree, pass the initial indentation level as *level*.

在 3.9 版新加入。

`xml.etree.ElementTree.iselement(element)`

Check if an object appears to be a valid element object. *element* is an element instance. Return `True` if this is an element object.

`xml.etree.ElementTree.iterparse(source, events=None, parser=None)`

Parses an XML section into an element tree incrementally, and reports what's going on to the user. *source* is a filename or *file object* containing XML data. *events* is a sequence of events to report back. The supported events are the strings "start", "end", "comment", "pi", "start-ns" and "end-ns" (the "ns" events are used to get detailed namespace information). If *events* is omitted, only "end" events are reported. *parser* is an optional parser instance. If not given, the standard `XMLParser` parser is used. *parser* must be a subclass of `XMLParser` and can only use the default `TreeBuilder` as a target. Returns an *iterator* providing (event, elem) pairs; it has a `root` attribute that references the root element of the resulting XML tree once *source* is fully read.

Note that while `iterparse()` builds the tree incrementally, it issues blocking reads on *source* (or the file it names). As such, it's unsuitable for applications where blocking reads can't be made. For fully non-blocking parsing, see `XMLPullParser`.

備 註: `iterparse()` only guarantees that it has seen the ">" character of a starting tag when it emits a "start" event, so the attributes are defined, but the contents of the text and tail attributes are undefined at that point. The same applies to the element children; they may or may not be present.

If you need a fully populated element, look for "end" events instead.

在 3.4 版之後被 用: *parser* 引數。

在 3.8 版的變更: 新增 *context* 與 *check_hostname* 事件。

`xml.etree.ElementTree.parse(source, parser=None)`

Parses an XML section into an element tree. *source* is a filename or file object containing XML data. *parser* is an optional parser instance. If not given, the standard `XMLParser` parser is used. Returns an *ElementTree* instance.

`xml.etree.ElementTree.ProcessingInstruction` (*target*, *text=None*)

PI element factory. This factory function creates a special element that will be serialized as an XML processing instruction. *target* is a string containing the PI target. *text* is a string containing the PI contents, if given. Returns an element instance, representing a processing instruction.

Note that *XMLParser* skips over processing instructions in the input instead of creating PI objects for them. An *ElementTree* will only contain processing instruction nodes if they have been inserted into to the tree using one of the *Element* methods.

`xml.etree.ElementTree.register_namespace` (*prefix*, *uri*)

Registers a namespace prefix. The registry is global, and any existing mapping for either the given prefix or the namespace URI will be removed. *prefix* is a namespace prefix. *uri* is a namespace uri. Tags and attributes in this namespace will be serialized with the given prefix, if at all possible.

在 3.2 版新加入。

`xml.etree.ElementTree.SubElement` (*parent*, *tag*, *attrib={}*, ***extra*)

Subelement factory. This function creates an element instance, and appends it to an existing element.

The element name, attribute names, and attribute values can be either bytestrings or Unicode strings. *parent* is the parent element. *tag* is the subelement name. *attrib* is an optional dictionary, containing element attributes. *extra* contains additional attributes, given as keyword arguments. Returns an element instance.

`xml.etree.ElementTree.tostring` (*element*, *encoding='us-ascii'*, *method='xml'*, *,
xml_declaration=None, *default_namespace=None*,
short_empty_elements=True)

Generates a string representation of an XML element, including all subelements. *element* is an *Element* instance. *encoding*¹ is the output encoding (default is US-ASCII). Use *encoding="unicode"* to generate a Unicode string (otherwise, a bytestring is generated). *method* is either "xml", "html" or "text" (default is "xml"). *xml_declaration*, *default_namespace* and *short_empty_elements* has the same meaning as in *ElementTree.write()*. Returns an (optionally) encoded string containing the XML data.

在 3.4 版的變更: Added the *short_empty_elements* parameter.

在 3.8 版的變更: Added the *xml_declaration* and *default_namespace* parameters.

在 3.8 版的變更: The *tostring()* function now preserves the attribute order specified by the user.

`xml.etree.ElementTree.tostringlist` (*element*, *encoding='us-ascii'*, *method='xml'*, *,
xml_declaration=None, *default_namespace=None*,
short_empty_elements=True)

Generates a string representation of an XML element, including all subelements. *element* is an *Element* instance. *encoding*^{Page 1237, 1} is the output encoding (default is US-ASCII). Use *encoding="unicode"* to generate a Unicode string (otherwise, a bytestring is generated). *method* is either "xml", "html" or "text" (default is "xml"). *xml_declaration*, *default_namespace* and *short_empty_elements* has the same meaning as in *ElementTree.write()*. Returns a list of (optionally) encoded strings containing the XML data. It does not guarantee any specific sequence, except that `b"".join(tostringlist(element)) == tostring(element)`.

在 3.2 版新加入。

在 3.4 版的變更: Added the *short_empty_elements* parameter.

在 3.8 版的變更: Added the *xml_declaration* and *default_namespace* parameters.

在 3.8 版的變更: The *tostringlist()* function now preserves the attribute order specified by the user.

`xml.etree.ElementTree.XML` (*text*, *parser=None*)

Parses an XML section from a string constant. This function can be used to embed "XML literals" in Python code. *text* is a string containing XML data. *parser* is an optional parser instance. If not given, the standard *XMLParser* parser is used. Returns an *Element* instance.

¹ The encoding string included in XML output should conform to the appropriate standards. For example, "UTF-8" is valid, but "UTF8" is not. See <https://www.w3.org/TR/2006/REC-xml11-20060816/#NT-EncodingDecl> and <https://www.iana.org/assignments/character-sets/character-sets.xhtml>.

`xml.etree.ElementTree.XMLID(text, parser=None)`

Parses an XML section from a string constant, and also returns a dictionary which maps from element id:s to elements. *text* is a string containing XML data. *parser* is an optional parser instance. If not given, the standard *XMLParser* parser is used. Returns a tuple containing an *Element* instance and a dictionary.

20.5.4 XInclude support

This module provides limited support for *XInclude* directives, via the `xml.etree.ElementInclude` helper module. This module can be used to insert subtrees and text strings into element trees, based on information in the tree.

范例

Here's an example that demonstrates use of the *XInclude* module. To include an XML document in the current document, use the `{http://www.w3.org/2001/XInclude}include` element and set the **parse** attribute to "xml", and use the **href** attribute to specify the document to include.

```
<?xml version="1.0"?>
<document xmlns:xi="http://www.w3.org/2001/XInclude">
  <xi:include href="source.xml" parse="xml" />
</document>
```

By default, the **href** attribute is treated as a file name. You can use custom loaders to override this behaviour. Also note that the standard helper does not support *XPointer* syntax.

To process this file, load it as usual, and pass the root element to the `xml.etree.ElementTree` module:

```
from xml.etree import ElementTree, ElementInclude

tree = ElementTree.parse("document.xml")
root = tree.getroot()

ElementInclude.include(root)
```

The *ElementInclude* module replaces the `{http://www.w3.org/2001/XInclude}include` element with the root element from the **source.xml** document. The result might look something like this:

```
<document xmlns:xi="http://www.w3.org/2001/XInclude">
  <para>This is a paragraph.</para>
</document>
```

If the **parse** attribute is omitted, it defaults to "xml". The **href** attribute is required.

To include a text document, use the `{http://www.w3.org/2001/XInclude}include` element, and set the **parse** attribute to "text":

```
<?xml version="1.0"?>
<document xmlns:xi="http://www.w3.org/2001/XInclude">
  Copyright (c) <xi:include href="year.txt" parse="text" />.
</document>
```

The result might look something like:

```
<document xmlns:xi="http://www.w3.org/2001/XInclude">
  Copyright (c) 2003.
</document>
```

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函式

`xml.etree.ElementInclude.default_loader(href, parse, encoding=None)`

Default loader. This default loader reads an included resource from disk. *href* is a URL. *parse* is for parse mode either "xml" or "text". *encoding* is an optional text encoding. If not given, encoding is `utf-8`. Returns the expanded resource. If the parse mode is "xml", this is an `ElementTree` instance. If the parse mode is "text", this is a Unicode string. If the loader fails, it can return `None` or raise an exception.

`xml.etree.ElementInclude.include(elem, loader=None, base_url=None, max_depth=6)`

This function expands XInclude directives. *elem* is the root element. *loader* is an optional resource loader. If omitted, it defaults to `default_loader()`. If given, it should be a callable that implements the same interface as `default_loader()`. *base_url* is base URL of the original file, to resolve relative include file references. *max_depth* is the maximum number of recursive inclusions. Limited to reduce the risk of malicious content explosion. Pass a negative value to disable the limitation.

Returns the expanded resource. If the parse mode is "xml", this is an `ElementTree` instance. If the parse mode is "text", this is a Unicode string. If the loader fails, it can return `None` or raise an exception.

在 3.9 版的變更: Added the *base_url* and *max_depth* parameters.

Element Objects

class `xml.etree.ElementTree.Element(tag, attrib={}, **extra)`

Element class. This class defines the Element interface, and provides a reference implementation of this interface.

The element name, attribute names, and attribute values can be either bytestrings or Unicode strings. *tag* is the element name. *attrib* is an optional dictionary, containing element attributes. *extra* contains additional attributes, given as keyword arguments.

tag

A string identifying what kind of data this element represents (the element type, in other words).

text

tail

These attributes can be used to hold additional data associated with the element. Their values are usually strings but may be any application-specific object. If the element is created from an XML file, the *text* attribute holds either the text between the element's start tag and its first child or end tag, or `None`, and the *tail* attribute holds either the text between the element's end tag and the next tag, or `None`. For the XML data

```
<a><b>1<c>2<d/>3</c></b>4</a>
```

the *a* element has `None` for both *text* and *tail* attributes, the *b* element has *text* "1" and *tail* "4", the *c* element has *text* "2" and *tail* `None`, and the *d* element has *text* `None` and *tail* "3".

To collect the inner text of an element, see `itertext()`, for example `"".join(element.itertext())`.

Applications may store arbitrary objects in these attributes.

attrib

A dictionary containing the element's attributes. Note that while the *attrib* value is always a real mutable Python dictionary, an `ElementTree` implementation may choose to use another internal representation, and create the dictionary only if someone asks for it. To take advantage of such implementations, use the dictionary methods below whenever possible.

The following dictionary-like methods work on the element attributes.

clear()

Resets an element. This function removes all subelements, clears all attributes, and sets the text and tail attributes to `None`.

get (*key*, *default=None*)

Gets the element attribute named *key*.

Returns the attribute value, or *default* if the attribute was not found.

items()

Returns the element attributes as a sequence of (name, value) pairs. The attributes are returned in an arbitrary order.

keys()

Returns the elements attribute names as a list. The names are returned in an arbitrary order.

set (*key*, *value*)

Set the attribute *key* on the element to *value*.

The following methods work on the element's children (subelements).

append (*subelement*)

Adds the element *subelement* to the end of this element's internal list of subelements. Raises `TypeError` if *subelement* is not an `Element`.

extend (*subelements*)

Appends *subelements* from a sequence object with zero or more elements. Raises `TypeError` if a subelement is not an `Element`.

在 3.2 版新加入.

find (*match*, *namespaces=None*)

Finds the first subelement matching *match*. *match* may be a tag name or a `path`. Returns an element instance or `None`. *namespaces* is an optional mapping from namespace prefix to full name. Pass `' '` as prefix to move all unprefix tag names in the expression into the given namespace.

findall (*match*, *namespaces=None*)

Finds all matching subelements, by tag name or `path`. Returns a list containing all matching elements in document order. *namespaces* is an optional mapping from namespace prefix to full name. Pass `' '` as prefix to move all unprefix tag names in the expression into the given namespace.

findtext (*match*, *default=None*, *namespaces=None*)

Finds text for the first subelement matching *match*. *match* may be a tag name or a `path`. Returns the text content of the first matching element, or *default* if no element was found. Note that if the matching element has no text content an empty string is returned. *namespaces* is an optional mapping from namespace prefix to full name. Pass `' '` as prefix to move all unprefix tag names in the expression into the given namespace.

insert (*index*, *subelement*)

Inserts *subelement* at the given position in this element. Raises `TypeError` if *subelement* is not an `Element`.

iter (*tag=None*)

Creates a tree `iterator` with the current element as the root. The iterator iterates over this element and all elements below it, in document (depth first) order. If *tag* is not `None` or `'*'`, only elements whose tag equals *tag* are returned from the iterator. If the tree structure is modified during iteration, the result is undefined.

在 3.2 版新加入.

iterfind (*match*, *namespaces=None*)

Finds all matching subelements, by tag name or *path*. Returns an iterable yielding all matching elements in document order. *namespaces* is an optional mapping from namespace prefix to full name.

在 3.2 版新加入.

itertext ()

Creates a text iterator. The iterator loops over this element and all subelements, in document order, and returns all inner text.

在 3.2 版新加入.

makeelement (*tag*, *attrib*)

Creates a new element object of the same type as this element. Do not call this method, use the *SubElement* () factory function instead.

remove (*subelement*)

Removes *subelement* from the element. Unlike the find* methods this method compares elements based on the instance identity, not on tag value or contents.

Element objects also support the following sequence type methods for working with subelements: *__delitem__* (), *__getitem__* (), *__setitem__* (), *__len__* () .

Caution: Elements with no subelements will test as *False*. This behavior will change in future versions. Use *specific len(elem) or elem is None* test instead.

```
element = root.find('foo')

if not element: # careful!
    print("element not found, or element has no subelements")

if element is None:
    print("element not found")
```

Prior to Python 3.8, the serialisation order of the XML attributes of elements was artificially made predictable by sorting the attributes by their name. Based on the now guaranteed ordering of dicts, this arbitrary reordering was removed in Python 3.8 to preserve the order in which attributes were originally parsed or created by user code.

In general, user code should try not to depend on a specific ordering of attributes, given that the *XML Information Set* explicitly excludes the attribute order from conveying information. Code should be prepared to deal with any ordering on input. In cases where deterministic XML output is required, e.g. for cryptographic signing or test data sets, canonical serialisation is available with the *canonicalize* () function.

In cases where canonical output is not applicable but a specific attribute order is still desirable on output, code should aim for creating the attributes directly in the desired order, to avoid perceptual mismatches for readers of the code. In cases where this is difficult to achieve, a recipe like the following can be applied prior to serialisation to enforce an order independently from the Element creation:

```
def reorder_attributes(root):
    for el in root.iter():
        attrib = el.attrib
        if len(attrib) > 1:
            # adjust attribute order, e.g. by sorting
            attribs = sorted(attrib.items())
            attrib.clear()
            attrib.update(attribs)
```

ElementTree 物件

class xml.etree.ElementTree.**ElementTree** (*element=None, file=None*)

ElementTree wrapper class. This class represents an entire element hierarchy, and adds some extra support for serialization to and from standard XML.

element is the root element. The tree is initialized with the contents of the XML *file* if given.

_setroot (*element*)

Replaces the root element for this tree. This discards the current contents of the tree, and replaces it with the given element. Use with care. *element* is an element instance.

find (*match, namespaces=None*)

Same as *Element.find()*, starting at the root of the tree.

findall (*match, namespaces=None*)

Same as *Element.findall()*, starting at the root of the tree.

findtext (*match, default=None, namespaces=None*)

Same as *Element.findtext()*, starting at the root of the tree.

getroot ()

Returns the root element for this tree.

iter (*tag=None*)

Creates and returns a tree iterator for the root element. The iterator loops over all elements in this tree, in section order. *tag* is the tag to look for (default is to return all elements).

iterfind (*match, namespaces=None*)

Same as *Element.iterfind()*, starting at the root of the tree.

在 3.2 版新加入。

parse (*source, parser=None*)

Loads an external XML section into this element tree. *source* is a file name or *file object*. *parser* is an optional parser instance. If not given, the standard *XMLParser* parser is used. Returns the section root element.

write (*file, encoding='us-ascii', xml_declaration=None, default_namespace=None, method='xml', *, short_empty_elements=True*)

Writes the element tree to a file, as XML. *file* is a file name, or a *file object* opened for writing. *encoding*¹ is the output encoding (default is US-ASCII). *xml_declaration* controls if an XML declaration should be added to the file. Use *False* for never, *True* for always, *None* for only if not US-ASCII or UTF-8 or Unicode (default is *None*). *default_namespace* sets the default XML namespace (for "xmlns"). *method* is either "xml", "html" or "text" (default is "xml"). The keyword-only *short_empty_elements* parameter controls the formatting of elements that contain no content. If *True* (the default), they are emitted as a single self-closed tag, otherwise they are emitted as a pair of start/end tags.

The output is either a string (*str*) or binary (*bytes*). This is controlled by the *encoding* argument. If *encoding* is "unicode", the output is a string; otherwise, it's binary. Note that this may conflict with the type of *file* if it's an open *file object*; make sure you do not try to write a string to a binary stream and vice versa.

在 3.4 版的變更: Added the *short_empty_elements* parameter.

在 3.8 版的變更: The *write()* method now preserves the attribute order specified by the user.

This is the XML file that is going to be manipulated:

```
<html>
  <head>
    <title>Example page</title>
  </head>
```

(繼續下一頁)

(繼續上一頁)

```
<body>
  <p>Moved to <a href="http://example.org/">example.org</a>
  or <a href="http://example.com/">example.com</a>.</p>
</body>
</html>
```

Example of changing the attribute "target" of every link in first paragraph:

```
>>> from xml.etree.ElementTree import ElementTree
>>> tree = ElementTree()
>>> tree.parse("index.xhtml")
<Element 'html' at 0xb77e6fac>
>>> p = tree.find("body/p")      # Finds first occurrence of tag p in body
>>> p
<Element 'p' at 0xb77ec26c>
>>> links = list(p.iter("a"))    # Returns list of all links
>>> links
[<Element 'a' at 0xb77ec2ac>, <Element 'a' at 0xb77ec1cc>]
>>> for i in links:             # Iterates through all found links
...     i.attrib["target"] = "blank"
>>> tree.write("output.xhtml")
```

QName 物件

class xml.etree.ElementTree.QName(*text_or_uri*, *tag=None*)

QName wrapper. This can be used to wrap a QName attribute value, in order to get proper namespace handling on output. *text_or_uri* is a string containing the QName value, in the form {uri}local, or, if the tag argument is given, the URI part of a QName. If *tag* is given, the first argument is interpreted as a URI, and this argument is interpreted as a local name. *QName* instances are opaque.

TreeBuilder 物件

class xml.etree.ElementTree.TreeBuilder(*element_factory=None*, *, *comment_factory=None*,
pi_factory=None, *insert_comments=False*,
insert_pis=False)

Generic element structure builder. This builder converts a sequence of start, data, end, comment and pi method calls to a well-formed element structure. You can use this class to build an element structure using a custom XML parser, or a parser for some other XML-like format.

element_factory, when given, must be a callable accepting two positional arguments: a tag and a dict of attributes. It is expected to return a new element instance.

The *comment_factory* and *pi_factory* functions, when given, should behave like the *Comment()* and *ProcessingInstruction()* functions to create comments and processing instructions. When not given, the default factories will be used. When *insert_comments* and/or *insert_pis* is true, comments/pis will be inserted into the tree if they appear within the root element (but not outside of it).

close()

Flushes the builder buffers, and returns the toplevel document element. Returns an *Element* instance.

data(*data*)

Adds text to the current element. *data* is a string. This should be either a bytestring, or a Unicode string.

end(*tag*)

Closes the current element. *tag* is the element name. Returns the closed element.

start (*tag*, *attrs*)

Opens a new element. *tag* is the element name. *attrs* is a dictionary containing element attributes. Returns the opened element.

comment (*text*)

Creates a comment with the given *text*. If `insert_comments` is true, this will also add it to the tree.

在 3.8 版新加入。

pi (*target*, *text*)

Creates a process instruction with the given *target* name and *text*. If `insert_pis` is true, this will also add it to the tree.

在 3.8 版新加入。

In addition, a custom *TreeBuilder* object can provide the following methods:

doctype (*name*, *pubid*, *system*)

Handles a doctype declaration. *name* is the doctype name. *pubid* is the public identifier. *system* is the system identifier. This method does not exist on the default *TreeBuilder* class.

在 3.2 版新加入。

start_ns (*prefix*, *uri*)

Is called whenever the parser encounters a new namespace declaration, before the `start()` callback for the opening element that defines it. *prefix* is `' '` for the default namespace and the declared namespace prefix name otherwise. *uri* is the namespace URI.

在 3.8 版新加入。

end_ns (*prefix*)

Is called after the `end()` callback of an element that declared a namespace prefix mapping, with the name of the *prefix* that went out of scope.

在 3.8 版新加入。

```
class xml.etree.ElementTree.C14NWriterTarget (write, *, with_comments=False,
                                             strip_text=False, rewrite_prefixes=False,
                                             qname_aware_tags=None,
                                             qname_aware_attrs=None,
                                             exclude_attrs=None, exclude_tags=None)
```

A C14N 2.0 writer. Arguments are the same as for the `canonicalize()` function. This class does not build a tree but translates the callback events directly into a serialised form using the `write` function.

在 3.8 版新加入。

XMLParser 物件

```
class xml.etree.ElementTree.XMLParser (*, target=None, encoding=None)
```

This class is the low-level building block of the module. It uses `xml.parsers.expat` for efficient, event-based parsing of XML. It can be fed XML data incrementally with the `feed()` method, and parsing events are translated to a push API - by invoking callbacks on the *target* object. If *target* is omitted, the standard *TreeBuilder* is used. If *encoding*^{Page 1237, 1} is given, the value overrides the encoding specified in the XML file.

在 3.8 版的變更: Parameters are now *keyword-only*. The *html* argument no longer supported.

close ()

Finishes feeding data to the parser. Returns the result of calling the `close()` method of the *target* passed during construction; by default, this is the toplevel document element.

feed(data)

Feeds data to the parser. *data* is encoded data.

flush()

Triggers parsing of any previously fed unparsed data, which can be used to ensure more immediate feedback, in particular with Expat >=2.6.0. The implementation of *flush()* temporarily disables reparsing deferral with Expat (if currently enabled) and triggers a reparsing. Disabling reparsing deferral has security consequences; please see *xml.parsers.expat.xmlparser.SetReparseDeferralEnabled()* for details.

Note that *flush()* has been backported to some prior releases of CPython as a security fix. Check for availability of *flush()* using *hasattr()* if used in code running across a variety of Python versions.

在 3.11.9 版新加入.

XMLParser.feed() calls *target's* *start(tag, attrs_dict)* method for each opening tag, its *end(tag)* method for each closing tag, and data is processed by method *data(data)*. For further supported callback methods, see the *TreeBuilder* class. *XMLParser.close()* calls *target's* method *close()*. *XMLParser* can be used not only for building a tree structure. This is an example of counting the maximum depth of an XML file:

```
>>> from xml.etree.ElementTree import XMLParser
>>> class MaxDepth:                                # The target object of the parser
...     maxDepth = 0
...     depth = 0
...     def start(self, tag, attrib):               # Called for each opening tag.
...         self.depth += 1
...         if self.depth > self.maxDepth:
...             self.maxDepth = self.depth
...     def end(self, tag):                           # Called for each closing tag.
...         self.depth -= 1
...     def data(self, data):
...         pass                                     # We do not need to do anything with data.
...     def close(self):                             # Called when all data has been parsed.
...         return self.maxDepth
...
>>> target = MaxDepth()
>>> parser = XMLParser(target=target)
>>> exampleXml = """
... <a>
...     <b>
...     </b>
...     <b>
...         <c>
...         <d>
...         </d>
...         </c>
...     </b>
... </a>"""
>>> parser.feed(exampleXml)
>>> parser.close()
4
```

XMLPullParser 物件

class xml.etree.ElementTree.XMLPullParser (*events=None*)

A pull parser suitable for non-blocking applications. Its input-side API is similar to that of *XMLParser*, but instead of pushing calls to a callback target, *XMLPullParser* collects an internal list of parsing events and lets the user read from it. *events* is a sequence of events to report back. The supported events are the strings "start", "end", "comment", "pi", "start-ns" and "end-ns" (the "ns" events are used to get detailed namespace information). If *events* is omitted, only "end" events are reported.

feed (*data*)

Feed the given bytes data to the parser.

flush ()

Triggers parsing of any previously fed unparsed data, which can be used to ensure more immediate feedback, in particular with Expat >=2.6.0. The implementation of *flush()* temporarily disables reparse deferral with Expat (if currently enabled) and triggers a reparse. Disabling reparse deferral has security consequences; please see *xml.parsers.expat.xmlparser.SetReparseDeferralEnabled()* for details.

Note that *flush()* has been backported to some prior releases of CPython as a security fix. Check for availability of *flush()* using *hasattr()* if used in code running across a variety of Python versions.

在 3.11.9 版新加入。

close ()

Signal the parser that the data stream is terminated. Unlike *XMLParser.close()*, this method always returns *None*. Any events not yet retrieved when the parser is closed can still be read with *read_events()*.

read_events ()

Return an iterator over the events which have been encountered in the data fed to the parser. The iterator yields (*event*, *elem*) pairs, where *event* is a string representing the type of event (e.g. "end") and *elem* is the encountered *Element* object, or other context value as follows.

- start, end: the current Element.
- comment, pi: the current comment / processing instruction
- start-ns: a tuple (*prefix*, *uri*) naming the declared namespace mapping.
- end-ns: *None* (this may change in a future version)

Events provided in a previous call to *read_events()* will not be yielded again. Events are consumed from the internal queue only when they are retrieved from the iterator, so multiple readers iterating in parallel over iterators obtained from *read_events()* will have unpredictable results.

備註: *XMLPullParser* only guarantees that it has seen the ">" character of a starting tag when it emits a "start" event, so the attributes are defined, but the contents of the text and tail attributes are undefined at that point. The same applies to the element children; they may or may not be present.

If you need a fully populated element, look for "end" events instead.

在 3.4 版新加入。

在 3.8 版的變更: 新增 *context* 與 *check_hostname* 事件。

例外

class `xml.etree.ElementTree.ParseError`

XML parse error, raised by the various parsing methods in this module when parsing fails. The string representation of an instance of this exception will contain a user-friendly error message. In addition, it will have the following attributes available:

code

A numeric error code from the expat parser. See the documentation of `xml.parsers.expat` for the list of error codes and their meanings.

position

A tuple of *line*, *column* numbers, specifying where the error occurred.

F 解

20.6 xml.dom --- The Document Object Model API

原始碼: `Lib/xml/dom/__init__.py`

The Document Object Model, or "DOM," is a cross-language API from the World Wide Web Consortium (W3C) for accessing and modifying XML documents. A DOM implementation presents an XML document as a tree structure, or allows client code to build such a structure from scratch. It then gives access to the structure through a set of objects which provided well-known interfaces.

The DOM is extremely useful for random-access applications. SAX only allows you a view of one bit of the document at a time. If you are looking at one SAX element, you have no access to another. If you are looking at a text node, you have no access to a containing element. When you write a SAX application, you need to keep track of your program's position in the document somewhere in your own code. SAX does not do it for you. Also, if you need to look ahead in the XML document, you are just out of luck.

Some applications are simply impossible in an event driven model with no access to a tree. Of course you could build some sort of tree yourself in SAX events, but the DOM allows you to avoid writing that code. The DOM is a standard tree representation for XML data.

The Document Object Model is being defined by the W3C in stages, or "levels" in their terminology. The Python mapping of the API is substantially based on the DOM Level 2 recommendation.

DOM applications typically start by parsing some XML into a DOM. How this is accomplished is not covered at all by DOM Level 1, and Level 2 provides only limited improvements: There is a `DOMImplementation` object class which provides access to `Document` creation methods, but no way to access an XML reader/parser/`Document` builder in an implementation-independent way. There is also no well-defined way to access these methods without an existing `Document` object. In Python, each DOM implementation will provide a function `getDOMImplementation()`. DOM Level 3 adds a Load/Store specification, which defines an interface to the reader, but this is not yet available in the Python standard library.

Once you have a DOM document object, you can access the parts of your XML document through its properties and methods. These properties are defined in the DOM specification; this portion of the reference manual describes the interpretation of the specification in Python.

The specification provided by the W3C defines the DOM API for Java, ECMAScript, and OMG IDL. The Python mapping defined here is based in large part on the IDL version of the specification, but strict compliance is not required (though implementations are free to support the strict mapping from IDL). See section [Conformance](#) for a detailed discussion of mapping requirements.

也参考:

Document Object Model (DOM) Level 2 Specification

The W3C recommendation upon which the Python DOM API is based.

Document Object Model (DOM) Level 1 Specification

The W3C recommendation for the DOM supported by `xml.dom.minidom`.

Python Language Mapping Specification

This specifies the mapping from OMG IDL to Python.

20.6.1 模組 內容

The `xml.dom` contains the following functions:

`xml.dom.registerDOMImplementation(name, factory)`

Register the *factory* function with the name *name*. The factory function should return an object which implements the `DOMImplementation` interface. The factory function can return the same object every time, or a new one for each call, as appropriate for the specific implementation (e.g. if that implementation supports some customization).

`xml.dom.getDOMImplementation(name=None, features=())`

Return a suitable DOM implementation. The *name* is either well-known, the module name of a DOM implementation, or `None`. If it is not `None`, imports the corresponding module and returns a `DOMImplementation` object if the import succeeds. If no name is given, and if the environment variable `PYTHON_DOM` is set, this variable is used to find the implementation.

If *name* is not given, this examines the available implementations to find one with the required feature set. If no implementation can be found, raise an `ImportError`. The features list must be a sequence of (*feature*, *version*) pairs which are passed to the `hasFeature()` method on available `DOMImplementation` objects.

Some convenience constants are also provided:

`xml.dom.EMPTY_NAMESPACE`

The value used to indicate that no namespace is associated with a node in the DOM. This is typically found as the `namespaceURI` of a node, or used as the *namespaceURI* parameter to a namespaces-specific method.

`xml.dom.XML_NAMESPACE`

The namespace URI associated with the reserved prefix `xml`, as defined by [Namespaces in XML](#) (section 4).

`xml.dom.XMLNS_NAMESPACE`

The namespace URI for namespace declarations, as defined by [Document Object Model \(DOM\) Level 2 Core Specification](#) (section 1.1.8).

`xml.dom.XHTML_NAMESPACE`

The URI of the XHTML namespace as defined by [XHTML 1.0: The Extensible HyperText Markup Language](#) (section 3.1.1).

In addition, `xml.dom` contains a base `Node` class and the DOM exception classes. The `Node` class provided by this module does not implement any of the methods or attributes defined by the DOM specification; concrete DOM implementations must provide those. The `Node` class provided as part of this module does provide the constants used for the `nodeType` attribute on concrete `Node` objects; they are located within the class rather than at the module level to conform with the DOM specifications.

20.6.2 Objects in the DOM

The definitive documentation for the DOM is the DOM specification from the W3C.

Note that DOM attributes may also be manipulated as nodes instead of as simple strings. It is fairly rare that you must do this, however, so this usage is not yet documented.

Interface	Section	Purpose
DOMImplementation	DOMImplementation 物件	Interface to the underlying implementation.
Node	Node Objects	Base interface for most objects in a document.
NodeList	NodeList 物件	Interface for a sequence of nodes.
DocumentType	DocumentType 物件	Information about the declarations needed to process a document.
Document	Document Objects	Object which represents an entire document.
Element	Element Objects	Element nodes in the document hierarchy.
Attr	Attr Objects	Attribute value nodes on element nodes.
Comment	Comment Objects	Representation of comments in the source document.
Text	Text and CDATASection Objects	Nodes containing textual content from the document.
ProcessingInstruction	ProcessingInstruction 物件	Processing instruction representation.

An additional section describes the exceptions defined for working with the DOM in Python.

DOMImplementation 物件

The `DOMImplementation` interface provides a way for applications to determine the availability of particular features in the DOM they are using. DOM Level 2 added the ability to create new `Document` and `DocumentType` objects using the `DOMImplementation` as well.

`DOMImplementation.hasFeature` (*feature*, *version*)

Return `True` if the feature identified by the pair of strings *feature* and *version* is implemented.

`DOMImplementation.createDocument` (*namespaceUri*, *qualifiedName*, *doctype*)

Return a new `Document` object (the root of the DOM), with a child `Element` object having the given *namespaceUri* and *qualifiedName*. The *doctype* must be a `DocumentType` object created by `createDocumentType()`, or `None`. In the Python DOM API, the first two arguments can also be `None` in order to indicate that no `Element` child is to be created.

`DOMImplementation.createDocumentType` (*qualifiedName*, *publicId*, *systemId*)

Return a new `DocumentType` object that encapsulates the given *qualifiedName*, *publicId*, and *systemId* strings, representing the information contained in an XML document type declaration.

Node Objects

All of the components of an XML document are subclasses of `Node`.

`Node.nodeType`

An integer representing the node type. Symbolic constants for the types are on the `Node` object: `ELEMENT_NODE`, `ATTRIBUTE_NODE`, `TEXT_NODE`, `CDATA_SECTION_NODE`, `ENTITY_NODE`, `PROCESSING_INSTRUCTION_NODE`, `COMMENT_NODE`, `DOCUMENT_NODE`, `DOCUMENT_TYPE_NODE`, `NOTATION_NODE`. This is a read-only attribute.

Node.parentNode

The parent of the current node, or `None` for the document node. The value is always a `Node` object or `None`. For `Element` nodes, this will be the parent element, except for the root element, in which case it will be the `Document` object. For `Attr` nodes, this is always `None`. This is a read-only attribute.

Node.attributes

A `NamedNodeMap` of attribute objects. Only elements have actual values for this; others provide `None` for this attribute. This is a read-only attribute.

Node.previousSibling

The node that immediately precedes this one with the same parent. For instance the element with an end-tag that comes just before the *self* element's start-tag. Of course, XML documents are made up of more than just elements so the previous sibling could be text, a comment, or something else. If this node is the first child of the parent, this attribute will be `None`. This is a read-only attribute.

Node.nextSibling

The node that immediately follows this one with the same parent. See also [previousSibling](#). If this is the last child of the parent, this attribute will be `None`. This is a read-only attribute.

Node.childNodes

A list of nodes contained within this node. This is a read-only attribute.

Node.firstChild

The first child of the node, if there are any, or `None`. This is a read-only attribute.

Node.lastChild

The last child of the node, if there are any, or `None`. This is a read-only attribute.

Node.localName

The part of the `tagName` following the colon if there is one, else the entire `tagName`. The value is a string.

Node.prefix

The part of the `tagName` preceding the colon if there is one, else the empty string. The value is a string, or `None`.

Node.namespaceURI

The namespace associated with the element name. This will be a string or `None`. This is a read-only attribute.

Node.nodeName

This has a different meaning for each node type; see the DOM specification for details. You can always get the information you would get here from another property such as the `tagName` property for elements or the `name` property for attributes. For all node types, the value of this attribute will be either a string or `None`. This is a read-only attribute.

Node.nodeValue

This has a different meaning for each node type; see the DOM specification for details. The situation is similar to that with [nodeName](#). The value is a string or `None`.

Node.hasAttributes()

Return `True` if the node has any attributes.

Node.hasChildNodes()

Return `True` if the node has any child nodes.

Node.isSameNode(*other*)

Return `True` if *other* refers to the same node as this node. This is especially useful for DOM implementations which use any sort of proxy architecture (because more than one object can refer to the same node).

備 F: This is based on a proposed DOM Level 3 API which is still in the "working draft" stage, but this particular interface appears uncontroversial. Changes from the W3C will not necessarily affect this method in the Python DOM interface (though any new W3C API for this would also be supported).

`Node.appendChild(newChild)`

Add a new child node to this node at the end of the list of children, returning *newChild*. If the node was already in the tree, it is removed first.

`Node.insertBefore(newChild, refChild)`

Insert a new child node before an existing child. It must be the case that *refChild* is a child of this node; if not, `ValueError` is raised. *newChild* is returned. If *refChild* is `None`, it inserts *newChild* at the end of the children's list.

`Node.removeChild(oldChild)`

Remove a child node. *oldChild* must be a child of this node; if not, `ValueError` is raised. *oldChild* is returned on success. If *oldChild* will not be used further, its `unlink()` method should be called.

`Node.replaceChild(newChild, oldChild)`

Replace an existing node with a new node. It must be the case that *oldChild* is a child of this node; if not, `ValueError` is raised.

`Node.normalize()`

Join adjacent text nodes so that all stretches of text are stored as single `Text` instances. This simplifies processing text from a DOM tree for many applications.

`Node.cloneNode(deep)`

Clone this node. Setting *deep* means to clone all child nodes as well. This returns the clone.

NodeList 物件

A `NodeList` represents a sequence of nodes. These objects are used in two ways in the DOM Core recommendation: an `Element` object provides one as its list of child nodes, and the `getElementsByTagName()` and `getElementsByTagNameNS()` methods of `Node` return objects with this interface to represent query results.

The DOM Level 2 recommendation defines one method and one attribute for these objects:

`NodeList.item(i)`

Return the *i*th item from the sequence, if there is one, or `None`. The index *i* is not allowed to be less than zero or greater than or equal to the length of the sequence.

`NodeList.length`

The number of nodes in the sequence.

In addition, the Python DOM interface requires that some additional support is provided to allow `NodeList` objects to be used as Python sequences. All `NodeList` implementations must include support for `__len__()` and `__getitem__()`; this allows iteration over the `NodeList` in `for` statements and proper support for the `len()` built-in function.

If a DOM implementation supports modification of the document, the `NodeList` implementation must also support the `__setitem__()` and `__delitem__()` methods.

DocumentType 物件

Information about the notations and entities declared by a document (including the external subset if the parser uses it and can provide the information) is available from a `DocumentType` object. The `DocumentType` for a document is available from the `Document` object's `doctype` attribute; if there is no `DOCTYPE` declaration for the document, the document's `doctype` attribute will be set to `None` instead of an instance of this interface.

`DocumentType` is a specialization of `Node`, and adds the following attributes:

`DocumentType.publicId`

The public identifier for the external subset of the document type definition. This will be a string or `None`.

`DocumentType.systemId`

The system identifier for the external subset of the document type definition. This will be a URI as a string, or `None`.

`DocumentType.internalSubset`

A string giving the complete internal subset from the document. This does not include the brackets which enclose the subset. If the document has no internal subset, this should be `None`.

`DocumentType.name`

The name of the root element as given in the DOCTYPE declaration, if present.

`DocumentType.entities`

This is a `NamedNodeMap` giving the definitions of external entities. For entity names defined more than once, only the first definition is provided (others are ignored as required by the XML recommendation). This may be `None` if the information is not provided by the parser, or if no entities are defined.

`DocumentType.notations`

This is a `NamedNodeMap` giving the definitions of notations. For notation names defined more than once, only the first definition is provided (others are ignored as required by the XML recommendation). This may be `None` if the information is not provided by the parser, or if no notations are defined.

Document Objects

A `Document` represents an entire XML document, including its constituent elements, attributes, processing instructions, comments etc. Remember that it inherits properties from `Node`.

`Document.documentElement`

The one and only root element of the document.

`Document.createElement(tagName)`

Create and return a new element node. The element is not inserted into the document when it is created. You need to explicitly insert it with one of the other methods such as `insertBefore()` or `appendChild()`.

`Document.createElementNS(namespaceURI, tagName)`

Create and return a new element with a namespace. The *tagName* may have a prefix. The element is not inserted into the document when it is created. You need to explicitly insert it with one of the other methods such as `insertBefore()` or `appendChild()`.

`Document.createTextNode(data)`

Create and return a text node containing the data passed as a parameter. As with the other creation methods, this one does not insert the node into the tree.

`Document.createComment(data)`

Create and return a comment node containing the data passed as a parameter. As with the other creation methods, this one does not insert the node into the tree.

`Document.createProcessingInstruction(target, data)`

Create and return a processing instruction node containing the *target* and *data* passed as parameters. As with the other creation methods, this one does not insert the node into the tree.

`Document.createAttribute(name)`

Create and return an attribute node. This method does not associate the attribute node with any particular element. You must use `setAttributeNode()` on the appropriate `Element` object to use the newly created attribute instance.

`Document.createAttributeNS(namespaceURI, qualifiedName)`

Create and return an attribute node with a namespace. The *tagName* may have a prefix. This method does not associate the attribute node with any particular element. You must use `setAttributeNode()` on the appropriate `Element` object to use the newly created attribute instance.

`Document.getElementsByTagName (tagName)`

Search for all descendants (direct children, children’s children, etc.) with a particular element type name.

`Document.getElementsByTagNameNS (namespaceURI, localName)`

Search for all descendants (direct children, children’s children, etc.) with a particular namespace URI and localname. The localname is the part of the namespace after the prefix.

Element Objects

`Element` is a subclass of `Node`, so inherits all the attributes of that class.

`Element.tagName`

The element type name. In a namespace-using document it may have colons in it. The value is a string.

`Element.getElementsByTagName (tagName)`

Same as equivalent method in the `Document` class.

`Element.getElementsByTagNameNS (namespaceURI, localName)`

Same as equivalent method in the `Document` class.

`Element.hasAttribute (name)`

Return `True` if the element has an attribute named by *name*.

`Element.hasAttributeNS (namespaceURI, localName)`

Return `True` if the element has an attribute named by *namespaceURI* and *localName*.

`Element.getAttribute (name)`

Return the value of the attribute named by *name* as a string. If no such attribute exists, an empty string is returned, as if the attribute had no value.

`Element.getAttributeNode (attrname)`

Return the `Attr` node for the attribute named by *attrname*.

`Element.getAttributeNS (namespaceURI, localName)`

Return the value of the attribute named by *namespaceURI* and *localName* as a string. If no such attribute exists, an empty string is returned, as if the attribute had no value.

`Element.getAttributeNodeNS (namespaceURI, localName)`

Return an attribute value as a node, given a *namespaceURI* and *localName*.

`Element.removeAttribute (name)`

Remove an attribute by name. If there is no matching attribute, a `NotFoundErr` is raised.

`Element.removeAttributeNode (oldAttr)`

Remove and return *oldAttr* from the attribute list, if present. If *oldAttr* is not present, `NotFoundErr` is raised.

`Element.removeAttributeNS (namespaceURI, localName)`

Remove an attribute by name. Note that it uses a *localName*, not a *qname*. No exception is raised if there is no matching attribute.

`Element.setAttribute (name, value)`

Set an attribute value from a string.

`Element.setAttributeNode (newAttr)`

Add a new attribute node to the element, replacing an existing attribute if necessary if the *name* attribute matches. If a replacement occurs, the old attribute node will be returned. If *newAttr* is already in use, `InuseAttributeErr` will be raised.

`Element.setAttributeNodeNS` (*newAttr*)

Add a new attribute node to the element, replacing an existing attribute if necessary if the `namespaceURI` and `localName` attributes match. If a replacement occurs, the old attribute node will be returned. If *newAttr* is already in use, `InuseAttributeErr` will be raised.

`Element.setAttributeNS` (*namespaceURI*, *qname*, *value*)

Set an attribute value from a string, given a *namespaceURI* and a *qname*. Note that a *qname* is the whole attribute name. This is different than above.

Attr Objects

`Attr` inherits from `Node`, so inherits all its attributes.

`Attr.name`

The attribute name. In a namespace-using document it may include a colon.

`Attr.localName`

The part of the name following the colon if there is one, else the entire name. This is a read-only attribute.

`Attr.prefix`

The part of the name preceding the colon if there is one, else the empty string.

`Attr.value`

The text value of the attribute. This is a synonym for the `nodeValue` attribute.

NamedNodeMap 物件

`NamedNodeMap` does *not* inherit from `Node`.

`NamedNodeMap.length`

The length of the attribute list.

`NamedNodeMap.item` (*index*)

Return an attribute with a particular index. The order you get the attributes in is arbitrary but will be consistent for the life of a DOM. Each item is an attribute node. Get its value with the `value` attribute.

There are also experimental methods that give this class more mapping behavior. You can use them or you can use the standardized `getAttribute*()` family of methods on the `Element` objects.

Comment Objects

`Comment` represents a comment in the XML document. It is a subclass of `Node`, but cannot have child nodes.

`Comment.data`

The content of the comment as a string. The attribute contains all characters between the leading `<!--` and trailing `-->`, but does not include them.

Text and CDATASection Objects

The `Text` interface represents text in the XML document. If the parser and DOM implementation support the DOM's XML extension, portions of the text enclosed in CDATA marked sections are stored in `CDATASection` objects. These two interfaces are identical, but provide different values for the `nodeType` attribute.

These interfaces extend the `Node` interface. They cannot have child nodes.

`Text.data`

The content of the text node as a string.

備註: The use of a `CDATASection` node does not indicate that the node represents a complete CDATA marked section, only that the content of the node was part of a CDATA section. A single CDATA section may be represented by more than one node in the document tree. There is no way to determine whether two adjacent `CDATASection` nodes represent different CDATA marked sections.

ProcessingInstruction 物件

Represents a processing instruction in the XML document; this inherits from the `Node` interface and cannot have child nodes.

`ProcessingInstruction.target`

The content of the processing instruction up to the first whitespace character. This is a read-only attribute.

`ProcessingInstruction.data`

The content of the processing instruction following the first whitespace character.

例外

The DOM Level 2 recommendation defines a single exception, `DOMException`, and a number of constants that allow applications to determine what sort of error occurred. `DOMException` instances carry a `code` attribute that provides the appropriate value for the specific exception.

The Python DOM interface provides the constants, but also expands the set of exceptions so that a specific exception exists for each of the exception codes defined by the DOM. The implementations must raise the appropriate specific exception, each of which carries the appropriate value for the `code` attribute.

exception `xml.dom.DOMException`

Base exception class used for all specific DOM exceptions. This exception class cannot be directly instantiated.

exception `xml.dom.DomstringSizeErr`

Raised when a specified range of text does not fit into a string. This is not known to be used in the Python DOM implementations, but may be received from DOM implementations not written in Python.

exception `xml.dom.HierarchyRequestErr`

Raised when an attempt is made to insert a node where the node type is not allowed.

exception `xml.dom.IndexSizeErr`

Raised when an index or size parameter to a method is negative or exceeds the allowed values.

exception `xml.dom.InuseAttributeErr`

Raised when an attempt is made to insert an `Attr` node that is already present elsewhere in the document.

exception `xml.dom.InvalidAccessErr`

Raised if a parameter or an operation is not supported on the underlying object.

exception `xml.dom.InvalidCharacterErr`

This exception is raised when a string parameter contains a character that is not permitted in the context it's being used in by the XML 1.0 recommendation. For example, attempting to create an `Element` node with a space in the element type name will cause this error to be raised.

exception `xml.dom.InvalidModificationErr`

Raised when an attempt is made to modify the type of a node.

exception `xml.dom.InvalidStateErr`

Raised when an attempt is made to use an object that is not defined or is no longer usable.

exception `xml.dom.NamespaceErr`

If an attempt is made to change any object in a way that is not permitted with regard to the [Namespaces](#) in XML recommendation, this exception is raised.

exception `xml.dom.NotFoundErr`

Exception when a node does not exist in the referenced context. For example, `NamedNodeMap.removeNamedItem()` will raise this if the node passed in does not exist in the map.

exception `xml.dom.NotSupportedErr`

Raised when the implementation does not support the requested type of object or operation.

exception `xml.dom.NoDataAllowedErr`

This is raised if data is specified for a node which does not support data.

exception `xml.dom.NoModificationAllowedErr`

Raised on attempts to modify an object where modifications are not allowed (such as for read-only nodes).

exception `xml.dom.SyntaxErr`

Raised when an invalid or illegal string is specified.

exception `xml.dom.WrongDocumentErr`

Raised when a node is inserted in a different document than it currently belongs to, and the implementation does not support migrating the node from one document to the other.

The exception codes defined in the DOM recommendation map to the exceptions described above according to this table:

常數	例外
DOMSTRING_SIZE_ERR	<i>DomstringSizeErr</i>
HIERARCHY_REQUEST_ERR	<i>HierarchyRequestErr</i>
INDEX_SIZE_ERR	<i>IndexSizeErr</i>
INUSE_ATTRIBUTE_ERR	<i>InuseAttributeErr</i>
INVALID_ACCESS_ERR	<i>InvalidAccessErr</i>
INVALID_CHARACTER_ERR	<i>InvalidCharacterErr</i>
INVALID_MODIFICATION_ERR	<i>InvalidModificationErr</i>
INVALID_STATE_ERR	<i>InvalidStateErr</i>
NAMESPACE_ERR	<i>NamespaceErr</i>
NOT_FOUND_ERR	<i>NotFoundErr</i>
NOT_SUPPORTED_ERR	<i>NotSupportedErr</i>
NO_DATA_ALLOWED_ERR	<i>NoDataAllowedErr</i>
NO_MODIFICATION_ALLOWED_ERR	<i>NoModificationAllowedErr</i>
SYNTAX_ERR	<i>SyntaxErr</i>
WRONG_DOCUMENT_ERR	<i>WrongDocumentErr</i>

20.6.3 Conformance

This section describes the conformance requirements and relationships between the Python DOM API, the W3C DOM recommendations, and the OMG IDL mapping for Python.

Type Mapping

The IDL types used in the DOM specification are mapped to Python types according to the following table.

IDL Type	Python Type
boolean	bool 或 int
int	int
long int	int
unsigned int	int
DOMString	str 或 bytes
null	None

Accessor Methods

The mapping from OMG IDL to Python defines accessor functions for IDL `attribute` declarations in much the way the Java mapping does. Mapping the IDL declarations

```
readonly attribute string someValue;
    attribute string anotherValue;
```

yields three accessor functions: a "get" method for `someValue` (`_get_someValue()`), and "get" and "set" methods for `anotherValue` (`_get_anotherValue()` and `_set_anotherValue()`). The mapping, in particular, does not require that the IDL attributes are accessible as normal Python attributes: `object.someValue` is *not* required to work, and may raise an `AttributeError`.

The Python DOM API, however, *does* require that normal attribute access work. This means that the typical surrogates generated by Python IDL compilers are not likely to work, and wrapper objects may be needed on the client if the DOM objects are accessed via CORBA. While this does require some additional consideration for CORBA DOM clients, the implementers with experience using DOM over CORBA from Python do not consider this a problem. Attributes that are declared `readonly` may not restrict write access in all DOM implementations.

In the Python DOM API, accessor functions are not required. If provided, they should take the form defined by the Python IDL mapping, but these methods are considered unnecessary since the attributes are accessible directly from Python. "Set" accessors should never be provided for `readonly` attributes.

The IDL definitions do not fully embody the requirements of the W3C DOM API, such as the notion of certain objects, such as the return value of `getElementsByTagName()`, being "live". The Python DOM API does not require implementations to enforce such requirements.

20.7 xml.dom.minidom --- Minimal DOM implementation

原始碼: [Lib/xml/dom/minidom.py](#)

`xml.dom.minidom` is a minimal implementation of the Document Object Model interface, with an API similar to that in other languages. It is intended to be simpler than the full DOM and also significantly smaller. Users who are not already proficient with the DOM should consider using the `xml.etree.ElementTree` module for their XML processing instead.

警告: The `xml.dom.minidom` module is not secure against maliciously constructed data. If you need to parse untrusted or unauthenticated data see [XML vulnerabilities](#).

DOM applications typically start by parsing some XML into a DOM. With `xml.dom.minidom`, this is done through the parse functions:

```

from xml.dom.minidom import parse, parseString

dom1 = parse('c:\\temp\\mydata.xml') # parse an XML file by name

datasource = open('c:\\temp\\mydata.xml')
dom2 = parse(datasource) # parse an open file

dom3 = parseString('<myxml>Some data<empty/> some more data</myxml>')

```

The `parse()` function can take either a filename or an open file object.

`xml.dom.minidom.parse(filename_or_file, parser=None, bufsize=None)`

Return a Document from the given input. *filename_or_file* may be either a file name, or a file-like object. *parser*, if given, must be a SAX2 parser object. This function will change the document handler of the parser and activate namespace support; other parser configuration (like setting an entity resolver) must have been done in advance.

If you have XML in a string, you can use the `parseString()` function instead:

`xml.dom.minidom.parseString(string, parser=None)`

Return a Document that represents the *string*. This method creates an `io.StringIO` object for the string and passes that on to `parse()`.

Both functions return a Document object representing the content of the document.

What the `parse()` and `parseString()` functions do is connect an XML parser with a “DOM builder” that can accept parse events from any SAX parser and convert them into a DOM tree. The name of the functions are perhaps misleading, but are easy to grasp when learning the interfaces. The parsing of the document will be completed before these functions return; it’s simply that these functions do not provide a parser implementation themselves.

You can also create a Document by calling a method on a “DOM Implementation” object. You can get this object either by calling the `getDOMImplementation()` function in the `xml.dom` package or the `xml.dom.minidom` module. Once you have a Document, you can add child nodes to it to populate the DOM:

```

from xml.dom.minidom import getDOMImplementation

impl = getDOMImplementation()

newdoc = impl.createDocument(None, "some_tag", None)
top_element = newdoc.documentElement
text = newdoc.createTextNode('Some textual content.')
top_element.appendChild(text)

```

Once you have a DOM document object, you can access the parts of your XML document through its properties and methods. These properties are defined in the DOM specification. The main property of the document object is the `documentElement` property. It gives you the main element in the XML document: the one that holds all others. Here is an example program:

```

dom3 = parseString("<myxml>Some data</myxml>")
assert dom3.documentElement.tagName == "myxml"

```

When you are finished with a DOM tree, you may optionally call the `unlink()` method to encourage early cleanup of the now-unneeded objects. `unlink()` is an `xml.dom.minidom`-specific extension to the DOM API that renders the node and its descendants essentially useless. Otherwise, Python’s garbage collector will eventually take care of the objects in the tree.

也参考:

Document Object Model (DOM) Level 1 Specification

The W3C recommendation for the DOM supported by `xml.dom.minidom`.

20.7.1 DOM 物件

The definition of the DOM API for Python is given as part of the `xml.dom` module documentation. This section lists the differences between the API and `xml.dom.minidom`.

Node.**unlink**()

Break internal references within the DOM so that it will be garbage collected on versions of Python without cyclic GC. Even when cyclic GC is available, using this can make large amounts of memory available sooner, so calling this on DOM objects as soon as they are no longer needed is good practice. This only needs to be called on the `Document` object, but may be called on child nodes to discard children of that node.

You can avoid calling this method explicitly by using the `with` statement. The following code will automatically unlink `dom` when the `with` block is exited:

```
with xml.dom.minidom.parse(datasource) as dom:
    ... # Work with dom.
```

Node.**writexml**(writer, indent="", addindent="", newl="", encoding=None, standalone=None)

Write XML to the writer object. The writer receives texts but not bytes as input, it should have a `write()` method which matches that of the file object interface. The `indent` parameter is the indentation of the current node. The `addindent` parameter is the incremental indentation to use for subnodes of the current one. The `newl` parameter specifies the string to use to terminate newlines.

For the `Document` node, an additional keyword argument `encoding` can be used to specify the encoding field of the XML header.

Similarly, explicitly stating the `standalone` argument causes the standalone document declarations to be added to the prologue of the XML document. If the value is set to `True`, `standalone="yes"` is added, otherwise it is set to `"no"`. Not stating the argument will omit the declaration from the document.

在 3.8 版的變更: The `writexml()` method now preserves the attribute order specified by the user.

在 3.9 版的變更: 新增 `standalone` 參數。

Node.**toxml**(encoding=None, standalone=None)

Return a string or byte string containing the XML represented by the DOM node.

With an explicit `encoding`¹ argument, the result is a byte string in the specified encoding. With no `encoding` argument, the result is a Unicode string, and the XML declaration in the resulting string does not specify an encoding. Encoding this string in an encoding other than UTF-8 is likely incorrect, since UTF-8 is the default encoding of XML.

The `standalone` argument behaves exactly as in `writexml()`.

在 3.8 版的變更: The `toxml()` method now preserves the attribute order specified by the user.

在 3.9 版的變更: 新增 `standalone` 參數。

Node.**toprettyxml**(indent='\t', newl='\n', encoding=None, standalone=None)

Return a pretty-printed version of the document. `indent` specifies the indentation string and defaults to a tabulator; `newl` specifies the string emitted at the end of each line and defaults to `\n`.

The `encoding` argument behaves like the corresponding argument of `toxml()`.

The `standalone` argument behaves exactly as in `writexml()`.

在 3.8 版的變更: The `toprettyxml()` method now preserves the attribute order specified by the user.

在 3.9 版的變更: 新增 `standalone` 參數。

¹ The encoding name included in the XML output should conform to the appropriate standards. For example, "UTF-8" is valid, but "UTF8" is not valid in an XML document's declaration, even though Python accepts it as an encoding name. See <https://www.w3.org/TR/2006/REC-xml11-20060816/#NT-EncodingDecl> and <https://www.iana.org/assignments/character-sets/character-sets.xhtml>.

20.7.2 DOM 范例

This example program is a fairly realistic example of a simple program. In this particular case, we do not take much advantage of the flexibility of the DOM.

```
import xml.dom.minidom

document = """\
<slideshow>
<title>Demo slideshow</title>
<slide><title>Slide title</title>
<point>This is a demo</point>
<point>Of a program for processing slides</point>
</slide>

<slide><title>Another demo slide</title>
<point>It is important</point>
<point>To have more than</point>
<point>one slide</point>
</slide>
</slideshow>
"""

dom = xml.dom.minidom.parseString(document)

def getText(nodelist):
    rc = []
    for node in nodelist:
        if node.nodeType == node.TEXT_NODE:
            rc.append(node.data)
    return ''.join(rc)

def handleSlideshow(slideshow):
    print("<html>")
    handleSlideshowTitle(slideshow.getElementsByTagName("title")[0])
    slides = slideshow.getElementsByTagName("slide")
    handleToc(slides)
    handleSlides(slides)
    print("</html>")

def handleSlides(slides):
    for slide in slides:
        handleSlide(slide)

def handleSlide(slide):
    handleSlideTitle(slide.getElementsByTagName("title")[0])
    handlePoints(slide.getElementsByTagName("point"))

def handleSlideshowTitle(title):
    print(f"<title>{getText(title.childNodes)}</title>")

def handleSlideTitle(title):
    print(f"<h2>{getText(title.childNodes)}</h2>")

def handlePoints(points):
    print("<ul>")
    for point in points:
        handlePoint(point)
    print("</ul>")

def handlePoint(point):
    print(f"<li>{getText(point.childNodes)}</li>")
```

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```
def handleToc(slides):
    for slide in slides:
        title = slide.getElementsByTagName("title")[0]
        print(f"<p>{getText(title.childNodes)}</p>")

handleSlideshow(dom)
```

20.7.3 minidom and the DOM standard

The `xml.dom.minidom` module is essentially a DOM 1.0-compatible DOM with some DOM 2 features (primarily namespace features).

Usage of the DOM interface in Python is straight-forward. The following mapping rules apply:

- Interfaces are accessed through instance objects. Applications should not instantiate the classes themselves; they should use the creator functions available on the `Document` object. Derived interfaces support all operations (and attributes) from the base interfaces, plus any new operations.
- Operations are used as methods. Since the DOM uses only `in` parameters, the arguments are passed in normal order (from left to right). There are no optional arguments. `void` operations return `None`.
- IDL attributes map to instance attributes. For compatibility with the OMG IDL language mapping for Python, an attribute `foo` can also be accessed through accessor methods `_get_foo()` and `_set_foo()`. `readonly` attributes must not be changed; this is not enforced at runtime.
- The types `short` `int`, `unsigned int`, `unsigned long` `long`, and `boolean` all map to Python integer objects.
- The type `DOMString` maps to Python strings. `xml.dom.minidom` supports either bytes or strings, but will normally produce strings. Values of type `DOMString` may also be `None` where allowed to have the IDL null value by the DOM specification from the W3C.
- `const` declarations map to variables in their respective scope (e.g. `xml.dom.minidom.Node.PROCESSING_INSTRUCTION_NODE`); they must not be changed.
- `DOMException` is currently not supported in `xml.dom.minidom`. Instead, `xml.dom.minidom` uses standard Python exceptions such as `TypeError` and `AttributeError`.
- `NodeList` objects are implemented using Python's built-in list type. These objects provide the interface defined in the DOM specification, but with earlier versions of Python they do not support the official API. They are, however, much more "Pythonic" than the interface defined in the W3C recommendations.

The following interfaces have no implementation in `xml.dom.minidom`:

- `DOMTimeStamp`
- `EntityReference`

Most of these reflect information in the XML document that is not of general utility to most DOM users.

解

20.8 xml.dom.pulldom --- Support for building partial DOM trees

原始碼: [Lib/xml/dom/pulldom.py](#)

The `xml.dom.pulldom` module provides a "pull parser" which can also be asked to produce DOM-accessible fragments of the document where necessary. The basic concept involves pulling "events" from a stream of incoming XML and processing them. In contrast to SAX which also employs an event-driven processing model together with

callbacks, the user of a pull parser is responsible for explicitly pulling events from the stream, looping over those events until either processing is finished or an error condition occurs.

警告: The `xml.dom.pulldom` module is not secure against maliciously constructed data. If you need to parse untrusted or unauthenticated data see [XML vulnerabilities](#).

在 3.7.1 版的變更: The SAX parser no longer processes general external entities by default to increase security by default. To enable processing of external entities, pass a custom parser instance in:

```
from xml.dom.pulldom import parse
from xml.sax import make_parser
from xml.sax.handler import feature_external_ges

parser = make_parser()
parser.setFeature(feature_external_ges, True)
parse(filename, parser=parser)
```

範例:

```
from xml.dom import pulldom

doc = pulldom.parse('sales_items.xml')
for event, node in doc:
    if event == pulldom.START_ELEMENT and node.tagName == 'item':
        if int(node.getAttribute('price')) > 50:
            doc.expandNode(node)
            print(node.toxml())
```

event is a constant and can be one of:

- `START_ELEMENT`
- `END_ELEMENT`
- `COMMENT`
- `START_DOCUMENT`
- `END_DOCUMENT`
- `CHARACTERS`
- `PROCESSING_INSTRUCTION`
- `IGNORABLE_WHITESPACE`

node is an object of type `xml.dom.minidom.Document`, `xml.dom.minidom.Element` or `xml.dom.minidom.Text`.

Since the document is treated as a “flat” stream of events, the document “tree” is implicitly traversed and the desired elements are found regardless of their depth in the tree. In other words, one does not need to consider hierarchical issues such as recursive searching of the document nodes, although if the context of elements were important, one would either need to maintain some context-related state (i.e. remembering where one is in the document at any given point) or to make use of the `DOMEventStream.expandNode()` method and switch to DOM-related processing.

class `xml.dom.pulldom.PullDom` (*documentFactory=None*)

Subclass of `xml.sax.handler.ContentHandler`.

class `xml.dom.pulldom.SAX2DOM` (*documentFactory=None*)

Subclass of `xml.sax.handler.ContentHandler`.

`xml.dom.pulldom.parse(stream_or_string, parser=None, bufsize=None)`

Return a *DOMEventStream* from the given input. *stream_or_string* may be either a file name, or a file-like object. *parser*, if given, must be an *XMLReader* object. This function will change the document handler of the parser and activate namespace support; other parser configuration (like setting an entity resolver) must have been done in advance.

If you have XML in a string, you can use the *parseString()* function instead:

`xml.dom.pulldom.parseString(string, parser=None)`

Return a *DOMEventStream* that represents the (Unicode) *string*.

`xml.dom.pulldom.default_bufsize`

Default value for the *bufsize* parameter to *parse()*.

The value of this variable can be changed before calling *parse()* and the new value will take effect.

20.8.1 DOMEventStream 物件

class `xml.dom.pulldom.DOMEventStream(stream, parser, bufsize)`

在 3.11 版的變更: Support for `__getitem__()` method has been removed.

getEvent()

Return a tuple containing *event* and the current *node* as `xml.dom.minidom.Document` if *event* equals `START_DOCUMENT`, `xml.dom.minidom.Element` if *event* equals `START_ELEMENT` or `END_ELEMENT` or `xml.dom.minidom.Text` if *event* equals `CHARACTERS`. The current node does not contain information about its children, unless *expandNode()* is called.

expandNode(node)

Expands all children of *node* into *node*. Example:

```
from xml.dom import pulldom

xml = '<html><title>Foo</title> <p>Some text <div>and more</div></p> </html>'
doc = pulldom.parseString(xml)
for event, node in doc:
    if event == pulldom.START_ELEMENT and node.tagName == 'p':
        # Following statement only prints '<p/>'
        print(node.toxml())
        doc.expandNode(node)
        # Following statement prints node with all its children '<p>Some_
        text <div>and more</div></p>'
        print(node.toxml())
```

reset()

20.9 xml.sax --- Support for SAX2 parsers

原始碼: `Lib/xml/sax/__init__.py`

The *xml.sax* package provides a number of modules which implement the Simple API for XML (SAX) interface for Python. The package itself provides the SAX exceptions and the convenience functions which will be most used by users of the SAX API.

警告: The *xml.sax* module is not secure against maliciously constructed data. If you need to parse untrusted or unauthenticated data see *XML vulnerabilities*.

在 3.7.1 版的變更: The SAX parser no longer processes general external entities by default to increase security. Before, the parser created network connections to fetch remote files or loaded local files from the file system for DTD and entities. The feature can be enabled again with method `setFeature()` on the parser object and argument `feature_external_ges`.

The convenience functions are:

`xml.sax.make_parser(parser_list=[])`

Create and return a SAX `XMLReader` object. The first parser found will be used. If `parser_list` is provided, it must be an iterable of strings which name modules that have a function named `create_parser()`. Modules listed in `parser_list` will be used before modules in the default list of parsers.

在 3.8 版的變更: The `parser_list` argument can be any iterable, not just a list.

`xml.sax.parse(filename_or_stream, handler, error_handler=handler.ErrorHandler())`

Create a SAX parser and use it to parse a document. The document, passed in as `filename_or_stream`, can be a filename or a file object. The `handler` parameter needs to be a SAX `ContentHandler` instance. If `error_handler` is given, it must be a SAX `ErrorHandler` instance; if omitted, `SAXParseException` will be raised on all errors. There is no return value; all work must be done by the `handler` passed in.

`xml.sax.parseString(string, handler, error_handler=handler.ErrorHandler())`

Similar to `parse()`, but parses from a buffer `string` received as a parameter. `string` must be a `str` instance or a *bytes-like object*.

在 3.5 版的變更: 新增 `str` 實例的支援。

A typical SAX application uses three kinds of objects: readers, handlers and input sources. "Reader" in this context is another term for parser, i.e. some piece of code that reads the bytes or characters from the input source, and produces a sequence of events. The events then get distributed to the handler objects, i.e. the reader invokes a method on the handler. A SAX application must therefore obtain a reader object, create or open the input sources, create the handlers, and connect these objects all together. As the final step of preparation, the reader is called to parse the input. During parsing, methods on the handler objects are called based on structural and syntactic events from the input data.

For these objects, only the interfaces are relevant; they are normally not instantiated by the application itself. Since Python does not have an explicit notion of interface, they are formally introduced as classes, but applications may use implementations which do not inherit from the provided classes. The `InputSource`, `Locator`, `Attributes`, `AttributesNS`, and `XMLReader` interfaces are defined in the module `xml.sax.xmlreader`. The handler interfaces are defined in `xml.sax.handler`. For convenience, `InputSource` (which is often instantiated directly) and the handler classes are also available from `xml.sax`. These interfaces are described below.

In addition to these classes, `xml.sax` provides the following exception classes.

exception `xml.sax.SAXException(msg, exception=None)`

Encapsulate an XML error or warning. This class can contain basic error or warning information from either the XML parser or the application: it can be subclassed to provide additional functionality or to add localization. Note that although the handlers defined in the `ErrorHandler` interface receive instances of this exception, it is not required to actually raise the exception --- it is also useful as a container for information.

When instantiated, `msg` should be a human-readable description of the error. The optional `exception` parameter, if given, should be `None` or an exception that was caught by the parsing code and is being passed along as information.

This is the base class for the other SAX exception classes.

exception `xml.sax.SAXParseException(msg, exception, locator)`

Subclass of `SAXException` raised on parse errors. Instances of this class are passed to the methods of the SAX `ErrorHandler` interface to provide information about the parse error. This class supports the SAX `Locator` interface as well as the `SAXException` interface.

exception `xml.sax.SAXNotRecognizedException(msg, exception=None)`

Subclass of `SAXException` raised when a SAX `XMLReader` is confronted with an unrecognized feature or property. SAX applications and extensions may use this class for similar purposes.

exception `xml.sax.SAXNotSupportedException` (*msg, exception=None*)

Subclass of `SAXException` raised when a SAX `XMLReader` is asked to enable a feature that is not supported, or to set a property to a value that the implementation does not support. SAX applications and extensions may use this class for similar purposes.

也參考:

SAX: The Simple API for XML

This site is the focal point for the definition of the SAX API. It provides a Java implementation and online documentation. Links to implementations and historical information are also available.

`xml.sax.handler` 模組

Definitions of the interfaces for application-provided objects.

`xml.sax.saxutils` 模組

Convenience functions for use in SAX applications.

`xml.sax.xmlreader` 模組

Definitions of the interfaces for parser-provided objects.

20.9.1 SAXException 物件

The `SAXException` exception class supports the following methods:

`SAXException.getMessage()`

Return a human-readable message describing the error condition.

`SAXException.getException()`

Return an encapsulated exception object, or `None`.

20.10 xml.sax.handler --- Base classes for SAX handlers

原始碼: [Lib/xml/sax/handler.py](https://github.com/python/cpython/blob/main/Lib/xml/sax/handler.py)

The SAX API defines five kinds of handlers: content handlers, DTD handlers, error handlers, entity resolvers and lexical handlers. Applications normally only need to implement those interfaces whose events they are interested in; they can implement the interfaces in a single object or in multiple objects. Handler implementations should inherit from the base classes provided in the module `xml.sax.handler`, so that all methods get default implementations.

class `xml.sax.handler.ContentHandler`

This is the main callback interface in SAX, and the one most important to applications. The order of events in this interface mirrors the order of the information in the document.

class `xml.sax.handler.DTDHandler`

Handle DTD events.

This interface specifies only those DTD events required for basic parsing (unparsed entities and attributes).

class `xml.sax.handler.EntityResolver`

Basic interface for resolving entities. If you create an object implementing this interface, then register the object with your Parser, the parser will call the method in your object to resolve all external entities.

class `xml.sax.handler.ErrorHandler`

Interface used by the parser to present error and warning messages to the application. The methods of this object control whether errors are immediately converted to exceptions or are handled in some other way.

class xml.sax.handler.LexicalHandler

Interface used by the parser to represent low frequency events which may not be of interest to many applications.

In addition to these classes, `xml.sax.handler` provides symbolic constants for the feature and property names.

xml.sax.handler.feature_namespaces

value: "http://xml.org/sax/features/namespaces"

true: Perform Namespace processing.

false: Optionally do not perform Namespace processing (implies namespace-prefixes; default).

access: (parsing) read-only; (not parsing) read/write

xml.sax.handler.feature_namespace_prefixes

value: "http://xml.org/sax/features/namespace-prefixes"

true: Report the original prefixed names and attributes used for Namespace declarations.

false: Do not report attributes used for Namespace declarations, and optionally do not report original prefixed names (default).

access: (parsing) read-only; (not parsing) read/write

xml.sax.handler.feature_string_interning

value: "http://xml.org/sax/features/string-interning"

true: All element names, prefixes, attribute names, Namespace URIs, and local names are interned using the built-in intern function.

false: Names are not necessarily interned, although they may be (default).

access: (parsing) read-only; (not parsing) read/write

xml.sax.handler.feature_validation

value: "http://xml.org/sax/features/validation"

true: Report all validation errors (implies external-general-entities and external-parameter-entities).

false: Do not report validation errors.

access: (parsing) read-only; (not parsing) read/write

xml.sax.handler.feature_external_ges

value: "http://xml.org/sax/features/external-general-entities"

true: Include all external general (text) entities.

false: Do not include external general entities.

access: (parsing) read-only; (not parsing) read/write

xml.sax.handler.feature_external_pes

value: "http://xml.org/sax/features/external-parameter-entities"

true: Include all external parameter entities, including the external DTD subset.

false: Do not include any external parameter entities, even the external DTD subset.

access: (parsing) read-only; (not parsing) read/write

xml.sax.handler.all_features

List of all features.

xml.sax.handler.property_lexical_handler

value: "http://xml.org/sax/properties/lexical-handler"

data type: xml.sax.handler.LexicalHandler (not supported in Python 2)

description: An optional extension handler for lexical events like comments.

access: read/write

xml.sax.handler.property_declaration_handler

value: "http://xml.org/sax/properties/declaration-handler"

data type: xml.sax.sax2lib.DeclHandler (not supported in Python 2)

description: An optional extension handler for DTD-related events other than notations and unparsed entities.

access: read/write

xml.sax.handler.property_dom_node

value: "http://xml.org/sax/properties/dom-node"

data type: org.w3c.dom.Node (not supported in Python 2)

description: When parsing, the current DOM node being visited if this is a DOM iterator; when not parsing, the root DOM node for iteration.

access: (parsing) read-only; (not parsing) read/write

xml.sax.handler.property_xml_string

value: "http://xml.org/sax/properties/xml-string"

data type: Bytes

description: The literal string of characters that was the source for the current event.

access: read-only

xml.sax.handler.all_properties

List of all known property names.

20.10.1 ContentHandler 物件

Users are expected to subclass *ContentHandler* to support their application. The following methods are called by the parser on the appropriate events in the input document:

ContentHandler.setDocumentLocator(*locator*)

Called by the parser to give the application a locator for locating the origin of document events.

SAX parsers are strongly encouraged (though not absolutely required) to supply a locator: if it does so, it must supply the locator to the application by invoking this method before invoking any of the other methods in the DocumentHandler interface.

The locator allows the application to determine the end position of any document-related event, even if the parser is not reporting an error. Typically, the application will use this information for reporting its own errors (such as character content that does not match an application's business rules). The information returned by the locator is probably not sufficient for use with a search engine.

Note that the locator will return correct information only during the invocation of the events in this interface. The application should not attempt to use it at any other time.

ContentHandler.startDocument()

Receive notification of the beginning of a document.

The SAX parser will invoke this method only once, before any other methods in this interface or in DTDHandler (except for *setDocumentLocator()*).

ContentHandler.endDocument()

Receive notification of the end of a document.

The SAX parser will invoke this method only once, and it will be the last method invoked during the parse. The parser shall not invoke this method until it has either abandoned parsing (because of an unrecoverable error) or reached the end of input.

`ContentHandler.startPrefixMapping(prefix, uri)`

Begin the scope of a prefix-URI Namespace mapping.

The information from this event is not necessary for normal Namespace processing: the SAX XML reader will automatically replace prefixes for element and attribute names when the `feature_namespaces` feature is enabled (the default).

There are cases, however, when applications need to use prefixes in character data or in attribute values, where they cannot safely be expanded automatically; the `startPrefixMapping()` and `endPrefixMapping()` events supply the information to the application to expand prefixes in those contexts itself, if necessary.

Note that `startPrefixMapping()` and `endPrefixMapping()` events are not guaranteed to be properly nested relative to each-other: all `startPrefixMapping()` events will occur before the corresponding `startElement()` event, and all `endPrefixMapping()` events will occur after the corresponding `endElement()` event, but their order is not guaranteed.

`ContentHandler.endPrefixMapping(prefix)`

End the scope of a prefix-URI mapping.

See `startPrefixMapping()` for details. This event will always occur after the corresponding `endElement()` event, but the order of `endPrefixMapping()` events is not otherwise guaranteed.

`ContentHandler.startElement(name, attrs)`

Signals the start of an element in non-namespace mode.

The `name` parameter contains the raw XML 1.0 name of the element type as a string and the `attrs` parameter holds an object of the `Attributes` interface (see *The Attributes Interface*) containing the attributes of the element. The object passed as `attrs` may be re-used by the parser; holding on to a reference to it is not a reliable way to keep a copy of the attributes. To keep a copy of the attributes, use the `copy()` method of the `attrs` object.

`ContentHandler.endElement(name)`

Signals the end of an element in non-namespace mode.

The `name` parameter contains the name of the element type, just as with the `startElement()` event.

`ContentHandler.startElementNS(name, qname, attrs)`

Signals the start of an element in namespace mode.

The `name` parameter contains the name of the element type as a `(uri, localname)` tuple, the `qname` parameter contains the raw XML 1.0 name used in the source document, and the `attrs` parameter holds an instance of the `AttributesNS` interface (see *The AttributesNS Interface*) containing the attributes of the element. If no namespace is associated with the element, the `uri` component of `name` will be `None`. The object passed as `attrs` may be re-used by the parser; holding on to a reference to it is not a reliable way to keep a copy of the attributes. To keep a copy of the attributes, use the `copy()` method of the `attrs` object.

Parsers may set the `qname` parameter to `None`, unless the `feature_namespace_prefixes` feature is activated.

`ContentHandler.endElementNS(name, qname)`

Signals the end of an element in namespace mode.

The `name` parameter contains the name of the element type, just as with the `startElementNS()` method, likewise the `qname` parameter.

`ContentHandler.characters(content)`

Receive notification of character data.

The Parser will call this method to report each chunk of character data. SAX parsers may return all contiguous character data in a single chunk, or they may split it into several chunks; however, all of the characters in any single event must come from the same external entity so that the Locator provides useful information.

`content` may be a string or bytes instance; the `expat` reader module always produces strings.

備 𐀀: The earlier SAX 1 interface provided by the Python XML Special Interest Group used a more Java-like interface for this method. Since most parsers used from Python did not take advantage of the older interface, the simpler signature was chosen to replace it. To convert old code to the new interface, use *content* instead of slicing content with the old *offset* and *length* parameters.

`ContentHandler.ignorableWhitespace` (*whitespace*)

Receive notification of ignorable whitespace in element content.

Validating Parsers must use this method to report each chunk of ignorable whitespace (see the W3C XML 1.0 recommendation, section 2.10): non-validating parsers may also use this method if they are capable of parsing and using content models.

SAX parsers may return all contiguous whitespace in a single chunk, or they may split it into several chunks; however, all of the characters in any single event must come from the same external entity, so that the Locator provides useful information.

`ContentHandler.processingInstruction` (*target, data*)

Receive notification of a processing instruction.

The Parser will invoke this method once for each processing instruction found: note that processing instructions may occur before or after the main document element.

A SAX parser should never report an XML declaration (XML 1.0, section 2.8) or a text declaration (XML 1.0, section 4.3.1) using this method.

`ContentHandler.skippedEntity` (*name*)

Receive notification of a skipped entity.

The Parser will invoke this method once for each entity skipped. Non-validating processors may skip entities if they have not seen the declarations (because, for example, the entity was declared in an external DTD subset). All processors may skip external entities, depending on the values of the `feature_external_ges` and the `feature_external_pes` properties.

20.10.2 DTDHandler 物件

`DTDHandler` instances provide the following methods:

`DTDHandlernotationDecl` (*name, publicId, systemId*)

Handle a notation declaration event.

`DTDHandler.unparsedEntityDecl` (*name, publicId, systemId, ndata*)

Handle an unparsed entity declaration event.

20.10.3 EntityResolver 物件

`EntityResolver.resolveEntity` (*publicId, systemId*)

Resolve the system identifier of an entity and return either the system identifier to read from as a string, or an `InputSource` to read from. The default implementation returns *systemId*.

20.10.4 ErrorHandler 物件

Objects with this interface are used to receive error and warning information from the *XMLReader*. If you create an object that implements this interface, then register the object with your *XMLReader*, the parser will call the methods in your object to report all warnings and errors. There are three levels of errors available: warnings, (possibly) recoverable errors, and unrecoverable errors. All methods take a *SAXParseException* as the only parameter. Errors and warnings may be converted to an exception by raising the passed-in exception object.

`ErrorHandler.error(exception)`

Called when the parser encounters a recoverable error. If this method does not raise an exception, parsing may continue, but further document information should not be expected by the application. Allowing the parser to continue may allow additional errors to be discovered in the input document.

`ErrorHandler.fatalError(exception)`

Called when the parser encounters an error it cannot recover from; parsing is expected to terminate when this method returns.

`ErrorHandler.warning(exception)`

Called when the parser presents minor warning information to the application. Parsing is expected to continue when this method returns, and document information will continue to be passed to the application. Raising an exception in this method will cause parsing to end.

20.10.5 LexicalHandler 物件

Optional SAX2 handler for lexical events.

This handler is used to obtain lexical information about an XML document. Lexical information includes information describing the document encoding used and XML comments embedded in the document, as well as section boundaries for the DTD and for any CDATA sections. The lexical handlers are used in the same manner as content handlers.

Set the *LexicalHandler* of an *XMLReader* by using the `setProperty` method with the property identifier `'http://xml.org/sax/properties/lexical-handler'`.

`LexicalHandler.comment(content)`

Reports a comment anywhere in the document (including the DTD and outside the document element).

`LexicalHandler.startDTD(name, public_id, system_id)`

Reports the start of the DTD declarations if the document has an associated DTD.

`LexicalHandler.endDTD()`

Reports the end of DTD declaration.

`LexicalHandler.startCDATA()`

Reports the start of a CDATA marked section.

The contents of the CDATA marked section will be reported through the characters handler.

`LexicalHandler.endCDATA()`

Reports the end of a CDATA marked section.

20.11 `xml.sax.saxutils` --- SAX Utilities

原始碼: `Lib/xml/sax/saxutils.py`

The module `xml.sax.saxutils` contains a number of classes and functions that are commonly useful when creating SAX applications, either in direct use, or as base classes.

`xml.sax.saxutils.escape(data, entities={})`

Escape '&', '<', and '>' in a string of data.

You can escape other strings of data by passing a dictionary as the optional `entities` parameter. The keys and values must all be strings; each key will be replaced with its corresponding value. The characters '&', '<' and '>' are always escaped, even if `entities` is provided.

`xml.sax.saxutils.unescape(data, entities={})`

Unescape '&', '<', and '>' in a string of data.

You can unescape other strings of data by passing a dictionary as the optional `entities` parameter. The keys and values must all be strings; each key will be replaced with its corresponding value. '&', '<', and '>' are always unescaped, even if `entities` is provided.

`xml.sax.saxutils.quoteattr(data, entities={})`

Similar to `escape()`, but also prepares `data` to be used as an attribute value. The return value is a quoted version of `data` with any additional required replacements. `quoteattr()` will select a quote character based on the content of `data`, attempting to avoid encoding any quote characters in the string. If both single- and double-quote characters are already in `data`, the double-quote characters will be encoded and `data` will be wrapped in double-quotes. The resulting string can be used directly as an attribute value:

```
>>> print("<element attr=%s>" % quoteattr("ab ' cd \" ef"))
<element attr="ab ' cd &quot; ef">
```

This function is useful when generating attribute values for HTML or any SGML using the reference concrete syntax.

class `xml.sax.saxutils.XMLGenerator` (`out=None`, `encoding='iso-8859-1'`,
`short_empty_elements=False`)

This class implements the `ContentHandler` interface by writing SAX events back into an XML document. In other words, using an `XMLGenerator` as the content handler will reproduce the original document being parsed. `out` should be a file-like object which will default to `sys.stdout`. `encoding` is the encoding of the output stream which defaults to `'iso-8859-1'`. `short_empty_elements` controls the formatting of elements that contain no content: if `False` (the default) they are emitted as a pair of start/end tags, if set to `True` they are emitted as a single self-closed tag.

在 3.2 版的變更: Added the `short_empty_elements` parameter.

class `xml.sax.saxutils.XMLFilterBase` (`base`)

This class is designed to sit between an `XMLReader` and the client application's event handlers. By default, it does nothing but pass requests up to the reader and events on to the handlers unmodified, but subclasses can override specific methods to modify the event stream or the configuration requests as they pass through.

`xml.sax.saxutils.prepare_input_source(source, base="")`

This function takes an input source and an optional base URL and returns a fully resolved `InputSource` object ready for reading. The input source can be given as a string, a file-like object, or an `InputSource` object; parsers will use this function to implement the polymorphic `source` argument to their `parse()` method.

20.12 `xml.sax.xmlreader` --- Interface for XML parsers

原始碼: [Lib/xml/sax/xmlreader.py](#)

SAX parsers implement the *XMLReader* interface. They are implemented in a Python module, which must provide a function `create_parser()`. This function is invoked by `xml.sax.make_parser()` with no arguments to create a new parser object.

class `xml.sax.xmlreader.XMLReader`

Base class which can be inherited by SAX parsers.

class `xml.sax.xmlreader.IncrementalParser`

In some cases, it is desirable not to parse an input source at once, but to feed chunks of the document as they get available. Note that the reader will normally not read the entire file, but read it in chunks as well; still `parse()` won't return until the entire document is processed. So these interfaces should be used if the blocking behaviour of `parse()` is not desirable.

When the parser is instantiated it is ready to begin accepting data from the feed method immediately. After parsing has been finished with a call to close the reset method must be called to make the parser ready to accept new data, either from feed or using the parse method.

Note that these methods must *not* be called during parsing, that is, after `parse` has been called and before it returns.

By default, the class also implements the parse method of the XMLReader interface using the feed, close and reset methods of the IncrementalParser interface as a convenience to SAX 2.0 driver writers.

class `xml.sax.xmlreader.Locator`

Interface for associating a SAX event with a document location. A locator object will return valid results only during calls to DocumentHandler methods; at any other time, the results are unpredictable. If information is not available, methods may return `None`.

class `xml.sax.xmlreader.InputSource` (*system_id=None*)

Encapsulation of the information needed by the *XMLReader* to read entities.

This class may include information about the public identifier, system identifier, byte stream (possibly with character encoding information) and/or the character stream of an entity.

Applications will create objects of this class for use in the *XMLReader.parse()* method and for returning from `EntityResolver.resolveEntity`.

An *InputSource* belongs to the application, the *XMLReader* is not allowed to modify *InputSource* objects passed to it from the application, although it may make copies and modify those.

class `xml.sax.xmlreader.AttributesImpl` (*attrs*)

This is an implementation of the *Attributes* interface (see section *The Attributes Interface*). This is a dictionary-like object which represents the element attributes in a `startElement()` call. In addition to the most useful dictionary operations, it supports a number of other methods as described by the interface. Objects of this class should be instantiated by readers; *attrs* must be a dictionary-like object containing a mapping from attribute names to attribute values.

class `xml.sax.xmlreader.AttributesNSImpl` (*attrs, qnames*)

Namespace-aware variant of *AttributesImpl*, which will be passed to `startElementNS()`. It is derived from *AttributesImpl*, but understands attribute names as two-tuples of *namespaceURI* and *localname*. In addition, it provides a number of methods expecting qualified names as they appear in the original document. This class implements the *AttributesNS* interface (see section *The AttributesNS Interface*).

20.12.1 XMLReader 物件

The *XMLReader* interface supports the following methods:

`XMLReader.parse(source)`

Process an input source, producing SAX events. The *source* object can be a system identifier (a string identifying the input source -- typically a file name or a URL), a *pathlib.Path* or *path-like* object, or an *InputSource* object. When *parse()* returns, the input is completely processed, and the parser object can be discarded or reset.

在 3.5 版的變更: Added support of character streams.

在 3.8 版的變更: Added support of path-like objects.

`XMLReader.getContentHandler()`

Return the current *ContentHandler*.

`XMLReader.setContentHandler(handler)`

Set the current *ContentHandler*. If no *ContentHandler* is set, content events will be discarded.

`XMLReader.getDTDHandler()`

Return the current *DTDHandler*.

`XMLReader.setDTDHandler(handler)`

Set the current *DTDHandler*. If no *DTDHandler* is set, DTD events will be discarded.

`XMLReader.getEntityResolver()`

Return the current *EntityResolver*.

`XMLReader.setEntityResolver(handler)`

Set the current *EntityResolver*. If no *EntityResolver* is set, attempts to resolve an external entity will result in opening the system identifier for the entity, and fail if it is not available.

`XMLReader.getErrorHandler()`

Return the current *ErrorHandler*.

`XMLReader.setErrorHandler(handler)`

Set the current error handler. If no *ErrorHandler* is set, errors will be raised as exceptions, and warnings will be printed.

`XMLReader.setLocale(locale)`

Allow an application to set the locale for errors and warnings.

SAX parsers are not required to provide localization for errors and warnings; if they cannot support the requested locale, however, they must raise a SAX exception. Applications may request a locale change in the middle of a parse.

`XMLReader.getFeature(featurename)`

Return the current setting for feature *featurename*. If the feature is not recognized, *SAXNotRecognizedException* is raised. The well-known featurenames are listed in the module *xml.sax.handler*.

`XMLReader.setFeature(featurename, value)`

Set the *featurename* to *value*. If the feature is not recognized, *SAXNotRecognizedException* is raised. If the feature or its setting is not supported by the parser, *SAXNotSupportedException* is raised.

`XMLReader.getProperty(propertyname)`

Return the current setting for property *propertyname*. If the property is not recognized, a *SAXNotRecognizedException* is raised. The well-known propertynames are listed in the module *xml.sax.handler*.

`XMLReader.setProperty(propertyname, value)`

Set the *propertyname* to *value*. If the property is not recognized, *SAXNotRecognizedException* is raised. If the property or its setting is not supported by the parser, *SAXNotSupportedException* is raised.

20.12.2 IncrementalParser 物件

Instances of *IncrementalParser* offer the following additional methods:

`IncrementalParser.feed(data)`

Process a chunk of *data*.

`IncrementalParser.close()`

Assume the end of the document. That will check well-formedness conditions that can be checked only at the end, invoke handlers, and may clean up resources allocated during parsing.

`IncrementalParser.reset()`

This method is called after close has been called to reset the parser so that it is ready to parse new documents. The results of calling parse or feed after close without calling reset are undefined.

20.12.3 Locator Objects

Instances of *Locator* provide these methods:

`Locator.getColumnNumber()`

Return the column number where the current event begins.

`Locator.getLineNumber()`

Return the line number where the current event begins.

`Locator.getPublicId()`

Return the public identifier for the current event.

`Locator.getSystemId()`

Return the system identifier for the current event.

20.12.4 InputSource 物件

`InputSource.setPublicId(id)`

Sets the public identifier of this *InputSource*.

`InputSource.getPublicId()`

Returns the public identifier of this *InputSource*.

`InputSource.setSystemId(id)`

Sets the system identifier of this *InputSource*.

`InputSource.getSystemId()`

Returns the system identifier of this *InputSource*.

`InputSource.setEncoding(encoding)`

Sets the character encoding of this *InputSource*.

The encoding must be a string acceptable for an XML encoding declaration (see section 4.3.3 of the XML recommendation).

The encoding attribute of the *InputSource* is ignored if the *InputSource* also contains a character stream.

`InputSource.getEncoding()`

Get the character encoding of this *InputSource*.

`InputSource.setByteStream (bytefile)`

Set the byte stream (a *binary file*) for this input source.

The SAX parser will ignore this if there is also a character stream specified, but it will use a byte stream in preference to opening a URI connection itself.

If the application knows the character encoding of the byte stream, it should set it with the `setEncoding` method.

`InputSource.getByteStream ()`

Get the byte stream for this input source.

The `getEncoding` method will return the character encoding for this byte stream, or `None` if unknown.

`InputSource.setCharacterStream (charfile)`

Set the character stream (a *text file*) for this input source.

If there is a character stream specified, the SAX parser will ignore any byte stream and will not attempt to open a URI connection to the system identifier.

`InputSource.getCharacterStream ()`

Get the character stream for this input source.

20.12.5 The `Attributes` Interface

`Attributes` objects implement a portion of the *mapping protocol*, including the methods `copy()`, `get()`, `__contains__()`, `items()`, `keys()`, and `values()`. The following methods are also provided:

`Attributes.getLength ()`

Return the number of attributes.

`Attributes.getNames ()`

Return the names of the attributes.

`Attributes.getType (name)`

Returns the type of the attribute *name*, which is normally `'CDATA'`.

`Attributes.getValue (name)`

Return the value of attribute *name*.

20.12.6 The `AttributesNS` Interface

This interface is a subtype of the `Attributes` interface (see section *The Attributes Interface*). All methods supported by that interface are also available on `AttributesNS` objects.

The following methods are also available:

`AttributesNS.getValueByQName (name)`

Return the value for a qualified name.

`AttributesNS.getNameByQName (name)`

Return the (namespace, localname) pair for a qualified *name*.

`AttributesNS.getQNameByName (name)`

Return the qualified name for a (namespace, localname) pair.

`AttributesNS.getQNames ()`

Return the qualified names of all attributes.

20.13 `xml.parsers.expat` --- Fast XML parsing using Expat

警告: The `pyexpat` module is not secure against maliciously constructed data. If you need to parse untrusted or unauthenticated data see [XML vulnerabilities](#).

The `xml.parsers.expat` module is a Python interface to the Expat non-validating XML parser. The module provides a single extension type, `xmlparser`, that represents the current state of an XML parser. After an `xmlparser` object has been created, various attributes of the object can be set to handler functions. When an XML document is then fed to the parser, the handler functions are called for the character data and markup in the XML document.

This module uses the `pyexpat` module to provide access to the Expat parser. Direct use of the `pyexpat` module is deprecated.

This module provides one exception and one type object:

exception `xml.parsers.expat.ExpatError`

The exception raised when Expat reports an error. See section [ExpatError 例外](#) for more information on interpreting Expat errors.

exception `xml.parsers.expat.error`

Alias for [ExpatError](#).

`xml.parsers.expat.XMLParserType`

The type of the return values from the [ParserCreate\(\)](#) function.

The `xml.parsers.expat` module contains two functions:

`xml.parsers.expat.ErrorString(errno)`

Returns an explanatory string for a given error number *errno*.

`xml.parsers.expat.ParserCreate(encoding=None, namespace_separator=None)`

Creates and returns a new `xmlparser` object. *encoding*, if specified, must be a string naming the encoding used by the XML data. Expat doesn't support as many encodings as Python does, and its repertoire of encodings can't be extended; it supports UTF-8, UTF-16, ISO-8859-1 (Latin1), and ASCII. If *encoding*¹ is given it will override the implicit or explicit encoding of the document.

Expat can optionally do XML namespace processing for you, enabled by providing a value for *namespace_separator*. The value must be a one-character string; a [ValueError](#) will be raised if the string has an illegal length (`None` is considered the same as omission). When namespace processing is enabled, element type names and attribute names that belong to a namespace will be expanded. The element name passed to the element handlers `StartElementHandler` and `EndElementHandler` will be the concatenation of the namespace URI, the namespace separator character, and the local part of the name. If the namespace separator is a zero byte (`chr(0)`) then the namespace URI and the local part will be concatenated without any separator.

For example, if *namespace_separator* is set to a space character (' ') and the following document is parsed:

```
<?xml version="1.0"?>
<root xmlns      = "http://default-namespace.org/"
      xmlns:py   = "http://www.python.org/ns/">
  <py:elem1 />
  <elem2 xmlns="" />
</root>
```

¹ The encoding string included in XML output should conform to the appropriate standards. For example, "UTF-8" is valid, but "UTF8" is not. See <https://www.w3.org/TR/2006/REC-xml11-20060816/#NT-EncodingDecl> and <https://www.iana.org/assignments/character-sets/character-sets.xhtml>.

StartElementHandler will receive the following strings for each element:

```
http://default-namespace.org/ root
http://www.python.org/ns/ elem1
elem2
```

Due to limitations in the Expat library used by pyexpat, the `xmlparser` instance returned can only be used to parse a single XML document. Call `ParserCreate` for each document to provide unique parser instances.

也参考:

The Expat XML Parser

Home page of the Expat project.

20.13.1 XMLParser 物件

`xmlparser` objects have the following methods:

`xmlparser.Parse(data[, isfinal])`

Parses the contents of the string *data*, calling the appropriate handler functions to process the parsed data. *isfinal* must be true on the final call to this method; it allows the parsing of a single file in fragments, not the submission of multiple files. *data* can be the empty string at any time.

`xmlparser.ParseFile(file)`

Parse XML data reading from the object *file*. *file* only needs to provide the `read(nbytes)` method, returning the empty string when there's no more data.

`xmlparser.SetBase(base)`

Sets the base to be used for resolving relative URIs in system identifiers in declarations. Resolving relative identifiers is left to the application: this value will be passed through as the *base* argument to the `ExternalEntityRefHandler()`, `NotationDeclHandler()`, and `UnparsedEntityDeclHandler()` functions.

`xmlparser.GetBase()`

Returns a string containing the base set by a previous call to `SetBase()`, or `None` if `SetBase()` hasn't been called.

`xmlparser.GetInputContext()`

Returns the input data that generated the current event as a string. The data is in the encoding of the entity which contains the text. When called while an event handler is not active, the return value is `None`.

`xmlparser.ExternalEntityParserCreate(context[, encoding])`

Create a "child" parser which can be used to parse an external parsed entity referred to by content parsed by the parent parser. The *context* parameter should be the string passed to the `ExternalEntityRefHandler()` handler function, described below. The child parser is created with the `ordered_attributes` and `specified_attributes` set to the values of this parser.

`xmlparser.SetParamEntityParsing(flag)`

Control parsing of parameter entities (including the external DTD subset). Possible *flag* values are `XML_PARAM_ENTITY_PARSING_NEVER`, `XML_PARAM_ENTITY_PARSING_UNLESS_STANDALONE` and `XML_PARAM_ENTITY_PARSING_ALWAYS`. Return true if setting the flag was successful.

`xmlparser.UseForeignDTD([flag])`

Calling this with a true value for *flag* (the default) will cause Expat to call the `ExternalEntityRefHandler` with `None` for all arguments to allow an alternate DTD to be loaded. If the document does not contain a document type declaration, the `ExternalEntityRefHandler` will still be called, but the `StartDoctypeDeclHandler` and `EndDoctypeDeclHandler` will not be called.

Passing a false value for *flag* will cancel a previous call that passed a true value, but otherwise has no effect.

This method can only be called before the `Parse()` or `ParseFile()` methods are called; calling it after either of those have been called causes `ExpatError` to be raised with the `code` attribute set to `errors.codes[errors.XML_ERROR_CANT_CHANGE_FEATURE_ONCE_PARSING]`.

`xmlparser.SetReparseDeferralEnabled(enabled)`

警告: Calling `SetReparseDeferralEnabled(False)` has security implications, as detailed below; please make sure to understand these consequences prior to using the `SetReparseDeferralEnabled` method.

Expat 2.6.0 introduced a security mechanism called “reparse deferral” where instead of causing denial of service through quadratic runtime from reparsing large tokens, reparsing of unfinished tokens is now delayed by default until a sufficient amount of input is reached. Due to this delay, registered handlers may—depending on the sizing of input chunks pushed to Expat—no longer be called right after pushing new input to the parser. Where immediate feedback and taking over responsibility of protecting against denial of service from large tokens are both wanted, calling `SetReparseDeferralEnabled(False)` disables reparse deferral for the current Expat parser instance, temporarily or altogether. Calling `SetReparseDeferralEnabled(True)` allows re-enabling reparse deferral.

Note that `SetReparseDeferralEnabled()` has been backported to some prior releases of CPython as a security fix. Check for availability of `SetReparseDeferralEnabled()` using `hasattr()` if used in code running across a variety of Python versions.

在 3.11.9 版新加入。

`xmlparser.GetReparseDeferralEnabled()`

Returns whether reparse deferral is currently enabled for the given Expat parser instance.

在 3.11.9 版新加入。

`xmlparser` 物件擁有以下屬性：

`xmlparser.buffer_size`

The size of the buffer used when `buffer_text` is true. A new buffer size can be set by assigning a new integer value to this attribute. When the size is changed, the buffer will be flushed.

`xmlparser.buffer_text`

Setting this to true causes the `xmlparser` object to buffer textual content returned by Expat to avoid multiple calls to the `CharacterDataHandler()` callback whenever possible. This can improve performance substantially since Expat normally breaks character data into chunks at every line ending. This attribute is false by default, and may be changed at any time. Note that when it is false, data that does not contain newlines may be chunked too.

`xmlparser.buffer_used`

If `buffer_text` is enabled, the number of bytes stored in the buffer. These bytes represent UTF-8 encoded text. This attribute has no meaningful interpretation when `buffer_text` is false.

`xmlparser.ordered_attributes`

Setting this attribute to a non-zero integer causes the attributes to be reported as a list rather than a dictionary. The attributes are presented in the order found in the document text. For each attribute, two list entries are presented: the attribute name and the attribute value. (Older versions of this module also used this format.) By default, this attribute is false; it may be changed at any time.

`xmlparser.specified_attributes`

If set to a non-zero integer, the parser will report only those attributes which were specified in the document instance and not those which were derived from attribute declarations. Applications which set this need to be especially careful to use what additional information is available from the declarations as needed to comply with the standards for the behavior of XML processors. By default, this attribute is false; it may be changed at any time.

The following attributes contain values relating to the most recent error encountered by an `xmlparser` object, and will only have correct values once a call to `Parse()` or `ParseFile()` has raised an `xml.parsers.expat.ExpatError` exception.

`xmlparser.ErrorCode`

Byte index at which an error occurred.

`xmlparser.ErrorCode`

Numeric code specifying the problem. This value can be passed to the `ErrorString()` function, or compared to one of the constants defined in the `errors` object.

`xmlparser.ErrorColumnNumber`

Column number at which an error occurred.

`xmlparser.ErrorLineNumber`

Line number at which an error occurred.

The following attributes contain values relating to the current parse location in an `xmlparser` object. During a callback reporting a parse event they indicate the location of the first of the sequence of characters that generated the event. When called outside of a callback, the position indicated will be just past the last parse event (regardless of whether there was an associated callback).

`xmlparser.CurrentByteIndex`

Current byte index in the parser input.

`xmlparser.CurrentColumnNumber`

Current column number in the parser input.

`xmlparser.CurrentLineNumber`

Current line number in the parser input.

Here is the list of handlers that can be set. To set a handler on an `xmlparser` object *o*, use `o.handlername = func`. *handlername* must be taken from the following list, and *func* must be a callable object accepting the correct number of arguments. The arguments are all strings, unless otherwise stated.

`xmlparser.XmlDeclHandler` (*version*, *encoding*, *standalone*)

Called when the XML declaration is parsed. The XML declaration is the (optional) declaration of the applicable version of the XML recommendation, the encoding of the document text, and an optional "standalone" declaration. *version* and *encoding* will be strings, and *standalone* will be 1 if the document is declared standalone, 0 if it is declared not to be standalone, or -1 if the standalone clause was omitted. This is only available with Expat version 1.95.0 or newer.

`xmlparser.StartDoctypeDeclHandler` (*doctypeName*, *systemId*, *publicId*, *has_internal_subset*)

Called when Expat begins parsing the document type declaration (`<!DOCTYPE ...`). The *doctypeName* is provided exactly as presented. The *systemId* and *publicId* parameters give the system and public identifiers if specified, or `None` if omitted. *has_internal_subset* will be true if the document contains an internal document declaration subset. This requires Expat version 1.2 or newer.

`xmlparser.EndDoctypeDeclHandler` ()

Called when Expat is done parsing the document type declaration. This requires Expat version 1.2 or newer.

`xmlparser.ElementDeclHandler` (*name*, *model*)

Called once for each element type declaration. *name* is the name of the element type, and *model* is a representation of the content model.

`xmlparser.AttnlistDeclHandler` (*elname*, *attname*, *type*, *default*, *required*)

Called for each declared attribute for an element type. If an attribute list declaration declares three attributes, this handler is called three times, once for each attribute. *elname* is the name of the element to which the declaration applies and *attname* is the name of the attribute declared. The attribute type is a string passed as *type*; the possible values are `'CDATA'`, `'ID'`, `'IDREF'`, ... *default* gives the default value for the attribute used when the attribute is not specified by the document instance, or `None` if there is no default value (`#IMPLIED` values). If the attribute is required to be given in the document instance, *required* will be true. This requires Expat version 1.95.0 or newer.

`xmlparser.StartElementHandler` (*name*, *attributes*)

Called for the start of every element. *name* is a string containing the element name, and *attributes* is the element attributes. If *ordered_attributes* is true, this is a list (see *ordered_attributes* for a full description). Otherwise it's a dictionary mapping names to values.

`xmlparser.EndElementHandler` (*name*)

Called for the end of every element.

`xmlparser.ProcessingInstructionHandler` (*target*, *data*)

Called for every processing instruction.

`xmlparser.CharacterDataHandler` (*data*)

Called for character data. This will be called for normal character data, CDATA marked content, and ignorable whitespace. Applications which must distinguish these cases can use the *StartCdataSectionHandler*, *EndCdataSectionHandler*, and *ElementDeclHandler* callbacks to collect the required information. Note that the character data may be chunked even if it is short and so you may receive more than one call to *CharacterDataHandler*(). Set the *buffer_text* instance attribute to True to avoid that.

`xmlparser.UnparsedEntityDeclHandler` (*entityName*, *base*, *systemId*, *publicId*, *notationName*)

Called for unparsed (NDATA) entity declarations. This is only present for version 1.2 of the Expat library; for more recent versions, use *EntityDeclHandler* instead. (The underlying function in the Expat library has been declared obsolete.)

`xmlparser.EntityDeclHandler` (*entityName*, *is_parameter_entity*, *value*, *base*, *systemId*, *publicId*, *notationName*)

Called for all entity declarations. For parameter and internal entities, *value* will be a string giving the declared contents of the entity; this will be None for external entities. The *notationName* parameter will be None for parsed entities, and the name of the notation for unparsed entities. *is_parameter_entity* will be true if the entity is a parameter entity or false for general entities (most applications only need to be concerned with general entities). This is only available starting with version 1.95.0 of the Expat library.

`xmlparser.NotationDeclHandler` (*notationName*, *base*, *systemId*, *publicId*)

Called for notation declarations. *notationName*, *base*, and *systemId*, and *publicId* are strings if given. If the public identifier is omitted, *publicId* will be None.

`xmlparser.StartNamespaceDeclHandler` (*prefix*, *uri*)

Called when an element contains a namespace declaration. Namespace declarations are processed before the *StartElementHandler* is called for the element on which declarations are placed.

`xmlparser.EndNamespaceDeclHandler` (*prefix*)

Called when the closing tag is reached for an element that contained a namespace declaration. This is called once for each namespace declaration on the element in the reverse of the order for which the *StartNamespaceDeclHandler* was called to indicate the start of each namespace declaration's scope. Calls to this handler are made after the corresponding *EndElementHandler* for the end of the element.

`xmlparser.CommentHandler` (*data*)

Called for comments. *data* is the text of the comment, excluding the leading '`<!--`' and trailing '`-->`'.

`xmlparser.StartCdataSectionHandler` ()

Called at the start of a CDATA section. This and *EndCdataSectionHandler* are needed to be able to identify the syntactical start and end for CDATA sections.

`xmlparser.EndCdataSectionHandler` ()

Called at the end of a CDATA section.

`xmlparser.DefaultHandler` (*data*)

Called for any characters in the XML document for which no applicable handler has been specified. This means characters that are part of a construct which could be reported, but for which no handler has been supplied.

`xmlparser.DefaultHandlerExpand(data)`

This is the same as the `DefaultHandler()`, but doesn't inhibit expansion of internal entities. The entity reference will not be passed to the default handler.

`xmlparser.NotStandaloneHandler()`

Called if the XML document hasn't been declared as being a standalone document. This happens when there is an external subset or a reference to a parameter entity, but the XML declaration does not set standalone to `yes` in an XML declaration. If this handler returns 0, then the parser will raise an `XML_ERROR_NOT_STANDALONE` error. If this handler is not set, no exception is raised by the parser for this condition.

`xmlparser.ExternalEntityRefHandler(context, base, systemId, publicId)`

Called for references to external entities. `base` is the current base, as set by a previous call to `SetBase()`. The public and system identifiers, `systemId` and `publicId`, are strings if given; if the public identifier is not given, `publicId` will be `None`. The `context` value is opaque and should only be used as described below.

For external entities to be parsed, this handler must be implemented. It is responsible for creating the sub-parser using `ExternalEntityParserCreate(context)`, initializing it with the appropriate callbacks, and parsing the entity. This handler should return an integer; if it returns 0, the parser will raise an `XML_ERROR_EXTERNAL_ENTITY_HANDLING` error, otherwise parsing will continue.

If this handler is not provided, external entities are reported by the `DefaultHandler` callback, if provided.

20.13.2 ExpatError 例外

`ExpatError` exceptions have a number of interesting attributes:

`ExpatError.code`

Expat's internal error number for the specific error. The `errors.messages` dictionary maps these error numbers to Expat's error messages. For example:

```
from xml.parsers.expat import ParserCreate, ExpatError, errors

p = ParserCreate()
try:
    p.Parse(some_xml_document)
except ExpatError as err:
    print("Error:", errors.messages[err.code])
```

The `errors` module also provides error message constants and a dictionary `codes` mapping these messages back to the error codes, see below.

`ExpatError.lineno`

Line number on which the error was detected. The first line is numbered 1.

`ExpatError.offset`

Character offset into the line where the error occurred. The first column is numbered 0.

20.13.3 范例

The following program defines three handlers that just print out their arguments.

```
import xml.parsers.expat

# 3 handler functions
def start_element(name, attrs):
    print('Start element:', name, attrs)
def end_element(name):
    print('End element:', name)
```

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```
def char_data(data):
    print('Character data:', repr(data))

p = xml.parsers.expat.ParserCreate()

p.StartElementHandler = start_element
p.EndElementHandler = end_element
p.CharacterDataHandler = char_data

p.Parse("""<?xml version="1.0"?>
<parent id="top"><child1 name="paul">Text goes here</child1>
<child2 name="fred">More text</child2>
</parent>""", 1)
```

The output from this program is:

```
Start element: parent {'id': 'top'}
Start element: child1 {'name': 'paul'}
Character data: 'Text goes here'
End element: child1
Character data: '\n'
Start element: child2 {'name': 'fred'}
Character data: 'More text'
End element: child2
Character data: '\n'
End element: parent
```

20.13.4 Content Model Descriptions

Content models are described using nested tuples. Each tuple contains four values: the type, the quantifier, the name, and a tuple of children. Children are simply additional content model descriptions.

The values of the first two fields are constants defined in the `xml.parsers.expat.model` module. These constants can be collected in two groups: the model type group and the quantifier group.

The constants in the model type group are:

`xml.parsers.expat.model.XML_CTYPE_ANY`

The element named by the model name was declared to have a content model of ANY.

`xml.parsers.expat.model.XML_CTYPE_CHOICE`

The named element allows a choice from a number of options; this is used for content models such as (A | B | C).

`xml.parsers.expat.model.XML_CTYPE_EMPTY`

Elements which are declared to be EMPTY have this model type.

`xml.parsers.expat.model.XML_CTYPE_MIXED`

`xml.parsers.expat.model.XML_CTYPE_NAME`

`xml.parsers.expat.model.XML_CTYPE_SEQ`

Models which represent a series of models which follow one after the other are indicated with this model type. This is used for models such as (A, B, C).

The constants in the quantifier group are:

`xml.parsers.expat.model.XML_CQUANT_NONE`

No modifier is given, so it can appear exactly once, as for A.

`xml.parsers.expat.model.XML_CQUANT_OPT`

The model is optional: it can appear once or not at all, as for A?.

`xml.parsers.expat.model.XML_CQUANT_PLUS`

The model must occur one or more times (like A+).

`xml.parsers.expat.model.XML_CQUANT_REP`

The model must occur zero or more times, as for A*.

20.13.5 Expat error constants

The following constants are provided in the `xml.parsers.expat.errors` module. These constants are useful in interpreting some of the attributes of the `ExpatError` exception objects raised when an error has occurred. Since for backwards compatibility reasons, the constants' value is the error *message* and not the numeric error *code*, you do this by comparing its `code` attribute with `errors.codes[errors.XML_ERROR_CONSTANT_NAME]`.

The `errors` module has the following attributes:

`xml.parsers.expat.errors.codes`

A dictionary mapping string descriptions to their error codes.

在 3.2 版新加入.

`xml.parsers.expat.errors.messages`

A dictionary mapping numeric error codes to their string descriptions.

在 3.2 版新加入.

`xml.parsers.expat.errors.XML_ERROR_ASYNC_ENTITY`

`xml.parsers.expat.errors.XML_ERROR_ATTRIBUTE_EXTERNAL_ENTITY_REF`

An entity reference in an attribute value referred to an external entity instead of an internal entity.

`xml.parsers.expat.errors.XML_ERROR_BAD_CHAR_REF`

A character reference referred to a character which is illegal in XML (for example, character 0, or '�').

`xml.parsers.expat.errors.XML_ERROR_BINARY_ENTITY_REF`

An entity reference referred to an entity which was declared with a notation, so cannot be parsed.

`xml.parsers.expat.errors.XML_ERROR_DUPLICATE_ATTRIBUTE`

An attribute was used more than once in a start tag.

`xml.parsers.expat.errors.XML_ERROR_INCORRECT_ENCODING`

`xml.parsers.expat.errors.XML_ERROR_INVALID_TOKEN`

Raised when an input byte could not properly be assigned to a character; for example, a NUL byte (value 0) in a UTF-8 input stream.

`xml.parsers.expat.errors.XML_ERROR_JUNK_AFTER_DOC_ELEMENT`

Something other than whitespace occurred after the document element.

`xml.parsers.expat.errors.XML_ERROR_MISPLACED_XML_PI`

An XML declaration was found somewhere other than the start of the input data.

`xml.parsers.expat.errors.XML_ERROR_NO_ELEMENTS`

The document contains no elements (XML requires all documents to contain exactly one top-level element).

`xml.parsers.expat.errors.XML_ERROR_NO_MEMORY`

Expat was not able to allocate memory internally.

`xml.parsers.expat.errors.XML_ERROR_PARAM_ENTITY_REF`

A parameter entity reference was found where it was not allowed.

`xml.parsers.expat.errors.XML_ERROR_PARTIAL_CHAR`

An incomplete character was found in the input.

`xml.parsers.expat.errors.XML_ERROR_RECURSIVE_ENTITY_REF`

An entity reference contained another reference to the same entity; possibly via a different name, and possibly indirectly.

`xml.parsers.expat.errors.XML_ERROR_SYNTAX`

Some unspecified syntax error was encountered.

`xml.parsers.expat.errors.XML_ERROR_TAG_MISMATCH`

An end tag did not match the innermost open start tag.

`xml.parsers.expat.errors.XML_ERROR_UNCLOSED_TOKEN`

Some token (such as a start tag) was not closed before the end of the stream or the next token was encountered.

`xml.parsers.expat.errors.XML_ERROR_UNDEFINED_ENTITY`

A reference was made to an entity which was not defined.

`xml.parsers.expat.errors.XML_ERROR_UNKNOWN_ENCODING`

The document encoding is not supported by Expat.

`xml.parsers.expat.errors.XML_ERROR_UNCLOSED_CDATA_SECTION`

A CDATA marked section was not closed.

`xml.parsers.expat.errors.XML_ERROR_EXTERNAL_ENTITY_HANDLING`

`xml.parsers.expat.errors.XML_ERROR_NOT_STANDALONE`

The parser determined that the document was not "standalone" though it declared itself to be in the XML declaration, and the `NotStandaloneHandler` was set and returned 0.

`xml.parsers.expat.errors.XML_ERROR_UNEXPECTED_STATE`

`xml.parsers.expat.errors.XML_ERROR_ENTITY_DECLARED_IN_PE`

`xml.parsers.expat.errors.XML_ERROR_FEATURE_REQUIRES_XML_DTD`

An operation was requested that requires DTD support to be compiled in, but Expat was configured without DTD support. This should never be reported by a standard build of the `xml.parsers.expat` module.

`xml.parsers.expat.errors.XML_ERROR_CANT_CHANGE_FEATURE_ONCE_PARSING`

A behavioral change was requested after parsing started that can only be changed before parsing has started. This is (currently) only raised by `UseForeignDTD()`.

`xml.parsers.expat.errors.XML_ERROR_UNBOUND_PREFIX`

An undeclared prefix was found when namespace processing was enabled.

`xml.parsers.expat.errors.XML_ERROR_UNDECLARING_PREFIX`

The document attempted to remove the namespace declaration associated with a prefix.

`xml.parsers.expat.errors.XML_ERROR_INCOMPLETE_PE`

A parameter entity contained incomplete markup.

`xml.parsers.expat.errors.XML_ERROR_XML_DECL`

The document contained no document element at all.

`xml.parsers.expat.errors.XML_ERROR_TEXT_DECL`

There was an error parsing a text declaration in an external entity.

`xml.parsers.expat.errors.XML_ERROR_PUBLICID`

Characters were found in the public id that are not allowed.

`xml.parsers.expat.errors.XML_ERROR_SUSPENDED`

The requested operation was made on a suspended parser, but isn't allowed. This includes attempts to provide additional input or to stop the parser.

`xml.parsers.expat.errors.XML_ERROR_NOT_SUSPENDED`

An attempt to resume the parser was made when the parser had not been suspended.

`xml.parsers.expat.errors.XML_ERROR_ABORTED`

This should not be reported to Python applications.

`xml.parsers.expat.errors.XML_ERROR_FINISHED`

The requested operation was made on a parser which was finished parsing input, but isn't allowed. This includes attempts to provide additional input or to stop the parser.

`xml.parsers.expat.errors.XML_ERROR_SUSPEND_PE`

`xml.parsers.expat.errors.XML_ERROR_RESERVED_PREFIX_XML`

An attempt was made to undeclare reserved namespace prefix `xml` or to bind it to another namespace URI.

`xml.parsers.expat.errors.XML_ERROR_RESERVED_PREFIX_XMLNS`

An attempt was made to declare or undeclare reserved namespace prefix `xmlns`.

`xml.parsers.expat.errors.XML_ERROR_RESERVED_NAMESPACE_URI`

An attempt was made to bind the URI of one the reserved namespace prefixes `xml` and `xmlns` to another namespace prefix.

`xml.parsers.expat.errors.XML_ERROR_INVALID_ARGUMENT`

This should not be reported to Python applications.

`xml.parsers.expat.errors.XML_ERROR_NO_BUFFER`

This should not be reported to Python applications.

`xml.parsers.expat.errors.XML_ERROR_AMPLIFICATION_LIMIT_BREACH`

The limit on input amplification factor (from DTD and entities) has been breached.

F 解

Internet Protocols and Support

The modules described in this chapter implement internet protocols and support for related technology. They are all implemented in Python. Most of these modules require the presence of the system-dependent module `socket`, which is currently supported on most popular platforms. Here is an overview:

21.1 `webbrowser` --- Convenient web-browser controller

原始碼: [Lib/webbrowser.py](#)

The `webbrowser` module provides a high-level interface to allow displaying web-based documents to users. Under most circumstances, simply calling the `open()` function from this module will do the right thing.

Under Unix, graphical browsers are preferred under X11, but text-mode browsers will be used if graphical browsers are not available or an X11 display isn't available. If text-mode browsers are used, the calling process will block until the user exits the browser.

If the environment variable `BROWSER` exists, it is interpreted as the `os.pathsep`-separated list of browsers to try ahead of the platform defaults. When the value of a list part contains the string `%s`, then it is interpreted as a literal browser command line to be used with the argument URL substituted for `%s`; if the part does not contain `%s`, it is simply interpreted as the name of the browser to launch.¹

For non-Unix platforms, or when a remote browser is available on Unix, the controlling process will not wait for the user to finish with the browser, but allow the remote browser to maintain its own windows on the display. If remote browsers are not available on Unix, the controlling process will launch a new browser and wait.

The script `webbrowser` can be used as a command-line interface for the module. It accepts a URL as the argument. It accepts the following optional parameters: `-n` opens the URL in a new browser window, if possible; `-t` opens the URL in a new browser page ("tab"). The options are, naturally, mutually exclusive. Usage example:

```
python -m webbrowser -t "https://www.python.org"
```

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

The following exception is defined:

¹ Executables named here without a full path will be searched in the directories given in the `PATH` environment variable.

exception `webbrowser.Error`

Exception raised when a browser control error occurs.

The following functions are defined:

`webbrowser.open(url, new=0, autoraise=True)`

Display *url* using the default browser. If *new* is 0, the *url* is opened in the same browser window if possible. If *new* is 1, a new browser window is opened if possible. If *new* is 2, a new browser page ("tab") is opened if possible. If *autoraise* is `True`, the window is raised if possible (note that under many window managers this will occur regardless of the setting of this variable).

Note that on some platforms, trying to open a filename using this function, may work and start the operating system's associated program. However, this is neither supported nor portable.

引發一個附帶引數 *url* 的稽核事件 `webbrowser.open`。

`webbrowser.open_new(url)`

Open *url* in a new window of the default browser, if possible, otherwise, open *url* in the only browser window.

`webbrowser.open_new_tab(url)`

Open *url* in a new page ("tab") of the default browser, if possible, otherwise equivalent to `open_new()`.

`webbrowser.get(using=None)`

Return a controller object for the browser type *using*. If *using* is `None`, return a controller for a default browser appropriate to the caller's environment.

`webbrowser.register(name, constructor, instance=None, *, preferred=False)`

Register the browser type *name*. Once a browser type is registered, the `get()` function can return a controller for that browser type. If *instance* is not provided, or is `None`, *constructor* will be called without parameters to create an instance when needed. If *instance* is provided, *constructor* will never be called, and may be `None`.

Setting *preferred* to `True` makes this browser a preferred result for a `get()` call with no argument. Otherwise, this entry point is only useful if you plan to either set the `BROWSER` variable or call `get()` with a nonempty argument matching the name of a handler you declare.

在 3.7 版的變更: *preferred* keyword-only parameter was added.

A number of browser types are predefined. This table gives the type names that may be passed to the `get()` function and the corresponding instantiations for the controller classes, all defined in this module.

Type Name	Class Name	解 F
'mozilla'	Mozilla('mozilla')	
'firefox'	Mozilla('mozilla')	
'netscape'	Mozilla('netscape')	
'galeon'	Galeon('galeon')	
'epiphany'	Galeon('epiphany')	
'skipstone'	BackgroundBrowser('skipstone')	
'kfmclient'	Konqueror()	(1)
'konqueror'	Konqueror()	(1)
'kfm'	Konqueror()	(1)
'mosaic'	BackgroundBrowser('mosaic')	
'opera'	Opera()	
'grail'	Grail()	
'links'	GenericBrowser('links')	
'elinks'	Elinks('elinks')	
'lynx'	GenericBrowser('lynx')	
'w3m'	GenericBrowser('w3m')	
'windows-default'	WindowsDefault	(2)
'macosx'	MacOSXOSAScript('default')	(3)
'safari'	MacOSXOSAScript('safari')	(3)
'google-chrome'	Chrome('google-chrome')	
'chrome'	Chrome('chrome')	
'chromium'	Chromium('chromium')	
'chromium-browser'	Chromium('chromium-browser')	

解 F:

- (1) "Konqueror" is the file manager for the KDE desktop environment for Unix, and only makes sense to use if KDE is running. Some way of reliably detecting KDE would be nice; the `KDEDIR` variable is not sufficient. Note also that the name "kfm" is used even when using the **konqueror** command with KDE 2 --- the implementation selects the best strategy for running Konqueror.
- (2) Only on Windows platforms.
- (3) Only on macOS platform.

在 3.3 版新加入: Support for Chrome/Chromium has been added.

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `MacOSX` is deprecated, use `MacOSXOSAScript` instead.

以下是一些簡單範例:

```
url = 'https://docs.python.org/'

# Open URL in a new tab, if a browser window is already open.
webbrowser.open_new_tab(url)

# Open URL in new window, raising the window if possible.
webbrowser.open_new(url)
```

21.1.1 Browser Controller Objects

Browser controllers provide these methods which parallel three of the module-level convenience functions:

`webbrowser.name`

System-dependent name for the browser.

`controller.open(url, new=0, autoraise=True)`

Display *url* using the browser handled by this controller. If *new* is 1, a new browser window is opened if possible. If *new* is 2, a new browser page (“tab”) is opened if possible.

`controller.open_new(url)`

Open *url* in a new window of the browser handled by this controller, if possible, otherwise, open *url* in the only browser window. Alias `open_new()`.

`controller.open_new_tab(url)`

Open *url* in a new page (“tab”) of the browser handled by this controller, if possible, otherwise equivalent to `open_new()`.

解

21.2 wsgiref --- WSGI Utilities and Reference Implementation

原始碼: [Lib/wsgiref](#)

The Web Server Gateway Interface (WSGI) is a standard interface between web server software and web applications written in Python. Having a standard interface makes it easy to use an application that supports WSGI with a number of different web servers.

Only authors of web servers and programming frameworks need to know every detail and corner case of the WSGI design. You don’t need to understand every detail of WSGI just to install a WSGI application or to write a web application using an existing framework.

`wsgiref` is a reference implementation of the WSGI specification that can be used to add WSGI support to a web server or framework. It provides utilities for manipulating WSGI environment variables and response headers, base classes for implementing WSGI servers, a demo HTTP server that serves WSGI applications, types for static type checking, and a validation tool that checks WSGI servers and applications for conformance to the WSGI specification ([PEP 3333](#)).

See wsgi.readthedocs.io for more information about WSGI, and links to tutorials and other resources.

21.2.1 wsgiref.util -- WSGI environment utilities

This module provides a variety of utility functions for working with WSGI environments. A WSGI environment is a dictionary containing HTTP request variables as described in [PEP 3333](#). All of the functions taking an *environ* parameter expect a WSGI-compliant dictionary to be supplied; please see [PEP 3333](#) for a detailed specification and `WSGIEnvironment` for a type alias that can be used in type annotations.

`wsgiref.util.guess_scheme(environ)`

Return a guess for whether `wsgi.url_scheme` should be “http” or “https”, by checking for a HTTPS environment variable in the *environ* dictionary. The return value is a string.

This function is useful when creating a gateway that wraps CGI or a CGI-like protocol such as FastCGI. Typically, servers providing such protocols will include a HTTPS variable with a value of “1”, “yes”, or “on” when a request is received via SSL. So, this function returns “https” if such a value is found, and “http” otherwise.

`wsgiref.util.request_uri (environ, include_query=True)`

Return the full request URI, optionally including the query string, using the algorithm found in the “URL Reconstruction” section of [PEP 3333](#). If `include_query` is false, the query string is not included in the resulting URI.

`wsgiref.util.application_uri (environ)`

Similar to `request_uri()`, except that the `PATH_INFO` and `QUERY_STRING` variables are ignored. The result is the base URI of the application object addressed by the request.

`wsgiref.util.shift_path_info (environ)`

Shift a single name from `PATH_INFO` to `SCRIPT_NAME` and return the name. The `environ` dictionary is *modified* in-place; use a copy if you need to keep the original `PATH_INFO` or `SCRIPT_NAME` intact.

If there are no remaining path segments in `PATH_INFO`, `None` is returned.

Typically, this routine is used to process each portion of a request URI path, for example to treat the path as a series of dictionary keys. This routine modifies the passed-in environment to make it suitable for invoking another WSGI application that is located at the target URI. For example, if there is a WSGI application at `/foo`, and the request URI path is `/foo/bar/baz`, and the WSGI application at `/foo` calls `shift_path_info()`, it will receive the string “bar”, and the environment will be updated to be suitable for passing to a WSGI application at `/foo/bar`. That is, `SCRIPT_NAME` will change from `/foo` to `/foo/bar`, and `PATH_INFO` will change from `/bar/baz` to `/baz`.

When `PATH_INFO` is just a “/”, this routine returns an empty string and appends a trailing slash to `SCRIPT_NAME`, even though empty path segments are normally ignored, and `SCRIPT_NAME` doesn’t normally end in a slash. This is intentional behavior, to ensure that an application can tell the difference between URIs ending in `/x` from ones ending in `/x/` when using this routine to do object traversal.

`wsgiref.util.setup_testing_defaults (environ)`

Update `environ` with trivial defaults for testing purposes.

This routine adds various parameters required for WSGI, including `HTTP_HOST`, `SERVER_NAME`, `SERVER_PORT`, `REQUEST_METHOD`, `SCRIPT_NAME`, `PATH_INFO`, and all of the [PEP 3333](#)-defined `wsgi.*` variables. It only supplies default values, and does not replace any existing settings for these variables.

This routine is intended to make it easier for unit tests of WSGI servers and applications to set up dummy environments. It should NOT be used by actual WSGI servers or applications, since the data is fake!

用法範例:

```
from wsgiref.util import setup_testing_defaults
from wsgiref.simple_server import make_server

# A relatively simple WSGI application. It's going to print out the
# environment dictionary after being updated by setup_testing_defaults
def simple_app(environ, start_response):
    setup_testing_defaults(environ)

    status = '200 OK'
    headers = [('Content-type', 'text/plain; charset=utf-8')]

    start_response(status, headers)

    ret = [("%s: %s\n" % (key, value)).encode("utf-8")
            for key, value in environ.items()]
    return ret

with make_server(' ', 8000, simple_app) as httpd:
    print("Serving on port 8000...")
    httpd.serve_forever()
```

In addition to the environment functions above, the `wsgiref.util` module also provides these miscellaneous utilities:

`wsgiref.util.is_hop_by_hop(header_name)`

Return True if `header_name` is an HTTP/1.1 "Hop-by-Hop" header, as defined by [RFC 2616](#).

class `wsgiref.util.FileWrapper(filelike, blksize=8192)`

A concrete implementation of the `wsgiref.types.FileWrapper` protocol used to convert a file-like object to an *iterator*. The resulting objects are *iterables*. As the object is iterated over, the optional `blksize` parameter will be repeatedly passed to the `filelike` object's `read()` method to obtain bytestrings to yield. When `read()` returns an empty bytestring, iteration is ended and is not resumable.

If `filelike` has a `close()` method, the returned object will also have a `close()` method, and it will invoke the `filelike` object's `close()` method when called.

用法範例:

```
from io import StringIO
from wsgiref.util import FileWrapper

# We're using a StringIO-buffer for as the file-like object
filelike = StringIO("This is an example file-like object"*10)
wrapper = FileWrapper(filelike, blksize=5)

for chunk in wrapper:
    print(chunk)
```

在 3.11 版的變更: Support for `__getitem__()` method has been removed.

21.2.2 wsgiref.headers -- WSGI response header tools

This module provides a single class, `Headers`, for convenient manipulation of WSGI response headers using a mapping-like interface.

class `wsgiref.headers.Headers([headers])`

Create a mapping-like object wrapping `headers`, which must be a list of header name/value tuples as described in [PEP 3333](#). The default value of `headers` is an empty list.

`Headers` objects support typical mapping operations including `__getitem__()`, `get()`, `__setitem__()`, `setdefault()`, `__delitem__()` and `__contains__()`. For each of these methods, the key is the header name (treated case-insensitively), and the value is the first value associated with that header name. Setting a header deletes any existing values for that header, then adds a new value at the end of the wrapped header list. Headers' existing order is generally maintained, with new headers added to the end of the wrapped list.

Unlike a dictionary, `Headers` objects do not raise an error when you try to get or delete a key that isn't in the wrapped header list. Getting a nonexistent header just returns `None`, and deleting a nonexistent header does nothing.

`Headers` objects also support `keys()`, `values()`, and `items()` methods. The lists returned by `keys()` and `items()` can include the same key more than once if there is a multi-valued header. The `len()` of a `Headers` object is the same as the length of its `items()`, which is the same as the length of the wrapped header list. In fact, the `items()` method just returns a copy of the wrapped header list.

Calling `bytes()` on a `Headers` object returns a formatted bytestring suitable for transmission as HTTP response headers. Each header is placed on a line with its value, separated by a colon and a space. Each line is terminated by a carriage return and line feed, and the bytestring is terminated with a blank line.

In addition to their mapping interface and formatting features, `Headers` objects also have the following methods for querying and adding multi-valued headers, and for adding headers with MIME parameters:

get_all(name)

Return a list of all the values for the named header.

The returned list will be sorted in the order they appeared in the original header list or were added to this instance, and may contain duplicates. Any fields deleted and re-inserted are always appended to the header list. If no fields exist with the given name, returns an empty list.

add_header (*name*, *value*, ***_params*)

Add a (possibly multi-valued) header, with optional MIME parameters specified via keyword arguments.

name is the header field to add. Keyword arguments can be used to set MIME parameters for the header field. Each parameter must be a string or `None`. Underscores in parameter names are converted to dashes, since dashes are illegal in Python identifiers, but many MIME parameter names include dashes. If the parameter value is a string, it is added to the header value parameters in the form `name="value"`. If it is `None`, only the parameter name is added. (This is used for MIME parameters without a value.) Example usage:

```
h.add_header('content-disposition', 'attachment', filename='bud.gif')
```

The above will add a header that looks like this:

```
Content-Disposition: attachment; filename="bud.gif"
```

在 3.5 版的變更: *headers* parameter is optional.

21.2.3 wsgiref.simple_server -- a simple WSGI HTTP server

This module implements a simple HTTP server (based on [http.server](#)) that serves WSGI applications. Each server instance serves a single WSGI application on a given host and port. If you want to serve multiple applications on a single host and port, you should create a WSGI application that parses `PATH_INFO` to select which application to invoke for each request. (E.g., using the `shift_path_info()` function from [wsgiref.util](#).)

`wsgiref.simple_server.make_server` (*host*, *port*, *app*, *server_class*=`WSGIServer`,
handler_class=`WSGIRequestHandler`)

Create a new WSGI server listening on *host* and *port*, accepting connections for *app*. The return value is an instance of the supplied *server_class*, and will process requests using the specified *handler_class*. *app* must be a WSGI application object, as defined by [PEP 3333](#).

用法範例:

```
from wsgiref.simple_server import make_server, demo_app

with make_server(' ', 8000, demo_app) as httpd:
    print("Serving HTTP on port 8000...")

    # Respond to requests until process is killed
    httpd.serve_forever()

    # Alternative: serve one request, then exit
    httpd.handle_request()
```

`wsgiref.simple_server.demo_app` (*environ*, *start_response*)

This function is a small but complete WSGI application that returns a text page containing the message "Hello world!" and a list of the key/value pairs provided in the *environ* parameter. It's useful for verifying that a WSGI server (such as [wsgiref.simple_server](#)) is able to run a simple WSGI application correctly.

class `wsgiref.simple_server.WSGIServer` (*server_address*, *RequestHandlerClass*)

Create a `WSGIServer` instance. *server_address* should be a (*host*, *port*) tuple, and *RequestHandlerClass* should be the subclass of `http.server.BaseHTTPRequestHandler` that will be used to process requests.

You do not normally need to call this constructor, as the `make_server()` function can handle all the details for you.

`WSGIServer` is a subclass of `http.server.HTTPServer`, so all of its methods (such as `serve_forever()` and `handle_request()`) are available. `WSGIServer` also provides these WSGI-specific methods:

set_app(*application*)

Sets the callable *application* as the WSGI application that will receive requests.

get_app()

Returns the currently set application callable.

Normally, however, you do not need to use these additional methods, as `set_app()` is normally called by `make_server()`, and the `get_app()` exists mainly for the benefit of request handler instances.

class `wsgiref.simple_server.WSGIRequestHandler`(*request*, *client_address*, *server*)

Create an HTTP handler for the given *request* (i.e. a socket), *client_address* (a (host,port) tuple), and *server* (`WSGIServer` instance).

You do not need to create instances of this class directly; they are automatically created as needed by `WSGIServer` objects. You can, however, subclass this class and supply it as a *handler_class* to the `make_server()` function. Some possibly relevant methods for overriding in subclasses:

get_environ()

Return a `WSGIEnvironment` dictionary for a request. The default implementation copies the contents of the `WSGIServer` object's `base_environ` dictionary attribute and then adds various headers derived from the HTTP request. Each call to this method should return a new dictionary containing all of the relevant CGI environment variables as specified in [PEP 3333](#).

get_stderr()

Return the object that should be used as the `wsgi.errors` stream. The default implementation just returns `sys.stderr`.

handle()

Process the HTTP request. The default implementation creates a handler instance using a `wsgiref.handlers` class to implement the actual WSGI application interface.

21.2.4 `wsgiref.validate` --- WSGI conformance checker

When creating new WSGI application objects, frameworks, servers, or middleware, it can be useful to validate the new code's conformance using `wsgiref.validate`. This module provides a function that creates WSGI application objects that validate communications between a WSGI server or gateway and a WSGI application object, to check both sides for protocol conformance.

Note that this utility does not guarantee complete [PEP 3333](#) compliance; an absence of errors from this module does not necessarily mean that errors do not exist. However, if this module does produce an error, then it is virtually certain that either the server or application is not 100% compliant.

This module is based on the `paste.lint` module from Ian Bicking's "Python Paste" library.

`wsgiref.validate.validator`(*application*)

Wrap *application* and return a new WSGI application object. The returned application will forward all requests to the original *application*, and will check that both the *application* and the server invoking it are conforming to the WSGI specification and to [RFC 2616](#).

Any detected nonconformance results in an `AssertionError` being raised; note, however, that how these errors are handled is server-dependent. For example, `wsgiref.simple_server` and other servers based on `wsgiref.handlers` (that don't override the error handling methods to do something else) will simply output a message that an error has occurred, and dump the traceback to `sys.stderr` or some other error stream.

This wrapper may also generate output using the `warnings` module to indicate behaviors that are questionable but which may not actually be prohibited by [PEP 3333](#). Unless they are suppressed using Python command-line options or the `warnings` API, any such warnings will be written to `sys.stderr` (not `wsgi.errors`, unless they happen to be the same object).

用法範例：

```
from wsgiref.validate import validator
from wsgiref.simple_server import make_server

# Our callable object which is intentionally not compliant to the
# standard, so the validator is going to break
def simple_app(environ, start_response):
    status = '200 OK' # HTTP Status
    headers = [('Content-type', 'text/plain')] # HTTP Headers
    start_response(status, headers)

    # This is going to break because we need to return a list, and
    # the validator is going to inform us
    return b"Hello World"

# This is the application wrapped in a validator
validator_app = validator(simple_app)

with make_server('', 8000, validator_app) as httpd:
    print("Listening on port 8000...")
    httpd.serve_forever()
```

21.2.5 wsgiref.handlers -- server/gateway base classes

This module provides base handler classes for implementing WSGI servers and gateways. These base classes handle most of the work of communicating with a WSGI application, as long as they are given a CGI-like environment, along with input, output, and error streams.

class wsgiref.handlers.CGIHandler

CGI-based invocation via `sys.stdin`, `sys.stdout`, `sys.stderr` and `os.environ`. This is useful when you have a WSGI application and want to run it as a CGI script. Simply invoke `CGIHandler().run(app)`, where `app` is the WSGI application object you wish to invoke.

This class is a subclass of `BaseCGIHandler` that sets `wsgi.run_once` to `true`, `wsgi.multithread` to `false`, and `wsgi.multiprocess` to `true`, and always uses `sys` and `os` to obtain the necessary CGI streams and environment.

class wsgiref.handlers.IISCGIHandler

A specialized alternative to `CGIHandler`, for use when deploying on Microsoft's IIS web server, without having set the config `allowPathInfo` option (IIS>=7) or metabase `allowPathInfoForScriptMappings` (IIS<7).

By default, IIS gives a `PATH_INFO` that duplicates the `SCRIPT_NAME` at the front, causing problems for WSGI applications that wish to implement routing. This handler strips any such duplicated path.

IIS can be configured to pass the correct `PATH_INFO`, but this causes another bug where `PATH_TRANSLATED` is wrong. Luckily this variable is rarely used and is not guaranteed by WSGI. On IIS<7, though, the setting can only be made on a vhost level, affecting all other script mappings, many of which break when exposed to the `PATH_TRANSLATED` bug. For this reason IIS<7 is almost never deployed with the fix (Even IIS7 rarely uses it because there is still no UI for it.).

There is no way for CGI code to tell whether the option was set, so a separate handler class is provided. It is used in the same way as `CGIHandler`, i.e., by calling `IISCGIHandler().run(app)`, where `app` is the WSGI application object you wish to invoke.

在 3.2 版新加入。

class wsgiref.handlers.BaseCGIHandler(*stdin, stdout, stderr, environ, multithread=True, multiprocess=False*)

Similar to `CGIHandler`, but instead of using the `sys` and `os` modules, the CGI environment and I/O streams are specified explicitly. The `multithread` and `multiprocess` values are used to set the `wsgi.multithread` and `wsgi.multiprocess` flags for any applications run by the handler instance.

This class is a subclass of `SimpleHandler` intended for use with software other than HTTP “origin servers”. If you are writing a gateway protocol implementation (such as CGI, FastCGI, SCGI, etc.) that uses a `Status:` header to send an HTTP status, you probably want to subclass this instead of `SimpleHandler`.

```
class wsgiref.handlers.SimpleHandler (stdin, stdout, stderr, environ, multithread=True,
                                     multiprocess=False)
```

Similar to `BaseCGIHandler`, but designed for use with HTTP origin servers. If you are writing an HTTP server implementation, you will probably want to subclass this instead of `BaseCGIHandler`.

This class is a subclass of `BaseHandler`. It overrides the `__init__()`, `get_stdin()`, `get_stderr()`, `add_cgi_vars()`, `_write()`, and `_flush()` methods to support explicitly setting the environment and streams via the constructor. The supplied environment and streams are stored in the `stdin`, `stdout`, `stderr`, and `environ` attributes.

The `write()` method of `stdout` should write each chunk in full, like `io.BufferedIOBase`.

```
class wsgiref.handlers.BaseHandler
```

This is an abstract base class for running WSGI applications. Each instance will handle a single HTTP request, although in principle you could create a subclass that was reusable for multiple requests.

`BaseHandler` instances have only one method intended for external use:

```
run (app)
```

Run the specified WSGI application, `app`.

All of the other `BaseHandler` methods are invoked by this method in the process of running the application, and thus exist primarily to allow customizing the process.

The following methods MUST be overridden in a subclass:

```
_write (data)
```

Buffer the bytes `data` for transmission to the client. It’s okay if this method actually transmits the data; `BaseHandler` just separates write and flush operations for greater efficiency when the underlying system actually has such a distinction.

```
_flush ()
```

Force buffered data to be transmitted to the client. It’s okay if this method is a no-op (i.e., if `_write()` actually sends the data).

```
get_stdin ()
```

Return an object compatible with `InputStream` suitable for use as the `wsgi.input` of the request currently being processed.

```
get_stderr ()
```

Return an object compatible with `ErrorStream` suitable for use as the `wsgi.errors` of the request currently being processed.

```
add_cgi_vars ()
```

Insert CGI variables for the current request into the `environ` attribute.

Here are some other methods and attributes you may wish to override. This list is only a summary, however, and does not include every method that can be overridden. You should consult the docstrings and source code for additional information before attempting to create a customized `BaseHandler` subclass.

Attributes and methods for customizing the WSGI environment:

```
wsgi_multithread
```

The value to be used for the `wsgi.multithread` environment variable. It defaults to true in `BaseHandler`, but may have a different default (or be set by the constructor) in the other subclasses.

```
wsgi_multiprocess
```

The value to be used for the `wsgi.multiprocess` environment variable. It defaults to true in `BaseHandler`, but may have a different default (or be set by the constructor) in the other subclasses.

wsgi_run_once

The value to be used for the `wsgi.run_once` environment variable. It defaults to false in *BaseHandler*, but *CGIHandler* sets it to true by default.

os_environ

The default environment variables to be included in every request's WSGI environment. By default, this is a copy of `os.environ` at the time that *wsgiref.handlers* was imported, but subclasses can either create their own at the class or instance level. Note that the dictionary should be considered read-only, since the default value is shared between multiple classes and instances.

server_software

If the *origin_server* attribute is set, this attribute's value is used to set the default `SERVER_SOFTWARE` WSGI environment variable, and also to set a default `Server:` header in HTTP responses. It is ignored for handlers (such as *BaseCGIHandler* and *CGIHandler*) that are not HTTP origin servers.

在 3.3 版的變更: The term "Python" is replaced with implementation specific term like "CPython", "Jython" etc.

get_scheme()

Return the URL scheme being used for the current request. The default implementation uses the `guess_scheme()` function from *wsgiref.util* to guess whether the scheme should be "http" or "https", based on the current request's `environ` variables.

setup_environ()

Set the `environ` attribute to a fully populated WSGI environment. The default implementation uses all of the above methods and attributes, plus the `get_stdin()`, `get_stderr()`, and `add_cgi_vars()` methods and the *wsgi_file_wrapper* attribute. It also inserts a `SERVER_SOFTWARE` key if not present, as long as the *origin_server* attribute is a true value and the *server_software* attribute is set.

Methods and attributes for customizing exception handling:

log_exception(exc_info)

Log the *exc_info* tuple in the server log. *exc_info* is a (type, value, traceback) tuple. The default implementation simply writes the traceback to the request's `wsgi.errors` stream and flushes it. Subclasses can override this method to change the format or retarget the output, mail the traceback to an administrator, or whatever other action may be deemed suitable.

traceback_limit

The maximum number of frames to include in tracebacks output by the default `log_exception()` method. If `None`, all frames are included.

error_output(environ, start_response)

This method is a WSGI application to generate an error page for the user. It is only invoked if an error occurs before headers are sent to the client.

This method can access the current error using `sys.exception()`, and should pass that information to *start_response* when calling it (as described in the "Error Handling" section of **PEP 3333**).

The default implementation just uses the *error_status*, *error_headers*, and *error_body* attributes to generate an output page. Subclasses can override this to produce more dynamic error output.

Note, however, that it's not recommended from a security perspective to spit out diagnostics to any old user; ideally, you should have to do something special to enable diagnostic output, which is why the default implementation doesn't include any.

error_status

The HTTP status used for error responses. This should be a status string as defined in **PEP 3333**; it defaults to a 500 code and message.

error_headers

The HTTP headers used for error responses. This should be a list of WSGI response headers ((name, value) tuples), as described in [PEP 3333](#). The default list just sets the content type to `text/plain`.

error_body

The error response body. This should be an HTTP response body bytestring. It defaults to the plain text, "A server error occurred. Please contact the administrator."

Methods and attributes for [PEP 3333](#)'s "Optional Platform-Specific File Handling" feature:

wsgi_file_wrapper

A `wsgi.file_wrapper` factory, compatible with `wsgiref.types.FileWrapper`, or `None`. The default value of this attribute is the `wsgiref.util.FileWrapper` class.

sendfile()

Override to implement platform-specific file transmission. This method is called only if the application's return value is an instance of the class specified by the `wsgi_file_wrapper` attribute. It should return a true value if it was able to successfully transmit the file, so that the default transmission code will not be executed. The default implementation of this method just returns a false value.

Miscellaneous methods and attributes:

origin_server

This attribute should be set to a true value if the handler's `_write()` and `_flush()` are being used to communicate directly to the client, rather than via a CGI-like gateway protocol that wants the HTTP status in a special `Status:` header.

This attribute's default value is true in `BaseHandler`, but false in `BaseCGIHandler` and `CGIHandler`.

http_version

If `origin_server` is true, this string attribute is used to set the HTTP version of the response set to the client. It defaults to "1.0".

wsgiref.handlers.read_environ()

Transcode CGI variables from `os.environ` to [PEP 3333](#) "bytes in unicode" strings, returning a new dictionary. This function is used by `CGIHandler` and `IISCGIHandler` in place of directly using `os.environ`, which is not necessarily WSGI-compliant on all platforms and web servers using Python 3 -- specifically, ones where the OS's actual environment is Unicode (i.e. Windows), or ones where the environment is bytes, but the system encoding used by Python to decode it is anything other than ISO-8859-1 (e.g. Unix systems using UTF-8).

If you are implementing a CGI-based handler of your own, you probably want to use this routine instead of just copying values out of `os.environ` directly.

在 3.2 版新加入.

21.2.6 `wsgiref.types` -- WSGI types for static type checking

This module provides various types for static type checking as described in [PEP 3333](#).

在 3.11 版新加入.

class `wsgiref.types.StartResponse`

A `typing.Protocol` describing `start_response()` callables ([PEP 3333](#)).

`wsgiref.types.WSGIEnvironment`

A type alias describing a WSGI environment dictionary.

`wsgiref.types.WSGIApplication`

A type alias describing a WSGI application callable.

class `wsgiref.types.InputStream`

A *typing.Protocol* describing a WSGI Input Stream.

class `wsgiref.types.ErrorStream`

A *typing.Protocol* describing a WSGI Error Stream.

class `wsgiref.types.FileWrapper`

A *typing.Protocol* describing a file wrapper. See `wsgiref.util.FileWrapper` for a concrete implementation of this protocol.

21.2.7 范例

This is a working "Hello World" WSGI application:

```
"""
Every WSGI application must have an application object - a callable
object that accepts two arguments. For that purpose, we're going to
use a function (note that you're not limited to a function, you can
use a class for example). The first argument passed to the function
is a dictionary containing CGI-style environment variables and the
second variable is the callable object.
"""
from wsgiref.simple_server import make_server

def hello_world_app(environ, start_response):
    status = "200 OK" # HTTP Status
    headers = [("Content-type", "text/plain; charset=utf-8")] # HTTP Headers
    start_response(status, headers)

    # The returned object is going to be printed
    return [b"Hello World"]

with make_server("", 8000, hello_world_app) as httpd:
    print("Serving on port 8000...")

    # Serve until process is killed
    httpd.serve_forever()
```

Example of a WSGI application serving the current directory, accept optional directory and port number (default: 8000) on the command line:

```
"""
Small wsgiref based web server. Takes a path to serve from and an
optional port number (defaults to 8000), then tries to serve files.
MIME types are guessed from the file names, 404 errors are raised
if the file is not found.
"""
import mimetypes
import os
import sys
from wsgiref import simple_server, util

def app(environ, respond):
    # Get the file name and MIME type
    fn = os.path.join(path, environ["PATH_INFO"][1:])
    if "." not in fn.split(os.path.sep)[-1]:
        fn = os.path.join(fn, "index.html")
    mime_type = mimetypes.guess_type(fn)[0]
```

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```

# Return 200 OK if file exists, otherwise 404 Not Found
if os.path.exists(fn):
    respond("200 OK", [("Content-Type", mime_type)])
    return util.FileWrapper(open(fn, "rb"))
else:
    respond("404 Not Found", [("Content-Type", "text/plain")])
    return [b"not found"]

if __name__ == "__main__":
    # Get the path and port from command-line arguments
    path = sys.argv[1] if len(sys.argv) > 1 else os.getcwd()
    port = int(sys.argv[2]) if len(sys.argv) > 2 else 8000

    # Make and start the server until control-c
    httpd = simple_server.make_server("", port, app)
    print(f"Serving {path} on port {port}, control-C to stop")
    try:
        httpd.serve_forever()
    except KeyboardInterrupt:
        print("Shutting down.")
        httpd.server_close()

```

21.3 urllib --- URL 處理模組

原始碼: [Lib/urllib/](#)

`urllib` 是一個匯集了許多處理 URLs 的 module (模組) 的 package (套件):

- `urllib.request` 用來開和讀取 URLs
- `urllib.error` 包含了 `urllib.request` 所引發的例外
- `urllib.parse` 用來剖析 URLs
- `urllib.robotparser` 用來剖析 `robots.txt` 檔案

21.4 urllib.request --- 用來開 URLs 的可擴充函式庫

原始碼: [Lib/urllib/request.py](#)

`urllib.request` module (模組) 定義了一些函式與 class (類) 用以開 URLs (大部分是 HTTP), 處理各式雜情如: basic 驗證與 digest 驗證、重新導向、cookies。

也參考:

有關於更高階的 HTTP 用端介面, 推薦使用 [Requests](#) 套件。

警告: On macOS it is unsafe to use this module in programs using `os.fork()` because the `getproxies()` implementation for macOS uses a higher-level system API. Set the environment variable `no_proxy` to `*` to avoid this problem (e.g. `os.environ["no_proxy"] = "*"`).

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

`urllib.request` module 定義下列函式：

```
urllib.request.urlopen(url, data=None, [timeout, ], *, cafile=None, capath=None, cadefault=False,
                        context=None)
```

打開 `url`，其值可以是一個包含有效且適當編碼 URL 的字串或是一個 `Request` 物件。

`data` 必須是一個包含傳送給伺服器額外資料的物件，若不需要傳送額外資料則指定 `None`。更多細節請見 `Request`。

`urllib.request` module 使用 HTTP/1.1 包含 `Connection:close` header (標頭) 在其 HTTP 請求中。

透過選擇性參數 `timeout` 來指定 blocking operations (阻塞性操作，如：嘗試連接) 的 timeout (超時時間)，以秒為單位。若有指定值，則會使用全域預設超時時間設定。實際上，此參數僅作用於 HTTP、HTTPS 以及 FTP 的連接。

若 `context` 有被指定時，它必須是一個 `ssl.SSLContext` 的實例描述著各種 SSL 選項。更多細節請見 `HTTPSConnection`。

選擇性參數 `cafile` 與 `capath` 用來指定一組 HTTPS 請求中所需之受信任 CA 憑證。`cafile` 的值應該指向包含一堆 CA 憑證的單一檔案，而 `capath` 則指向存放一堆雜湊後的憑證檔案的目錄。欲解更多的資訊請參見 `ssl.SSLContext.load_verify_locations()`。

參數 `cadefault` 已被忽略。

這個函式總是回傳一個可作 `context manager` 使用的物件，有著特性 (property) `url`、`headers` 與 `status`。欲知更多這些特性細節請參見 `urllib.response.addinfourl`。

對於 HTTP 與 HTTPS 的 URLs，這個函式回傳一個稍有不同的 `http.client.HTTPResponse` 物件。除了上述提到的三個方法外，另有 `msg` 屬性有著與 `reason` 相同的資訊 --- 由伺服器回傳的原因 (reason phrase)，而不是在 `HTTPResponse` 文件中提到的回應 headers。

對於 FTP、檔案、資料的 URLs、以及那些由傳統 classes `URLopener` 與 `FancyURLopener` 所處理的請求，這個函式會回傳一個 `urllib.response.addinfourl` 物件。

當遇到協定上的錯誤時會引發 `URLError`。

請注意若有 `handler` 處理請求時，`None` 值將會被回傳。(即使有預設的全域類 `OpenerDirector` 使用 `UnknownHandler` 來確保這種情況不會發生)

In addition, if proxy settings are detected (for example, when a `*_proxy` environment variable like `http_proxy` is set), `ProxyHandler` is default installed and makes sure the requests are handled through the proxy.

Python 2.6 或更早版本的遺留函式 `urllib.urlopen` 已經不再被維護；新函式 `urllib.request.urlopen()` 對應到舊函式 `urllib2.urlopen`。有關代理服務的處理，以往是透過傳遞 dictionary (字典) 參數給 `urllib.urlopen` 來取得的，現在則可以透過 `ProxyHandler` 物件來取得。

觸發一個 *auditing event* `urllib.Request` 及其引數 `fullurl`、`data`、`headers`、`method`。

在 3.2 版的變更：新增 `cafile` 與 `capath`。

HTTPS virtual hosts are now supported if possible (that is, if `ssl.HAS_SNI` is true).

`data` 可以是一個可代物件。

在 3.3 版的變更：`cadefault` 被新增。

在 3.4.3 版的變更：`context` 被新增。

在 3.10 版的變更：HTTPS connection now send an ALPN extension with protocol indicator `http/1.1` when no `context` is given. Custom `context` should set ALPN protocols with `set_alpn_protocols()`.

在 3.6 版之後被用：`cafile`、`capath`、`cadefault` 已經被用應改用 `context`。請改用 `ssl.SSLContext.load_cert_chain()`，或是讓 `ssl.create_default_context()` 選取系統中受信任的 CA 憑證。

```
urllib.request.install_opener(opener)
```

安裝一個 `OpenerDirector` 實例作預設的全域 opener。僅在當你想要讓 `urlopen` 使用該 opener 時安裝一個 opener，否則的話應直接呼叫 `OpenerDirector.open()` 而非 `urlopen()`。程式碼不會檢查 class 是否真的 `OpenerDirector`，而是任何具有正確介面的 class 都能適用。

```
urllib.request.build_opener([handler, ...])
```

回傳一個 `OpenerDirector` 實例，以給定的順序把 handlers 串接起來。handlers 可以是 `BaseHandler` 的實例，亦或是 `BaseHandler` 的 subclasses（這個情況下必須有不帶參數的建構函式能被呼叫）。以下 classes 的實例順位會在 handlers 之前，除非 handlers 已經包含它們，是它們的實例，或是它們的 subclasses: `ProxyHandler`（如果代理服務設定被偵測到）、`UnknownHandler`、`HTTPHandler`、`HTTPDefaultErrorHandler`、`HTTPRedirectHandler`、`FTPHandler`、`FileHandler`、`HTTPErrorProcessor`。

如果 Python 安裝時已帶有 SSL 支援（如果 `ssl` module 能被 import），則 `HTTPSHandler` 也在上述 class 之中。

一個 `BaseHandler` 的 subclass 可能透過改變其 `handler_order` 屬性來調整它在 handlers list 中的位置。

```
urllib.request.pathname2url(path)
```

將路徑名 `path` 從路徑的本地語法 (local syntax) 轉成 URL 中的 path component（路徑元件）格式。本函式不會生成完整的 URL。回傳值將使用 `quote()` 函式先進行編碼過。

```
urllib.request.url2pathname(path)
```

將一個用“%”編碼過的 URL path component `path` 轉成路徑的本地語法 (local syntax)。本函式不接受完整的 URL。本函式使用 `unquote()` 來將 `path` 解碼。

```
urllib.request.getproxies()
```

這個輔助函式 (helper function) 回傳一個代理伺服器 URL mappings（對映）的 dictionary。在所有的作業系統中，它首先掃描環境中有著 `<scheme>_proxy` 名稱的變數（忽略大小寫的），如果找不到的話就會在 macOS 中的系統設定 (System Configuration) 或是 Windows 系統中的 Windows Systems Registry 尋找代理服務設定。如果大小寫的環境變數同時存在且值有不同，小寫的環境變數會被選用。

備註：如果環境變數 `REQUEST_METHOD` 有被設置（通常這代表著你的 script 是運行在一個共用閘道介面 (CGI) 環境中），那環境變數 `HTTP_PROXY`（大寫的 `_PROXY`）將被忽略。這是因為變數可以透過使用“Proxy:” HTTP header 被注入。如果需要在共用閘道介面環境中使用 HTTP 代理服務，可以明確使用 `ProxyHandler`，亦或是確認變數名稱是小寫的（或至少 `_proxy` 後綴是小寫的）。

提供了以下的 classes：

```
class urllib.request.Request(url, data=None, headers={}, origin_req_host=None,
                             unverifiable=False, method=None)
```

這個 class 是一個 URL 請求的抽象 class。

`url` 是一個包含有效且適當編碼的 URL 字串。

`data` 必須是一個包含要送到伺服器的附加資料的物件，若不需帶附加資料則其值應為 `None`。目前 HTTP 請求是唯一有使用 `data` 參數的，其支援的物件型包含位元組、類檔案物件 (file-like objects)、以及可代的類位元組串物件 (bytes-like objects)。如果有提供 `Content-Length` 及 `Transfer-Encoding` headers 欄位，`HTTPHandler` 將會根據 `data` 的型設置這些 header。`Content-Length` 會被用來傳送位元組串物件，而 **RFC 7230** 章節 3.3.1 所定義的 `Transfer-Encoding: chunked` 則會被用來傳送檔案或是其它可代物件 (iterables)。

對於一個 HTTP POST 請求方法，`data` 應為一個標準 `application/x-www-form-urlencoded` 格式的 buffer。`urllib.parse.urlencode()` 方法接受一個 mapping 或是 sequence（序列）的 2-tuples，回傳一個對應格式的 ASCII 字串。在被作 `data` 參數前它應該被編碼成位元組串。

`headers` 必須是一個 dictionary，會被視為如同每對 key 和 value 作引數來呼叫 `add_header()`。經常用於「包裝」User-Agent header 的值，這個 header 是用來讓一個瀏覽器向伺服器表明自己的身分 --- 有些 HTTP 伺服器僅允許來自普通瀏覽器的請求，而不接受來自程式本的請求。

例如，Mozilla Firefox 會將 `header` 的值設為 "Mozilla/5.0 (X11; U; Linux i686) Gecko/20071127 Firefox/2.0.0.11"，而 `urllib` 的值則是 "Python-urllib/2.6"（在 Python 2.6 上）。所有 `header` 的鍵都會以 camel case（駝峰式大小寫）來傳送。

當有給定 `data` 引數時，一個適當的 `Content-Type` header 應該被設置。如果這個 header 有被提供且 `data` 也不為 `None` 時，預設值 `Content-Type: application/x-www-form-urlencoded` 會被新增至請求中。

接下來的兩個引數的介紹提供給那些有興趣正確處理第三方 HTTP cookies 的使用者：

`origin_req_host` 應為原始傳輸互動的請求主機 (request-host)，如同在 RFC 2965 中的定義。預設值為 `http.cookiejar.request_host(self)`。這是使用者發起的原始請求的主機名稱或是 IP 位址。例如當請求是要求一個 HTML 文件中的一個影像，則這個屬性應為請求包含影像頁面的請求主機。

`unverifiable` 應該標示一個請求是否是無法驗證的，如同在 RFC 2965 中的定義。其預設值為 `False`。一個無法驗證的請求是指使用者有機會去批准請求的 URL，例如一個對於 HTML 文件中的影像所做的請求，而使用者有機會去批准是否能自動取影像，則這個值應該為 `true`。

`method` 應為一個標示 HTTP 請求方法的字串（例如：'HEAD'）。如果有提供值，則會被存在 `method` 屬性中且被 `get_method()` 所使用。當 `data` 是 `None` 時，其預設值為 'GET'，否則預設值為 'POST'。Subclasses 可以透過設置其 `method` 屬性來設定不一樣的預設請求方法。

備註： 如果資料物件無法重提供其內容（例如一個檔案或是只能產生一次內容的可代物件）且請求因 HTTP 重導向 (redirects) 或是 HTTP 驗證 (authentication) 而被重新嘗試傳送，則該請求不會正常運作。`data` 會接在 `headers` 之後被送至 HTTP 伺服器。此函式庫有支援 100-continue expectation。

在 3.3 版的變更：新增 `Request.method` 引數到 `Request` class。

在 3.4 版的變更：能在 class 中設置預設的 `Request.method`。

在 3.6 版的變更：如果 `Content-Length` 尚未被提供且 `data` 既不是 `None` 也不是一個位元組串物件，則不會觸發錯誤，會 fall back（後備）使用分塊傳輸編碼 (chunked transfer encoding)。

class urllib.request.OpenerDirector

The `OpenerDirector` class opens URLs via `BaseHandlers` chained together. It manages the chaining of handlers, and recovery from errors.

class urllib.request.BaseHandler

This is the base class for all registered handlers --- and handles only the simple mechanics of registration.

class urllib.request.HTTPDefaultErrorHandler

A class which defines a default handler for HTTP error responses; all responses are turned into `HTTPError` exceptions.

class urllib.request.HTTPRedirectHandler

A class to handle redirections.

class urllib.request.HTTPCookieProcessor (*cookiejar=None*)

A class to handle HTTP Cookies.

class urllib.request.ProxyHandler (*proxies=None*)

Cause requests to go through a proxy. If *proxies* is given, it must be a dictionary mapping protocol names to URLs of proxies. The default is to read the list of proxies from the environment variables `<protocol>_proxy`. If no proxy environment variables are set, then in a Windows environment proxy settings are obtained from the registry's Internet Settings section, and in a macOS environment proxy information is retrieved from the System Configuration Framework.

To disable autodetected proxy pass an empty dictionary.

The `no_proxy` environment variable can be used to specify hosts which shouldn't be reached via proxy; if set, it should be a comma-separated list of hostname suffixes, optionally with `:port` appended, for example `cern.ch, ncsa.uiuc.edu, some.host:8080`.

備 註: `HTTP_PROXY` will be ignored if a variable `REQUEST_METHOD` is set; see the documentation on [`getproxies\(\)`](#).

class `urllib.request.HTTPPasswordMgr`

Keep a database of (realm, uri) -> (user, password) mappings.

class `urllib.request.HTTPPasswordMgrWithDefaultRealm`

Keep a database of (realm, uri) -> (user, password) mappings. A realm of None is considered a catch-all realm, which is searched if no other realm fits.

class `urllib.request.HTTPPasswordMgrWithPriorAuth`

A variant of `HTTPPasswordMgrWithDefaultRealm` that also has a database of uri -> is_authenticated mappings. Can be used by a BasicAuth handler to determine when to send authentication credentials immediately instead of waiting for a 401 response first.

在 3.5 版新加入。

class `urllib.request.AbstractBasicAuthHandler` (*password_mgr=None*)

This is a mixin class that helps with HTTP authentication, both to the remote host and to a proxy. *password_mgr*, if given, should be something that is compatible with `HTTPPasswordMgr`; refer to section [HTTPPasswordMgr 物件](#) for information on the interface that must be supported. If *password_mgr* also provides `is_authenticated` and `update_authenticated` methods (see [HTTPPasswordMgrWithPriorAuth 物件](#)), then the handler will use the `is_authenticated` result for a given URI to determine whether or not to send authentication credentials with the request. If `is_authenticated` returns True for the URI, credentials are sent. If `is_authenticated` is False, credentials are not sent, and then if a 401 response is received the request is re-sent with the authentication credentials. If authentication succeeds, `update_authenticated` is called to set `is_authenticated` True for the URI, so that subsequent requests to the URI or any of its super-URIs will automatically include the authentication credentials.

在 3.5 版新加入: 新增 `is_authenticated` 的支援。

class `urllib.request.HTTPBasicAuthHandler` (*password_mgr=None*)

Handle authentication with the remote host. *password_mgr*, if given, should be something that is compatible with `HTTPPasswordMgr`; refer to section [HTTPPasswordMgr 物件](#) for information on the interface that must be supported. `HTTPBasicAuthHandler` will raise a `ValueError` when presented with a wrong Authentication scheme.

class `urllib.request.ProxyBasicAuthHandler` (*password_mgr=None*)

Handle authentication with the proxy. *password_mgr*, if given, should be something that is compatible with `HTTPPasswordMgr`; refer to section [HTTPPasswordMgr 物件](#) for information on the interface that must be supported.

class `urllib.request.AbstractDigestAuthHandler` (*password_mgr=None*)

This is a mixin class that helps with HTTP authentication, both to the remote host and to a proxy. *password_mgr*, if given, should be something that is compatible with `HTTPPasswordMgr`; refer to section [HTTPPasswordMgr 物件](#) for information on the interface that must be supported.

class `urllib.request.HTTPDigestAuthHandler` (*password_mgr=None*)

Handle authentication with the remote host. *password_mgr*, if given, should be something that is compatible with `HTTPPasswordMgr`; refer to section [HTTPPasswordMgr 物件](#) for information on the interface that must be supported. When both Digest Authentication Handler and Basic Authentication Handler are both added, Digest Authentication is always tried first. If the Digest Authentication returns a 40x response again, it is sent to Basic Authentication handler to Handle. This Handler method will raise a `ValueError` when presented with an authentication scheme other than Digest or Basic.

在 3.3 版的變更: Raise `ValueError` on unsupported Authentication Scheme.

class `urllib.request.ProxyDigestAuthHandler` (*password_mgr=None*)

Handle authentication with the proxy. *password_mgr*, if given, should be something that is compatible with

`HTTPPasswordMgr`; refer to section *HTTPPasswordMgr* 物件 for information on the interface that must be supported.

class `urllib.request.HTTPHandler`

A class to handle opening of HTTP URLs.

class `urllib.request.HTTPSHandler` (*debuglevel=0, context=None, check_hostname=None*)

A class to handle opening of HTTPS URLs. *context* and *check_hostname* have the same meaning as in *http.client.HTTPSConnection*.

在 3.2 版的變更: 新增 *context* 與 *check_hostname*。

class `urllib.request.FileHandler`

Open local files.

class `urllib.request.DataHandler`

Open data URLs.

在 3.4 版新加入。

class `urllib.request.FTPHandler`

Open FTP URLs.

class `urllib.request.CacheFTPHandler`

Open FTP URLs, keeping a cache of open FTP connections to minimize delays.

class `urllib.request.UnknownHandler`

A catch-all class to handle unknown URLs.

class `urllib.request.HTTPErrorProcessor`

Process HTTP error responses.

21.4.1 Request Objects

The following methods describe *Request*'s public interface, and so all may be overridden in subclasses. It also defines several public attributes that can be used by clients to inspect the parsed request.

`Request.full_url`

The original URL passed to the constructor.

在 3.4 版的變更。

`Request.full_url` is a property with setter, getter and a deleter. Getting *full_url* returns the original request URL with the fragment, if it was present.

`Request.type`

The URI scheme.

`Request.host`

The URI authority, typically a host, but may also contain a port separated by a colon.

`Request.origin_req_host`

The original host for the request, without port.

`Request.selector`

The URI path. If the *Request* uses a proxy, then selector will be the full URL that is passed to the proxy.

`Request.data`

The entity body for the request, or None if not specified.

在 3.4 版的變更: Changing value of *Request.data* now deletes "Content-Length" header if it was previously set or calculated.

`Request.unverifiable`

boolean, indicates whether the request is unverifiable as defined by [RFC 2965](#).

`Request.method`

The HTTP request method to use. By default its value is `None`, which means that `get_method()` will do its normal computation of the method to be used. Its value can be set (thus overriding the default computation in `get_method()`) either by providing a default value by setting it at the class level in a `Request` subclass, or by passing a value in to the `Request` constructor via the `method` argument.

在 3.3 版新加入.

在 3.4 版的變更: A default value can now be set in subclasses; previously it could only be set via the constructor argument.

`Request.get_method()`

Return a string indicating the HTTP request method. If `Request.method` is not `None`, return its value, otherwise return 'GET' if `Request.data` is `None`, or 'POST' if it's not. This is only meaningful for HTTP requests.

在 3.3 版的變更: `get_method` now looks at the value of `Request.method`.

`Request.add_header(key, val)`

Add another header to the request. Headers are currently ignored by all handlers except HTTP handlers, where they are added to the list of headers sent to the server. Note that there cannot be more than one header with the same name, and later calls will overwrite previous calls in case the `key` collides. Currently, this is no loss of HTTP functionality, since all headers which have meaning when used more than once have a (header-specific) way of gaining the same functionality using only one header. Note that headers added using this method are also added to redirected requests.

`Request.add_unredirected_header(key, header)`

Add a header that will not be added to a redirected request.

`Request.has_header(header)`

Return whether the instance has the named header (checks both regular and unredirected).

`Request.remove_header(header)`

Remove named header from the request instance (both from regular and unredirected headers).

在 3.4 版新加入.

`Request.get_full_url()`

Return the URL given in the constructor.

在 3.4 版的變更.

Returns `Request.full_url`

`Request.set_proxy(host, type)`

Prepare the request by connecting to a proxy server. The `host` and `type` will replace those of the instance, and the instance's selector will be the original URL given in the constructor.

`Request.get_header(header_name, default=None)`

Return the value of the given header. If the header is not present, return the default value.

`Request.header_items()`

Return a list of tuples (header_name, header_value) of the Request headers.

在 3.4 版的變更: The request methods `add_data`, `has_data`, `get_data`, `get_type`, `get_host`, `get_selector`, `get_origin_req_host` and `is_unverifiable` that were deprecated since 3.3 have been removed.

21.4.2 OpenerDirector 物件

OpenerDirector instances have the following methods:

`OpenerDirector.add_handler(handler)`

handler should be an instance of *BaseHandler*. The following methods are searched, and added to the possible chains (note that HTTP errors are a special case). Note that, in the following, *protocol* should be replaced with the actual protocol to handle, for example `http_response()` would be the HTTP protocol response handler. Also *type* should be replaced with the actual HTTP code, for example `http_error_404()` would handle HTTP 404 errors.

- `<protocol>_open()` --- signal that the handler knows how to open *protocol* URLs.
更多資訊請見 *BaseHandler.<protocol>_open()*。
- `http_error_<type>()` --- signal that the handler knows how to handle HTTP errors with HTTP error code *type*.
更多資訊請見 *BaseHandler.http_error_<nnn>()*。
- `<protocol>_error()` --- signal that the handler knows how to handle errors from (non-http) *protocol*.
- `<protocol>_request()` --- signal that the handler knows how to pre-process *protocol* requests.
更多資訊請見 *BaseHandler.<protocol>_request()*。
- `<protocol>_response()` --- signal that the handler knows how to post-process *protocol* responses.
更多資訊請見 *BaseHandler.<protocol>_response()*。

`OpenerDirector.open(url, data=None[, timeout])`

Open the given *url* (which can be a request object or a string), optionally passing the given *data*. Arguments, return values and exceptions raised are the same as those of *urlopen()* (which simply calls the *open()* method on the currently installed global *OpenerDirector*). The optional *timeout* parameter specifies a timeout in seconds for blocking operations like the connection attempt (if not specified, the global default timeout setting will be used). The timeout feature actually works only for HTTP, HTTPS and FTP connections.

`OpenerDirector.error(proto, *args)`

Handle an error of the given protocol. This will call the registered error handlers for the given protocol with the given arguments (which are protocol specific). The HTTP protocol is a special case which uses the HTTP response code to determine the specific error handler; refer to the `http_error_<type>()` methods of the handler classes.

Return values and exceptions raised are the same as those of *urlopen()*.

OpenerDirector objects open URLs in three stages:

The order in which these methods are called within each stage is determined by sorting the handler instances.

1. Every handler with a method named like `<protocol>_request()` has that method called to pre-process the request.
2. Handlers with a method named like `<protocol>_open()` are called to handle the request. This stage ends when a handler either returns a non-*None* value (ie. a response), or raises an exception (usually *URLError*). Exceptions are allowed to propagate.

In fact, the above algorithm is first tried for methods named *default_open()*. If all such methods return *None*, the algorithm is repeated for methods named like `<protocol>_open()`. If all such methods return *None*, the algorithm is repeated for methods named *unknown_open()*.

Note that the implementation of these methods may involve calls of the parent *OpenerDirector* instance's *open()* and *error()* methods.

3. Every handler with a method named like `<protocol>_response()` has that method called to post-process the response.

21.4.3 BaseHandler 物件

BaseHandler objects provide a couple of methods that are directly useful, and others that are meant to be used by derived classes. These are intended for direct use:

`BaseHandler.add_parent (director)`

Add a director as parent.

`BaseHandler.close ()`

Remove any parents.

The following attribute and methods should only be used by classes derived from *BaseHandler*.

備 F: The convention has been adopted that subclasses defining `<protocol>_request ()` or `<protocol>_response ()` methods are named **Processor*; all others are named **Handler*.

`BaseHandler.parent`

A valid *OpenerDirector*, which can be used to open using a different protocol, or handle errors.

`BaseHandler.default_open (req)`

This method is *not* defined in *BaseHandler*, but subclasses should define it if they want to catch all URLs.

This method, if implemented, will be called by the parent *OpenerDirector*. It should return a file-like object as described in the return value of the *open ()* method of *OpenerDirector*, or None. It should raise *URLError*, unless a truly exceptional thing happens (for example, *MemoryError* should not be mapped to *URLError*).

This method will be called before any protocol-specific open method.

`BaseHandler.<protocol>_open (req)`

This method is *not* defined in *BaseHandler*, but subclasses should define it if they want to handle URLs with the given protocol.

This method, if defined, will be called by the parent *OpenerDirector*. Return values should be the same as for *default_open ()*.

`BaseHandler.unknown_open (req)`

This method is *not* defined in *BaseHandler*, but subclasses should define it if they want to catch all URLs with no specific registered handler to open it.

This method, if implemented, will be called by the *parent OpenerDirector*. Return values should be the same as for *default_open ()*.

`BaseHandler.http_error_default (req, fp, code, msg, hdrs)`

This method is *not* defined in *BaseHandler*, but subclasses should override it if they intend to provide a catch-all for otherwise unhandled HTTP errors. It will be called automatically by the *OpenerDirector* getting the error, and should not normally be called in other circumstances.

req will be a *Request* object, *fp* will be a file-like object with the HTTP error body, *code* will be the three-digit code of the error, *msg* will be the user-visible explanation of the code and *hdrs* will be a mapping object with the headers of the error.

Return values and exceptions raised should be the same as those of *urlopen ()*.

`BaseHandler.http_error_<nnn> (req, fp, code, msg, hdrs)`

nnn should be a three-digit HTTP error code. This method is also not defined in *BaseHandler*, but will be called, if it exists, on an instance of a subclass, when an HTTP error with code *nnn* occurs.

Subclasses should override this method to handle specific HTTP errors.

Arguments, return values and exceptions raised should be the same as for *http_error_default ()*.

BaseHandler.<protocol>_request (req)

This method is *not* defined in *BaseHandler*, but subclasses should define it if they want to pre-process requests of the given protocol.

This method, if defined, will be called by the parent *OpenerDirector*. *req* will be a *Request* object. The return value should be a *Request* object.

BaseHandler.<protocol>_response (req, response)

This method is *not* defined in *BaseHandler*, but subclasses should define it if they want to post-process responses of the given protocol.

This method, if defined, will be called by the parent *OpenerDirector*. *req* will be a *Request* object. *response* will be an object implementing the same interface as the return value of *urlopen()*. The return value should implement the same interface as the return value of *urlopen()*.

21.4.4 HTTPRedirectHandler 物件

備註: Some HTTP redirections require action from this module's client code. If this is the case, *HTTPError* is raised. See [RFC 2616](#) for details of the precise meanings of the various redirection codes.

An *HTTPError* exception raised as a security consideration if the *HTTPRedirectHandler* is presented with a redirected URL which is not an HTTP, HTTPS or FTP URL.

HTTPRedirectHandler.redirect_request (req, fp, code, msg, hdrs, newurl)

Return a *Request* or None in response to a redirect. This is called by the default implementations of the *http_error_30**() methods when a redirection is received from the server. If a redirection should take place, return a new *Request* to allow *http_error_30**() to perform the redirect to *newurl*. Otherwise, raise *HTTPError* if no other handler should try to handle this URL, or return None if you can't but another handler might.

備註: The default implementation of this method does not strictly follow [RFC 2616](#), which says that 301 and 302 responses to POST requests must not be automatically redirected without confirmation by the user. In reality, browsers do allow automatic redirection of these responses, changing the POST to a GET, and the default implementation reproduces this behavior.

HTTPRedirectHandler.http_error_301 (req, fp, code, msg, hdrs)

Redirect to the Location: or URI: URL. This method is called by the parent *OpenerDirector* when getting an HTTP 'moved permanently' response.

HTTPRedirectHandler.http_error_302 (req, fp, code, msg, hdrs)

The same as *http_error_301()*, but called for the 'found' response.

HTTPRedirectHandler.http_error_303 (req, fp, code, msg, hdrs)

The same as *http_error_301()*, but called for the 'see other' response.

HTTPRedirectHandler.http_error_307 (req, fp, code, msg, hdrs)

The same as *http_error_301()*, but called for the 'temporary redirect' response. It does not allow changing the request method from POST to GET.

HTTPRedirectHandler.http_error_308 (req, fp, code, msg, hdrs)

The same as *http_error_301()*, but called for the 'permanent redirect' response. It does not allow changing the request method from POST to GET.

在 3.11 版新加入。

21.4.5 HTTPCookieProcessor 物件

HTTPCookieProcessor instances have one attribute:

`HTTPCookieProcessor.cookiejar`

The `http.cookiejar.CookieJar` in which cookies are stored.

21.4.6 ProxyHandler 物件

`ProxyHandler.<protocol>_open(request)`

The *ProxyHandler* will have a method `<protocol>_open()` for every *protocol* which has a proxy in the *proxies* dictionary given in the constructor. The method will modify requests to go through the proxy, by calling `request.set_proxy()`, and call the next handler in the chain to actually execute the protocol.

21.4.7 HTTPPasswordMgr 物件

These methods are available on *HTTPPasswordMgr* and *HTTPPasswordMgrWithDefaultRealm* objects.

`HTTPPasswordMgr.add_password(realm, uri, user, passwd)`

uri can be either a single URI, or a sequence of URIs. *realm*, *user* and *passwd* must be strings. This causes (*user*, *passwd*) to be used as authentication tokens when authentication for *realm* and a super-URI of any of the given URIs is given.

`HTTPPasswordMgr.find_user_password(realm, authuri)`

Get user/password for given realm and URI, if any. This method will return (*None*, *None*) if there is no matching user/password.

For *HTTPPasswordMgrWithDefaultRealm* objects, the realm *None* will be searched if the given *realm* has no matching user/password.

21.4.8 HTTPPasswordMgrWithPriorAuth 物件

This password manager extends *HTTPPasswordMgrWithDefaultRealm* to support tracking URIs for which authentication credentials should always be sent.

`HTTPPasswordMgrWithPriorAuth.add_password(realm, uri, user, passwd, is_authenticated=False)`

realm, *uri*, *user*, *passwd* are as for *HTTPPasswordMgr.add_password()*. *is_authenticated* sets the initial value of the *is_authenticated* flag for the given URI or list of URIs. If *is_authenticated* is specified as *True*, *realm* is ignored.

`HTTPPasswordMgrWithPriorAuth.find_user_password(realm, authuri)`

Same as for *HTTPPasswordMgrWithDefaultRealm* objects

`HTTPPasswordMgrWithPriorAuth.update_authenticated(self, uri, is_authenticated=False)`

Update the *is_authenticated* flag for the given *uri* or list of URIs.

`HTTPPasswordMgrWithPriorAuth.is_authenticated(self, authuri)`

Returns the current state of the *is_authenticated* flag for the given URI.

21.4.9 AbstractBasicAuthHandler 物件

`AbstractBasicAuthHandler.http_error_auth_reged` (*authreq*, *host*, *req*, *headers*)

Handle an authentication request by getting a user/password pair, and re-trying the request. *authreq* should be the name of the header where the information about the realm is included in the request, *host* specifies the URL and path to authenticate for, *req* should be the (failed) *Request* object, and *headers* should be the error headers.

host is either an authority (e.g. "python.org") or a URL containing an authority component (e.g. "http://python.org/"). In either case, the authority must not contain a userinfo component (so, "python.org" and "python.org:80" are fine, "joe:password@python.org" is not).

21.4.10 HTTPBasicAuthHandler 物件

`HTTPBasicAuthHandler.http_error_401` (*req*, *fp*, *code*, *msg*, *hdrs*)

Retry the request with authentication information, if available.

21.4.11 ProxyBasicAuthHandler 物件

`ProxyBasicAuthHandler.http_error_407` (*req*, *fp*, *code*, *msg*, *hdrs*)

Retry the request with authentication information, if available.

21.4.12 AbstractDigestAuthHandler 物件

`AbstractDigestAuthHandler.http_error_auth_reged` (*authreq*, *host*, *req*, *headers*)

authreq should be the name of the header where the information about the realm is included in the request, *host* should be the host to authenticate to, *req* should be the (failed) *Request* object, and *headers* should be the error headers.

21.4.13 HTTPDigestAuthHandler 物件

`HTTPDigestAuthHandler.http_error_401` (*req*, *fp*, *code*, *msg*, *hdrs*)

Retry the request with authentication information, if available.

21.4.14 ProxyDigestAuthHandler 物件

`ProxyDigestAuthHandler.http_error_407` (*req*, *fp*, *code*, *msg*, *hdrs*)

Retry the request with authentication information, if available.

21.4.15 HTTPHandler 物件

`HTTPHandler.http_open` (*req*)

Send an HTTP request, which can be either GET or POST, depending on `req.has_data()`.

21.4.16 HTTPSHandler 物件

`HTTPSHandler.https_open(req)`

Send an HTTPS request, which can be either GET or POST, depending on `req.has_data()`.

21.4.17 FileHandler 物件

`FileHandler.file_open(req)`

Open the file locally, if there is no host name, or the host name is `'localhost'`.

在 3.2 版的變更: This method is applicable only for local hostnames. When a remote hostname is given, an `URLError` is raised.

21.4.18 DataHandler 物件

`DataHandler.data_open(req)`

Read a data URL. This kind of URL contains the content encoded in the URL itself. The data URL syntax is specified in [RFC 2397](#). This implementation ignores white spaces in base64 encoded data URLs so the URL may be wrapped in whatever source file it comes from. But even though some browsers don't mind about a missing padding at the end of a base64 encoded data URL, this implementation will raise an `ValueError` in that case.

21.4.19 FTPHandler 物件

`FTPHandler.ftp_open(req)`

Open the FTP file indicated by `req`. The login is always done with empty username and password.

21.4.20 CacheFTPHandler 物件

`CacheFTPHandler` objects are `FTPHandler` objects with the following additional methods:

`CacheFTPHandler.setTimeout(t)`

Set timeout of connections to `t` seconds.

`CacheFTPHandler.setMaxConns(m)`

Set maximum number of cached connections to `m`.

21.4.21 UnknownHandler 物件

`UnknownHandler.unknown_open()`

Raise a `URLError` exception.

21.4.22 HTTPErrorProcessor 物件

`HTTPErrorProcessor.http_response(request, response)`

Process HTTP error responses.

For 200 error codes, the response object is returned immediately.

For non-200 error codes, this simply passes the job on to the `http_error_<type>()` handler methods, via `OpenerDirector.error()`. Eventually, `HTTPDefaultErrorHandler` will raise an `HTTPError` if no other handler handles the error.

`HTTPErrorProcessor.https_response(request, response)`

Process HTTPS error responses.

The behavior is same as `http_response()`.

21.4.23 Examples

In addition to the examples below, more examples are given in `urllib-howto`.

This example gets the `python.org` main page and displays the first 300 bytes of it.

```
>>> import urllib.request
>>> with urllib.request.urlopen('http://www.python.org/') as f:
...     print(f.read(300))
...
b'<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">\n\n<html
xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en">\n\n<head>\n
<meta http-equiv="content-type" content="text/html; charset=utf-8" />\n
<title>Python Programming '
```

Note that `urlopen` returns a bytes object. This is because there is no way for `urlopen` to automatically determine the encoding of the byte stream it receives from the HTTP server. In general, a program will decode the returned bytes object to string once it determines or guesses the appropriate encoding.

The following W3C document, <https://www.w3.org/International/O-charset>, lists the various ways in which an (X)HTML or an XML document could have specified its encoding information.

As the `python.org` website uses `utf-8` encoding as specified in its meta tag, we will use the same for decoding the bytes object.

```
>>> with urllib.request.urlopen('http://www.python.org/') as f:
...     print(f.read(100).decode('utf-8'))
...
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml
```

It is also possible to achieve the same result without using the *context manager* approach.

```
>>> import urllib.request
>>> f = urllib.request.urlopen('http://www.python.org/')
>>> print(f.read(100).decode('utf-8'))
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml
```

In the following example, we are sending a data-stream to the `stdin` of a CGI and reading the data it returns to us. Note that this example will only work when the Python installation supports SSL.

```
>>> import urllib.request
>>> req = urllib.request.Request(url='https://localhost/cgi-bin/test.cgi',
...                               data=b'This data is passed to stdin of the CGI')
```

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```
>>> with urllib.request.urlopen(req) as f:
...     print(f.read().decode('utf-8'))
...
Got Data: "This data is passed to stdin of the CGI"
```

The code for the sample CGI used in the above example is:

```
#!/usr/bin/env python
import sys
data = sys.stdin.read()
print('Content-type: text/plain\n\nGot Data: "%s"' % data)
```

Here is an example of doing a PUT request using *Request*:

```
import urllib.request
DATA = b'some data'
req = urllib.request.Request(url='http://localhost:8080', data=DATA, method='PUT')
with urllib.request.urlopen(req) as f:
    pass
print(f.status)
print(f.reason)
```

Use of Basic HTTP Authentication:

```
import urllib.request
# Create an OpenerDirector with support for Basic HTTP Authentication...
auth_handler = urllib.request.HTTPBasicAuthHandler()
auth_handler.add_password(realm='PDQ Application',
                        uri='https://mahler:8092/site-updates.py',
                        user='klem',
                        passwd='kadidd!ehopper')
opener = urllib.request.build_opener(auth_handler)
# ...and install it globally so it can be used with urlopen.
urllib.request.install_opener(opener)
urllib.request.urlopen('http://www.example.com/login.html')
```

build_opener() provides many handlers by default, including a *ProxyHandler*. By default, *ProxyHandler* uses the environment variables named `<scheme>_proxy`, where `<scheme>` is the URL scheme involved. For example, the `http_proxy` environment variable is read to obtain the HTTP proxy's URL.

This example replaces the default *ProxyHandler* with one that uses programmatically supplied proxy URLs, and adds proxy authorization support with *ProxyBasicAuthHandler*.

```
proxy_handler = urllib.request.ProxyHandler({'http': 'http://www.example.com:3128/
↪'})
proxy_auth_handler = urllib.request.ProxyBasicAuthHandler()
proxy_auth_handler.add_password('realm', 'host', 'username', 'password')

opener = urllib.request.build_opener(proxy_handler, proxy_auth_handler)
# This time, rather than install the OpenerDirector, we use it directly:
opener.open('http://www.example.com/login.html')
```

Adding HTTP headers:

Use the *headers* argument to the *Request* constructor, or:

```
import urllib.request
req = urllib.request.Request('http://www.example.com/')
req.add_header('Referer', 'http://www.python.org/')
# Customize the default User-Agent header value:
req.add_header('User-Agent', 'urllib-example/0.1 (Contact: . . .)')
r = urllib.request.urlopen(req)
```

`OpenerDirector` automatically adds a *User-Agent* header to every *Request*. To change this:

```
import urllib.request
opener = urllib.request.build_opener()
opener.addheaders = [('User-agent', 'Mozilla/5.0')]
opener.open('http://www.example.com/')
```

Also, remember that a few standard headers (*Content-Length*, *Content-Type* and *Host*) are added when the *Request* is passed to `urlopen()` (or `OpenerDirector.open()`).

Here is an example session that uses the GET method to retrieve a URL containing parameters:

```
>>> import urllib.request
>>> import urllib.parse
>>> params = urllib.parse.urlencode({'spam': 1, 'eggs': 2, 'bacon': 0})
>>> url = "http://www.musi-cal.com/cgi-bin/query?%s" % params
>>> with urllib.request.urlopen(url) as f:
...     print(f.read().decode('utf-8'))
... 
```

The following example uses the POST method instead. Note that params output from `urlencode` is encoded to bytes before it is sent to `urlopen` as data:

```
>>> import urllib.request
>>> import urllib.parse
>>> data = urllib.parse.urlencode({'spam': 1, 'eggs': 2, 'bacon': 0})
>>> data = data.encode('ascii')
>>> with urllib.request.urlopen("http://requestb.in/xrb182xr", data) as f:
...     print(f.read().decode('utf-8'))
... 
```

The following example uses an explicitly specified HTTP proxy, overriding environment settings:

```
>>> import urllib.request
>>> proxies = {'http': 'http://proxy.example.com:8080/'}
>>> opener = urllib.request.FancyURLopener(proxies)
>>> with opener.open("http://www.python.org") as f:
...     f.read().decode('utf-8')
... 
```

The following example uses no proxies at all, overriding environment settings:

```
>>> import urllib.request
>>> opener = urllib.request.FancyURLopener({})
>>> with opener.open("http://www.python.org/") as f:
...     f.read().decode('utf-8')
... 
```

21.4.24 Legacy interface

The following functions and classes are ported from the Python 2 module `urllib` (as opposed to `urllib2`). They might become deprecated at some point in the future.

`urllib.request.urlretrieve(url, filename=None, reporthook=None, data=None)`

Copy a network object denoted by a URL to a local file. If the URL points to a local file, the object will not be copied unless `filename` is supplied. Return a tuple (`filename`, `headers`) where `filename` is the local file name under which the object can be found, and `headers` is whatever the `info()` method of the object returned by `urlopen()` returned (for a remote object). Exceptions are the same as for `urlopen()`.

The second argument, if present, specifies the file location to copy to (if absent, the location will be a tempfile with a generated name). The third argument, if present, is a callable that will be called once on establishment of

the network connection and once after each block read thereafter. The callable will be passed three arguments; a count of blocks transferred so far, a block size in bytes, and the total size of the file. The third argument may be `-1` on older FTP servers which do not return a file size in response to a retrieval request.

The following example illustrates the most common usage scenario:

```
>>> import urllib.request
>>> local_filename, headers = urllib.request.urlretrieve('http://python.org/')
>>> html = open(local_filename)
>>> html.close()
```

If the *url* uses the `http:` scheme identifier, the optional *data* argument may be given to specify a POST request (normally the request type is GET). The *data* argument must be a bytes object in standard *application/x-www-form-urlencoded* format; see the `urllib.parse.urlencode()` function.

`urlretrieve()` will raise `ContentTooShortError` when it detects that the amount of data available was less than the expected amount (which is the size reported by a *Content-Length* header). This can occur, for example, when the download is interrupted.

The *Content-Length* is treated as a lower bound: if there's more data to read, `urlretrieve` reads more data, but if less data is available, it raises the exception.

You can still retrieve the downloaded data in this case, it is stored in the `content` attribute of the exception instance.

If no *Content-Length* header was supplied, `urlretrieve` can not check the size of the data it has downloaded, and just returns it. In this case you just have to assume that the download was successful.

`urllib.request.urlcleanup()`

Cleans up temporary files that may have been left behind by previous calls to `urlretrieve()`.

class `urllib.request.URLOpener` (*proxies=None, **x509*)

在 3.3 版之後被 F 用。

Base class for opening and reading URLs. Unless you need to support opening objects using schemes other than `http:`, `ftp:`, or `file:`, you probably want to use `FancyURLOpener`.

By default, the `URLOpener` class sends a *User-Agent* header of `urllib/VVV`, where *VVV* is the `urllib` version number. Applications can define their own *User-Agent* header by subclassing `URLOpener` or `FancyURLOpener` and setting the class attribute *version* to an appropriate string value in the subclass definition.

The optional *proxies* parameter should be a dictionary mapping scheme names to proxy URLs, where an empty dictionary turns proxies off completely. Its default value is `None`, in which case environmental proxy settings will be used if present, as discussed in the definition of `urlopen()`, above.

Additional keyword parameters, collected in *x509*, may be used for authentication of the client when using the `https:` scheme. The keywords *key_file* and *cert_file* are supported to provide an SSL key and certificate; both are needed to support client authentication.

`URLOpener` objects will raise an `OSError` exception if the server returns an error code.

open (*fullurl*, *data=None*)

Open *fullurl* using the appropriate protocol. This method sets up cache and proxy information, then calls the appropriate open method with its input arguments. If the scheme is not recognized, `open_unknown()` is called. The *data* argument has the same meaning as the *data* argument of `urlopen()`.

This method always quotes *fullurl* using `quote()`.

open_unknown (*fullurl*, *data=None*)

Overridable interface to open unknown URL types.

retrieve (*url*, *filename=None*, *reporthook=None*, *data=None*)

Retrieves the contents of *url* and places it in *filename*. The return value is a tuple consisting of a local filename and either an `email.message.Message` object containing the response headers (for remote URLs) or `None` (for local URLs). The caller must then open and read the contents of *filename*. If *filename* is not given and the URL refers to a local file, the input filename is returned. If the URL is non-local and *filename* is not given, the filename is the output of `tempfile.mktemp()` with a suffix that matches the suffix of the last path component of the input URL. If *reporthook* is given, it must be a function accepting three numeric parameters: A chunk number, the maximum size chunks are read in and the total size of the download (-1 if unknown). It will be called once at the start and after each chunk of data is read from the network. *reporthook* is ignored for local URLs.

If the *url* uses the `http:` scheme identifier, the optional *data* argument may be given to specify a POST request (normally the request type is GET). The *data* argument must in standard `application/x-www-form-urlencoded` format; see the `urllib.parse.urlencode()` function.

version

Variable that specifies the user agent of the opener object. To get `urllib` to tell servers that it is a particular user agent, set this in a subclass as a class variable or in the constructor before calling the base constructor.

class `urllib.request.FancyURLopener` (...)

在 3.3 版之後被用。

`FancyURLopener` subclasses `URLopener` providing default handling for the following HTTP response codes: 301, 302, 303, 307 and 401. For the 30x response codes listed above, the `Location` header is used to fetch the actual URL. For 401 response codes (authentication required), basic HTTP authentication is performed. For the 30x response codes, recursion is bounded by the value of the `maxtries` attribute, which defaults to 10.

For all other response codes, the method `http_error_default()` is called which you can override in subclasses to handle the error appropriately.

備註: According to the letter of [RFC 2616](#), 301 and 302 responses to POST requests must not be automatically redirected without confirmation by the user. In reality, browsers do allow automatic redirection of these responses, changing the POST to a GET, and `urllib` reproduces this behaviour.

The parameters to the constructor are the same as those for `URLopener`.

備註: When performing basic authentication, a `FancyURLopener` instance calls its `prompt_user_passwd()` method. The default implementation asks the users for the required information on the controlling terminal. A subclass may override this method to support more appropriate behavior if needed.

The `FancyURLopener` class offers one additional method that should be overloaded to provide the appropriate behavior:

prompt_user_passwd (*host*, *realm*)

Return information needed to authenticate the user at the given host in the specified security realm. The return value should be a tuple, (`user`, `password`), which can be used for basic authentication.

The implementation prompts for this information on the terminal; an application should override this method to use an appropriate interaction model in the local environment.

21.4.25 urllib.request Restrictions

- Currently, only the following protocols are supported: HTTP (versions 0.9 and 1.0), FTP, local files, and data URLs.

在 3.4 版的變更: Added support for data URLs.

- The caching feature of `urlretrieve()` has been disabled until someone finds the time to hack proper processing of Expiration time headers.
- There should be a function to query whether a particular URL is in the cache.
- For backward compatibility, if a URL appears to point to a local file but the file can't be opened, the URL is re-interpreted using the FTP protocol. This can sometimes cause confusing error messages.
- The `urlopen()` and `urlretrieve()` functions can cause arbitrarily long delays while waiting for a network connection to be set up. This means that it is difficult to build an interactive web client using these functions without using threads.
- The data returned by `urlopen()` or `urlretrieve()` is the raw data returned by the server. This may be binary data (such as an image), plain text or (for example) HTML. The HTTP protocol provides type information in the reply header, which can be inspected by looking at the *Content-Type* header. If the returned data is HTML, you can use the module `html.parser` to parse it.
- The code handling the FTP protocol cannot differentiate between a file and a directory. This can lead to unexpected behavior when attempting to read a URL that points to a file that is not accessible. If the URL ends in a `/`, it is assumed to refer to a directory and will be handled accordingly. But if an attempt to read a file leads to a 550 error (meaning the URL cannot be found or is not accessible, often for permission reasons), then the path is treated as a directory in order to handle the case when a directory is specified by a URL but the trailing `/` has been left off. This can cause misleading results when you try to fetch a file whose read permissions make it inaccessible; the FTP code will try to read it, fail with a 550 error, and then perform a directory listing for the unreadable file. If fine-grained control is needed, consider using the `ftplib` module, subclassing `FancyURLopener`, or changing `_urlopener` to meet your needs.

21.5 urllib.response --- Response classes used by urllib

The `urllib.response` module defines functions and classes which define a minimal file-like interface, including `read()` and `readline()`. Functions defined by this module are used internally by the `urllib.request` module. The typical response object is a `urllib.response.addinfourl` instance:

class `urllib.response.addinfourl`

url

URL of the resource retrieved, commonly used to determine if a redirect was followed.

headers

Returns the headers of the response in the form of an `EmailMessage` instance.

status

在 3.9 版新加入.

Status code returned by server.

geturl()

在 3.9 版之後被 用: Deprecated in favor of `url`.

info()

在 3.9 版之後被 用: Deprecated in favor of `headers`.

code

在 3.9 版之後被 用: Deprecated in favor of `status`.

`getcode()`

在 3.9 版之後被`弃用`: Deprecated in favor of `status`.

21.6 urllib.parse --- Parse URLs into components

原始碼: [Lib/urllib/parse.py](#)

This module defines a standard interface to break Uniform Resource Locator (URL) strings up in components (addressing scheme, network location, path etc.), to combine the components back into a URL string, and to convert a “relative URL” to an absolute URL given a “base URL.”

The module has been designed to match the internet RFC on Relative Uniform Resource Locators. It supports the following URL schemes: file, ftp, gopher, hdl, http, https, imap, mailto, mms, news, nntp, prospero, rsync, rtsp, rtsp, rtspu, sftp, shhttp, sip, sips, snews, svn, svn+ssh, telnet, wais, ws, wss.

The `urllib.parse` module defines functions that fall into two broad categories: URL parsing and URL quoting. These are covered in detail in the following sections.

21.6.1 URL Parsing

The URL parsing functions focus on splitting a URL string into its components, or on combining URL components into a URL string.

`urllib.parse.urlparse(urlstring, scheme='', allow_fragments=True)`

Parse a URL into six components, returning a 6-item *named tuple*. This corresponds to the general structure of a URL: `scheme://netloc/path;parameters?query#fragment`. Each tuple item is a string, possibly empty. The components are not broken up into smaller parts (for example, the network location is a single string), and `%` escapes are not expanded. The delimiters as shown above are not part of the result, except for a leading slash in the *path* component, which is retained if present. For example:

```
>>> from urllib.parse import urlparse
>>> urlparse("scheme://netloc/path;parameters?query#fragment")
ParseResult(scheme='scheme', netloc='netloc', path='/path;parameters', params='
→',
            query='query', fragment='fragment')
>>> o = urlparse("http://docs.python.org:80/3/library/urllib.parse.html?"
...             "highlight=params#url-parsing")
>>> o
ParseResult(scheme='http', netloc='docs.python.org:80',
            path='/3/library/urllib.parse.html', params='',
            query='highlight=params', fragment='url-parsing')
>>> o.scheme
'http'
>>> o.netloc
'docs.python.org:80'
>>> o.hostname
'docs.python.org'
>>> o.port
80
>>> o._replace(fragment="").geturl()
'http://docs.python.org:80/3/library/urllib.parse.html?highlight=params'
```

Following the syntax specifications in [RFC 1808](#), `urlparse` recognizes a netloc only if it is properly introduced by `'//'`. Otherwise the input is presumed to be a relative URL and thus to start with a path component.


```
>>> from urllib.parse import urlparse
>>> urlparse('://www.cwi.nl:80/%7Eguido/Python.html')
ParseResult(scheme='', netloc='www.cwi.nl:80', path='/%7Eguido/Python.html',
            params='', query='', fragment='')
>>> urlparse('www.cwi.nl/%7Eguido/Python.html')
ParseResult(scheme='', netloc='', path='www.cwi.nl/%7Eguido/Python.html',
            params='', query='', fragment='')
>>> urlparse('help/Python.html')
ParseResult(scheme='', netloc='', path='help/Python.html', params='',
            query='', fragment='')
```

The *scheme* argument gives the default addressing scheme, to be used only if the URL does not specify one. It should be the same type (text or bytes) as *urlstring*, except that the default value '' is always allowed, and is automatically converted to b'' if appropriate.

If the *allow_fragments* argument is false, fragment identifiers are not recognized. Instead, they are parsed as part of the path, parameters or query component, and *fragment* is set to the empty string in the return value.

The return value is a *named tuple*, which means that its items can be accessed by index or as named attributes, which are:

屬性	Index	Value	Value if not present
scheme	0	URL scheme specifier	<i>scheme</i> parameter
netloc	1	Network location part	empty string
path	2	Hierarchical path	empty string
params	3	Parameters for last path element	empty string
query	4	Query component	empty string
fragment	5	Fragment identifier	empty string
username		User name	<i>None</i>
password		Password	<i>None</i>
hostname		Host name (lower case)	<i>None</i>
port		Port number as integer, if present	<i>None</i>

Reading the *port* attribute will raise a *ValueError* if an invalid port is specified in the URL. See section *Structured Parse Results* for more information on the result object.

Unmatched square brackets in the *netloc* attribute will raise a *ValueError*.

Characters in the *netloc* attribute that decompose under NFKC normalization (as used by the IDNA encoding) into any of /, ?, #, @, or : will raise a *ValueError*. If the URL is decomposed before parsing, no error will be raised.

As is the case with all named tuples, the subclass has a few additional methods and attributes that are particularly useful. One such method is *_replace()*. The *_replace()* method will return a new *ParseResult* object replacing specified fields with new values.

```
>>> from urllib.parse import urlparse
>>> u = urlparse('://www.cwi.nl:80/%7Eguido/Python.html')
>>> u
ParseResult(scheme='', netloc='www.cwi.nl:80', path='/%7Eguido/Python.html',
            params='', query='', fragment='')
>>> u._replace(scheme='http')
ParseResult(scheme='http', netloc='www.cwi.nl:80', path='/%7Eguido/Python.html',
            params='', query='', fragment='')
```

警告: *urlparse()* does not perform validation. See *URL parsing security* for details.

在 3.2 版的變更: Added IPv6 URL parsing capabilities.

在 3.3 版的變更: The fragment is now parsed for all URL schemes (unless *allow_fragment* is false), in accordance with [RFC 3986](#). Previously, an allowlist of schemes that support fragments existed.

在 3.6 版的變更: Out-of-range port numbers now raise *ValueError*, instead of returning *None*.

在 3.8 版的變更: Characters that affect netloc parsing under NFKC normalization will now raise *ValueError*.

```
urllib.parse.parse_qs(qs, keep_blank_values=False, strict_parsing=False, encoding='utf-8',
                      errors='replace', max_num_fields=None, separator='&')
```

Parse a query string given as a string argument (data of type *application/x-www-form-urlencoded*). Data are returned as a dictionary. The dictionary keys are the unique query variable names and the values are lists of values for each name.

The optional argument *keep_blank_values* is a flag indicating whether blank values in percent-encoded queries should be treated as blank strings. A true value indicates that blanks should be retained as blank strings. The default false value indicates that blank values are to be ignored and treated as if they were not included.

The optional argument *strict_parsing* is a flag indicating what to do with parsing errors. If false (the default), errors are silently ignored. If true, errors raise a *ValueError* exception.

The optional *encoding* and *errors* parameters specify how to decode percent-encoded sequences into Unicode characters, as accepted by the *bytes.decode()* method.

The optional argument *max_num_fields* is the maximum number of fields to read. If set, then throws a *ValueError* if there are more than *max_num_fields* fields read.

The optional argument *separator* is the symbol to use for separating the query arguments. It defaults to *&*.

Use the *urllib.parse.urlencode()* function (with the *doseq* parameter set to True) to convert such dictionaries into query strings.

在 3.2 版的變更: Add *encoding* and *errors* parameters.

在 3.8 版的變更: 新增 *max_num_fields* 參數。

在 3.10 版的變更: Added *separator* parameter with the default value of *&*. Python versions earlier than Python 3.10 allowed using both *;* and *&* as query parameter separator. This has been changed to allow only a single separator key, with *&* as the default separator.

```
urllib.parse.parse_qsl(qs, keep_blank_values=False, strict_parsing=False, encoding='utf-8',
                      errors='replace', max_num_fields=None, separator='&')
```

Parse a query string given as a string argument (data of type *application/x-www-form-urlencoded*). Data are returned as a list of name, value pairs.

The optional argument *keep_blank_values* is a flag indicating whether blank values in percent-encoded queries should be treated as blank strings. A true value indicates that blanks should be retained as blank strings. The default false value indicates that blank values are to be ignored and treated as if they were not included.

The optional argument *strict_parsing* is a flag indicating what to do with parsing errors. If false (the default), errors are silently ignored. If true, errors raise a *ValueError* exception.

The optional *encoding* and *errors* parameters specify how to decode percent-encoded sequences into Unicode characters, as accepted by the *bytes.decode()* method.

The optional argument *max_num_fields* is the maximum number of fields to read. If set, then throws a *ValueError* if there are more than *max_num_fields* fields read.

The optional argument *separator* is the symbol to use for separating the query arguments. It defaults to *&*.

Use the *urllib.parse.urlencode()* function to convert such lists of pairs into query strings.

在 3.2 版的變更: Add *encoding* and *errors* parameters.

在 3.8 版的變更: 新增 *max_num_fields* 參數。

在 3.10 版的變更: Added *separator* parameter with the default value of *&*. Python versions earlier than Python 3.10 allowed using both *;* and *&* as query parameter separator. This has been changed to allow only a single separator key, with *&* as the default separator.

`urllib.parse.urlunparse (parts)`

Construct a URL from a tuple as returned by `urlparse()`. The *parts* argument can be any six-item iterable. This may result in a slightly different, but equivalent URL, if the URL that was parsed originally had unnecessary delimiters (for example, a `?` with an empty query; the RFC states that these are equivalent).

`urllib.parse.urlsplit (urlstring, scheme="", allow_fragments=True)`

This is similar to `urlparse()`, but does not split the params from the URL. This should generally be used instead of `urlparse()` if the more recent URL syntax allowing parameters to be applied to each segment of the *path* portion of the URL (see [RFC 2396](#)) is wanted. A separate function is needed to separate the path segments and parameters. This function returns a 5-item *named tuple*:

(addressing scheme, network location, path, query, fragment identifier).

The return value is a *named tuple*, its items can be accessed by index or as named attributes:

屬性	Index	Value	Value if not present
scheme	0	URL scheme specifier	<i>scheme</i> parameter
netloc	1	Network location part	empty string
path	2	Hierarchical path	empty string
query	3	Query component	empty string
fragment	4	Fragment identifier	empty string
username		User name	<i>None</i>
password		Password	<i>None</i>
hostname		Host name (lower case)	<i>None</i>
port		Port number as integer, if present	<i>None</i>

Reading the `port` attribute will raise a *ValueError* if an invalid port is specified in the URL. See section *Structured Parse Results* for more information on the result object.

Unmatched square brackets in the `netloc` attribute will raise a *ValueError*.

Characters in the `netloc` attribute that decompose under NFKC normalization (as used by the IDNA encoding) into any of `/`, `?`, `#`, `@`, or `:` will raise a *ValueError*. If the URL is decomposed before parsing, no error will be raised.

Following some of the [WHATWG spec](#) that updates RFC 3986, leading C0 control and space characters are stripped from the URL. `\n`, `\r` and tab `\t` characters are removed from the URL at any position.

警告: `urlsplit()` does not perform validation. See [URL parsing security](#) for details.

在 3.6 版的變更: Out-of-range port numbers now raise *ValueError*, instead of returning *None*.

在 3.8 版的變更: Characters that affect `netloc` parsing under NFKC normalization will now raise *ValueError*.

在 3.10 版的變更: ASCII newline and tab characters are stripped from the URL.

在 3.11.4 版的變更: Leading WHATWG C0 control and space characters are stripped from the URL.

`urllib.parse.urlunsplit (parts)`

Combine the elements of a tuple as returned by `urlsplit()` into a complete URL as a string. The *parts* argument can be any five-item iterable. This may result in a slightly different, but equivalent URL, if the URL that was parsed originally had unnecessary delimiters (for example, a `?` with an empty query; the RFC states that these are equivalent).

`urllib.parse.urljoin (base, url, allow_fragments=True)`

Construct a full ("absolute") URL by combining a "base URL" (*base*) with another URL (*url*). Informally, this uses components of the base URL, in particular the addressing scheme, the network location and (part of) the path, to provide missing components in the relative URL. For example:

```
>>> from urllib.parse import urljoin
>>> urljoin('http://www.cwi.nl/%7Eguido/Python.html', 'FAQ.html')
'http://www.cwi.nl/%7Eguido/FAQ.html'
```

The `allow_fragments` argument has the same meaning and default as for `urlparse()`.

備 備: If `url` is an absolute URL (that is, it starts with `//` or `scheme://`), the `url`'s hostname and/or scheme will be present in the result. For example:

```
>>> urljoin('http://www.cwi.nl/%7Eguido/Python.html',
...         '//www.python.org/%7Eguido')
'http://www.python.org/%7Eguido'
```

If you do not want that behavior, preprocess the `url` with `urlsplit()` and `urlunsplit()`, removing possible `scheme` and `netloc` parts.

在 3.5 版的變更: Behavior updated to match the semantics defined in **RFC 3986**.

`urllib.parse.urldefrag(url)`

If `url` contains a fragment identifier, return a modified version of `url` with no fragment identifier, and the fragment identifier as a separate string. If there is no fragment identifier in `url`, return `url` unmodified and an empty string.

The return value is a *named tuple*, its items can be accessed by index or as named attributes:

屬性	Index	Value	Value if not present
<code>url</code>	0	URL with no fragment	empty string
<code>fragment</code>	1	Fragment identifier	empty string

See section *Structured Parse Results* for more information on the result object.

在 3.2 版的變更: Result is a structured object rather than a simple 2-tuple.

`urllib.parse.unwrap(url)`

Extract the `url` from a wrapped URL (that is, a string formatted as `<URL:scheme://host/path>`, `<scheme://host/path>`, `URL:scheme://host/path` or `scheme://host/path`). If `url` is not a wrapped URL, it is returned without changes.

21.6.2 URL parsing security

The `urlsplit()` and `urlparse()` APIs do not perform **validation** of inputs. They may not raise errors on inputs that other applications consider invalid. They may also succeed on some inputs that might not be considered URLs elsewhere. Their purpose is for practical functionality rather than purity.

Instead of raising an exception on unusual input, they may instead return some component parts as empty strings. Or components may contain more than perhaps they should.

We recommend that users of these APIs where the values may be used anywhere with security implications code defensively. Do some verification within your code before trusting a returned component part. Does that `scheme` make sense? Is that a sensible `path`? Is there anything strange about that `hostname`? etc.

What constitutes a URL is not universally well defined. Different applications have different needs and desired constraints. For instance the living **WHATWG spec** describes what user facing web clients such as a web browser require. While **RFC 3986** is more general. These functions incorporate some aspects of both, but cannot be claimed compliant with either. The APIs and existing user code with expectations on specific behaviors predate both standards leading us to be very cautious about making API behavior changes.

21.6.3 Parsing ASCII Encoded Bytes

The URL parsing functions were originally designed to operate on character strings only. In practice, it is useful to be able to manipulate properly quoted and encoded URLs as sequences of ASCII bytes. Accordingly, the URL parsing functions in this module all operate on *bytes* and *bytearray* objects in addition to *str* objects.

If *str* data is passed in, the result will also contain only *str* data. If *bytes* or *bytearray* data is passed in, the result will contain only *bytes* data.

Attempting to mix *str* data with *bytes* or *bytearray* in a single function call will result in a *TypeError* being raised, while attempting to pass in non-ASCII byte values will trigger *UnicodeDecodeError*.

To support easier conversion of result objects between *str* and *bytes*, all return values from URL parsing functions provide either an `encode()` method (when the result contains *str* data) or a `decode()` method (when the result contains *bytes* data). The signatures of these methods match those of the corresponding *str* and *bytes* methods (except that the default encoding is 'ascii' rather than 'utf-8'). Each produces a value of a corresponding type that contains either *bytes* data (for `encode()` methods) or *str* data (for `decode()` methods).

Applications that need to operate on potentially improperly quoted URLs that may contain non-ASCII data will need to do their own decoding from bytes to characters before invoking the URL parsing methods.

The behaviour described in this section applies only to the URL parsing functions. The URL quoting functions use their own rules when producing or consuming byte sequences as detailed in the documentation of the individual URL quoting functions.

在 3.2 版的變更: URL parsing functions now accept ASCII encoded byte sequences

21.6.4 Structured Parse Results

The result objects from the `urlparse()`, `urlsplit()` and `urldefrag()` functions are subclasses of the *tuple* type. These subclasses add the attributes listed in the documentation for those functions, the encoding and decoding support described in the previous section, as well as an additional method:

`urllib.parse.SplitResult.geturl()`

Return the re-combined version of the original URL as a string. This may differ from the original URL in that the scheme may be normalized to lower case and empty components may be dropped. Specifically, empty parameters, queries, and fragment identifiers will be removed.

For `urldefrag()` results, only empty fragment identifiers will be removed. For `urlsplit()` and `urlparse()` results, all noted changes will be made to the URL returned by this method.

The result of this method remains unchanged if passed back through the original parsing function:

```
>>> from urllib.parse import urlsplit
>>> url = 'HTTP://www.Python.org/doc/#'
>>> r1 = urlsplit(url)
>>> r1.geturl()
'http://www.Python.org/doc/'
>>> r2 = urlsplit(r1.geturl())
>>> r2.geturl()
'http://www.Python.org/doc/'
```

The following classes provide the implementations of the structured parse results when operating on *str* objects:

class `urllib.parse.DefragResult` (*url*, *fragment*)

Concrete class for `urldefrag()` results containing *str* data. The `encode()` method returns a *DefragResultBytes* instance.

在 3.2 版新加入.

class `urllib.parse.ParseResult` (*scheme*, *netloc*, *path*, *params*, *query*, *fragment*)

Concrete class for `urlparse()` results containing *str* data. The `encode()` method returns a *ParseResultBytes* instance.

class `urllib.parse.SplitResult` (*scheme, netloc, path, query, fragment*)

Concrete class for `urlsplit()` results containing *str* data. The `encode()` method returns a `SplitResultBytes` instance.

The following classes provide the implementations of the parse results when operating on *bytes* or *bytearray* objects:

class `urllib.parse.DefragResultBytes` (*url, fragment*)

Concrete class for `urldefrag()` results containing *bytes* data. The `decode()` method returns a `DefragResult` instance.

在 3.2 版新加入。

class `urllib.parse.ParseResultBytes` (*scheme, netloc, path, params, query, fragment*)

Concrete class for `urlparse()` results containing *bytes* data. The `decode()` method returns a `ParseResult` instance.

在 3.2 版新加入。

class `urllib.parse.SplitResultBytes` (*scheme, netloc, path, query, fragment*)

Concrete class for `urlsplit()` results containing *bytes* data. The `decode()` method returns a `SplitResult` instance.

在 3.2 版新加入。

21.6.5 URL Quoting

The URL quoting functions focus on taking program data and making it safe for use as URL components by quoting special characters and appropriately encoding non-ASCII text. They also support reversing these operations to recreate the original data from the contents of a URL component if that task isn't already covered by the URL parsing functions above.

`urllib.parse.quote` (*string, safe='/', encoding=None, errors=None*)

Replace special characters in *string* using the `%xx` escape. Letters, digits, and the characters `'_.-~'` are never quoted. By default, this function is intended for quoting the path section of a URL. The optional *safe* parameter specifies additional ASCII characters that should not be quoted --- its default value is `'/'`.

string may be either a *str* or a *bytes* object.

在 3.7 版的變更: Moved from **RFC 2396** to **RFC 3986** for quoting URL strings. `"~"` is now included in the set of unreserved characters.

The optional *encoding* and *errors* parameters specify how to deal with non-ASCII characters, as accepted by the `str.encode()` method. *encoding* defaults to `'utf-8'`. *errors* defaults to `'strict'`, meaning unsupported characters raise a `UnicodeEncodeError`. *encoding* and *errors* must not be supplied if *string* is a *bytes*, or a `TypeError` is raised.

Note that `quote(string, safe, encoding, errors)` is equivalent to `quote_from_bytes(string.encode(encoding, errors), safe)`.

Example: `quote('/El Niño/')` yields `'/El%20Ni%C3%B1o/'`.

`urllib.parse.quote_plus` (*string, safe='+', encoding=None, errors=None*)

Like `quote()`, but also replace spaces with plus signs, as required for quoting HTML form values when building up a query string to go into a URL. Plus signs in the original string are escaped unless they are included in *safe*. It also does not have *safe* default to `'/'`.

Example: `quote_plus('/El Niño/')` yields `'%2FEl+Ni%C3%B1o%2F'`.

`urllib.parse.quote_from_bytes` (*bytes, safe='/'*)

Like `quote()`, but accepts a *bytes* object rather than a *str*, and does not perform string-to-bytes encoding.

Example: `quote_from_bytes(b'a&\xef')` yields `'a%26EF'`.

`urllib.parse.unquote(string, encoding='utf-8', errors='replace')`

Replace `%xx` escapes with their single-character equivalent. The optional *encoding* and *errors* parameters specify how to decode percent-encoded sequences into Unicode characters, as accepted by the `bytes.decode()` method.

string may be either a *str* or a *bytes* object.

encoding defaults to `'utf-8'`. *errors* defaults to `'replace'`, meaning invalid sequences are replaced by a placeholder character.

Example: `unquote('/El%20Ni%C3%B1o/')` yields `'/El Niño/'`.

在 3.9 版的變更: *string* parameter supports bytes and str objects (previously only str).

`urllib.parse.unquote_plus(string, encoding='utf-8', errors='replace')`

Like `unquote()`, but also replace plus signs with spaces, as required for unquoting HTML form values.

string must be a *str*.

Example: `unquote_plus('/El+Ni%C3%B1o/')` yields `'/El Niño/'`.

`urllib.parse.unquote_to_bytes(string)`

Replace `%xx` escapes with their single-octet equivalent, and return a *bytes* object.

string may be either a *str* or a *bytes* object.

If it is a *str*, unescaped non-ASCII characters in *string* are encoded into UTF-8 bytes.

Example: `unquote_to_bytes('a%26%EF')` yields `b'a&\xef'`.

`urllib.parse.urlencode(query, doseq=False, safe="", encoding=None, errors=None, quote_via=quote_plus)`

Convert a mapping object or a sequence of two-element tuples, which may contain *str* or *bytes* objects, to a percent-encoded ASCII text string. If the resultant string is to be used as a *data* for POST operation with the `urlopen()` function, then it should be encoded to bytes, otherwise it would result in a *TypeError*.

The resulting string is a series of *key=value* pairs separated by `'&'` characters, where both *key* and *value* are quoted using the *quote_via* function. By default, `quote_plus()` is used to quote the values, which means spaces are quoted as a `'+'` character and `'/'` characters are encoded as `%2F`, which follows the standard for GET requests (`application/x-www-form-urlencoded`). An alternate function that can be passed as *quote_via* is `quote()`, which will encode spaces as `%20` and not encode `'/'` characters. For maximum control of what is quoted, use `quote` and specify a value for *safe*.

When a sequence of two-element tuples is used as the *query* argument, the first element of each tuple is a key and the second is a value. The value element in itself can be a sequence and in that case, if the optional parameter *doseq* evaluates to `True`, individual *key=value* pairs separated by `'&'` are generated for each element of the value sequence for the key. The order of parameters in the encoded string will match the order of parameter tuples in the sequence.

The *safe*, *encoding*, and *errors* parameters are passed down to *quote_via* (the *encoding* and *errors* parameters are only passed when a query element is a *str*).

To reverse this encoding process, `parse_qs()` and `parse_qsl()` are provided in this module to parse query strings into Python data structures.

Refer to *urllib examples* to find out how the `urllib.parse.urlencode()` method can be used for generating the query string of a URL or data for a POST request.

在 3.2 版的變更: *query* supports bytes and string objects.

在 3.5 版的變更: Added the *quote_via* parameter.

也參考:

WHATWG - URL Living standard

Working Group for the URL Standard that defines URLs, domains, IP addresses, the `application/x-www-form-urlencoded` format, and their API.

RFC 3986 - Uniform Resource Identifiers

This is the current standard (STD66). Any changes to `urllib.parse` module should conform to this. Certain deviations could be observed, which are mostly for backward compatibility purposes and for certain de-facto parsing requirements as commonly observed in major browsers.

RFC 2732 - Format for Literal IPv6 Addresses in URL's.

This specifies the parsing requirements of IPv6 URLs.

RFC 2396 - Uniform Resource Identifiers (URI): Generic Syntax

Document describing the generic syntactic requirements for both Uniform Resource Names (URNs) and Uniform Resource Locators (URLs).

RFC 2368 - The mailto URL scheme.

Parsing requirements for mailto URL schemes.

RFC 1808 - 相對的統一資源定位器 (Relative Uniform Resource Locators)

This Request For Comments includes the rules for joining an absolute and a relative URL, including a fair number of "Abnormal Examples" which govern the treatment of border cases.

RFC 1738 - 統一資源定位器 (URL, Uniform Resource Locators)

This specifies the formal syntax and semantics of absolute URLs.

21.7 urllib.error --- urllib.request 引發的例外類 F

原始碼: [Lib/urllib/error.py](#)

`urllib.error` module (模組) F `urllib.request` 所引發的例外定義了例外 (exception) 類 F。基礎例外類 F 是 `URLError`。

下列例外會被 `urllib.error` 適時引發:

exception urllib.error.URLError

處理程式 (handler) 在遇到問題時會引發此例外 (或其衍生例外)。它是 `OSError` 的一個子類 F。

reason

此錯誤的原因。它可以是一個訊息字串或另一個例外實例。

在 3.3 版的變更: `URLError` used to be a subtype of `IOError`, which is now an alias of `OSError`.

exception urllib.error.HTTPError

雖然是一個例外 (`URLError` 的一個子類 F), `HTTPError` 也可以作 F 一個非例外的類檔案回傳值 (與 `urlopen()` 所回傳的物件相同)。這適用於處理特殊 HTTP 錯誤, 例如 F 請求認證。

code

一個 HTTP 狀態碼, 具體定義見 **RFC 2616**。這個數值會對應到存放在 `http.server.BaseHTTPRequestHandler.responses` 程式碼 dictionary 中的某個值。

reason

這通常是一個解釋本次錯誤原因的字串。

headers

導致 `HTTPError` 的特定 HTTP 請求的 HTTP 回應 header。

在 3.4 版新加入。

exception urllib.error.ContentTooShortError (msg, content)

This exception is raised when the `urlretrieve()` function detects that the amount of the downloaded data is less than the expected amount (given by the *Content-Length* header).

content

The downloaded (and supposedly truncated) data.

21.8 urllib.robotparser --- robots.txt 的剖析器

原始碼: [Lib/urllib/robotparser.py](https://github.com/python/cpython/blob/main/Lib/urllib/robotparser.py)

此模組 (module) 提供了一個單獨的類 (class) `RobotFileParser`，它可以知道某個特定 user agent (使用者代理) 是否能在有發布 robots.txt 文件的網站 fetch (取得) 特定 URL。有關 robots.txt 文件結構的更多細節，請參 <http://www.robotstxt.org/orig.html>。

class `urllib.robotparser.RobotFileParser(url=)`

此類提供了一些方法可以讀取、剖析和回答關於 url 上的 robots.txt 文件的問題。

set_url(url)

設置指向 robots.txt 文件的 URL。

read()

讀取 robots.txt URL 將其輸入到剖析器。

parse(lines)

剖析 lines 引數。

can_fetch(useragent, url)

根據從 robots.txt 文件中剖析出的規則，如果 useragent 被允許 fetch url 的話，則回傳 True。

mtime()

回傳最近一次 fetch robots.txt 文件的時間。這適用於需要定期檢查 robots.txt 文件更新情況的長時間運行網頁爬蟲。

modified()

將最近一次 fetch robots.txt 文件的時間設置為當前時間。

crawl_delay(useragent)

針對指定的 useragent 從 robots.txt 回傳 Crawl-delay 參數的值。如果此參數不存在、不適用於指定的 useragent，或是此參數在 robots.txt 中所指的條目含有無效語法，則回傳 None。

在 3.6 版新加入。

request_rate(useragent)

以 `named tuple` `RequestRate(requests, seconds)` 的形式從 robots.txt 回傳 Request-rate 參數的內容。如果此參數不存在、不適用於指定的 useragent，或是此參數在 robots.txt 中所指的條目含有無效語法，則回傳 None。

在 3.6 版新加入。

site_maps()

以 `list()` 的形式從 robots.txt 回傳 Sitemap 參數的內容。如果此參數不存在或此參數在 robots.txt 中所指的條目含有無效語法，則回傳 None。

在 3.8 版新加入。

下面的範例展示了 `RobotFileParser` 類的基本用法：

```
>>> import urllib.robotparser
>>> rp = urllib.robotparser.RobotFileParser()
>>> rp.set_url("http://www.musi-cal.com/robots.txt")
>>> rp.read()
>>> rrate = rp.request_rate("*")
>>> rrate.requests
3
>>> rrate.seconds
20
```

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(繼續上一頁)

```
>>> rp.crawl_delay("")
6
>>> rp.can_fetch("", "http://www.musi-cal.com/cgi-bin/search?city=San+Francisco")
False
>>> rp.can_fetch("", "http://www.musi-cal.com/")
True
```

21.9 http --- HTTP 模組

原始碼: [Lib/http/__init__.py](#)

`http` 是一個收集了多個用於處理超文本傳輸協定 (HyperText Transfer Protocol) 之模組 (module) 的套件:

- `http.client` 是一個低階的 HTTP 協定客戶端; 對於高階的 URL 訪問請使用 `urllib.request`
- `http.server` 包含基於 `socketserver` 的基本 HTTP 伺服器類
- `http.cookies` 包含通過 cookies 實作狀態管理的工具程式 (utilities)
- `http.cookiejar` 提供了 cookies 的持續留存 (persistence)

The `http` module also defines the following enums that help you work with http related code:

class `http.HTTPStatus`

在 3.5 版新加入.

`enum.IntEnum` 的子類, 它定義了一組 HTTP 狀態碼、原理短語 (reason phrase) 以及英文長描述。

用法:

```
>>> from http import HTTPStatus
>>> HTTPStatus.OK
HTTPStatus.OK
>>> HTTPStatus.OK == 200
True
>>> HTTPStatus.OK.value
200
>>> HTTPStatus.OK.phrase
'OK'
>>> HTTPStatus.OK.description
'Request fulfilled, document follows'
>>> list(HTTPStatus)
[HTTPStatus.CONTINUE, HTTPStatus.SWITCHING_PROTOCOLS, ...]
```

21.9.1 HTTP 狀態碼

`http.HTTPStatus` 當中, 已支援且有於 IANA 的狀態碼有:

狀態碼	列舉名徵	詳情
100	CONTINUE	HTTP/1.1 RFC 7231 , 6.2.1 節
101	SWITCHING_PROTOCOLS	HTTP/1.1 RFC 7231 , 6.2.2 節
102	PROCESSING	WebDAV RFC 2518 , 10.1 節
103	EARLY_HINTS	用於指定提示 (Indicating Hints) RFC 8297 的 HTTP 狀態碼
200	OK	HTTP/1.1 RFC 7231 , 6.3.1 節
201	CREATED	HTTP/1.1 RFC 7231 , 6.3.2 節

表格 1 – 繼續上一頁

狀態碼	列舉名徵	詳情
202	ACCEPTED	HTTP/1.1 RFC 7231 , 6.3.3 節
203	NON_AUTHORITATIVE_INFORMATION	HTTP/1.1 RFC 7231 , 6.3.4 節
204	NO_CONTENT	HTTP/1.1 RFC 7231 , 6.3.5 節
205	RESET_CONTENT	HTTP/1.1 RFC 7231 , 6.3.6 節
206	PARTIAL_CONTENT	HTTP/1.1 RFC 7233 , 4.1 節
207	MULTI_STATUS	WebDAV RFC 4918 , 11.1 節
208	ALREADY_REPORTED	WebDAV RFC 4918 結擴充 (Binding Extensions) RFC 5842 , 7.1 節 (實驗性)
226	IM_USED	HTTP 中的差分編碼 RFC 3229 , 10.4.1 節
300	MULTIPLE_CHOICES	HTTP/1.1 RFC 7231 , 6.4.1 節
301	MOVED_PERMANENTLY	HTTP/1.1 RFC 7231 , 6.4.2 節
302	FOUND	HTTP/1.1 RFC 7231 , 6.4.3 節
303	SEE_OTHER	HTTP/1.1 RFC 7231 , 6.4.4 節
304	NOT_MODIFIED	HTTP/1.1 RFC 7232 , 4.1 節
305	USE_PROXY	HTTP/1.1 RFC 7231 , 6.4.5 節
307	TEMPORARY_REDIRECT	HTTP/1.1 RFC 7231 , 6.4.7 節
308	PERMANENT_REDIRECT	永久重定向 RFC 7238 , 3 節 (實驗性)
400	BAD_REQUEST	HTTP/1.1 RFC 7231 , 6.5.1 節
401	UNAUTHORIZED	HTTP/1.1 身分驗證 (Authentication) RFC 7235 , 3.1 節
402	PAYMENT_REQUIRED	HTTP/1.1 RFC 7231 , 6.5.2 節
403	FORBIDDEN	HTTP/1.1 RFC 7231 , 6.5.3 節
404	NOT_FOUND	HTTP/1.1 RFC 7231 , 6.5.4 節
405	METHOD_NOT_ALLOWED	HTTP/1.1 RFC 7231 , 6.5.5 節
406	NOT_ACCEPTABLE	HTTP/1.1 RFC 7231 , 6.5.6 節
407	PROXY_AUTHENTICATION_REQUIRED	HTTP/1.1 身分驗證 RFC 7235 , 3.2 節
408	REQUEST_TIMEOUT	HTTP/1.1 RFC 7231 , 6.5.7 節
409	CONFLICT	HTTP/1.1 RFC 7231 , 6.5.8 節
410	GONE	HTTP/1.1 RFC 7231 , 6.5.9 節
411	LENGTH_REQUIRED	HTTP/1.1 RFC 7231 , 6.5.10 節
412	PRECONDITION_FAILED	HTTP/1.1 RFC 7232 , 4.2 節
413	REQUEST_ENTITY_TOO_LARGE	HTTP/1.1 RFC 7231 , 6.5.11 節
414	REQUEST_URI_TOO_LONG	HTTP/1.1 RFC 7231 , 6.5.12 節
415	UNSUPPORTED_MEDIA_TYPE	HTTP/1.1 RFC 7231 , 6.5.13 節
416	REQUESTED_RANGE_NOT_SATISFIABLE	HTTP/1.1 範圍請求 (Range Requests) RFC 7233 , 4.4 節
417	EXPECTATION_FAILED	HTTP/1.1 RFC 7231 , 6.5.14 節
418	IM_A_TEAPOT	HTCPCP/1.0 RFC 2324 , Section 2.3.2
421	MISDIRECTED_REQUEST	HTTP/2 RFC 7540 , 9.1.2 節
422	UNPROCESSABLE_ENTITY	WebDAV RFC 4918 , 11.2 節
423	LOCKED	WebDAV RFC 4918 , 11.3 節
424	FAILED_DEPENDENCY	WebDAV RFC 4918 , 11.4 節
425	TOO_EARLY	使用 HTTP 中的早期資料 RFC 8470
426	UPGRADE_REQUIRED	HTTP/1.1 RFC 7231 , 6.5.15 節
428	PRECONDITION_REQUIRED	額外的 HTTP 狀態碼 RFC 6585
429	TOO_MANY_REQUESTS	額外的 HTTP 狀態碼 RFC 6585
431	REQUEST_HEADER_FIELDS_TOO_LARGE	額外的 HTTP 狀態碼 RFC 6585
451	UNAVAILABLE_FOR_LEGAL_REASONS	一個用來回報合法性障礙 (Legal Obstacles) 的 HTTP 狀態碼 RFC 8538
500	INTERNAL_SERVER_ERROR	HTTP/1.1 RFC 7231 , 6.6.1 節
501	NOT_IMPLEMENTED	HTTP/1.1 RFC 7231 , 6.6.2 節
502	BAD_GATEWAY	HTTP/1.1 RFC 7231 , 6.6.3 節
503	SERVICE_UNAVAILABLE	HTTP/1.1 RFC 7231 , 6.6.4 節
504	GATEWAY_TIMEOUT	HTTP/1.1 RFC 7231 , 6.6.5 節
505	HTTP_VERSION_NOT_SUPPORTED	HTTP/1.1 RFC 7231 , 6.6.6 節
506	VARIANT_ALSO_NEGOTIATES	HTTP 中的透明內容協商 (Transparent Content Negotiation) RFC 2295
507	INSUFFICIENT_STORAGE	WebDAV RFC 4918 , 11.5 節
508	LOOP_DETECTED	WebDAV RFC 4918 結擴充 RFC 5842 , 7.2 節 (實驗性)
510	NOT_EXTENDED	一個 HTTP 擴充框架 RFC 2774 , 7 節 (實驗性)

表格 1 – 繼續上一頁

狀態碼	列舉名徵	詳情
511	NETWORK_AUTHENTICATION_REQUIRED	額外的 HTTP 狀態碼 RFC 6585 , 6 節

為了向後相容性，列舉值也以常數形式出現在 `http.client` 模組中。列舉名稱等於常數名稱（例如 `http.HTTPStatus.OK` 也可以是 `http.client.OK`）。

在 3.7 版的變更：新增 421 `MISDIRECTED_REQUEST` 狀態碼。

在 3.8 版新加入：新增 451 `UNAVAILABLE_FOR_LEGAL_REASONS` 狀態碼。

在 3.9 版新加入：新增 103 `EARLY_HINTS`、418 `IM_A_TEAPOT` 與 425 `TOO_EARLY` 狀態碼。

class `http.HTTPMethod`

在 3.11 版新加入。

`enum.StrEnum` 的子類，它定義了一組 HTTP 方法以及英文描述。

用法：

```
>>> from http import HTTPMethod
>>>
>>> HTTPMethod.GET
<HTTPMethod.GET>
>>> HTTPMethod.GET == 'GET'
True
>>> HTTPMethod.GET.value
'GET'
>>> HTTPMethod.GET.description
'Retrieve the target.'
>>> list(HTTPMethod)
[<HTTPMethod.CONNECT>,
 <HTTPMethod.DELETE>,
 <HTTPMethod.GET>,
 <HTTPMethod.HEAD>,
 <HTTPMethod.OPTIONS>,
 <HTTPMethod.PATCH>,
 <HTTPMethod.POST>,
 <HTTPMethod.PUT>,
 <HTTPMethod.TRACE>]
```

21.9.2 HTTP 方法

`http.HTTPStatus` 當中，已支援且有於 IANA 的狀態碼有：

方法	列舉名徵	詳情
GET	GET	HTTP/1.1 RFC 7231 , 4.3.1 節
HEAD	HEAD	HTTP/1.1 RFC 7231 , 4.3.2 節
POST	POST	HTTP/1.1 RFC 7231 , 4.3.3 節
PUT	PUT	HTTP/1.1 RFC 7231 , 4.3.4 節
DELETE	DELETE	HTTP/1.1 RFC 7231 , 6.3.5 節
CONNECT	CONNECT	HTTP/1.1 RFC 7231 , 4.3.6 節
OPTIONS	OPTIONS	HTTP/1.1 RFC 7231 , 4.3.7 節
TRACE	TRACE	HTTP/1.1 RFC 7231 , 4.3.8 節
PATCH	PATCH	HTTP/1.1 RFC 5789

21.10 `http.client` --- HTTP protocol client

原始碼: [Lib/http/client.py](#)

This module defines classes that implement the client side of the HTTP and HTTPS protocols. It is normally not used directly --- the module `urllib.request` uses it to handle URLs that use HTTP and HTTPS.

也參考:

The [Requests package](#) is recommended for a higher-level HTTP client interface.

備註: HTTPS support is only available if Python was compiled with SSL support (through the `ssl` module).

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

The module provides the following classes:

```
class http.client.HTTPConnection(host, port=None, [timeout, ]source_address=None,
                                blocksize=8192)
```

An `HTTPConnection` instance represents one transaction with an HTTP server. It should be instantiated by passing it a host and optional port number. If no port number is passed, the port is extracted from the host string if it has the form `host:port`, else the default HTTP port (80) is used. If the optional `timeout` parameter is given, blocking operations (like connection attempts) will timeout after that many seconds (if it is not given, the global default timeout setting is used). The optional `source_address` parameter may be a tuple of a (host, port) to use as the source address the HTTP connection is made from. The optional `blocksize` parameter sets the buffer size in bytes for sending a file-like message body.

For example, the following calls all create instances that connect to the server at the same host and port:

```
>>> h1 = http.client.HTTPConnection('www.python.org')
>>> h2 = http.client.HTTPConnection('www.python.org:80')
>>> h3 = http.client.HTTPConnection('www.python.org', 80)
>>> h4 = http.client.HTTPConnection('www.python.org', 80, timeout=10)
```

在 3.2 版的變更: 新增 `source_address`。

在 3.4 版的變更: The `strict` parameter was removed. HTTP 0.9-style "Simple Responses" are no longer supported.

在 3.7 版的變更: 新增 `blocksize` 參數。

```
class http.client.HTTPSConnection(host, port=None, key_file=None, cert_file=None, [timeout,
    ]source_address=None, *, context=None,
    check_hostname=None, blocksize=8192)
```

A subclass of `HTTPConnection` that uses SSL for communication with secure servers. Default port is 443. If `context` is specified, it must be a `ssl.SSLContext` instance describing the various SSL options.

Please read [Security considerations](#) for more information on best practices.

在 3.2 版的變更: 新增 `source_address`、`context` 與 `check_hostname`。

在 3.2 版的變更: This class now supports HTTPS virtual hosts if possible (that is, if `ssl.HAS_SNI` is true).

在 3.4 版的變更: The `strict` parameter was removed. HTTP 0.9-style "Simple Responses" are no longer supported.

在 3.4.3 版的變更: This class now performs all the necessary certificate and hostname checks by default. To revert to the previous, unverified, behavior `ssl._create_unverified_context()` can be passed to the `context` parameter.

在 3.8 版的變更: This class now enables TLS 1.3 `ssl.SSLContext.post_handshake_auth` for the default `context` or when `cert_file` is passed with a custom `context`.

在 3.10 版的變更: This class now sends an ALPN extension with protocol indicator `http/1.1` when no `context` is given. Custom `context` should set ALPN protocols with `set_alpn_protocols()`.

在 3.6 版之後被 用: `key_file` and `cert_file` are deprecated in favor of `context`. Please use `ssl.SSLContext.load_cert_chain()` instead, or let `ssl.create_default_context()` select the system's trusted CA certificates for you.

The `check_hostname` parameter is also deprecated; the `ssl.SSLContext.check_hostname` attribute of `context` should be used instead.

class `http.client.HTTPResponse` (*sock, debuglevel=0, method=None, url=None*)

Class whose instances are returned upon successful connection. Not instantiated directly by user.

在 3.4 版的變更: The `strict` parameter was removed. HTTP 0.9 style "Simple Responses" are no longer supported.

This module provides the following function:

`http.client.parse_headers(fp)`

Parse the headers from a file pointer *fp* representing a HTTP request/response. The file has to be a `BufferedIOBase` reader (i.e. not text) and must provide a valid **RFC 2822** style header.

This function returns an instance of `http.client.HTTPMessage` that holds the header fields, but no payload (the same as `HTTPResponse.msg` and `http.server.BaseHTTPRequestHandler.headers`). After returning, the file pointer *fp* is ready to read the HTTP body.

備 注: `parse_headers()` does not parse the start-line of a HTTP message; it only parses the `Name: value` lines. The file has to be ready to read these field lines, so the first line should already be consumed before calling the function.

The following exceptions are raised as appropriate:

exception `http.client.HTTPException`

The base class of the other exceptions in this module. It is a subclass of `Exception`.

exception `http.client.NotConnected`

A subclass of `HTTPException`.

exception `http.client.InvalidURL`

A subclass of `HTTPException`, raised if a port is given and is either non-numeric or empty.

exception `http.client.UnknownProtocol`

A subclass of `HTTPException`.

exception `http.client.UnknownTransferEncoding`

A subclass of `HTTPException`.

exception `http.client.UnimplementedFileMode`

A subclass of `HTTPException`.

exception `http.client.IncompleteRead`

A subclass of `HTTPException`.

exception `http.client.ImproperConnectionState`

A subclass of `HTTPException`.

exception `http.client.CannotSendRequest`

A subclass of `ImproperConnectionState`.

exception `http.client.CannotSendHeader`

A subclass of *ImproperConnectionState*.

exception `http.client.ResponseNotReady`

A subclass of *ImproperConnectionState*.

exception `http.client.BadStatusLine`

A subclass of *HTTPException*. Raised if a server responds with a HTTP status code that we don't understand.

exception `http.client.LineTooLong`

A subclass of *HTTPException*. Raised if an excessively long line is received in the HTTP protocol from the server.

exception `http.client.RemoteDisconnected`

A subclass of *ConnectionResetError* and *BadStatusLine*. Raised by *HTTPConnection.getresponse()* when the attempt to read the response results in no data read from the connection, indicating that the remote end has closed the connection.

在 3.5 版新加入: Previously, *BadStatusLine*(' ') was raised.

The constants defined in this module are:

`http.client.HTTP_PORT`

The default port for the HTTP protocol (always 80).

`http.client.HTTPS_PORT`

The default port for the HTTPS protocol (always 443).

`http.client.responses`

This dictionary maps the HTTP 1.1 status codes to the W3C names.

Example: `http.client.responses[http.client.NOT_FOUND]` is 'Not Found'.

See *HTTP 狀態碼* for a list of HTTP status codes that are available in this module as constants.

21.10.1 HTTPConnection 物件

HTTPConnection instances have the following methods:

HTTPConnection.request (*method*, *url*, *body=None*, *headers={}*, **, encode_chunked=False*)

This will send a request to the server using the HTTP request method *method* and the request URI *url*. The provided *url* must be an absolute path to conform with **RFC 2616 §5.1.2** (unless connecting to an HTTP proxy server or using the `OPTIONS` or `CONNECT` methods).

If *body* is specified, the specified data is sent after the headers are finished. It may be a *str*, a *bytes-like object*, an open *file object*, or an iterable of *bytes*. If *body* is a string, it is encoded as ISO-8859-1, the default for HTTP. If it is a bytes-like object, the bytes are sent as is. If it is a *file object*, the contents of the file is sent; this file object should support at least the `read()` method. If the file object is an instance of *io.TextIOBase*, the data returned by the `read()` method will be encoded as ISO-8859-1, otherwise the data returned by `read()` is sent as is. If *body* is an iterable, the elements of the iterable are sent as is until the iterable is exhausted.

The *headers* argument should be a mapping of extra HTTP headers to send with the request. A **Host header** must be provided to conform with **RFC 2616 §5.1.2** (unless connecting to an HTTP proxy server or using the `OPTIONS` or `CONNECT` methods).

If *headers* contains neither Content-Length nor Transfer-Encoding, but there is a request body, one of those header fields will be added automatically. If *body* is `None`, the Content-Length header is set to 0 for methods that expect a body (`PUT`, `POST`, and `PATCH`). If *body* is a string or a bytes-like object that is not also a *file*, the Content-Length header is set to its length. Any other type of *body* (files and iterables in general) will be chunk-encoded, and the Transfer-Encoding header will automatically be set instead of Content-Length.

The `encode_chunked` argument is only relevant if Transfer-Encoding is specified in *headers*. If `encode_chunked` is `False`, the `HTTPConnection` object assumes that all encoding is handled by the calling code. If it is `True`, the body will be chunk-encoded.

For example, to perform a GET request to `https://docs.python.org/3/`:

```
>>> import http.client
>>> host = "docs.python.org"
>>> conn = http.client.HTTPSConnection(host)
>>> conn.request("GET", "/3/", headers={"Host": host})
>>> response = conn.getresponse()
>>> print(response.status, response.reason)
200 OK
```

備F: Chunked transfer encoding has been added to the HTTP protocol version 1.1. Unless the HTTP server is known to handle HTTP 1.1, the caller must either specify the Content-Length, or must pass a *str* or bytes-like object that is not also a file as the body representation.

在 3.2 版的變更: *body* can now be an iterable.

在 3.6 版的變更: If neither Content-Length nor Transfer-Encoding are set in *headers*, file and iterable *body* objects are now chunk-encoded. The `encode_chunked` argument was added. No attempt is made to determine the Content-Length for file objects.

`HTTPConnection.getresponse()`

Should be called after a request is sent to get the response from the server. Returns an *HTTPResponse* instance.

備F: Note that you must have read the whole response before you can send a new request to the server.

在 3.5 版的變更: If a *ConnectionError* or subclass is raised, the *HTTPConnection* object will be ready to reconnect when a new request is sent.

`HTTPConnection.set_debuglevel(level)`

Set the debugging level. The default debug level is 0, meaning no debugging output is printed. Any value greater than 0 will cause all currently defined debug output to be printed to stdout. The `debuglevel` is passed to any new *HTTPResponse* objects that are created.

在 3.1 版新加入.

`HTTPConnection.set_tunnel(host, port=None, headers=None)`

Set the host and the port for HTTP Connect Tunnelling. This allows running the connection through a proxy server.

The host and port arguments specify the endpoint of the tunneled connection (i.e. the address included in the CONNECT request, *not* the address of the proxy server).

The headers argument should be a mapping of extra HTTP headers to send with the CONNECT request.

For example, to tunnel through a HTTPS proxy server running locally on port 8080, we would pass the address of the proxy to the *HTTPSConnection* constructor, and the address of the host that we eventually want to reach to the `set_tunnel()` method:

```
>>> import http.client
>>> conn = http.client.HTTPSConnection("localhost", 8080)
>>> conn.set_tunnel("www.python.org")
>>> conn.request("HEAD", "/index.html")
```

在 3.2 版新加入.

`HTTPConnection.connect()`

Connect to the server specified when the object was created. By default, this is called automatically when making a request if the client does not already have a connection.

引發一個附帶引數 `self`、`host`、`port` 的稽核事件 `http.client.connect`。

`HTTPConnection.close()`

Close the connection to the server.

`HTTPConnection.blocksize`

Buffer size in bytes for sending a file-like message body.

在 3.7 版新加入。

As an alternative to using the `request()` method described above, you can also send your request step by step, by using the four functions below.

`HTTPConnection.putrequest(method, url, skip_host=False, skip_accept_encoding=False)`

This should be the first call after the connection to the server has been made. It sends a line to the server consisting of the *method* string, the *url* string, and the HTTP version (HTTP/1.1). To disable automatic sending of `Host:` or `Accept-Encoding:` headers (for example to accept additional content encodings), specify *skip_host* or *skip_accept_encoding* with non-False values.

`HTTPConnection.putheader(header, argument[, ...])`

Send an **RFC 822**-style header to the server. It sends a line to the server consisting of the header, a colon and a space, and the first argument. If more arguments are given, continuation lines are sent, each consisting of a tab and an argument.

`HTTPConnection.endheaders(message_body=None, *, encode_chunked=False)`

Send a blank line to the server, signalling the end of the headers. The optional *message_body* argument can be used to pass a message body associated with the request.

If *encode_chunked* is `True`, the result of each iteration of *message_body* will be chunk-encoded as specified in **RFC 7230**, Section 3.3.1. How the data is encoded is dependent on the type of *message_body*. If *message_body* implements the buffer interface the encoding will result in a single chunk. If *message_body* is a `collections.abc.Iterable`, each iteration of *message_body* will result in a chunk. If *message_body* is a *file object*, each call to `.read()` will result in a chunk. The method automatically signals the end of the chunk-encoded data immediately after *message_body*.

備[Ⓔ]: Due to the chunked encoding specification, empty chunks yielded by an iterator body will be ignored by the chunk-encoder. This is to avoid premature termination of the read of the request by the target server due to malformed encoding.

在 3.6 版的變更: Added chunked encoding support and the *encode_chunked* parameter.

`HTTPConnection.send(data)`

Send data to the server. This should be used directly only after the `endheaders()` method has been called and before `getresponse()` is called.

引發一個附帶引數 `self`、`data` 的稽核事件 `http.client.send`。

21.10.2 HTTPResponse 物件

An *HTTPResponse* instance wraps the HTTP response from the server. It provides access to the request headers and the entity body. The response is an iterable object and can be used in a with statement.

在 3.5 版的變更: The *io.BufferedIOBase* interface is now implemented and all of its reader operations are supported.

`HTTPResponse.read([amt])`

Reads and returns the response body, or up to the next *amt* bytes.

`HTTPResponse.readinto(b)`

Reads up to the next len(*b*) bytes of the response body into the buffer *b*. Returns the number of bytes read.

在 3.3 版新加入.

`HTTPResponse.getheader(name, default=None)`

Return the value of the header *name*, or *default* if there is no header matching *name*. If there is more than one header with the name *name*, return all of the values joined by ','. If *default* is any iterable other than a single string, its elements are similarly returned joined by commas.

`HTTPResponse.getheaders()`

Return a list of (header, value) tuples.

`HTTPResponse.fileno()`

Return the fileno of the underlying socket.

`HTTPResponse.msg`

A *http.client.HTTPMessage* instance containing the response headers. *http.client.HTTPMessage* is a subclass of *email.message.Message*.

`HTTPResponse.version`

HTTP protocol version used by server. 10 for HTTP/1.0, 11 for HTTP/1.1.

`HTTPResponse.url`

URL of the resource retrieved, commonly used to determine if a redirect was followed.

`HTTPResponse.headers`

Headers of the response in the form of an *email.message.EmailMessage* instance.

`HTTPResponse.status`

Status code returned by server.

`HTTPResponse.reason`

Reason phrase returned by server.

`HTTPResponse.debuglevel`

A debugging hook. If *debuglevel* is greater than zero, messages will be printed to stdout as the response is read and parsed.

`HTTPResponse.closed`

Is True if the stream is closed.

`HTTPResponse.geturl()`

在 3.9 版之後被廢用: Deprecated in favor of *url*.

`HTTPResponse.info()`

在 3.9 版之後被廢用: Deprecated in favor of *headers*.

`HTTPResponse.getcode()`

在 3.9 版之後被廢用: Deprecated in favor of *status*.

21.10.3 范例

Here is an example session that uses the GET method:

```
>>> import http.client
>>> conn = http.client.HTTPSConnection("www.python.org")
>>> conn.request("GET", "/")
>>> r1 = conn.getresponse()
>>> print(r1.status, r1.reason)
200 OK
>>> data1 = r1.read() # This will return entire content.
>>> # The following example demonstrates reading data in chunks.
>>> conn.request("GET", "/")
>>> r1 = conn.getresponse()
>>> while chunk := r1.read(200):
...     print(repr(chunk))
b'<!doctype html>\n<!--[if"...
...
>>> # Example of an invalid request
>>> conn = http.client.HTTPSConnection("docs.python.org")
>>> conn.request("GET", "/parrot.spam")
>>> r2 = conn.getresponse()
>>> print(r2.status, r2.reason)
404 Not Found
>>> data2 = r2.read()
>>> conn.close()
```

Here is an example session that uses the HEAD method. Note that the HEAD method never returns any data.

```
>>> import http.client
>>> conn = http.client.HTTPSConnection("www.python.org")
>>> conn.request("HEAD", "/")
>>> res = conn.getresponse()
>>> print(res.status, res.reason)
200 OK
>>> data = res.read()
>>> print(len(data))
0
>>> data == b''
True
```

Here is an example session that uses the POST method:

```
>>> import http.client, urllib.parse
>>> params = urllib.parse.urlencode({'@number': 12524, '@type': 'issue', '@action': 'show'})
>>> headers = {"Content-type": "application/x-www-form-urlencoded",
...           "Accept": "text/plain"}
>>> conn = http.client.HTTPConnection("bugs.python.org")
>>> conn.request("POST", "", params, headers)
>>> response = conn.getresponse()
>>> print(response.status, response.reason)
302 Found
>>> data = response.read()
>>> data
b'Redirecting to <a href="https://bugs.python.org/issue12524">https://bugs.python.org/issue12524</a>'
>>> conn.close()
```

Client side HTTP PUT requests are very similar to POST requests. The difference lies only on the server side where HTTP servers will allow resources to be created via PUT requests. It should be noted that custom HTTP methods are also handled in `urllib.request.Request` by setting the appropriate method attribute. Here is an example session that uses the PUT method:

```
>>> # This creates an HTTP request
>>> # with the content of BODY as the enclosed representation
>>> # for the resource http://localhost:8080/file
...
>>> import http.client
>>> BODY = "***filecontents***"
>>> conn = http.client.HTTPConnection("localhost", 8080)
>>> conn.request("PUT", "/file", BODY)
>>> response = conn.getresponse()
>>> print(response.status, response.reason)
200, OK
```

21.10.4 HTTPMessage 物件

class `http.client.HTTPMessage` (*email.message.Message*)

An `http.client.HTTPMessage` instance holds the headers from an HTTP response. It is implemented using the `email.message.Message` class.

21.11 ftplib --- FTP 協定用端

原始碼: `Lib/ftplib.py`

這個模組定義了 `FTP` 類和一些相關的項目。`FTP` 類實作了 FTP 協定的用端。你可以使用它來編寫能執行各種 FTP 自動作業的 Python 程式，例如鏡像 (mirror) 其他 FTP 伺服器。`urllib.request` 模組也使用它來處理使用 FTP 的 URL。有關 FTP（檔案傳輸協定）的更多資訊，請參 [RFC 959](#)。

預設編碼是 UTF-8，遵循 [RFC 2640](#)。

Availability: 非 Emscripten、非 WASI。

此模組在 WebAssembly 平台 `wasm32-emscripten` 和 `wasm32-wasi` 上不起作用或無法使用。有關更多資訊，請參 [WebAssembly](#) 平台。

這是一個使用 `ftplib` 模組的會話範例：

```
>>> from ftplib import FTP
>>> ftp = FTP('ftp.us.debian.org') # connect to host, default port
>>> ftp.login()                    # user anonymous, passwd anonymous@
'230 Login successful.'
>>> ftp.cwd('debian')              # change into "debian" directory
'250 Directory successfully changed.'
>>> ftp.retrlines('LIST')          # list directory contents
-rw-rw-r-- 1 1176 1176 1063 Jun 15 10:18 README
...
drwxr-sr-x 5 1176 1176 4096 Dec 19 2000 pool
drwxr-sr-x 4 1176 1176 4096 Nov 17 2008 project
drwxr-xr-x 3 1176 1176 4096 Oct 10 2012 tools
'226 Directory send OK.'
>>> with open('README', 'wb') as fp:
>>>     ftp.retrbinary('RETR README', fp.write)
'226 Transfer complete.'
>>> ftp.quit()
'221 Goodbye.'
```

21.11.1 Reference

FTP objects

class `ftplib.FTP` (*host=""*, *user=""*, *passwd=""*, *acct=""*, *timeout=None*, *source_address=None*, *, *encoding='utf-8'*)

Return a new instance of the *FTP* class.

參數

- **host** (*str*) -- The hostname to connect to. If given, `connect(host)` is implicitly called by the constructor.
- **user** (*str*) -- The username to log in with (default: `'anonymous'`). If given, `login(host, passwd, acct)` is implicitly called by the constructor.
- **passwd** (*str*) -- The password to use when logging in. If not given, and if *passwd* is the empty string or `"-"`, a password will be automatically generated.
- **acct** (*str*) -- Account information to be used for the ACCT FTP command. Few systems implement this. See [RFC-959](#) for more details.
- **timeout** (*float* / *None*) -- A timeout in seconds for blocking operations like `connect()` (default: the global default timeout setting).
- **source_address** (*tuple* / *None*) -- A 2-tuple (*host*, *port*) for the socket to bind to as its source address before connecting.
- **encoding** (*str*) -- The encoding for directories and filenames (default: `'utf-8'`).

FTP 類支援 `with` 陳述式，例如：

```
>>> from ftplib import FTP
>>> with FTP("ftp1.at.proftpd.org") as ftp:
...     ftp.login()
...     ftp.dir()
...
'230 Anonymous login ok, restrictions apply.'
dr-xr-xr-x   9 ftp      ftp          154 May  6 10:43 .
dr-xr-xr-x   9 ftp      ftp          154 May  6 10:43 ..
dr-xr-xr-x   5 ftp      ftp         4096 May  6 10:43 CentOS
dr-xr-xr-x   3 ftp      ftp           18 Jul 10  2008 Fedora
>>>
```

在 3.2 版的變更：新增了對 `with` 陳述式的支援。

在 3.3 版的變更：新增 *source_address* 參數。

在 3.9 版的變更：如果 *timeout* 參數設定為零，它將引發 *ValueError* 以防止建立非阻塞 socket。新增了 *encoding* 參數，預設值從 Latin-1 更改為 UTF-8 以遵循 [RFC 2640](#)。

Several FTP methods are available in two flavors: one for handling text files and another for binary files. The methods are named for the command which is used followed by *lines* for the text version or *binary* for the binary version.

FTP 實例具有以下方法：

set_debuglevel (*level*)

Set the instance's debugging level as an *int*. This controls the amount of debugging output printed. The debug levels are:

- 0 (default): No debug output.
- 1: Produce a moderate amount of debug output, generally a single line per request.
- 2 or higher: Produce the maximum amount of debugging output, logging each line sent and received on the control connection.

connect (*host=""*, *port=0*, *timeout=None*, *source_address=None*)

Connect to the given host and port. This function should be called only once for each instance; it should not be called if a *host* argument was given when the *FTP* instance was created. All other *FTP* methods can only be called after a connection has successfully been made.

參數

- **host** (*str*) -- The host to connect to.
- **port** (*int*) -- The TCP port to connect to (default: 21, as specified by the FTP protocol specification). It is rarely needed to specify a different port number.
- **timeout** (*float* / *None*) -- A timeout in seconds for the connection attempt (default: the global default timeout setting).
- **source_address** (*tuple* / *None*) -- A 2-tuple (*host*, *port*) for the socket to bind to as its source address before connecting.

引發一個附帶引數 *self*、*host*、*port* 的稽核事件 `ftplib.connect`。

在 3.3 版的變更: 新增 *source_address* 參數。

getwelcome ()

回傳伺服器回應初始連而發送的歡迎訊息。(此訊息有時會包含與使用者相關的免責聲明或幫助資訊。)

login (*user='anonymous'*, *passwd=""*, *acct=""*)

Log on to the connected FTP server. This function should be called only once for each instance, after a connection has been established; it should not be called if the *host* and *user* arguments were given when the *FTP* instance was created. Most FTP commands are only allowed after the client has logged in.

參數

- **user** (*str*) -- The username to log in with (default: 'anonymous').
- **passwd** (*str*) -- The password to use when logging in. If not given, and if *passwd* is the empty string or "-", a password will be automatically generated.
- **acct** (*str*) -- Account information to be used for the ACCT FTP command. Few systems implement this. See [RFC-959](#) for more details.

abort ()

中止正在進行的檔案傳輸。使用它不是都會成功，但值得一試。

sendcmd (*cmd*)

向伺服器發送一個簡單的命令字串回傳回應字串。

引發一個附帶引數 *self*、*cmd* 的稽核事件 `ftplib.sendcmd`。

voidcmd (*cmd*)

Send a simple command string to the server and handle the response. Return the response string if the response code corresponds to success (codes in the range 200--299). Raise *error_reply* otherwise.

引發一個附帶引數 *self*、*cmd* 的稽核事件 `ftplib.sendcmd`。

retrbinary (*cmd*, *callback*, *blocksize=8192*, *rest=None*)

Retrieve a file in binary transfer mode.

參數

- **cmd** (*str*) -- An appropriate STOR command: "STOR *filename*".
- **callback** (*callable*) -- A single parameter callable that is called for each block of data received, with its single argument being the data as *bytes*.
- **blocksize** (*int*) -- The maximum chunk size to read on the low-level *socket* object created to do the actual transfer. This also corresponds to the largest size of data that will be passed to *callback*. Defaults to 8192.

- **rest** (*int*) -- A REST command to be sent to the server. See the documentation for the *rest* parameter of the `transfercmd()` method.

retrlines (*cmd*, *callback*=None)

Retrieve a file or directory listing in the encoding specified by the *encoding* parameter at initialization. *cmd* should be an appropriate RETR command (see `retrbinary()`) or a command such as LIST or NLST (usually just the string 'LIST'). LIST retrieves a list of files and information about those files. NLST retrieves a list of file names. The *callback* function is called for each line with a string argument containing the line with the trailing CRLF stripped. The default *callback* prints the line to `sys.stdout`.

set_pasv (*val*)

如果 *val* 為真，則用「被動」模式，否則禁用被動模式。被動模式預設關閉。

storbinary (*cmd*, *fp*, *blocksize*=8192, *callback*=None, *rest*=None)

Store a file in binary transfer mode.

參數

- **cmd** (*str*) -- An appropriate STOR command: "STOR *filename*".
- **fp** (*file object*) -- A file object (opened in binary mode) which is read until EOF, using its `read()` method in blocks of size *blocksize* to provide the data to be stored.
- **blocksize** (*int*) -- The read block size. Defaults to 8192.
- **callback** (*callable*) -- A single parameter callable that is called for each block of data sent, with its single argument being the data as *bytes*.
- **rest** (*int*) -- A REST command to be sent to the server. See the documentation for the *rest* parameter of the `transfercmd()` method.

在 3.2 版的變更: The *rest* parameter was added.

storlines (*cmd*, *fp*, *callback*=None)

以行模式 (line mode) 儲存檔案。 *cmd* 應是一個正確的 STOR 命令 (參見 `storbinary()`)。使用其 `readline()` 方法從檔案物件 *fp* (以二進位模式打開) 讀取各行、直到 EOF，以提供要儲存的資料。 *callback* 是可選的單參數可呼叫物件，於發送後以各行進行呼叫。

transfercmd (*cmd*, *rest*=None)

通過資料連動傳輸。如果傳輸主動 (active) 模式，則發送 EPRT 或 PORT 命令和 *cmd* 指定的傳輸命令，接受連。如果伺服器是被動 (passive) 模式，則發送 EPSV 或 PASV 命令、連、動傳輸命令。無論哪種方式，都是回傳連的 socket。

如果有給定可選的 *rest*，一個 REST 命令會被發送到伺服器，以 *rest* 作引數。 *rest* 通常是請求檔案的一個位元組偏移量 (byte offset)，告訴伺服器以請求的偏移量重新開始發送檔案的位元組，跳過初始位元組。但是請注意， `transfercmd()` 方法將 *rest* 轉為帶有初始化時指定的 *encoding* 參數的字串，但不會對字串的容執行檢查。如果伺服器無法識 REST 命令，則會引發 `error_reply` 例外。如果發生這種情況，只需在有 *rest* 引數的情況下呼叫 `transfercmd()`。

ntransfercmd (*cmd*, *rest*=None)

類似於 `transfercmd()`，但回傳一個帶有資料連和資料預期大小的元組。如果無法計算預期大小，則回傳 None。 *cmd* 和 *rest* 與 `transfercmd()` 中的含義相同。

mlsd (*path*="", *facts*=[])

使用 MLSD 命令 (RFC 3659) 列出標準格式的目。如果省略 *path* 則假定作用於當前目。 *facts* 是表示所需資訊類型的字串列表 (例如 ["type", "size", "perm"])。會回傳一個生器物件，每個在路徑中找到的檔案生成一個包含兩個元素的元組，第一個元素是檔案名稱，第二個元素是包含有關檔案名稱 *facts* 的字典。該字典的容可能受 *facts* 引數限制，但不保證伺服器會回傳所有請求的 *facts*。

在 3.3 版新加入。

nlst (*argument*[, ...])

回傳由 NLST 命令回傳的檔案名稱列表。可選的 *argument* 是要列出的目 (預設當前伺服器目)。多個引數可用於將非標準選項傳遞給 NLST 命令。

備: 如果你的伺服器支援該命令, `mlsd()` 會提供更好的 API。

dir (*argument*[, ...])

Produce a directory listing as returned by the LIST command, printing it to standard output. The optional *argument* is a directory to list (default is the current server directory). Multiple arguments can be used to pass non-standard options to the LIST command. If the last argument is a function, it is used as a *callback* function as for `retrlines()`; the default prints to `sys.stdout`. This method returns None.

備: 如果你的伺服器支援該命令, `mlsd()` 會提供更好的 API。

rename (*fromname*, *toname*)

將伺服器上的檔案 *fromname* 重新命名 *toname*。

delete (*filename*)

從伺服器中除名 *filename* 的檔案。如果成功, 回傳回應的文字, 否則引發 `error_perm` 權限錯誤或在其他錯誤發生時引發 `error_reply`。

cwd (*pathname*)

設定伺服器上的當前目。

mkd (*pathname*)

在伺服器上建立一個新目。

pwd ()

回傳伺服器上當前目的路徑名。

rmd (*dirname*)

除伺服器上名 *dirname* 的目。

size (*filename*)

請求伺服器上名 *filename* 的檔案的大小。成功時, 檔案的大小作整數回傳, 否則回傳 None。請注意, SIZE 命令不是標準化的, 但被許多常見的伺服器實作支援。

quit ()

向伺服器發送 QUIT 命令關閉連。這是關閉連的「禮貌」方式, 但如果伺服器對 QUIT 命令作出錯誤回應, 它可能會引發例外。這意味著呼叫 `close()` 方法使 FTP 實例無法用於後續呼叫 (見下文)。

close ()

單方面關閉連。這不應該使用於已經關閉的連, 例如在成功呼叫 `quit()` 之後。呼叫後就不應該再次使用 FTP 實例 (在呼叫 `close()` 或 `quit()` 後, 你不能通過發出另一個 `login()` 方法重新打開連)。

FTP_TLS objects

class ftplib.FTP_TLS (*host=""*, *user=""*, *passwd=""*, *acct=""*, *keyfile=None*, *certfile=None*, *context=None*, *timeout=None*, *source_address=None*, *, *encoding='utf-8'*)

An *FTP* subclass which adds TLS support to FTP as described in [RFC 4217](#). Connect to port 21 implicitly securing the FTP control connection before authenticating.

備註: The user must explicitly secure the data connection by calling the *prot_p()* method.

參數

- **host** (*str*) -- The hostname to connect to. If given, *connect(host)* is implicitly called by the constructor.
- **user** (*str*) -- The username to log in with (default: 'anonymous'). If given, *login(host, passwd, acct)* is implicitly called by the constructor.
- **passwd** (*str*) -- The password to use when logging in. If not given, and if *passwd* is the empty string or "-", a password will be automatically generated.
- **acct** (*str*) -- Account information to be used for the ACCT FTP command. Few systems implement this. See [RFC-959](#) for more details.
- **context** (*ssl.SSLContext*) -- An SSL context object which allows bundling SSL configuration options, certificates and private keys into a single, potentially long-lived, structure. Please read [Security considerations](#) for best practices.
- **timeout** (*float* / *None*) -- A timeout in seconds for blocking operations like *connect()* (default: the global default timeout setting).
- **source_address** (*tuple* / *None*) -- A 2-tuple (*host*, *port*) for the socket to bind to as its source address before connecting.
- **encoding** (*str*) -- The encoding for directories and filenames (default: 'utf-8').

keyfile 和 *certfile* 是 *context* 的傳統替代方案 -- 它們可以 (分) 指向 SSL 連的 PEM 格式私鑰和憑證鏈檔案。

在 3.2 版新加入。

在 3.3 版的變更: Added the *source_address* parameter.

在 3.4 版的變更: The class now supports hostname check with *ssl.SSLContext.check_hostname* and *Server Name Indication* (see *ssl.HAS_SNI*).

在 3.6 版之後被用: *keyfile* 和 *certfile* 已用, 取而代之的是 *context*。請改用 *ssl.SSLContext.load_cert_chain()*, 或讓 *ssl.create_default_context()* 你選擇系統的可信 CA 憑證。

在 3.9 版的變更: 如果 *timeout* 參數設定零, 它將引發 *ValueError* 以防止建立非阻塞 socket。新增了 *encoding* 參數, 預設值從 Latin-1 更改 UTF-8 以遵循 [RFC 2640](#)。

這是一個使用 *FTP_TLS* 類的範例會話:

```
>>> ftps = FTP_TLS('ftp.pureftpd.org')
>>> ftps.login()
'230 Anonymous user logged in'
>>> ftps.prot_p()
'200 Data protection level set to "private"'
>>> ftps.nlst()
['6jack', 'OpenBSD', 'antilink', 'blogbench', 'bsdcam', 'clockspeed', 'djb dns-
→jedi', 'docs', 'eaccelerator-jedi', 'favicon.ico', 'francotone', 'fugu',
→'ignore', 'libpuzzle', 'metalog', 'minidentd', 'misc', 'mysql-udf-global-
```

(繼續下一頁)

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```

→user-variables', 'php-jenkins-hash', 'php-skein-hash', 'php-webdav',
→'phpaudit', 'phpbench', 'pincaster', 'ping', 'posto', 'pub', 'public',
→'public_keys', 'pure-ftpd', 'qscan', 'qtc', 'sharedance', 'skycache', 'sound
→', 'tmp', 'ucarp']

```

FTP_TLS class inherits from `FTP`, defining these additional methods and attributes:

ssl_version

The SSL version to use (defaults to `ssl.PROTOCOL_SSLv23`).

auth()

根據 `ssl_version` 屬性中指定的內容，使用 TLS 或 SSL 設定安全控制連。

在 3.4 版的變更: The method now supports hostname check with `ssl.SSLContext.check_hostname` and Server Name Indication (see `ssl.HAS_SNI`).

ccc()

將控制通道恢復純文本。這對於利用知道如何在不打開固定連接埠的情況下使用非安全 (non-secure) FTP 以處理 NAT 的防火很有用。

在 3.3 版新加入。

prot_p()

設定安全資料連。

prot_c()

設定明文資料 (clear text data) 連。

Module variables

exception ftplib.error_reply

伺服器收到意外回覆時所引發的例外。

exception ftplib.error_temp

當收到表示暫時錯誤的錯誤碼 (400--499 範圍的回應狀態碼) 時引發的例外。

exception ftplib.error_perm

當收到表示永久錯誤的錯誤碼 (500--599 範圍的回應狀態碼) 時引發的例外。

exception ftplib.error_proto

當從伺服器收到不符合檔案傳輸協定回應規範的回覆時引發例外，即 1--5 範圍的數字開頭。

ftplib.all_errors

`FTP` 實例方法由於 FTP 連問題 (相對於呼叫者的程式錯誤) 而可能引發的所有例外集合 (元組形式)。該集合包括上面列出的四個例外以及 `OSError` 和 `EOFError`。

也參考:

netrc 模組

`.netrc` 檔案格式的剖析器。`.netrc` 檔案通常被 FTP 用端用來在提示使用者之前載入使用者身份驗證資訊。

21.12 poplib --- POP3 protocol client

原始碼: [Lib/poplib.py](#)

This module defines a class, `POP3`, which encapsulates a connection to a POP3 server and implements the protocol as defined in [RFC 1939](#). The `POP3` class supports both the minimal and optional command sets from [RFC 1939](#). The `POP3` class also supports the STLS command introduced in [RFC 2595](#) to enable encrypted communication on an already established connection.

Additionally, this module provides a class `POP3_SSL`, which provides support for connecting to POP3 servers that use SSL as an underlying protocol layer.

Note that POP3, though widely supported, is obsolescent. The implementation quality of POP3 servers varies widely, and too many are quite poor. If your mailserver supports IMAP, you would be better off using the `imaplib.IMAP4` class, as IMAP servers tend to be better implemented.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

The `poplib` module provides two classes:

class `poplib.POP3` (*host*, *port*=`POP3_PORT`[, *timeout*])

This class implements the actual POP3 protocol. The connection is created when the instance is initialized. If *port* is omitted, the standard POP3 port (110) is used. The optional *timeout* parameter specifies a timeout in seconds for the connection attempt (if not specified, the global default timeout setting will be used).

引發一個附帶引數 `self`、`host`、`port` 的稽核事件 `poplib.connect`。

引發一個附帶引數 `self`、`line` 的稽核事件 `poplib.putline`。

在 3.9 版的變更: If the *timeout* parameter is set to be zero, it will raise a `ValueError` to prevent the creation of a non-blocking socket.

class `poplib.POP3_SSL` (*host*, *port*=`POP3_SSL_PORT`, *keyfile*=`None`, *certfile*=`None`, *timeout*=`None`, *context*=`None`)

This is a subclass of `POP3` that connects to the server over an SSL encrypted socket. If *port* is not specified, 995, the standard POP3-over-SSL port is used. *timeout* works as in the `POP3` constructor. *context* is an optional `ssl.SSLContext` object which allows bundling SSL configuration options, certificates and private keys into a single (potentially long-lived) structure. Please read [Security considerations](#) for best practices.

keyfile and *certfile* are a legacy alternative to *context* - they can point to PEM-formatted private key and certificate chain files, respectively, for the SSL connection.

引發一個附帶引數 `self`、`host`、`port` 的稽核事件 `poplib.connect`。

引發一個附帶引數 `self`、`line` 的稽核事件 `poplib.putline`。

在 3.2 版的變更: *context* parameter added.

在 3.4 版的變更: The class now supports hostname check with `ssl.SSLContext.check_hostname` and *Server Name Indication* (see `ssl.HAS_SNI`).

在 3.6 版之後被 用: *keyfile* and *certfile* are deprecated in favor of *context*. Please use `ssl.SSLContext.load_cert_chain()` instead, or let `ssl.create_default_context()` select the system's trusted CA certificates for you.

在 3.9 版的變更: If the *timeout* parameter is set to be zero, it will raise a `ValueError` to prevent the creation of a non-blocking socket.

One exception is defined as an attribute of the `poplib` module:

exception `poplib.error_proto`

Exception raised on any errors from this module (errors from `socket` module are not caught). The reason for the exception is passed to the constructor as a string.

也參考:

imaplib 模組

The standard Python IMAP module.

關於 **Fetchmail** 的常見問題

The FAQ for the **fetchmail** POP/IMAP client collects information on POP3 server variations and RFC noncompliance that may be useful if you need to write an application based on the POP protocol.

21.12.1 POP3 物件

All POP3 commands are represented by methods of the same name, in lowercase; most return the response text sent by the server.

A `POP3` instance has the following methods:

`POP3.set_debuglevel (level)`

Set the instance's debugging level. This controls the amount of debugging output printed. The default, 0, produces no debugging output. A value of 1 produces a moderate amount of debugging output, generally a single line per request. A value of 2 or higher produces the maximum amount of debugging output, logging each line sent and received on the control connection.

`POP3.getwelcome ()`

Returns the greeting string sent by the POP3 server.

`POP3.capa ()`

Query the server's capabilities as specified in **RFC 2449**. Returns a dictionary in the form `{'name': ['param'...]}`.

在 3.4 版新加入。

`POP3.user (username)`

Send user command, response should indicate that a password is required.

`POP3.pass_ (password)`

Send password, response includes message count and mailbox size. Note: the mailbox on the server is locked until `quit ()` is called.

`POP3.apop (user, secret)`

Use the more secure APOP authentication to log into the POP3 server.

`POP3.rpop (user)`

Use RPOP authentication (similar to UNIX r-commands) to log into POP3 server.

`POP3.stat ()`

Get mailbox status. The result is a tuple of 2 integers: (message count, mailbox size).

`POP3.list ([which])`

Request message list, result is in the form (response, ['mesg_num octets', ...], octets). If *which* is set, it is the message to list.

`POP3.retr (which)`

Retrieve whole message number *which*, and set its seen flag. Result is in form (response, ['line', ...], octets).

`POP3.delete (which)`

Flag message number *which* for deletion. On most servers deletions are not actually performed until QUIT (the major exception is Eudora QPOP, which deliberately violates the RFCs by doing pending deletes on any disconnect).

`POP3.reset()`

Remove any deletion marks for the mailbox.

`POP3.noop()`

Do nothing. Might be used as a keep-alive.

`POP3.quit()`

Signoff: commit changes, unlock mailbox, drop connection.

`POP3.top(which, howmuch)`

Retrieves the message header plus *howmuch* lines of the message after the header of message number *which*. Result is in form `(response, ['line', ...], octets)`.

The POP3 TOP command this method uses, unlike the RETR command, doesn't set the message's seen flag; unfortunately, TOP is poorly specified in the RFCs and is frequently broken in off-brand servers. Test this method by hand against the POP3 servers you will use before trusting it.

`POP3.uidl(which=None)`

Return message digest (unique id) list. If *which* is specified, result contains the unique id for that message in the form `'response mesgnum uid'`, otherwise result is list `(response, ['mesgnum uid', ...], octets)`.

`POP3.utf8()`

Try to switch to UTF-8 mode. Returns the server response if successful, raises `error_proto` if not. Specified in [RFC 6856](#).

在 3.5 版新加入.

`POP3.stls(context=None)`

Start a TLS session on the active connection as specified in [RFC 2595](#). This is only allowed before user authentication

context parameter is a `ssl.SSLContext` object which allows bundling SSL configuration options, certificates and private keys into a single (potentially long-lived) structure. Please read [Security considerations](#) for best practices.

This method supports hostname checking via `ssl.SSLContext.check_hostname` and *Server Name Indication* (see `ssl.HAS_SNI`).

在 3.4 版新加入.

Instances of `POP3_SSL` have no additional methods. The interface of this subclass is identical to its parent.

21.12.2 POP3 范例

Here is a minimal example (without error checking) that opens a mailbox and retrieves and prints all messages:

```
import getpass, poplib

M = poplib.POP3('localhost')
M.user(getpass.getuser())
M.pass_(getpass.getpass())
numMessages = len(M.list()[1])
for i in range(numMessages):
    for j in M.retr(i+1)[1]:
        print(j)
```

At the end of the module, there is a test section that contains a more extensive example of usage.

21.13 imaplib --- IMAP4 protocol client

原始碼: [Lib/imaplib.py](#)

This module defines three classes, *IMAP4*, *IMAP4_SSL* and *IMAP4_stream*, which encapsulate a connection to an IMAP4 server and implement a large subset of the IMAP4rev1 client protocol as defined in [RFC 2060](#). It is backward compatible with IMAP4 ([RFC 1730](#)) servers, but note that the `STATUS` command is not supported in IMAP4.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

Three classes are provided by the *imaplib* module, *IMAP4* is the base class:

class `imaplib.IMAP4` (*host*="", *port*=`IMAP4_PORT`, *timeout*=`None`)

This class implements the actual IMAP4 protocol. The connection is created and protocol version (IMAP4 or IMAP4rev1) is determined when the instance is initialized. If *host* is not specified, `' '` (the local host) is used. If *port* is omitted, the standard IMAP4 port (143) is used. The optional *timeout* parameter specifies a timeout in seconds for the connection attempt. If *timeout* is not given or is `None`, the global default socket timeout is used.

The *IMAP4* class supports the `with` statement. When used like this, the IMAP4 `LOGOUT` command is issued automatically when the `with` statement exits. E.g.:

```
>>> from imaplib import IMAP4
>>> with IMAP4("domain.org") as M:
...     M.noop()
...
('OK', [b'Nothing Accomplished. d25if65hy903weo.87'])
```

在 3.5 版的變更: Support for the `with` statement was added.

在 3.9 版的變更: 新增 *timeout* 選用參數。

Three exceptions are defined as attributes of the *IMAP4* class:

exception `IMAP4.error`

Exception raised on any errors. The reason for the exception is passed to the constructor as a string.

exception `IMAP4.abort`

IMAP4 server errors cause this exception to be raised. This is a sub-class of *IMAP4.error*. Note that closing the instance and instantiating a new one will usually allow recovery from this exception.

exception `IMAP4.readonly`

This exception is raised when a writable mailbox has its status changed by the server. This is a sub-class of *IMAP4.error*. Some other client now has write permission, and the mailbox will need to be re-opened to re-obtain write permission.

There's also a subclass for secure connections:

class `imaplib.IMAP4_SSL` (*host*="", *port*=`IMAP4_SSL_PORT`, *keyfile*=`None`, *certfile*=`None`, *ssl_context*=`None`, *timeout*=`None`)

This is a subclass derived from *IMAP4* that connects over an SSL encrypted socket (to use this class you need a socket module that was compiled with SSL support). If *host* is not specified, `' '` (the local host) is used. If *port* is omitted, the standard IMAP4-over-SSL port (993) is used. *ssl_context* is a *ssl.SSLContext* object which allows bundling SSL configuration options, certificates and private keys into a single (potentially long-lived) structure. Please read [Security considerations](#) for best practices.

keyfile and *certfile* are a legacy alternative to *ssl_context* - they can point to PEM-formatted private key and certificate chain files for the SSL connection. Note that the *keyfile/certfile* parameters are mutually exclusive with *ssl_context*, a *ValueError* is raised if *keyfile/certfile* is provided along with *ssl_context*.

The optional *timeout* parameter specifies a timeout in seconds for the connection attempt. If timeout is not given or is None, the global default socket timeout is used.

在 3.3 版的變更: 新增 *ssl_context* 參數。

在 3.4 版的變更: The class now supports hostname check with *ssl.SSLContext.check_hostname* and *Server Name Indication* (see *ssl.HAS_SNI*).

在 3.6 版之後被 用: *keyfile* and *certfile* are deprecated in favor of *ssl_context*. Please use *ssl.SSLContext.load_cert_chain()* instead, or let *ssl.create_default_context()* select the system's trusted CA certificates for you.

在 3.9 版的變更: 新增 *timeout* 選用參數。

The second subclass allows for connections created by a child process:

class *imaplib.IMAP4_stream*(*command*)

This is a subclass derived from *IMAP4* that connects to the *stdin*/*stdout* file descriptors created by passing *command* to *subprocess.Popen()*.

The following utility functions are defined:

imaplib.Internaldate2tuple(*datestr*)

Parse an IMAP4 INTERNALDATE string and return corresponding local time. The return value is a *time.struct_time* tuple or None if the string has wrong format.

imaplib.Int2AP(*num*)

Converts an integer into a bytes representation using characters from the set [A .. P].

imaplib.ParseFlags(*flagstr*)

Converts an IMAP4 FLAGS response to a tuple of individual flags.

imaplib.Time2Internaldate(*date_time*)

Convert *date_time* to an IMAP4 INTERNALDATE representation. The return value is a string in the form: "DD-Mmm-YYYY HH:MM:SS +HHMM" (including double-quotes). The *date_time* argument can be a number (int or float) representing seconds since epoch (as returned by *time.time()*), a 9-tuple representing local time an instance of *time.struct_time* (as returned by *time.localtime()*), an aware instance of *datetime.datetime*, or a double-quoted string. In the last case, it is assumed to already be in the correct format.

Note that IMAP4 message numbers change as the mailbox changes; in particular, after an EXPUNGE command performs deletions the remaining messages are renumbered. So it is highly advisable to use UIDs instead, with the UID command.

At the end of the module, there is a test section that contains a more extensive example of usage.

也參考:

Documents describing the protocol, sources for servers implementing it, by the University of Washington's IMAP Information Center can all be found at (**Source Code**) <https://github.com/uw-imap/imap> (**Not Maintained**).

21.13.1 IMAP4 物件

All IMAP4rev1 commands are represented by methods of the same name, either upper-case or lower-case.

All arguments to commands are converted to strings, except for AUTHENTICATE, and the last argument to APPEND which is passed as an IMAP4 literal. If necessary (the string contains IMAP4 protocol-sensitive characters and isn't enclosed with either parentheses or double quotes) each string is quoted. However, the *password* argument to the LOGIN command is always quoted. If you want to avoid having an argument string quoted (eg: the *flags* argument to STORE) then enclose the string in parentheses (eg: *r'(\Deleted)'*).

Each command returns a tuple: (*type*, [*data*, ...]) where *type* is usually 'OK' or 'NO', and *data* is either the text from the command response, or mandated results from the command. Each *data* is either a *bytes*, or a tuple. If a tuple, then the first part is the header of the response, and the second part contains the data (ie: 'literal' value).

The *message_set* options to commands below is a string specifying one or more messages to be acted upon. It may be a simple message number ('1'), a range of message numbers ('2:4'), or a group of non-contiguous ranges separated by commas ('1:3, 6:9'). A range can contain an asterisk to indicate an infinite upper bound ('3:*').

An *IMAP4* instance has the following methods:

IMAP4.append (*mailbox*, *flags*, *date_time*, *message*)

Append *message* to named mailbox.

IMAP4.authenticate (*mechanism*, *authobject*)

Authenticate command --- requires response processing.

mechanism specifies which authentication mechanism is to be used - it should appear in the instance variable *capabilities* in the form AUTH=*mechanism*.

authobject must be a callable object:

```
data = authobject(response)
```

It will be called to process server continuation responses; the *response* argument it is passed will be *bytes*. It should return *bytes* *data* that will be base64 encoded and sent to the server. It should return *None* if the client abort response * should be sent instead.

在 3.5 版的變更: string usernames and passwords are now encoded to *utf-8* instead of being limited to ASCII.

IMAP4.check ()

Checkpoint mailbox on server.

IMAP4.close ()

Close currently selected mailbox. Deleted messages are removed from writable mailbox. This is the recommended command before LOGOUT.

IMAP4.copy (*message_set*, *new_mailbox*)

Copy *message_set* messages onto end of *new_mailbox*.

IMAP4.create (*mailbox*)

Create new mailbox named *mailbox*.

IMAP4.delete (*mailbox*)

Delete old mailbox named *mailbox*.

IMAP4.deleteacl (*mailbox*, *who*)

Delete the ACLs (remove any rights) set for *who* on mailbox.

IMAP4.enable (*capability*)

Enable *capability* (see [RFC 5161](#)). Most capabilities do not need to be enabled. Currently only the UTF8=ACCEPT capability is supported (see [RFC 6855](#)).

在 3.5 版新加入: The *enable* () method itself, and [RFC 6855](#) support.

IMAP4.expunge ()

Permanently remove deleted items from selected mailbox. Generates an EXPUNGE response for each deleted message. Returned data contains a list of EXPUNGE message numbers in order received.

IMAP4.fetch (*message_set*, *message_parts*)

Fetch (parts of) messages. *message_parts* should be a string of message part names enclosed within parentheses, eg: " (UID BODY [TEXT]) ". Returned data are tuples of message part envelope and data.

IMAP4.getacl (*mailbox*)

Get the ACLs for *mailbox*. The method is non-standard, but is supported by the Cyrus server.

`IMAP4.getannotation (mailbox, entry, attribute)`

Retrieve the specified ANNOTATIONS for *mailbox*. The method is non-standard, but is supported by the Cyrus server.

`IMAP4.getquota (root)`

Get the quota *root*'s resource usage and limits. This method is part of the IMAP4 QUOTA extension defined in rfc2087.

`IMAP4.getquotaroot (mailbox)`

Get the list of quota roots for the named *mailbox*. This method is part of the IMAP4 QUOTA extension defined in rfc2087.

`IMAP4.list ([directory[, pattern]])`

List mailbox names in *directory* matching *pattern*. *directory* defaults to the top-level mail folder, and *pattern* defaults to match anything. Returned data contains a list of LIST responses.

`IMAP4.login (user, password)`

Identify the client using a plaintext password. The *password* will be quoted.

`IMAP4.login_cram_md5 (user, password)`

Force use of CRAM-MD5 authentication when identifying the client to protect the password. Will only work if the server CAPABILITY response includes the phrase AUTH=CRAM-MD5.

`IMAP4.logout ()`

Shutdown connection to server. Returns server BYE response.

在 3.8 版的變更: The method no longer ignores silently arbitrary exceptions.

`IMAP4.lsub (directory="*", pattern='*')`

List subscribed mailbox names in *directory* matching *pattern*. *directory* defaults to the top level directory and *pattern* defaults to match any mailbox. Returned data are tuples of message part envelope and data.

`IMAP4.myrights (mailbox)`

Show my ACLs for a mailbox (i.e. the rights that I have on mailbox).

`IMAP4.namespace ()`

Returns IMAP namespaces as defined in [RFC 2342](#).

`IMAP4.noop ()`

Send NOOP to server.

`IMAP4.open (host, port, timeout=None)`

Opens socket to *port* at *host*. The optional *timeout* parameter specifies a timeout in seconds for the connection attempt. If timeout is not given or is None, the global default socket timeout is used. Also note that if the *timeout* parameter is set to be zero, it will raise a [ValueError](#) to reject creating a non-blocking socket. This method is implicitly called by the `IMAP4` constructor. The connection objects established by this method will be used in the `IMAP4.read()`, `IMAP4.readline()`, `IMAP4.send()`, and `IMAP4.shutdown()` methods. You may override this method.

引發一個附帶引數 `self`、`host`、`port` 的稽核事件 `imaplib.open`。

在 3.9 版的變更: 新增 *timeout* 參數。

`IMAP4.partial (message_num, message_part, start, length)`

Fetch truncated part of a message. Returned data is a tuple of message part envelope and data.

`IMAP4.proxyauth (user)`

Assume authentication as *user*. Allows an authorised administrator to proxy into any user's mailbox.

`IMAP4.read (size)`

Reads *size* bytes from the remote server. You may override this method.

`IMAP4.readline()`

Reads one line from the remote server. You may override this method.

`IMAP4.recent()`

Prompt server for an update. Returned data is `None` if no new messages, else value of RECENT response.

`IMAP4.rename(oldmailbox, newmailbox)`

Rename mailbox named *oldmailbox* to *newmailbox*.

`IMAP4.response(code)`

Return data for response *code* if received, or `None`. Returns the given code, instead of the usual type.

`IMAP4.search(charset, criterion[, ...])`

Search mailbox for matching messages. *charset* may be `None`, in which case no CHARSET will be specified in the request to the server. The IMAP protocol requires that at least one criterion be specified; an exception will be raised when the server returns an error. *charset* must be `None` if the UTF8=ACCEPT capability was enabled using the *enable()* command.

範例：

```
# M is a connected IMAP4 instance...
typ, msgnums = M.search(None, 'FROM', '"LDJ"')

# or:
typ, msgnums = M.search(None, '(FROM "LDJ")')
```

`IMAP4.select(mailbox='INBOX', readonly=False)`

Select a mailbox. Returned data is the count of messages in *mailbox* (EXISTS response). The default *mailbox* is 'INBOX'. If the *readonly* flag is set, modifications to the mailbox are not allowed.

`IMAP4.send(data)`

Sends data to the remote server. You may override this method.

引發一個附帶引數 *self*、*data* 的稽核事件 `imaplib.send`。

`IMAP4.setacl(mailbox, who, what)`

Set an ACL for *mailbox*. The method is non-standard, but is supported by the Cyrus server.

`IMAP4.setannotation(mailbox, entry, attribute[, ...])`

Set ANNOTATIONS for *mailbox*. The method is non-standard, but is supported by the Cyrus server.

`IMAP4.setquota(root, limits)`

Set the quota *root*'s resource *limits*. This method is part of the IMAP4 QUOTA extension defined in rfc2087.

`IMAP4.shutdown()`

Close connection established in `open`. This method is implicitly called by `IMAP4.logout()`. You may override this method.

`IMAP4.socket()`

Returns socket instance used to connect to server.

`IMAP4.sort(sort_criteria, charset, search_criterion[, ...])`

The `sort` command is a variant of `search` with sorting semantics for the results. Returned data contains a space separated list of matching message numbers.

Sort has two arguments before the *search_criterion* argument(s); a parenthesized list of *sort_criteria*, and the searching *charset*. Note that unlike `search`, the searching *charset* argument is mandatory. There is also a `uid sort` command which corresponds to sort the way that `uid search` corresponds to `search`. The `sort` command first searches the mailbox for messages that match the given searching criteria using the *charset* argument for the interpretation of strings in the searching criteria. It then returns the numbers of matching messages.

This is an IMAP4rev1 extension command.

IMAP4.**starttls** (*ssl_context=None*)

Send a STARTTLS command. The *ssl_context* argument is optional and should be a `ssl.SSLContext` object. This will enable encryption on the IMAP connection. Please read *Security considerations* for best practices.

在 3.2 版新加入.

在 3.4 版的變更: The method now supports hostname check with `ssl.SSLContext.check_hostname` and Server Name Indication (see `ssl.HAS_SNI`).

IMAP4.**status** (*mailbox, names*)

Request named status conditions for *mailbox*.

IMAP4.**store** (*message_set, command, flag_list*)

Alters flag dispositions for messages in mailbox. *command* is specified by section 6.4.6 of **RFC 2060** as being one of "FLAGS", "+FLAGS", or "-FLAGS", optionally with a suffix of ".SILENT".

For example, to set the delete flag on all messages:

```
typ, data = M.search(None, 'ALL')
for num in data[0].split():
    M.store(num, '+FLAGS', '\\Deleted')
M.expunge()
```

備 F: Creating flags containing '[' (for example: "[test]") violates **RFC 3501** (the IMAP protocol). However, imaplib has historically allowed creation of such tags, and popular IMAP servers, such as Gmail, accept and produce such flags. There are non-Python programs which also create such tags. Although it is an RFC violation and IMAP clients and servers are supposed to be strict, imaplib nonetheless continues to allow such tags to be created for backward compatibility reasons, and as of Python 3.6, handles them if they are sent from the server, since this improves real-world compatibility.

IMAP4.**subscribe** (*mailbox*)

Subscribe to new mailbox.

IMAP4.**thread** (*threading_algorithm, charset, search_criterion[, ...]*)

The *thread* command is a variant of *search* with threading semantics for the results. Returned data contains a space separated list of thread members.

Thread members consist of zero or more messages numbers, delimited by spaces, indicating successive parent and child.

Thread has two arguments before the *search_criterion* argument(s); a *threading_algorithm*, and the searching *charset*. Note that unlike *search*, the searching *charset* argument is mandatory. There is also a *uid thread* command which corresponds to *thread* the way that *uid search* corresponds to *search*. The *thread* command first searches the mailbox for messages that match the given searching criteria using the *charset* argument for the interpretation of strings in the searching criteria. It then returns the matching messages threaded according to the specified threading algorithm.

This is an IMAP4rev1 extension command.

IMAP4.**uid** (*command, arg[, ...]*)

Execute command args with messages identified by UID, rather than message number. Returns response appropriate to command. At least one argument must be supplied; if none are provided, the server will return an error and an exception will be raised.

IMAP4.**unsubscribe** (*mailbox*)

Unsubscribe from old mailbox.

IMAP4.**unselect** ()

`imaplib.IMAP4.unselect()` frees server's resources associated with the selected mailbox and returns

the server to the authenticated state. This command performs the same actions as `imaplib.IMAP4.close()`, except that no messages are permanently removed from the currently selected mailbox.

在 3.9 版新加入.

`IMAP4.xatom(name[, ...])`

Allow simple extension commands notified by server in CAPABILITY response.

The following attributes are defined on instances of `IMAP4`:

`IMAP4.PROTOCOL_VERSION`

The most recent supported protocol in the CAPABILITY response from the server.

`IMAP4.debug`

Integer value to control debugging output. The initialize value is taken from the module variable `Debug`. Values greater than three trace each command.

`IMAP4.utf8_enabled`

Boolean value that is normally `False`, but is set to `True` if an `enable()` command is successfully issued for the UTF8=ACCEPT capability.

在 3.5 版新加入.

21.13.2 IMAP4 范例

Here is a minimal example (without error checking) that opens a mailbox and retrieves and prints all messages:

```
import getpass, imaplib

M = imaplib.IMAP4(host='example.org')
M.login(getpass.getuser(), getpass.getpass())
M.select()
typ, data = M.search(None, 'ALL')
for num in data[0].split():
    typ, data = M.fetch(num, '(RFC822)')
    print('Message %s\n%s\n' % (num, data[0][1]))
M.close()
M.logout()
```

21.14 smtplib --- SMTP protocol client

原始碼: [Lib/smtplib.py](#)

The `smtplib` module defines an SMTP client session object that can be used to send mail to any internet machine with an SMTP or ESMTP listener daemon. For details of SMTP and ESMTP operation, consult [RFC 821](#) (Simple Mail Transfer Protocol) and [RFC 1869](#) (SMTP Service Extensions).

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

class `smtplib.SMTP` (`host=""`, `port=0`, `local_hostname=None`, [`timeout`,], `source_address=None`)

An `SMTP` instance encapsulates an SMTP connection. It has methods that support a full repertoire of SMTP and ESMTP operations. If the optional `host` and `port` parameters are given, the `SMTP.connect()` method is called with those parameters during initialization. If specified, `local_hostname` is used as the FQDN of the local host in the HELO/EHLO command. Otherwise, the local hostname is found using `socket.getfqdn()`. If the `connect()` call returns anything other than a success code, an `SMTPConnectError` is raised. The optional `timeout` parameter specifies a timeout in seconds for blocking operations like the connection attempt

(if not specified, the global default timeout setting will be used). If the timeout expires, `TimeoutError` is raised. The optional `source_address` parameter allows binding to some specific source address in a machine with multiple network interfaces, and/or to some specific source TCP port. It takes a 2-tuple (`host`, `port`), for the socket to bind to as its source address before connecting. If omitted (or if `host` or `port` are '' and/or 0 respectively) the OS default behavior will be used.

For normal use, you should only require the initialization/connect, `sendmail()`, and `SMTP.quit()` methods. An example is included below.

The `SMTP` class supports the `with` statement. When used like this, the SMTP QUIT command is issued automatically when the `with` statement exits. E.g.:

```
>>> from smtplib import SMTP
>>> with SMTP("domain.org") as smtp:
...     smtp.noop()
...
(250, b'Ok')
>>>
```

引發一個附帶引數 `self`、`data` 的稽核事件 `smtplib.send`。

在 3.3 版的變更: Support for the `with` statement was added.

在 3.3 版的變更: 新增 `source_address` 引數。

在 3.5 版新加入: The SMTPUTF8 extension (RFC 6531) is now supported.

在 3.9 版的變更: If the `timeout` parameter is set to be zero, it will raise a `ValueError` to prevent the creation of a non-blocking socket

```
class smtplib.SMTP_SSL(host="", port=0, local_hostname=None, keyfile=None, certfile=None, [timeout,
]context=None, source_address=None)
```

An `SMTP_SSL` instance behaves exactly the same as instances of `SMTP`. `SMTP_SSL` should be used for situations where SSL is required from the beginning of the connection and using `starttls()` is not appropriate. If `host` is not specified, the local host is used. If `port` is zero, the standard SMTP-over-SSL port (465) is used. The optional arguments `local_hostname`, `timeout` and `source_address` have the same meaning as they do in the `SMTP` class. `context`, also optional, can contain a `SSLContext` and allows configuring various aspects of the secure connection. Please read *Security considerations* for best practices.

`keyfile` and `certfile` are a legacy alternative to `context`, and can point to a PEM formatted private key and certificate chain file for the SSL connection.

在 3.3 版的變更: 新增 `context`。

在 3.3 版的變更: 新增 `source_address` 引數。

在 3.4 版的變更: The class now supports hostname check with `ssl.SSLContext.check_hostname` and Server Name Indication (see `ssl.HAS_SNI`).

在 3.6 版之後被用: `keyfile` and `certfile` are deprecated in favor of `context`. Please use `ssl.SSLContext.load_cert_chain()` instead, or let `ssl.create_default_context()` select the system's trusted CA certificates for you.

在 3.9 版的變更: If the `timeout` parameter is set to be zero, it will raise a `ValueError` to prevent the creation of a non-blocking socket

```
class smtplib.LMTP(host="", port=LMTP_PORT, local_hostname=None, source_address=None, [timeout
])
```

The LMTP protocol, which is very similar to ESMTP, is heavily based on the standard SMTP client. It's common to use Unix sockets for LMTP, so our `connect()` method must support that as well as a regular host:port server. The optional arguments `local_hostname` and `source_address` have the same meaning as they do in the `SMTP` class. To specify a Unix socket, you must use an absolute path for `host`, starting with a '/

Authentication is supported, using the regular SMTP mechanism. When using a Unix socket, LMTP generally don't support or require any authentication, but your mileage might vary.

在 3.9 版的變更: 新增 *timeout* 選用參數。

A nice selection of exceptions is defined as well:

exception `smtpplib.SMTPException`

Subclass of *OSError* that is the base exception class for all the other exceptions provided by this module.

在 3.4 版的變更: SMTPException became subclass of *OSError*

exception `smtpplib.SMTPServerDisconnected`

This exception is raised when the server unexpectedly disconnects, or when an attempt is made to use the *SMTP* instance before connecting it to a server.

exception `smtpplib.SMTPResponseException`

Base class for all exceptions that include an SMTP error code. These exceptions are generated in some instances when the SMTP server returns an error code. The error code is stored in the `smtp_code` attribute of the error, and the `smtp_error` attribute is set to the error message.

exception `smtpplib.SMTPSenderRefused`

Sender address refused. In addition to the attributes set by on all *SMTPResponseException* exceptions, this sets 'sender' to the string that the SMTP server refused.

exception `smtpplib.SMTPRecipientsRefused`

All recipient addresses refused. The errors for each recipient are accessible through the attribute `recipients`, which is a dictionary of exactly the same sort as *SMTP.sendmail()* returns.

exception `smtpplib.SMTPDataError`

The SMTP server refused to accept the message data.

exception `smtpplib.SMTPConnectError`

Error occurred during establishment of a connection with the server.

exception `smtpplib.SMTPHeloError`

The server refused our HELO message.

exception `smtpplib.SMTPNotSupportedError`

The command or option attempted is not supported by the server.

在 3.5 版新加入.

exception `smtpplib.SMTPAuthenticationError`

SMTP authentication went wrong. Most probably the server didn't accept the username/password combination provided.

也參考:

RFC 821 - Simple Mail Transfer Protocol

Protocol definition for SMTP. This document covers the model, operating procedure, and protocol details for SMTP.

RFC 1869 - SMTP Service Extensions

Definition of the ESMTP extensions for SMTP. This describes a framework for extending SMTP with new commands, supporting dynamic discovery of the commands provided by the server, and defines a few additional commands.

21.14.1 SMTP 物件

An *SMTP* instance has the following methods:

`SMTP.set_debuglevel(level)`

Set the debug output level. A value of 1 or `True` for *level* results in debug messages for connection and for all messages sent to and received from the server. A value of 2 for *level* results in these messages being timestamped.

在 3.5 版的變更: Added debuglevel 2.

`SMTP.docmd(cmd, args=")`

Send a command *cmd* to the server. The optional argument *args* is simply concatenated to the command, separated by a space.

This returns a 2-tuple composed of a numeric response code and the actual response line (multiline responses are joined into one long line.)

In normal operation it should not be necessary to call this method explicitly. It is used to implement other methods and may be useful for testing private extensions.

If the connection to the server is lost while waiting for the reply, *SMTPServerDisconnected* will be raised.

`SMTP.connect(host='localhost', port=0)`

Connect to a host on a given port. The defaults are to connect to the local host at the standard SMTP port (25). If the hostname ends with a colon (':') followed by a number, that suffix will be stripped off and the number interpreted as the port number to use. This method is automatically invoked by the constructor if a host is specified during instantiation. Returns a 2-tuple of the response code and message sent by the server in its connection response.

Raises an *auditing event* `smtplib.connect` with arguments `self, host, port`.

`SMTP.helo(name=")`

Identify yourself to the SMTP server using HELO. The hostname argument defaults to the fully qualified domain name of the local host. The message returned by the server is stored as the `helo_resp` attribute of the object.

In normal operation it should not be necessary to call this method explicitly. It will be implicitly called by the `sendmail()` when necessary.

`SMTP.ehlo(name=")`

Identify yourself to an ESMTP server using EHLO. The hostname argument defaults to the fully qualified domain name of the local host. Examine the response for ESMTP option and store them for use by `has_extn()`. Also sets several informational attributes: the message returned by the server is stored as the `ehlo_resp` attribute, `does_esmtp` is set to `True` or `False` depending on whether the server supports ESMTP, and `esmtp_features` will be a dictionary containing the names of the SMTP service extensions this server supports, and their parameters (if any).

Unless you wish to use `has_extn()` before sending mail, it should not be necessary to call this method explicitly. It will be implicitly called by `sendmail()` when necessary.

`SMTP.ehlo_or_helo_if_needed()`

This method calls `ehlo()` and/or `helo()` if there has been no previous EHLO or HELO command this session. It tries ESMTP EHLO first.

SMTPHeloError

The server didn't reply properly to the HELO greeting.

`SMTP.has_extn(name)`

Return `True` if *name* is in the set of SMTP service extensions returned by the server, `False` otherwise. Case is ignored.

`SMTP.verify(address)`

Check the validity of an address on this server using SMTP VRFY. Returns a tuple consisting of code 250 and a full [RFC 822](#) address (including human name) if the user address is valid. Otherwise returns an SMTP error code of 400 or greater and an error string.

備註: Many sites disable SMTP VRFY in order to foil spammers.

`SMTP.login(user, password, *, initial_response_ok=True)`

Log in on an SMTP server that requires authentication. The arguments are the username and the password to authenticate with. If there has been no previous EHLO or HELO command this session, this method tries ESMTP EHLO first. This method will return normally if the authentication was successful, or may raise the following exceptions:

`SMTPHeloError`

The server didn't reply properly to the HELO greeting.

`SMTPAuthenticationError`

The server didn't accept the username/password combination.

`SMTPNotSupportedError`

The AUTH command is not supported by the server.

`SMTPException`

No suitable authentication method was found.

Each of the authentication methods supported by `smtplib` are tried in turn if they are advertised as supported by the server. See `auth()` for a list of supported authentication methods. `initial_response_ok` is passed through to `auth()`.

Optional keyword argument `initial_response_ok` specifies whether, for authentication methods that support it, an "initial response" as specified in [RFC 4954](#) can be sent along with the AUTH command, rather than requiring a challenge/response.

在 3.5 版的變更: `SMTPNotSupportedError` may be raised, and the `initial_response_ok` parameter was added.

`SMTP.auth(mechanism, authobject, *, initial_response_ok=True)`

Issue an SMTP AUTH command for the specified authentication *mechanism*, and handle the challenge response via *authobject*.

mechanism specifies which authentication mechanism is to be used as argument to the AUTH command; the valid values are those listed in the `auth` element of `esmtplib.features`.

authobject must be a callable object taking an optional single argument:

```
data = authobject(challenge=None)
```

If optional keyword argument `initial_response_ok` is true, `authobject()` will be called first with no argument. It can return the [RFC 4954](#) "initial response" ASCII `str` which will be encoded and sent with the AUTH command as below. If the `authobject()` does not support an initial response (e.g. because it requires a challenge), it should return `None` when called with `challenge=None`. If `initial_response_ok` is false, then `authobject()` will not be called first with `None`.

If the initial response check returns `None`, or if `initial_response_ok` is false, `authobject()` will be called to process the server's challenge response; the *challenge* argument it is passed will be a `bytes`. It should return ASCII `str` *data* that will be base64 encoded and sent to the server.

The SMTP class provides `authobjects` for the CRAM-MD5, PLAIN, and LOGIN mechanisms; they are named `SMTP.auth_cram_md5`, `SMTP.auth_plain`, and `SMTP.auth_login` respectively. They all require that the `user` and `password` properties of the SMTP instance are set to appropriate values.

User code does not normally need to call `auth` directly, but can instead call the `login()` method, which will try each of the above mechanisms in turn, in the order listed. `auth` is exposed to facilitate the implementation of authentication methods not (or not yet) supported directly by `smtplib`.

在 3.5 版新加入。

`SMTP.starttls` (*keyfile=None, certfile=None, context=None*)

Put the SMTP connection in TLS (Transport Layer Security) mode. All SMTP commands that follow will be encrypted. You should then call `ehlo()` again.

If *keyfile* and *certfile* are provided, they are used to create an `ssl.SSLContext`.

Optional *context* parameter is an `ssl.SSLContext` object; This is an alternative to using a keyfile and a certfile and if specified both *keyfile* and *certfile* should be `None`.

If there has been no previous EHLO or HELO command this session, this method tries ESMTP EHLO first.

在 3.6 版之後被 用: *keyfile* and *certfile* are deprecated in favor of *context*. Please use `ssl.SSLContext.load_cert_chain()` instead, or let `ssl.create_default_context()` select the system's trusted CA certificates for you.

`SMTPHelloError`

The server didn't reply properly to the HELO greeting.

`SMTPNotSupportedError`

The server does not support the STARTTLS extension.

`RuntimeError`

SSL/TLS support is not available to your Python interpreter.

在 3.3 版的變更: 新增 *context*。

在 3.4 版的變更: The method now supports hostname check with `SSLContext.check_hostname` and *Server Name Indicator* (see `HAS_SNI`).

在 3.5 版的變更: The error raised for lack of STARTTLS support is now the `SMTPNotSupportedError` subclass instead of the base `SMTPException`.

`SMTP.sendmail` (*from_addr, to_addrs, msg, mail_options=(), rcpt_options=()*)

Send mail. The required arguments are an **RFC 822** from-address string, a list of **RFC 822** to-address strings (a bare string will be treated as a list with 1 address), and a message string. The caller may pass a list of ESMTP options (such as `8bitmime`) to be used in MAIL FROM commands as *mail_options*. ESMTP options (such as `DSN` commands) that should be used with all RCPT commands can be passed as *rcpt_options*. (If you need to use different ESMTP options to different recipients you have to use the low-level methods such as `mail()`, `rcpt()` and `data()` to send the message.)

備 用: The *from_addr* and *to_addrs* parameters are used to construct the message envelope used by the transport agents. `sendmail` does not modify the message headers in any way.

msg may be a string containing characters in the ASCII range, or a byte string. A string is encoded to bytes using the `ascii` codec, and lone `\r` and `\n` characters are converted to `\r\n` characters. A byte string is not modified.

If there has been no previous EHLO or HELO command this session, this method tries ESMTP EHLO first. If the server does ESMTP, message size and each of the specified options will be passed to it (if the option is in the feature set the server advertises). If EHLO fails, HELO will be tried and ESMTP options suppressed.

This method will return normally if the mail is accepted for at least one recipient. Otherwise it will raise an exception. That is, if this method does not raise an exception, then someone should get your mail. If this method does not raise an exception, it returns a dictionary, with one entry for each recipient that was refused. Each entry contains a tuple of the SMTP error code and the accompanying error message sent by the server.

If `SMTPUTF8` is included in *mail_options*, and the server supports it, *from_addr* and *to_addrs* may contain non-ASCII characters.

This method may raise the following exceptions:

`SMTPRecipientsRefused`

All recipients were refused. Nobody got the mail. The *recipients* attribute of the exception object

is a dictionary with information about the refused recipients (like the one returned when at least one recipient was accepted).

SMTPHelloError

The server didn't reply properly to the HELO greeting.

SMTPSenderRefused

The server didn't accept the *from_addr*.

SMTPDataError

The server replied with an unexpected error code (other than a refusal of a recipient).

SMTPNotSupportedError

SMTPUTF8 was given in the *mail_options* but is not supported by the server.

Unless otherwise noted, the connection will be open even after an exception is raised.

在 3.2 版的變更: *msg* may be a byte string.

在 3.5 版的變更: SMTPUTF8 support added, and *SMTPNotSupportedError* may be raised if SMTPUTF8 is specified but the server does not support it.

SMTP . **send_message** (*msg*, *from_addr*=None, *to_addrs*=None, *mail_options*=(), *rcpt_options*=())

This is a convenience method for calling *sendmail()* with the message represented by an *email.message.Message* object. The arguments have the same meaning as for *sendmail()*, except that *msg* is a Message object.

If *from_addr* is None or *to_addrs* is None, *send_message* fills those arguments with addresses extracted from the headers of *msg* as specified in **RFC 5322**: *from_addr* is set to the *Sender* field if it is present, and otherwise to the *From* field. *to_addrs* combines the values (if any) of the *To*, *Cc*, and *Bcc* fields from *msg*. If exactly one set of *Resent-** headers appear in the message, the regular headers are ignored and the *Resent-** headers are used instead. If the message contains more than one set of *Resent-** headers, a *ValueError* is raised, since there is no way to unambiguously detect the most recent set of *Resent-** headers.

send_message serializes *msg* using *BytesGenerator* with `\r\n` as the *linesep*, and calls *sendmail()* to transmit the resulting message. Regardless of the values of *from_addr* and *to_addrs*, *send_message* does not transmit any *Bcc* or *Resent-Bcc* headers that may appear in *msg*. If any of the addresses in *from_addr* and *to_addrs* contain non-ASCII characters and the server does not advertise SMTPUTF8 support, an *SMTPNotSupported* error is raised. Otherwise the Message is serialized with a clone of its *policy* with the *utf8* attribute set to True, and SMTPUTF8 and BODY=8BITMIME are added to *mail_options*.

在 3.2 版新加入.

在 3.5 版新加入: Support for internationalized addresses (SMTPUTF8).

SMTP . **quit** ()

Terminate the SMTP session and close the connection. Return the result of the SMTP QUIT command.

Low-level methods corresponding to the standard SMTP/ESMTP commands HELP, RSET, NOOP, MAIL, RCPT, and DATA are also supported. Normally these do not need to be called directly, so they are not documented here. For details, consult the module code.

21.14.2 SMTP 范例

This example prompts the user for addresses needed in the message envelope ('To' and 'From' addresses), and the message to be delivered. Note that the headers to be included with the message must be included in the message as entered; this example doesn't do any processing of the [RFC 822](#) headers. In particular, the 'To' and 'From' addresses must be included in the message headers explicitly.

```
import smtplib

def prompt(prompt):
    return input(prompt).strip()

fromaddr = prompt("From: ")
toaddrs = prompt("To: ").split()
print("Enter message, end with ^D (Unix) or ^Z (Windows):")

# Add the From: and To: headers at the start!
msg = ("From: %s\r\nTo: %s\r\n\r\n"
       % (fromaddr, ",".join(toaddrs)))
while True:
    try:
        line = input()
    except EOFError:
        break
    if not line:
        break
    msg = msg + line

print("Message length is", len(msg))

server = smtplib.SMTP('localhost')
server.set_debuglevel(1)
server.sendmail(fromaddr, toaddrs, msg)
server.quit()
```

備 F: In general, you will want to use the [email](#) package's features to construct an email message, which you can then send via [send_message\(\)](#); see [email: Examples](#).

21.15 uuid --- UUID objects according to RFC 4122

原始碼: [Lib/uuid.py](#)

This module provides immutable [UUID](#) objects (the [UUID](#) class) and the functions [uuid1\(\)](#), [uuid3\(\)](#), [uuid4\(\)](#), [uuid5\(\)](#) for generating version 1, 3, 4, and 5 UUIDs as specified in [RFC 4122](#).

If all you want is a unique ID, you should probably call [uuid1\(\)](#) or [uuid4\(\)](#). Note that [uuid1\(\)](#) may compromise privacy since it creates a UUID containing the computer's network address. [uuid4\(\)](#) creates a random UUID.

Depending on support from the underlying platform, [uuid1\(\)](#) may or may not return a "safe" UUID. A safe UUID is one which is generated using synchronization methods that ensure no two processes can obtain the same UUID. All instances of [UUID](#) have an [is_safe](#) attribute which relays any information about the UUID's safety, using this enumeration:

```
class uuid.SafeUUID
```

在 3.7 版新加入。

safe

The UUID was generated by the platform in a multiprocessing-safe way.

unsafe

The UUID was not generated in a multiprocessing-safe way.

unknown

The platform does not provide information on whether the UUID was generated safely or not.

class `uuid.UUID` (*hex=None, bytes=None, bytes_le=None, fields=None, int=None, version=None, *, is_safe=SafeUUID.unknown*)

Create a UUID from either a string of 32 hexadecimal digits, a string of 16 bytes in big-endian order as the *bytes* argument, a string of 16 bytes in little-endian order as the *bytes_le* argument, a tuple of six integers (32-bit *time_low*, 16-bit *time_mid*, 16-bit *time_hi_version*, 8-bit *clock_seq_hi_variant*, 8-bit *clock_seq_low*, 48-bit *node*) as the *fields* argument, or a single 128-bit integer as the *int* argument. When a string of hex digits is given, curly braces, hyphens, and a URN prefix are all optional. For example, these expressions all yield the same UUID:

```
UUID('{12345678-1234-5678-1234-567812345678}')
UUID('12345678123456781234567812345678')
UUID('urn:uuid:12345678-1234-5678-1234-567812345678')
UUID(bytes=b'\x12\x34\x56\x78'*4)
UUID(bytes_le=b'\x78\x56\x34\x12\x34\x12\x78\x56' +
          b'\x12\x34\x56\x78\x12\x34\x56\x78')
UUID(fields=(0x12345678, 0x1234, 0x5678, 0x12, 0x34, 0x567812345678))
UUID(int=0x12345678123456781234567812345678)
```

Exactly one of *hex*, *bytes*, *bytes_le*, *fields*, or *int* must be given. The *version* argument is optional; if given, the resulting UUID will have its variant and version number set according to [RFC 4122](#), overriding bits in the given *hex*, *bytes*, *bytes_le*, *fields*, or *int*.

Comparison of UUID objects are made by way of comparing their *UUID.int* attributes. Comparison with a non-UUID object raises a *TypeError*.

`str(uuid)` returns a string in the form 12345678-1234-5678-1234-567812345678 where the 32 hexadecimal digits represent the UUID.

UUID instances have these read-only attributes:

UUID.bytes

The UUID as a 16-byte string (containing the six integer fields in big-endian byte order).

UUID.bytes_le

The UUID as a 16-byte string (with *time_low*, *time_mid*, and *time_hi_version* in little-endian byte order).

UUID.fields

A tuple of the six integer fields of the UUID, which are also available as six individual attributes and two derived attributes:

欄位	意義
<code>UUID.time_low</code>	The first 32 bits of the UUID.
<code>UUID.time_mid</code>	The next 16 bits of the UUID.
<code>UUID.time_hi_version</code>	The next 16 bits of the UUID.
<code>UUID.clock_seq_hi_variant</code>	The next 8 bits of the UUID.
<code>UUID.clock_seq_low</code>	The next 8 bits of the UUID.
<code>UUID.node</code>	The last 48 bits of the UUID.
<code>UUID.time</code>	The 60-bit timestamp.
<code>UUID.clock_seq</code>	The 14-bit sequence number.

UUID.hex

The UUID as a 32-character lowercase hexadecimal string.

UUID.int

The UUID as a 128-bit integer.

UUID.urn

The UUID as a URN as specified in [RFC 4122](#).

UUID.variant

The UUID variant, which determines the internal layout of the UUID. This will be one of the constants [RESERVED_NCS](#), [RFC_4122](#), [RESERVED_MICROSOFT](#), or [RESERVED_FUTURE](#).

UUID.version

The UUID version number (1 through 5, meaningful only when the variant is [RFC_4122](#)).

UUID.is_safe

An enumeration of [SafeUUID](#) which indicates whether the platform generated the UUID in a multiprocessing-safe way.

在 3.7 版新加入。

The `uuid` module defines the following functions:

uuid.getnode()

Get the hardware address as a 48-bit positive integer. The first time this runs, it may launch a separate program, which could be quite slow. If all attempts to obtain the hardware address fail, we choose a random 48-bit number with the multicast bit (least significant bit of the first octet) set to 1 as recommended in [RFC 4122](#). "Hardware address" means the MAC address of a network interface. On a machine with multiple network interfaces, universally administered MAC addresses (i.e. where the second least significant bit of the first octet is *unset*) will be preferred over locally administered MAC addresses, but with no other ordering guarantees.

在 3.7 版的變更: Universally administered MAC addresses are preferred over locally administered MAC addresses, since the former are guaranteed to be globally unique, while the latter are not.

`uuid.uuid1 (node=None, clock_seq=None)`

Generate a UUID from a host ID, sequence number, and the current time. If *node* is not given, `getnode()` is used to obtain the hardware address. If *clock_seq* is given, it is used as the sequence number; otherwise a random 14-bit sequence number is chosen.

`uuid.uuid3 (namespace, name)`

Generate a UUID based on the MD5 hash of a namespace identifier (which is a UUID) and a name (which is a string).

`uuid.uuid4 ()`

Generate a random UUID.

`uuid.uuid5 (namespace, name)`

Generate a UUID based on the SHA-1 hash of a namespace identifier (which is a UUID) and a name (which is a string).

The `uuid` module defines the following namespace identifiers for use with `uuid3()` or `uuid5()`.

`uuid.NAMESPACE_DNS`

When this namespace is specified, the *name* string is a fully qualified domain name.

`uuid.NAMESPACE_URL`

When this namespace is specified, the *name* string is a URL.

`uuid.NAMESPACE_OID`

When this namespace is specified, the *name* string is an ISO OID.

`uuid.NAMESPACE_X500`

When this namespace is specified, the *name* string is an X.500 DN in DER or a text output format.

The `uuid` module defines the following constants for the possible values of the *variant* attribute:

`uuid.RESERVED_NCS`

Reserved for NCS compatibility.

`uuid.RFC_4122`

Specifies the UUID layout given in [RFC 4122](#).

`uuid.RESERVED_MICROSOFT`

Reserved for Microsoft compatibility.

`uuid.RESERVED_FUTURE`

Reserved for future definition.

也參考:

RFC 4122 - A Universally Unique Identifier (UUID) URN Namespace

This specification defines a Uniform Resource Name namespace for UUIDs, the internal format of UUIDs, and methods of generating UUIDs.

21.15.1 范例

Here are some examples of typical usage of the `uuid` module:

```
>>> import uuid

>>> # make a UUID based on the host ID and current time
>>> uuid.uuid1()
UUID('a8098c1a-f86e-11da-bd1a-00112444be1e')

>>> # make a UUID using an MD5 hash of a namespace UUID and a name
>>> uuid.uuid3(uuid.NAMESPACE_DNS, 'python.org')
```

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(繼續上一頁)

```

UUID('6fa459ea-ee8a-3ca4-894e-db77e160355e')

>>> # make a random UUID
>>> uuid.uuid4()
UUID('16fd2706-8baf-433b-82eb-8c7fada847da')

>>> # make a UUID using a SHA-1 hash of a namespace UUID and a name
>>> uuid.uuid5(uuid.NAMESPACE_DNS, 'python.org')
UUID('886313e1-3b8a-5372-9b90-0c9aee199e5d')

>>> # make a UUID from a string of hex digits (braces and hyphens ignored)
>>> x = uuid.UUID('{00010203-0405-0607-0809-0a0b0c0d0e0f}')

>>> # convert a UUID to a string of hex digits in standard form
>>> str(x)
'00010203-0405-0607-0809-0a0b0c0d0e0f'

>>> # get the raw 16 bytes of the UUID
>>> x.bytes
b'\x00\x01\x02\x03\x04\x05\x06\x07\x08\t\n\x0b\x0c\r\x0e\x0f'

>>> # make a UUID from a 16-byte string
>>> uuid.UUID(bytes=x.bytes)
UUID('00010203-0405-0607-0809-0a0b0c0d0e0f')

```

21.16 socketserver --- A framework for network servers

原始碼: [Lib/socketserver.py](#)

The `socketserver` module simplifies the task of writing network servers.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

There are four basic concrete server classes:

class `socketserver.TCPServer` (*server_address*, *RequestHandlerClass*, *bind_and_activate=True*)

This uses the internet TCP protocol, which provides for continuous streams of data between the client and server. If *bind_and_activate* is true, the constructor automatically attempts to invoke `server_bind()` and `server_activate()`. The other parameters are passed to the `BaseServer` base class.

class `socketserver.UDPServer` (*server_address*, *RequestHandlerClass*, *bind_and_activate=True*)

This uses datagrams, which are discrete packets of information that may arrive out of order or be lost while in transit. The parameters are the same as for `TCPServer`.

class `socketserver.UnixStreamServer` (*server_address*, *RequestHandlerClass*,
bind_and_activate=True)

class `socketserver.UnixDatagramServer` (*server_address*, *RequestHandlerClass*,
bind_and_activate=True)

These more infrequently used classes are similar to the TCP and UDP classes, but use Unix domain sockets; they're not available on non-Unix platforms. The parameters are the same as for `TCPServer`.

These four classes process requests *synchronously*; each request must be completed before the next request can be started. This isn't suitable if each request takes a long time to complete, because it requires a lot of computation, or because it returns a lot of data which the client is slow to process. The solution is to create a separate process or

thread to handle each request; the *ForkingMixIn* and *ThreadingMixIn* mix-in classes can be used to support asynchronous behaviour.

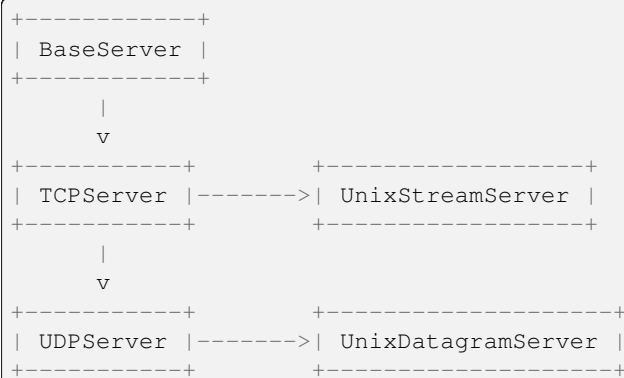
Creating a server requires several steps. First, you must create a request handler class by subclassing the *BaseRequestHandler* class and overriding its *handle()* method; this method will process incoming requests. Second, you must instantiate one of the server classes, passing it the server's address and the request handler class. It is recommended to use the server in a *with* statement. Then call the *handle_request()* or *serve_forever()* method of the server object to process one or many requests. Finally, call *server_close()* to close the socket (unless you used a *with* statement).

When inheriting from *ThreadingMixIn* for threaded connection behavior, you should explicitly declare how you want your threads to behave on an abrupt shutdown. The *ThreadingMixIn* class defines an attribute *daemon_threads*, which indicates whether or not the server should wait for thread termination. You should set the flag explicitly if you would like threads to behave autonomously; the default is *False*, meaning that Python will not exit until all threads created by *ThreadingMixIn* have exited.

Server classes have the same external methods and attributes, no matter what network protocol they use.

21.16.1 Server Creation Notes

There are five classes in an inheritance diagram, four of which represent synchronous servers of four types:



Note that *UnixDatagramServer* derives from *UDPServer*, not from *UnixStreamServer* --- the only difference between an IP and a Unix server is the address family.

class socketserver.*ForkingMixIn*

class socketserver.*ThreadingMixIn*

Forking and threading versions of each type of server can be created using these mix-in classes. For instance, *ThreadingUDPServer* is created as follows:

```

class ThreadingUDPServer(ThreadingMixIn, UDPServer):
    pass

```

The mix-in class comes first, since it overrides a method defined in *UDPServer*. Setting the various attributes also changes the behavior of the underlying server mechanism.

ForkingMixIn and the Forking classes mentioned below are only available on POSIX platforms that support *fork()*.

block_on_close

ForkingMixIn.server_close waits until all child processes complete, except if *block_on_close* attribute is *False*.

ThreadingMixIn.server_close waits until all non-daemon threads complete, except if *block_on_close* attribute is *False*.

daemon_threads

For *ThreadingMixIn* use daemonic threads by setting *ThreadingMixIn.daemon_threads* to *True* to not wait until threads complete.

在 3.7 版的變更: *ForkingMixIn.server_close* and *ThreadingMixIn.server_close* now waits until all child processes and non-daemonic threads complete. Add a new *ForkingMixIn.block_on_close* class attribute to opt-in for the pre-3.7 behaviour.

```
class socketserver.ForkingTCPServer
class socketserver.ForkingUDPServer
class socketserver.ThreadingTCPServer
class socketserver.ThreadingUDPServer
```

These classes are pre-defined using the mix-in classes.

To implement a service, you must derive a class from *BaseRequestHandler* and redefine its *handle()* method. You can then run various versions of the service by combining one of the server classes with your request handler class. The request handler class must be different for datagram or stream services. This can be hidden by using the handler subclasses *StreamRequestHandler* or *DatagramRequestHandler*.

Of course, you still have to use your head! For instance, it makes no sense to use a forking server if the service contains state in memory that can be modified by different requests, since the modifications in the child process would never reach the initial state kept in the parent process and passed to each child. In this case, you can use a threading server, but you will probably have to use locks to protect the integrity of the shared data.

On the other hand, if you are building an HTTP server where all data is stored externally (for instance, in the file system), a synchronous class will essentially render the service "deaf" while one request is being handled -- which may be for a very long time if a client is slow to receive all the data it has requested. Here a threading or forking server is appropriate.

In some cases, it may be appropriate to process part of a request synchronously, but to finish processing in a forked child depending on the request data. This can be implemented by using a synchronous server and doing an explicit fork in the request handler class *handle()* method.

Another approach to handling multiple simultaneous requests in an environment that supports neither threads nor *fork()* (or where these are too expensive or inappropriate for the service) is to maintain an explicit table of partially finished requests and to use *selectors* to decide which request to work on next (or whether to handle a new incoming request). This is particularly important for stream services where each client can potentially be connected for a long time (if threads or subprocesses cannot be used). See *asyncore* for another way to manage this.

21.16.2 Server Objects

```
class socketserver.BaseServer (server_address, RequestHandlerClass)
```

This is the superclass of all Server objects in the module. It defines the interface, given below, but does not implement most of the methods, which is done in subclasses. The two parameters are stored in the respective *server_address* and *RequestHandlerClass* attributes.

fileno()

Return an integer file descriptor for the socket on which the server is listening. This function is most commonly passed to *selectors*, to allow monitoring multiple servers in the same process.

handle_request()

Process a single request. This function calls the following methods in order: *get_request()*, *verify_request()*, and *process_request()*. If the user-provided *handle()* method of the handler class raises an exception, the server's *handle_error()* method will be called. If no request is received within *timeout* seconds, *handle_timeout()* will be called and *handle_request()* will return.

serve_forever (poll_interval=0.5)

Handle requests until an explicit *shutdown()* request. Poll for shutdown every *poll_interval* seconds. Ignores the *timeout* attribute. It also calls *service_actions()*, which may be used by a subclass

or *mixin* to provide actions specific to a given service. For example, the *ForkingMixIn* class uses *service_actions()* to clean up zombie child processes.

在 3.3 版的變更: Added *service_actions* call to the *serve_forever* method.

service_actions()

This is called in the *serve_forever()* loop. This method can be overridden by subclasses or *mixin* classes to perform actions specific to a given service, such as cleanup actions.

在 3.3 版新加入.

shutdown()

Tell the *serve_forever()* loop to stop and wait until it does. *shutdown()* must be called while *serve_forever()* is running in a different thread otherwise it will deadlock.

server_close()

Clean up the server. May be overridden.

address_family

The family of protocols to which the server's socket belongs. Common examples are *socket.AF_INET* and *socket.AF_UNIX*.

RequestHandlerClass

The user-provided request handler class; an instance of this class is created for each request.

server_address

The address on which the server is listening. The format of addresses varies depending on the protocol family; see the documentation for the *socket* module for details. For internet protocols, this is a tuple containing a string giving the address, and an integer port number: *('127.0.0.1', 80)*, for example.

socket

The socket object on which the server will listen for incoming requests.

The server classes support the following class variables:

allow_reuse_address

Whether the server will allow the reuse of an address. This defaults to *False*, and can be set in subclasses to change the policy.

request_queue_size

The size of the request queue. If it takes a long time to process a single request, any requests that arrive while the server is busy are placed into a queue, up to *request_queue_size* requests. Once the queue is full, further requests from clients will get a "Connection denied" error. The default value is usually 5, but this can be overridden by subclasses.

socket_type

The type of socket used by the server; *socket.SOCK_STREAM* and *socket.SOCK_DGRAM* are two common values.

timeout

Timeout duration, measured in seconds, or *None* if no timeout is desired. If *handle_request()* receives no incoming requests within the timeout period, the *handle_timeout()* method is called.

There are various server methods that can be overridden by subclasses of base server classes like *TCPServer*; these methods aren't useful to external users of the server object.

finish_request(request, client_address)

Actually processes the request by instantiating *RequestHandlerClass* and calling its *handle()* method.

get_request()

Must accept a request from the socket, and return a 2-tuple containing the *new* socket object to be used to communicate with the client, and the client's address.

handle_error (*request*, *client_address*)

This function is called if the *handle()* method of a *RequestHandlerClass* instance raises an exception. The default action is to print the traceback to standard error and continue handling further requests.

在 3.6 版的變更: Now only called for exceptions derived from the *Exception* class.

handle_timeout ()

This function is called when the *timeout* attribute has been set to a value other than *None* and the timeout period has passed with no requests being received. The default action for forking servers is to collect the status of any child processes that have exited, while in threading servers this method does nothing.

process_request (*request*, *client_address*)

Calls *finish_request()* to create an instance of the *RequestHandlerClass*. If desired, this function can create a new process or thread to handle the request; the *ForkingMixin* and *ThreadingMixin* classes do this.

server_activate ()

Called by the server's constructor to activate the server. The default behavior for a TCP server just invokes *listen()* on the server's socket. May be overridden.

server_bind ()

Called by the server's constructor to bind the socket to the desired address. May be overridden.

verify_request (*request*, *client_address*)

Must return a Boolean value; if the value is *True*, the request will be processed, and if it's *False*, the request will be denied. This function can be overridden to implement access controls for a server. The default implementation always returns *True*.

在 3.6 版的變更: Support for the *context manager* protocol was added. Exiting the context manager is equivalent to calling *server_close()*.

21.16.3 Request Handler Objects

class `socketserver.BaseRequestHandler`

This is the superclass of all request handler objects. It defines the interface, given below. A concrete request handler subclass must define a new *handle()* method, and can override any of the other methods. A new instance of the subclass is created for each request.

setup ()

Called before the *handle()* method to perform any initialization actions required. The default implementation does nothing.

handle ()

This function must do all the work required to service a request. The default implementation does nothing. Several instance attributes are available to it; the request is available as *request*; the client address as *client_address*; and the server instance as *server*, in case it needs access to per-server information.

The type of *request* is different for datagram or stream services. For stream services, *request* is a socket object; for datagram services, *request* is a pair of string and socket.

finish ()

Called after the *handle()* method to perform any clean-up actions required. The default implementation does nothing. If *setup()* raises an exception, this function will not be called.

request

The new *socket.socket* object to be used to communicate with the client.

client_address

Client address returned by `BaseServer.get_request()`.

server

`BaseServer` object used for handling the request.

class `socketserver.StreamRequestHandler`

class `socketserver.DatagramRequestHandler`

These `BaseRequestHandler` subclasses override the `setup()` and `finish()` methods, and provide `rfile` and `wfile` attributes.

rfile

A file object from which receives the request is read. Support the `io.BufferedIOBase` readable interface.

wfile

A file object to which the reply is written. Support the `io.BufferedIOBase` writable interface

在 3.6 版的變更: `wfile` also supports the `io.BufferedIOBase` writable interface.

21.16.4 范例

`socketserver.TCPServer` 范例

This is the server side:

```
import socketserver

class MyTCPHandler(socketserver.BaseRequestHandler):
    """
    The request handler class for our server.

    It is instantiated once per connection to the server, and must
    override the handle() method to implement communication to the
    client.
    """

    def handle(self):
        # self.request is the TCP socket connected to the client
        self.data = self.request.recv(1024).strip()
        print("Received from {}:{}".format(self.client_address[0]))
        print(self.data)
        # just send back the same data, but upper-cased
        self.request.sendall(self.data.upper())

if __name__ == "__main__":
    HOST, PORT = "localhost", 9999

    # Create the server, binding to localhost on port 9999
    with socketserver.TCPServer((HOST, PORT), MyTCPHandler) as server:
        # Activate the server; this will keep running until you
        # interrupt the program with Ctrl-C
        server.serve_forever()
```

An alternative request handler class that makes use of streams (file-like objects that simplify communication by providing the standard file interface):

```
class MyTCPHandler(socketserver.StreamRequestHandler):

    def handle(self):
```

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```

# self.rfile is a file-like object created by the handler;
# we can now use e.g. readline() instead of raw recv() calls
self.data = self.rfile.readline().strip()
print("{} wrote:".format(self.client_address[0]))
print(self.data)
# Likewise, self.wfile is a file-like object used to write back
# to the client
self.wfile.write(self.data.upper())

```

The difference is that the `readline()` call in the second handler will call `recv()` multiple times until it encounters a newline character, while the single `recv()` call in the first handler will just return what has been received so far from the client's `sendall()` call (typically all of it, but this is not guaranteed by the TCP protocol).

This is the client side:

```

import socket
import sys

HOST, PORT = "localhost", 9999
data = " ".join(sys.argv[1:])

# Create a socket (SOCK_STREAM means a TCP socket)
with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as sock:
    # Connect to server and send data
    sock.connect((HOST, PORT))
    sock.sendall(bytes(data + "\n", "utf-8"))

    # Receive data from the server and shut down
    received = str(sock.recv(1024), "utf-8")

print("Sent:      {}".format(data))
print("Received: {}".format(received))

```

The output of the example should look something like this:

Server:

```

$ python TCPServer.py
127.0.0.1 wrote:
b'hello world with TCP'
127.0.0.1 wrote:
b'python is nice'

```

Client:

```

$ python TCPClient.py hello world with TCP
Sent:      hello world with TCP
Received:  HELLO WORLD WITH TCP
$ python TCPClient.py python is nice
Sent:      python is nice
Received:  PYTHON IS NICE

```

socketserver.UDPServer 范例

This is the server side:

```
import socketserver

class MyUDPHandler(socketserver.BaseRequestHandler):
    """
    This class works similar to the TCP handler class, except that
    self.request consists of a pair of data and client socket, and since
    there is no connection the client address must be given explicitly
    when sending data back via sendto().
    """

    def handle(self):
        data = self.request[0].strip()
        socket = self.request[1]
        print("{} wrote:".format(self.client_address[0]))
        print(data)
        socket.sendto(data.upper(), self.client_address)

if __name__ == "__main__":
    HOST, PORT = "localhost", 9999
    with socketserver.UDPServer((HOST, PORT), MyUDPHandler) as server:
        server.serve_forever()
```

This is the client side:

```
import socket
import sys

HOST, PORT = "localhost", 9999
data = " ".join(sys.argv[1:])

# SOCK_DGRAM is the socket type to use for UDP sockets
sock = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)

# As you can see, there is no connect() call; UDP has no connections.
# Instead, data is directly sent to the recipient via sendto().
sock.sendto(bytes(data + "\n", "utf-8"), (HOST, PORT))
received = str(sock.recv(1024), "utf-8")

print("Sent:      {}".format(data))
print("Received: {}".format(received))
```

The output of the example should look exactly like for the TCP server example.

Asynchronous Mixins

To build asynchronous handlers, use the *ThreadingMixIn* and *ForkingMixIn* classes.

An example for the *ThreadingMixIn* class:

```
import socket
import threading
import socketserver

class ThreadedTCPRequestHandler(socketserver.BaseRequestHandler):

    def handle(self):
        data = str(self.request.recv(1024), 'ascii')
```

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```

cur_thread = threading.current_thread()
response = bytes("{}: {}".format(cur_thread.name, data), 'ascii')
self.request.sendall(response)

class ThreadedTCPServer(socketserver.ThreadingMixIn, socketserver.TCPServer):
    pass

def client(ip, port, message):
    with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as sock:
        sock.connect((ip, port))
        sock.sendall(bytes(message, 'ascii'))
        response = str(sock.recv(1024), 'ascii')
        print("Received: {}".format(response))

if __name__ == "__main__":
    # Port 0 means to select an arbitrary unused port
    HOST, PORT = "localhost", 0

    server = ThreadedTCPServer((HOST, PORT), ThreadedTCPRequestHandler)
    with server:
        ip, port = server.server_address

        # Start a thread with the server -- that thread will then start one
        # more thread for each request
        server_thread = threading.Thread(target=server.serve_forever)
        # Exit the server thread when the main thread terminates
        server_thread.daemon = True
        server_thread.start()
        print("Server loop running in thread:", server_thread.name)

        client(ip, port, "Hello World 1")
        client(ip, port, "Hello World 2")
        client(ip, port, "Hello World 3")

    server.shutdown()

```

The output of the example should look something like this:

```

$ python ThreadedTCPServer.py
Server loop running in thread: Thread-1
Received: Thread-2: Hello World 1
Received: Thread-3: Hello World 2
Received: Thread-4: Hello World 3

```

The *ForkingMixIn* class is used in the same way, except that the server will spawn a new process for each request. Available only on POSIX platforms that support *fork()*.

21.17 http.server --- HTTP servers

原始碼: <Lib/http/server.py>

This module defines classes for implementing HTTP servers.

警告: *http.server* is not recommended for production. It only implements *basic security checks*.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

One class, `HTTPServer`, is a `socketserver.TCPServer` subclass. It creates and listens at the HTTP socket, dispatching the requests to a handler. Code to create and run the server looks like this:

```
def run(server_class=HTTPServer, handler_class=BaseHTTPRequestHandler):
    server_address = ('', 8000)
    httpd = server_class(server_address, handler_class)
    httpd.serve_forever()
```

class `http.server.HTTPServer` (*server_address*, *RequestHandlerClass*)

This class builds on the `TCPServer` class by storing the server address as instance variables named `server_name` and `server_port`. The server is accessible by the handler, typically through the handler's `server` instance variable.

class `http.server.ThreadingHTTPServer` (*server_address*, *RequestHandlerClass*)

This class is identical to `HTTPServer` but uses threads to handle requests by using the `ThreadingMixIn`. This is useful to handle web browsers pre-opening sockets, on which `HTTPServer` would wait indefinitely.

在 3.7 版新加入。

The `HTTPServer` and `ThreadingHTTPServer` must be given a `RequestHandlerClass` on instantiation, of which this module provides three different variants:

class `http.server.BaseHTTPRequestHandler` (*request*, *client_address*, *server*)

This class is used to handle the HTTP requests that arrive at the server. By itself, it cannot respond to any actual HTTP requests; it must be subclassed to handle each request method (e.g. GET or POST). `BaseHTTPRequestHandler` provides a number of class and instance variables, and methods for use by subclasses.

The handler will parse the request and the headers, then call a method specific to the request type. The method name is constructed from the request. For example, for the request method SPAM, the `do_SPAM()` method will be called with no arguments. All of the relevant information is stored in instance variables of the handler. Subclasses should not need to override or extend the `__init__()` method.

`BaseHTTPRequestHandler` has the following instance variables:

client_address

Contains a tuple of the form (`host`, `port`) referring to the client's address.

server

Contains the server instance.

close_connection

Boolean that should be set before `handle_one_request()` returns, indicating if another request may be expected, or if the connection should be shut down.

requestline

Contains the string representation of the HTTP request line. The terminating CRLF is stripped. This attribute should be set by `handle_one_request()`. If no valid request line was processed, it should be set to the empty string.

command

Contains the command (request type). For example, 'GET'.

path

Contains the request path. If query component of the URL is present, then `path` includes the query. Using the terminology of [RFC 3986](#), `path` here includes `hier-part` and the query.

request_version

Contains the version string from the request. For example, 'HTTP/1.0'.

headers

Holds an instance of the class specified by the *MessageClass* class variable. This instance parses and manages the headers in the HTTP request. The *parse_headers()* function from *http.client* is used to parse the headers and it requires that the HTTP request provide a valid **RFC 2822** style header.

rfile

An *io.BufferedReader* input stream, ready to read from the start of the optional input data.

wfile

Contains the output stream for writing a response back to the client. Proper adherence to the HTTP protocol must be used when writing to this stream in order to achieve successful interoperoperation with HTTP clients.

在 3.6 版的變更: This is an *io.BufferedReader* stream.

BaseHTTPRequestHandler 擁有以下屬性:

server_version

Specifies the server software version. You may want to override this. The format is multiple whitespace-separated strings, where each string is of the form name[/version]. For example, 'BaseHTTP/0.2'.

sys_version

Contains the Python system version, in a form usable by the *version_string* method and the *server_version* class variable. For example, 'Python/1.4'.

error_message_format

Specifies a format string that should be used by *send_error()* method for building an error response to the client. The string is filled by default with variables from *responses* based on the status code that passed to *send_error()*.

error_content_type

Specifies the Content-Type HTTP header of error responses sent to the client. The default value is 'text/html'.

protocol_version

Specifies the HTTP version to which the server is conformant. It is sent in responses to let the client know the server's communication capabilities for future requests. If set to 'HTTP/1.1', the server will permit HTTP persistent connections; however, your server *must* then include an accurate Content-Length header (using *send_header()*) in all of its responses to clients. For backwards compatibility, the setting defaults to 'HTTP/1.0'.

MessageClass

Specifies an *email.message.Message*-like class to parse HTTP headers. Typically, this is not overridden, and it defaults to *http.client.HTTPMessage*.

responses

This attribute contains a mapping of error code integers to two-element tuples containing a short and long message. For example, {code: (shortmessage, longmessage)}. The *shortmessage* is usually used as the *message* key in an error response, and *longmessage* as the *explain* key. It is used by *send_response_only()* and *send_error()* methods.

A *BaseHTTPRequestHandler* instance has the following methods:

handle()

Calls *handle_one_request()* once (or, if persistent connections are enabled, multiple times) to handle incoming HTTP requests. You should never need to override it; instead, implement appropriate *do_*()* methods.

handle_one_request()

This method will parse and dispatch the request to the appropriate *do_*()* method. You should never need to override it.

handle_expect_100()

When an HTTP/1.1 conformant server receives an `Expect: 100-continue` request header it responds back with a 100 Continue followed by 200 OK headers. This method can be overridden to raise an error if the server does not want the client to continue. For e.g. server can choose to send 417 Expectation Failed as a response header and return False.

在 3.2 版新加入.

send_error (*code*, *message=None*, *explain=None*)

Sends and logs a complete error reply to the client. The numeric *code* specifies the HTTP error code, with *message* as an optional, short, human readable description of the error. The *explain* argument can be used to provide more detailed information about the error; it will be formatted using the `error_message_format` attribute and emitted, after a complete set of headers, as the response body. The `responses` attribute holds the default values for *message* and *explain* that will be used if no value is provided; for unknown codes the default value for both is the string `???`. The body will be empty if the method is HEAD or the response code is one of the following: 1xx, 204 No Content, 205 Reset Content, 304 Not Modified.

在 3.4 版的變更: The error response includes a Content-Length header. Added the *explain* argument.

send_response (*code*, *message=None*)

Adds a response header to the headers buffer and logs the accepted request. The HTTP response line is written to the internal buffer, followed by *Server* and *Date* headers. The values for these two headers are picked up from the `version_string()` and `date_time_string()` methods, respectively. If the server does not intend to send any other headers using the `send_header()` method, then `send_response()` should be followed by an `end_headers()` call.

在 3.3 版的變更: Headers are stored to an internal buffer and `end_headers()` needs to be called explicitly.

send_header (*keyword*, *value*)

Adds the HTTP header to an internal buffer which will be written to the output stream when either `end_headers()` or `flush_headers()` is invoked. *keyword* should specify the header keyword, with *value* specifying its value. Note that, after the `send_header` calls are done, `end_headers()` MUST BE called in order to complete the operation.

在 3.2 版的變更: Headers are stored in an internal buffer.

send_response_only (*code*, *message=None*)

Sends the response header only, used for the purposes when 100 Continue response is sent by the server to the client. The headers not buffered and sent directly the output stream. If the *message* is not specified, the HTTP message corresponding the response *code* is sent.

在 3.2 版新加入.

end_headers ()

Adds a blank line (indicating the end of the HTTP headers in the response) to the headers buffer and calls `flush_headers()`.

在 3.2 版的變更: The buffered headers are written to the output stream.

flush_headers ()

Finally send the headers to the output stream and flush the internal headers buffer.

在 3.3 版新加入.

log_request (*code*='-', *size*='-')

Logs an accepted (successful) request. *code* should specify the numeric HTTP code associated with the response. If a size of the response is available, then it should be passed as the *size* parameter.

log_error (...)

Logs an error when a request cannot be fulfilled. By default, it passes the message to `log_message()`, so it takes the same arguments (*format* and additional values).

log_message (*format*, ...)

Logs an arbitrary message to `sys.stderr`. This is typically overridden to create custom error logging mechanisms. The *format* argument is a standard printf-style format string, where the additional arguments to `log_message()` are applied as inputs to the formatting. The client ip address and current date and time are prefixed to every message logged.

version_string ()

Returns the server software's version string. This is a combination of the `server_version` and `sys_version` attributes.

date_time_string (*timestamp=None*)

Returns the date and time given by *timestamp* (which must be `None` or in the format returned by `time.time()`), formatted for a message header. If *timestamp* is omitted, it uses the current date and time.

The result looks like 'Sun, 06 Nov 1994 08:49:37 GMT'.

log_date_time_string ()

Returns the current date and time, formatted for logging.

address_string ()

Returns the client address.

在 3.3 版的變更: Previously, a name lookup was performed. To avoid name resolution delays, it now always returns the IP address.

class `http.server.SimpleHTTPRequestHandler` (*request, client_address, server, directory=None*)

This class serves files from the directory *directory* and below, or the current directory if *directory* is not provided, directly mapping the directory structure to HTTP requests.

在 3.7 版的變更: Added the *directory* parameter.

在 3.9 版的變更: The *directory* parameter accepts a *path-like object*.

A lot of the work, such as parsing the request, is done by the base class `BaseHTTPRequestHandler`. This class implements the `do_GET()` and `do_HEAD()` functions.

The following are defined as class-level attributes of `SimpleHTTPRequestHandler`:

server_version

This will be "SimpleHTTP/" + `__version__`, where `__version__` is defined at the module level.

extensions_map

A dictionary mapping suffixes into MIME types, contains custom overrides for the default system mappings. The mapping is used case-insensitively, and so should contain only lower-cased keys.

在 3.9 版的變更: This dictionary is no longer filled with the default system mappings, but only contains overrides.

The `SimpleHTTPRequestHandler` class defines the following methods:

do_HEAD ()

This method serves the 'HEAD' request type: it sends the headers it would send for the equivalent GET request. See the `do_GET()` method for a more complete explanation of the possible headers.

do_GET ()

The request is mapped to a local file by interpreting the request as a path relative to the current working directory.

If the request was mapped to a directory, the directory is checked for a file named `index.html` or `index.htm` (in that order). If found, the file's contents are returned; otherwise a directory listing is generated by calling the `list_directory()` method. This method uses `os.listdir()` to scan the directory, and returns a 404 error response if the `listdir()` fails.

If the request was mapped to a file, it is opened. Any `OSError` exception in opening the requested file is mapped to a 404, 'File not found' error. If there was a 'If-Modified-Since' header in the request, and the file was not modified after this time, a 304, 'Not Modified' response is sent. Otherwise, the content type is guessed by calling the `guess_type()` method, which in turn uses the `extensions_map` variable, and the file contents are returned.

A 'Content-type:' header with the guessed content type is output, followed by a 'Content-Length:' header with the file's size and a 'Last-Modified:' header with the file's modification time.

Then follows a blank line signifying the end of the headers, and then the contents of the file are output. If the file's MIME type starts with `text/` the file is opened in text mode; otherwise binary mode is used.

For example usage, see the implementation of the `test` function in [Lib/http/server.py](#).

在 3.7 版的變更: Support of the 'If-Modified-Since' header.

The `SimpleHTTPRequestHandler` class can be used in the following manner in order to create a very basic webserver serving files relative to the current directory:

```
import http.server
import socketserver

PORT = 8000

Handler = http.server.SimpleHTTPRequestHandler

with socketserver.TCPServer(("", PORT), Handler) as httpd:
    print("serving at port", PORT)
    httpd.serve_forever()
```

`http.server` can also be invoked directly using the `-m` switch of the interpreter. Similar to the previous example, this serves files relative to the current directory:

```
python -m http.server
```

The server listens to port 8000 by default. The default can be overridden by passing the desired port number as an argument:

```
python -m http.server 9000
```

By default, the server binds itself to all interfaces. The option `-b/--bind` specifies a specific address to which it should bind. Both IPv4 and IPv6 addresses are supported. For example, the following command causes the server to bind to localhost only:

```
python -m http.server --bind 127.0.0.1
```

在 3.4 版的變更: Added the `--bind` option.

在 3.8 版的變更: Support IPv6 in the `--bind` option.

By default, the server uses the current directory. The option `-d/--directory` specifies a directory to which it should serve the files. For example, the following command uses a specific directory:

```
python -m http.server --directory /tmp/
```

在 3.7 版的變更: Added the `--directory` option.

By default, the server is conformant to HTTP/1.0. The option `-p/--protocol` specifies the HTTP version to which the server is conformant. For example, the following command runs an HTTP/1.1 conformant server:

```
python -m http.server --protocol HTTP/1.1
```

在 3.11 版的變更: Added the `--protocol` option.

class `http.server.CGIHTTPRequestHandler` (*request, client_address, server*)

This class is used to serve either files or output of CGI scripts from the current directory and below. Note that mapping HTTP hierarchic structure to local directory structure is exactly as in *SimpleHTTPRequestHandler*.

備註: CGI scripts run by the *CGIHTTPRequestHandler* class cannot execute redirects (HTTP code 302), because code 200 (script output follows) is sent prior to execution of the CGI script. This pre-empts the status code.

The class will however, run the CGI script, instead of serving it as a file, if it guesses it to be a CGI script. Only directory-based CGI are used --- the other common server configuration is to treat special extensions as denoting CGI scripts.

The `do_GET()` and `do_HEAD()` functions are modified to run CGI scripts and serve the output, instead of serving files, if the request leads to somewhere below the `cgi_directories` path.

The *CGIHTTPRequestHandler* defines the following data member:

`cgi_directories`

This defaults to `['/cgi-bin', '/htbin']` and describes directories to treat as containing CGI scripts.

The *CGIHTTPRequestHandler* defines the following method:

`do_POST()`

This method serves the 'POST' request type, only allowed for CGI scripts. Error 501, "Can only POST to CGI scripts", is output when trying to POST to a non-CGI url.

Note that CGI scripts will be run with UID of user nobody, for security reasons. Problems with the CGI script will be translated to error 403.

CGIHTTPRequestHandler can be enabled in the command line by passing the `--cgi` option:

```
python -m http.server --cgi
```

警告: *CGIHTTPRequestHandler* and the `--cgi` command line option are not intended for use by untrusted clients and may be vulnerable to exploitation. Always use within a secure environment.

21.17.1 Security Considerations

SimpleHTTPRequestHandler will follow symbolic links when handling requests, this makes it possible for files outside of the specified directory to be served.

Earlier versions of Python did not scrub control characters from the log messages emitted to stderr from `python -m http.server` or the default *BaseHTTPRequestHandler*.`log_message` implementation. This could allow remote clients connecting to your server to send nefarious control codes to your terminal.

在 3.11.1 版的變更: Control characters are scrubbed in stderr logs.

21.18 http.cookies --- HTTP state management

原始碼: [Lib/http/cookies.py](https://lib.python.org/3.11.8/http/cookies.py)

The `http.cookies` module defines classes for abstracting the concept of cookies, an HTTP state management mechanism. It supports both simple string-only cookies, and provides an abstraction for having any serializable data-type as cookie value.

The module formerly strictly applied the parsing rules described in the [RFC 2109](#) and [RFC 2068](#) specifications. It has since been discovered that MSIE 3.0x didn't follow the character rules outlined in those specs; many current-day browsers and servers have also relaxed parsing rules when it comes to cookie handling. As a result, this module now uses parsing rules that are a bit less strict than they once were.

The character set, `string.ascii_letters`, `string.digits` and `!#$%&'*+-.^_`|~:` denote the set of valid characters allowed by this module in a cookie name (as *key*).

在 3.3 版的變更: Allowed `'` as a valid cookie name character.

備註: On encountering an invalid cookie, `CookieError` is raised, so if your cookie data comes from a browser you should always prepare for invalid data and catch `CookieError` on parsing.

exception `http.cookies.CookieError`

Exception failing because of [RFC 2109](#) invalidity: incorrect attributes, incorrect *Set-Cookie* header, etc.

class `http.cookies.BaseCookie` (`[input]`)

This class is a dictionary-like object whose keys are strings and whose values are *Morsel* instances. Note that upon setting a key to a value, the value is first converted to a *Morsel* containing the key and the value.

If *input* is given, it is passed to the `load()` method.

class `http.cookies.SimpleCookie` (`[input]`)

This class derives from *BaseCookie* and overrides `value_decode()` and `value_encode()`. *SimpleCookie* supports strings as cookie values. When setting the value, *SimpleCookie* calls the builtin `str()` to convert the value to a string. Values received from HTTP are kept as strings.

也參考:

[http.cookiejar](#) 模組

HTTP cookie handling for web *clients*. The `http.cookiejar` and `http.cookies` modules do not depend on each other.

[RFC 2109](#) - HTTP State Management Mechanism

This is the state management specification implemented by this module.

21.18.1 Cookie 物件

`BaseCookie.value_decode(val)`

Return a tuple (*real_value*, *coded_value*) from a string representation. *real_value* can be any type. This method does no decoding in *BaseCookie* --- it exists so it can be overridden.

`BaseCookie.value_encode(val)`

Return a tuple (*real_value*, *coded_value*). *val* can be any type, but *coded_value* will always be converted to a string. This method does no encoding in *BaseCookie* --- it exists so it can be overridden.

In general, it should be the case that `value_encode()` and `value_decode()` are inverses on the range of `value_decode`.

`BaseCookie.output(attrs=None, header='Set-Cookie:', sep='\r\n')`

Return a string representation suitable to be sent as HTTP headers. *attrs* and *header* are sent to each *Morsel*'s *output()* method. *sep* is used to join the headers together, and is by default the combination `'\r\n'` (CRLF).

`BaseCookie.js_output(attrs=None)`

Return an embeddable JavaScript snippet, which, if run on a browser which supports JavaScript, will act the same as if the HTTP headers was sent.

The meaning for *attrs* is the same as in *output()*.

`BaseCookie.load(rawdata)`

If *rawdata* is a string, parse it as an HTTP_COOKIE and add the values found there as *Morsels*. If it is a dictionary, it is equivalent to:

```
for k, v in rawdata.items():
    cookie[k] = v
```

21.18.2 Morsel 物件

`class http.cookies.Morsel`

Abstract a key/value pair, which has some **RFC 2109** attributes.

Morsels are dictionary-like objects, whose set of keys is constant --- the valid **RFC 2109** attributes, which are:

expires
path
comment
domain
max-age
secure
version
httponly
samesite

The attribute *httponly* specifies that the cookie is only transferred in HTTP requests, and is not accessible through JavaScript. This is intended to mitigate some forms of cross-site scripting.

The attribute *samesite* specifies that the browser is not allowed to send the cookie along with cross-site requests. This helps to mitigate CSRF attacks. Valid values for this attribute are "Strict" and "Lax".

The keys are case-insensitive and their default value is `''`.

在 3.5 版的變更: `__eq__()` now takes *key* and *value* into account.

在 3.7 版的變更: Attributes *key*, *value* and *coded_value* are read-only. Use *set()* for setting them.

在 3.8 版的變更: 新增 *samesite* 屬性的支援

`Morsel.value`

The value of the cookie.

`Morsel.coded_value`

The encoded value of the cookie --- this is what should be sent.

`Morsel.key`

The name of the cookie.

`Morsel.set(key, value, coded_value)`

Set the *key*, *value* and *coded_value* attributes.

`Morsel.isReservedKey(K)`

Whether *K* is a member of the set of keys of a *Morsel*.

`Morsel.output(attrs=None, header='Set-Cookie:')`

Return a string representation of the Morsel, suitable to be sent as an HTTP header. By default, all the attributes are included, unless *attrs* is given, in which case it should be a list of attributes to use. *header* is by default "Set-Cookie:".

`Morsel.js_output(attrs=None)`

Return an embeddable JavaScript snippet, which, if run on a browser which supports JavaScript, will act the same as if the HTTP header was sent.

The meaning for *attrs* is the same as in `output()`.

`Morsel.OutputString(attrs=None)`

Return a string representing the Morsel, without any surrounding HTTP or JavaScript.

The meaning for *attrs* is the same as in `output()`.

`Morsel.update(values)`

Update the values in the Morsel dictionary with the values in the dictionary *values*. Raise an error if any of the keys in the *values* dict is not a valid **RFC 2109** attribute.

在 3.5 版的變更: an error is raised for invalid keys.

`Morsel.copy(value)`

Return a shallow copy of the Morsel object.

在 3.5 版的變更: return a Morsel object instead of a dict.

`Morsel.setdefault(key, value=None)`

Raise an error if key is not a valid **RFC 2109** attribute, otherwise behave the same as `dict.setdefault()`.

21.18.3 范例

The following example demonstrates how to use the `http.cookies` module.

```
>>> from http import cookies
>>> C = cookies.SimpleCookie()
>>> C["fig"] = "newton"
>>> C["sugar"] = "wafer"
>>> print(C) # generate HTTP headers
Set-Cookie: fig=newton
Set-Cookie: sugar=wafer
>>> print(C.output()) # same thing
Set-Cookie: fig=newton
Set-Cookie: sugar=wafer
>>> C = cookies.SimpleCookie()
>>> C["rocky"] = "road"
>>> C["rocky"]["path"] = "/cookie"
>>> print(C.output(header="Cookie:"))
Cookie: rocky=road; Path=/cookie
>>> print(C.output(attrs=[], header="Cookie:"))
Cookie: rocky=road
>>> C = cookies.SimpleCookie()
>>> C.load("chips=ahoy; vienna=finger") # load from a string (HTTP header)
>>> print(C)
Set-Cookie: chips=ahoy
Set-Cookie: vienna=finger
>>> C = cookies.SimpleCookie()
>>> C.load('keebler="E=everybody; L\\"Loves\\"; fudge=\012;"')
>>> print(C)
```

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```

Set-Cookie: keebler="E=everybody; L=\"Loves\"; fudge=\012;"
>>> C = cookies.SimpleCookie()
>>> C["oreo"] = "doublestuff"
>>> C["oreo"]["path"] = "/"
>>> print(C)
Set-Cookie: oreo=doublestuff; Path=/
>>> C = cookies.SimpleCookie()
>>> C["twix"] = "none for you"
>>> C["twix"].value
'none for you'
>>> C = cookies.SimpleCookie()
>>> C["number"] = 7 # equivalent to C["number"] = str(7)
>>> C["string"] = "seven"
>>> C["number"].value
'7'
>>> C["string"].value
'seven'
>>> print(C)
Set-Cookie: number=7
Set-Cookie: string=seven

```

21.19 http.cookiejar --- Cookie handling for HTTP clients

原始碼: Lib/http/cookiejar.py

The `http.cookiejar` module defines classes for automatic handling of HTTP cookies. It is useful for accessing web sites that require small pieces of data -- *cookies* -- to be set on the client machine by an HTTP response from a web server, and then returned to the server in later HTTP requests.

Both the regular Netscape cookie protocol and the protocol defined by [RFC 2965](#) are handled. RFC 2965 handling is switched off by default. [RFC 2109](#) cookies are parsed as Netscape cookies and subsequently treated either as Netscape or RFC 2965 cookies according to the 'policy' in effect. Note that the great majority of cookies on the internet are Netscape cookies. `http.cookiejar` attempts to follow the de-facto Netscape cookie protocol (which differs substantially from that set out in the original Netscape specification), including taking note of the `max-age` and `port` cookie-attributes introduced with RFC 2965.

備註: The various named parameters found in *Set-Cookie* and *Set-Cookie2* headers (eg. domain and expires) are conventionally referred to as *attributes*. To distinguish them from Python attributes, the documentation for this module uses the term *cookie-attribute* instead.

The module defines the following exception:

exception `http.cookiejar.LoadError`

Instances of `FileCookieJar` raise this exception on failure to load cookies from a file. `LoadError` is a subclass of `OSError`.

在 3.3 版的變更: `LoadError` used to be a subtype of `IOError`, which is now an alias of `OSError`.

The following classes are provided:

class `http.cookiejar.CookieJar` (*policy=None*)

policy is an object implementing the `CookiePolicy` interface.

The `CookieJar` class stores HTTP cookies. It extracts cookies from HTTP requests, and returns them in HTTP responses. `CookieJar` instances automatically expire contained cookies when necessary. Subclasses are also responsible for storing and retrieving cookies from a file or database.

class `http.cookiejar.FileCookieJar` (*filename=None, delayload=None, policy=None*)

policy is an object implementing the `CookiePolicy` interface. For the other arguments, see the documentation for the corresponding attributes.

A `CookieJar` which can load cookies from, and perhaps save cookies to, a file on disk. Cookies are **NOT** loaded from the named file until either the `load()` or `revert()` method is called. Subclasses of this class are documented in section *FileCookieJar subclasses and co-operation with web browsers*.

This should not be initialized directly –use its subclasses below instead.

在 3.8 版的變更: The filename parameter supports a *path-like object*.

class `http.cookiejar.CookiePolicy`

This class is responsible for deciding whether each cookie should be accepted from / returned to the server.

class `http.cookiejar.DefaultCookiePolicy` (*blocked_domains=None, allowed_domains=None, netscape=True, rfc2965=False, rfc2109_as_netscape=None, hide_cookie2=False, strict_domain=False, strict_rfc2965_unverifiable=True, strict_ns_unverifiable=False, strict_ns_domain=DefaultCookiePolicy.DomainLiberal, strict_ns_set_initial_dollar=False, strict_ns_set_path=False, secure_protocols=('https', 'wss')*)

Constructor arguments should be passed as keyword arguments only. *blocked_domains* is a sequence of domain names that we never accept cookies from, nor return cookies to. *allowed_domains* if not *None*, this is a sequence of the only domains for which we accept and return cookies. *secure_protocols* is a sequence of protocols for which secure cookies can be added to. By default *https* and *wss* (secure websocket) are considered secure protocols. For all other arguments, see the documentation for `CookiePolicy` and `DefaultCookiePolicy` objects.

`DefaultCookiePolicy` implements the standard accept / reject rules for Netscape and **RFC 2965** cookies. By default, **RFC 2109** cookies (ie. cookies received in a *Set-Cookie* header with a version cookie-attribute of 1) are treated according to the RFC 2965 rules. However, if RFC 2965 handling is turned off or *rfc2109_as_netscape* is *True*, RFC 2109 cookies are 'downgraded' by the `CookieJar` instance to Netscape cookies, by setting the *version* attribute of the `Cookie` instance to 0. `DefaultCookiePolicy` also provides some parameters to allow some fine-tuning of policy.

class `http.cookiejar.Cookie`

This class represents Netscape, **RFC 2109** and **RFC 2965** cookies. It is not expected that users of `http.cookiejar` construct their own `Cookie` instances. Instead, if necessary, call `make_cookies()` on a `CookieJar` instance.

也參考:

`urllib.request` 模組

URL opening with automatic cookie handling.

`http.cookies` 模組

HTTP cookie classes, principally useful for server-side code. The `http.cookiejar` and `http.cookies` modules do not depend on each other.

`https://curl.se/rfc/cookie_spec.html`

The specification of the original Netscape cookie protocol. Though this is still the dominant protocol, the 'Netscape cookie protocol' implemented by all the major browsers (and `http.cookiejar`) only bears a passing resemblance to the one sketched out in `cookie_spec.html`.

RFC 2109 - HTTP State Management Mechanism

Obsoleted by **RFC 2965**. Uses *Set-Cookie* with *version=1*.

RFC 2965 - HTTP State Management Mechanism

The Netscape protocol with the bugs fixed. Uses *Set-Cookie2* in place of *Set-Cookie*. Not widely used.

<http://kristol.org/cookie/errata.html>

Unfinished errata to **RFC 2965**.

RFC 2964 - Use of HTTP State Management

21.19.1 CookieJar 與 FileCookieJar 物件

CookieJar objects support the *iterator* protocol for iterating over contained *Cookie* objects.

CookieJar has the following methods:

`CookieJar.add_cookie_header(request)`

Add correct *Cookie* header to *request*.

If policy allows (ie. the `rfc2965` and `hide_cookie2` attributes of the *CookieJar*'s *CookiePolicy* instance are true and false respectively), the *Cookie2* header is also added when appropriate.

The *request* object (usually a `urllib.request.Request` instance) must support the methods `get_full_url()`, `has_header()`, `get_header()`, `header_items()`, `add_unredirected_header()` and the attributes `host`, `type`, `unverifiable` and `origin_req_host` as documented by `urllib.request`.

在 3.3 版的變更: *request* object needs `origin_req_host` attribute. Dependency on a deprecated method `get_origin_req_host()` has been removed.

`CookieJar.extract_cookies(response, request)`

Extract cookies from HTTP *response* and store them in the *CookieJar*, where allowed by policy.

The *CookieJar* will look for allowable *Set-Cookie* and *Set-Cookie2* headers in the *response* argument, and store cookies as appropriate (subject to the *CookiePolicy.set_ok()* method's approval).

The *response* object (usually the result of a call to `urllib.request.urlopen()`, or similar) should support an `info()` method, which returns an `email.message.Message` instance.

The *request* object (usually a `urllib.request.Request` instance) must support the method `get_full_url()` and the attributes `host`, `unverifiable` and `origin_req_host`, as documented by `urllib.request`. The request is used to set default values for cookie-attributes as well as for checking that the cookie is allowed to be set.

在 3.3 版的變更: *request* object needs `origin_req_host` attribute. Dependency on a deprecated method `get_origin_req_host()` has been removed.

`CookieJar.set_policy(policy)`

Set the *CookiePolicy* instance to be used.

`CookieJar.make_cookies(response, request)`

Return sequence of *Cookie* objects extracted from *response* object.

See the documentation for `extract_cookies()` for the interfaces required of the *response* and *request* arguments.

`CookieJar.set_cookie_if_ok(cookie, request)`

Set a *Cookie* if policy says it's OK to do so.

`CookieJar.set_cookie(cookie)`

Set a *Cookie*, without checking with policy to see whether or not it should be set.

`CookieJar.clear([domain[, path[, name]])`

Clear some cookies.

If invoked without arguments, clear all cookies. If given a single argument, only cookies belonging to that *domain* will be removed. If given two arguments, cookies belonging to the specified *domain* and URL *path* are removed. If given three arguments, then the cookie with the specified *domain*, *path* and *name* is removed.

Raises *KeyError* if no matching cookie exists.

`CookieJar.clear_session_cookies()`

Discard all session cookies.

Discards all contained cookies that have a true `discard` attribute (usually because they had either no `max-age` or `expires` cookie-attribute, or an explicit `discard` cookie-attribute). For interactive browsers, the end of a session usually corresponds to closing the browser window.

Note that the `save()` method won't save session cookies anyway, unless you ask otherwise by passing a true `ignore_discard` argument.

`FileCookieJar` implements the following additional methods:

`FileCookieJar.save(filename=None, ignore_discard=False, ignore_expires=False)`

Save cookies to a file.

This base class raises `NotImplementedError`. Subclasses may leave this method unimplemented.

`filename` is the name of file in which to save cookies. If `filename` is not specified, `self.filename` is used (whose default is the value passed to the constructor, if any); if `self.filename` is `None`, `ValueError` is raised.

`ignore_discard`: save even cookies set to be discarded. `ignore_expires`: save even cookies that have expired

The file is overwritten if it already exists, thus wiping all the cookies it contains. Saved cookies can be restored later using the `load()` or `revert()` methods.

`FileCookieJar.load(filename=None, ignore_discard=False, ignore_expires=False)`

Load cookies from a file.

Old cookies are kept unless overwritten by newly loaded ones.

Arguments are as for `save()`.

The named file must be in the format understood by the class, or `LoadError` will be raised. Also, `OSError` may be raised, for example if the file does not exist.

在 3.3 版的變更: `IOError` used to be raised, it is now an alias of `OSError`.

`FileCookieJar.revert(filename=None, ignore_discard=False, ignore_expires=False)`

Clear all cookies and reload cookies from a saved file.

`revert()` can raise the same exceptions as `load()`. If there is a failure, the object's state will not be altered.

`FileCookieJar` instances have the following public attributes:

`FileCookieJar.filename`

Filename of default file in which to keep cookies. This attribute may be assigned to.

`FileCookieJar.delayload`

If true, load cookies lazily from disk. This attribute should not be assigned to. This is only a hint, since this only affects performance, not behaviour (unless the cookies on disk are changing). A `CookieJar` object may ignore it. None of the `FileCookieJar` classes included in the standard library lazily loads cookies.

21.19.2 FileCookieJar subclasses and co-operation with web browsers

The following `CookieJar` subclasses are provided for reading and writing.

class `http.cookiejar.MozillaCookieJar(filename=None, delayload=None, policy=None)`

A `FileCookieJar` that can load from and save cookies to disk in the Mozilla `cookies.txt` file format (which is also used by curl and the Lynx and Netscape browsers).

備 F: This loses information about **RFC 2965** cookies, and also about newer or non-standard cookie-attributes such as `port`.

警告: Back up your cookies before saving if you have cookies whose loss / corruption would be inconvenient (there are some subtleties which may lead to slight changes in the file over a load / save round-trip).

Also note that cookies saved while Mozilla is running will get clobbered by Mozilla.

class `http.cookiejar.LWPCookieJar` (*filename=None, delayload=None, policy=None*)

A *FileCookieJar* that can load from and save cookies to disk in format compatible with the libwww-perl library's Set-Cookie3 file format. This is convenient if you want to store cookies in a human-readable file.

在 3.8 版的變更: The filename parameter supports a *path-like object*.

21.19.3 CookiePolicy 物件

Objects implementing the *CookiePolicy* interface have the following methods:

`CookiePolicy.set_ok(cookie, request)`

Return boolean value indicating whether cookie should be accepted from server.

cookie is a *Cookie* instance. *request* is an object implementing the interface defined by the documentation for *CookieJar.extract_cookies()*.

`CookiePolicy.return_ok(cookie, request)`

Return boolean value indicating whether cookie should be returned to server.

cookie is a *Cookie* instance. *request* is an object implementing the interface defined by the documentation for *CookieJar.add_cookie_header()*.

`CookiePolicy.domain_return_ok(domain, request)`

Return False if cookies should not be returned, given cookie domain.

This method is an optimization. It removes the need for checking every cookie with a particular domain (which might involve reading many files). Returning true from *domain_return_ok()* and *path_return_ok()* leaves all the work to *return_ok()*.

If *domain_return_ok()* returns true for the cookie domain, *path_return_ok()* is called for the cookie path. Otherwise, *path_return_ok()* and *return_ok()* are never called for that cookie domain. If *path_return_ok()* returns true, *return_ok()* is called with the *Cookie* object itself for a full check. Otherwise, *return_ok()* is never called for that cookie path.

Note that *domain_return_ok()* is called for every *cookie* domain, not just for the *request* domain. For example, the function might be called with both ".example.com" and "www.example.com" if the request domain is "www.example.com". The same goes for *path_return_ok()*.

The *request* argument is as documented for *return_ok()*.

`CookiePolicy.path_return_ok(path, request)`

Return False if cookies should not be returned, given cookie path.

關於 *domain_return_ok()* 請見文件。

In addition to implementing the methods above, implementations of the *CookiePolicy* interface must also supply the following attributes, indicating which protocols should be used, and how. All of these attributes may be assigned to.

`CookiePolicy.netscape`

Implement Netscape protocol.

`CookiePolicy.rfc2965`

Implement **RFC 2965** protocol.

`CookiePolicy.hide_cookie2`

Don't add `Cookie2` header to requests (the presence of this header indicates to the server that we understand [RFC 2965](#) cookies).

The most useful way to define a `CookiePolicy` class is by subclassing from `DefaultCookiePolicy` and overriding some or all of the methods above. `CookiePolicy` itself may be used as a 'null policy' to allow setting and receiving any and all cookies (this is unlikely to be useful).

21.19.4 DefaultCookiePolicy 物件

Implements the standard rules for accepting and returning cookies.

Both [RFC 2965](#) and Netscape cookies are covered. RFC 2965 handling is switched off by default.

The easiest way to provide your own policy is to override this class and call its methods in your overridden implementations before adding your own additional checks:

```
import http.cookiejar
class MyCookiePolicy(http.cookiejar.DefaultCookiePolicy):
    def set_ok(self, cookie, request):
        if not http.cookiejar.DefaultCookiePolicy.set_ok(self, cookie, request):
            return False
        if i_dont_want_to_store_this_cookie(cookie):
            return False
        return True
```

In addition to the features required to implement the `CookiePolicy` interface, this class allows you to block and allow domains from setting and receiving cookies. There are also some strictness switches that allow you to tighten up the rather loose Netscape protocol rules a little bit (at the cost of blocking some benign cookies).

A domain blocklist and allowlist is provided (both off by default). Only domains not in the blocklist and present in the allowlist (if the allowlist is active) participate in cookie setting and returning. Use the `blocked_domains` constructor argument, and `blocked_domains()` and `set_blocked_domains()` methods (and the corresponding argument and methods for `allowed_domains`). If you set an allowlist, you can turn it off again by setting it to `None`.

Domains in block or allow lists that do not start with a dot must equal the cookie domain to be matched. For example, "example.com" matches a blocklist entry of "example.com", but "www.example.com" does not. Domains that do start with a dot are matched by more specific domains too. For example, both "www.example.com" and "www.coyote.example.com" match ".example.com" (but "example.com" itself does not). IP addresses are an exception, and must match exactly. For example, if `blocked_domains` contains "192.168.1.2" and ".168.1.2", 192.168.1.2 is blocked, but 193.168.1.2 is not.

`DefaultCookiePolicy` implements the following additional methods:

`DefaultCookiePolicy.blocked_domains()`

Return the sequence of blocked domains (as a tuple).

`DefaultCookiePolicy.set_blocked_domains(blocked_domains)`

Set the sequence of blocked domains.

`DefaultCookiePolicy.is_blocked(domain)`

Return True if `domain` is on the blocklist for setting or receiving cookies.

`DefaultCookiePolicy.allowed_domains()`

Return `None`, or the sequence of allowed domains (as a tuple).

`DefaultCookiePolicy.set_allowed_domains(allowed_domains)`

Set the sequence of allowed domains, or `None`.

`DefaultCookiePolicy.is_not_allowed(domain)`

Return True if `domain` is not on the allowlist for setting or receiving cookies.

`DefaultCookiePolicy` instances have the following attributes, which are all initialised from the constructor arguments of the same name, and which may all be assigned to.

`DefaultCookiePolicy.rfc2109_as_netscape`

If true, request that the `CookieJar` instance downgrade **RFC 2109** cookies (ie. cookies received in a `Set-Cookie` header with a version cookie-attribute of 1) to Netscape cookies by setting the version attribute of the `Cookie` instance to 0. The default value is `None`, in which case RFC 2109 cookies are downgraded if and only if **RFC 2965** handling is turned off. Therefore, RFC 2109 cookies are downgraded by default.

General strictness switches:

`DefaultCookiePolicy.strict_domain`

Don't allow sites to set two-component domains with country-code top-level domains like `.co.uk`, `.gov.uk`, `.co.nz`.etc. This is far from perfect and isn't guaranteed to work!

RFC 2965 protocol strictness switches:

`DefaultCookiePolicy.strict_rfc2965_unverifiable`

Follow **RFC 2965** rules on unverifiable transactions (usually, an unverifiable transaction is one resulting from a redirect or a request for an image hosted on another site). If this is false, cookies are *never* blocked on the basis of verifiability

Netscape protocol strictness switches:

`DefaultCookiePolicy.strict_ns_unverifiable`

Apply **RFC 2965** rules on unverifiable transactions even to Netscape cookies.

`DefaultCookiePolicy.strict_ns_domain`

Flags indicating how strict to be with domain-matching rules for Netscape cookies. See below for acceptable values.

`DefaultCookiePolicy.strict_ns_set_initial_dollar`

Ignore cookies in Set-Cookie: headers that have names starting with '\$'.

`DefaultCookiePolicy.strict_ns_set_path`

Don't allow setting cookies whose path doesn't path-match request URI.

`strict_ns_domain` is a collection of flags. Its value is constructed by or-ing together (for example, `DomainStrictNoDots|DomainStrictNonDomain` means both flags are set).

`DefaultCookiePolicy.DomainStrictNoDots`

When setting cookies, the 'host prefix' must not contain a dot (eg. `www.foo.bar.com` can't set a cookie for `.bar.com`, because `www.foo` contains a dot).

`DefaultCookiePolicy.DomainStrictNonDomain`

Cookies that did not explicitly specify a domain cookie-attribute can only be returned to a domain equal to the domain that set the cookie (eg. `spam.example.com` won't be returned cookies from `example.com` that had no domain cookie-attribute).

`DefaultCookiePolicy.DomainRFC2965Match`

When setting cookies, require a full **RFC 2965** domain-match.

The following attributes are provided for convenience, and are the most useful combinations of the above flags:

`DefaultCookiePolicy.DomainLiberal`

Equivalent to 0 (ie. all of the above Netscape domain strictness flags switched off).

`DefaultCookiePolicy.DomainStrict`

等價於 `DomainStrictNoDots|DomainStrictNonDomain`.

21.19.5 Cookie 物件

Cookie instances have Python attributes roughly corresponding to the standard cookie-attributes specified in the various cookie standards. The correspondence is not one-to-one, because there are complicated rules for assigning default values, because the `max-age` and `expires` cookie-attributes contain equivalent information, and because **RFC 2109** cookies may be 'downgraded' by *http.cookiejar* from version 1 to version 0 (Netscape) cookies.

Assignment to these attributes should not be necessary other than in rare circumstances in a *CookiePolicy* method. The class does not enforce internal consistency, so you should know what you're doing if you do that.

`Cookie.version`

Integer or *None*. Netscape cookies have *version* 0. **RFC 2965** and **RFC 2109** cookies have a *version* cookie-attribute of 1. However, note that *http.cookiejar* may 'downgrade' RFC 2109 cookies to Netscape cookies, in which case *version* is 0.

`Cookie.name`

Cookie name (a string).

`Cookie.value`

Cookie value (a string), or *None*.

`Cookie.port`

String representing a port or a set of ports (eg. '80', or '80,8080'), or *None*.

`Cookie.domain`

Cookie domain (a string).

`Cookie.path`

Cookie path (a string, eg. '/acme/rocket_launchers').

`Cookie.secure`

True if cookie should only be returned over a secure connection.

`Cookie.expires`

Integer expiry date in seconds since epoch, or *None*. See also the *is_expired()* method.

`Cookie.discard`

True if this is a session cookie.

`Cookie.comment`

String comment from the server explaining the function of this cookie, or *None*.

`Cookie.comment_url`

URL linking to a comment from the server explaining the function of this cookie, or *None*.

`Cookie.rfc2109`

True if this cookie was received as an **RFC 2109** cookie (ie. the cookie arrived in a *Set-Cookie* header, and the value of the Version cookie-attribute in that header was 1). This attribute is provided because *http.cookiejar* may 'downgrade' RFC 2109 cookies to Netscape cookies, in which case *version* is 0.

`Cookie.port_specified`

True if a port or set of ports was explicitly specified by the server (in the *Set-Cookie* / *Set-Cookie2* header).

`Cookie.domain_specified`

True if a domain was explicitly specified by the server.

`Cookie.domain_initial_dot`

True if the domain explicitly specified by the server began with a dot ('.').

Cookies may have additional non-standard cookie-attributes. These may be accessed using the following methods:

`Cookie.has_nonstandard_attr(name)`

Return True if cookie has the named cookie-attribute.

`Cookie.get_nonstandard_attr(name, default=None)`

If cookie has the named cookie-attribute, return its value. Otherwise, return *default*.

`Cookie.set_nonstandard_attr(name, value)`

Set the value of the named cookie-attribute.

The `Cookie` class also defines the following method:

`Cookie.is_expired(now=None)`

True if cookie has passed the time at which the server requested it should expire. If *now* is given (in seconds since the epoch), return whether the cookie has expired at the specified time.

21.19.6 范例

The first example shows the most common usage of `http.cookiejar`:

```
import http.cookiejar, urllib.request
cj = http.cookiejar.CookieJar()
opener = urllib.request.build_opener(urllib.request.HTTPCookieProcessor(cj))
r = opener.open("http://example.com/")
```

This example illustrates how to open a URL using your Netscape, Mozilla, or Lynx cookies (assumes Unix/Netscape convention for location of the cookies file):

```
import os, http.cookiejar, urllib.request
cj = http.cookiejar.MozillaCookieJar()
cj.load(os.path.join(os.path.expanduser("~"), ".netscape", "cookies.txt"))
opener = urllib.request.build_opener(urllib.request.HTTPCookieProcessor(cj))
r = opener.open("http://example.com/")
```

The next example illustrates the use of `DefaultCookiePolicy`. Turn on **RFC 2965** cookies, be more strict about domains when setting and returning Netscape cookies, and block some domains from setting cookies or having them returned:

```
import urllib.request
from http.cookiejar import CookieJar, DefaultCookiePolicy
policy = DefaultCookiePolicy(
    rfc2965=True, strict_ns_domain=Policy.DomainStrict,
    blocked_domains=["ads.net", ".ads.net"])
cj = CookieJar(policy)
opener = urllib.request.build_opener(urllib.request.HTTPCookieProcessor(cj))
r = opener.open("http://example.com/")
```

21.20 xmlrpc --- XMLRPC server and client modules

XML-RPC 是一種遠端程序呼叫 (Remote Procedure Call) 方法，它使用通過 HTTP 傳輸 (transport) 的 XML 來做傳遞。有了它，客戶端可以在遠端伺服器上呼叫帶有參數的方法（伺服器以 URI 命名）獲取結構化的資料。

`xmlrpc` 是一個集合了 XML-RPC 伺服器與客戶端模組實作的套件。這些模組是：

- `xmlrpc.client`
- `xmlrpc.server`

21.21 `xmlrpc.client` --- XML-RPC client access

原始碼: [Lib/xmlrpc/client.py](#)

XML-RPC is a Remote Procedure Call method that uses XML passed via HTTP(S) as a transport. With it, a client can call methods with parameters on a remote server (the server is named by a URI) and get back structured data. This module supports writing XML-RPC client code; it handles all the details of translating between conformable Python objects and XML on the wire.

警告: The `xmlrpc.client` module is not secure against maliciously constructed data. If you need to parse untrusted or unauthenticated data see [XML vulnerabilities](#).

在 3.5 版的變更: For HTTPS URIs, `xmlrpc.client` now performs all the necessary certificate and hostname checks by default.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

```
class xmlrpc.client.ServerProxy(uri, transport=None, encoding=None, verbose=False,
                                allow_none=False, use_datetime=False, use_builtin_types=False,
                                *, headers=(), context=None)
```

A `ServerProxy` instance is an object that manages communication with a remote XML-RPC server. The required first argument is a URI (Uniform Resource Indicator), and will normally be the URL of the server. The optional second argument is a transport factory instance; by default it is an internal `SafeTransport` instance for https: URLs and an internal `HTTPTransport` instance otherwise. The optional third argument is an encoding, by default UTF-8. The optional fourth argument is a debugging flag.

The following parameters govern the use of the returned proxy instance. If `allow_none` is true, the Python constant `None` will be translated into XML; the default behaviour is for `None` to raise a `TypeError`. This is a commonly used extension to the XML-RPC specification, but isn't supported by all clients and servers; see <http://ontosys.com/xml-rpc/extensions.php> for a description. The `use_builtin_types` flag can be used to cause date/time values to be presented as `datetime.datetime` objects and binary data to be presented as `bytes` objects; this flag is false by default. `datetime.datetime`, `bytes` and `bytearray` objects may be passed to calls. The `headers` parameter is an optional sequence of HTTP headers to send with each request, expressed as a sequence of 2-tuples representing the header name and value. (e.g. `[('Header-Name', 'value')]`). The obsolete `use_datetime` flag is similar to `use_builtin_types` but it applies only to date/time values.

在 3.3 版的變更: 新增 `use_builtin_types` 旗標。

在 3.8 版的變更: 新增 `headers` 參數。

Both the HTTP and HTTPS transports support the URL syntax extension for HTTP Basic Authentication: `http://user:pass@host:port/path`. The `user:pass` portion will be base64-encoded as an HTTP 'Authorization' header, and sent to the remote server as part of the connection process when invoking an XML-RPC method. You only need to use this if the remote server requires a Basic Authentication user and password. If an HTTPS URL is provided, `context` may be `ssl.SSLContext` and configures the SSL settings of the underlying HTTPS connection.

The returned instance is a proxy object with methods that can be used to invoke corresponding RPC calls on the remote server. If the remote server supports the introspection API, the proxy can also be used to query the remote server for the methods it supports (service discovery) and fetch other server-associated metadata.

Types that are conformable (e.g. that can be marshalled through XML), include the following (and except where noted, they are unmarshalled as the same Python type):

XML-RPC type	Python type
boolean	<i>bool</i>
int, i1, i2, i4, i8 或 biginteger	<i>int</i> in range from -2147483648 to 2147483647. Values get the <code><int></code> tag.
double 或 float	<i>float</i> . Values get the <code><double></code> tag.
string	<i>str</i>
array	<i>list</i> or <i>tuple</i> containing conformable elements. Arrays are returned as <i>lists</i> .
struct	<i>dict</i> . Keys must be strings, values may be any conformable type. Objects of user-defined classes can be passed in; only their <code>__dict__</code> attribute is transmitted.
dateTime.iso8601	<i>DateTime</i> or <i>datetime.datetime</i> . Returned type depends on values of <i>use_builtin_types</i> and <i>use_datetime</i> flags.
base64	<i>Binary</i> , <i>bytes</i> or <i>bytearray</i> . Returned type depends on the value of the <i>use_builtin_types</i> flag.
nil	The <code>None</code> constant. Passing is allowed only if <i>allow_none</i> is true.
bigdecimal	<i>decimal.Decimal</i> . Returned type only.

This is the full set of data types supported by XML-RPC. Method calls may also raise a special *Fault* instance, used to signal XML-RPC server errors, or *ProtocolError* used to signal an error in the HTTP/HTTPS transport layer. Both *Fault* and *ProtocolError* derive from a base class called `Error`. Note that the `xmlrpc` client module currently does not marshal instances of subclasses of built-in types.

When passing strings, characters special to XML such as `<`, `>`, and `&` will be automatically escaped. However, it's the caller's responsibility to ensure that the string is free of characters that aren't allowed in XML, such as the control characters with ASCII values between 0 and 31 (except, of course, tab, newline and carriage return); failing to do this will result in an XML-RPC request that isn't well-formed XML. If you have to pass arbitrary bytes via XML-RPC, use *bytes* or *bytearray* classes or the *Binary* wrapper class described below.

Server is retained as an alias for *ServerProxy* for backwards compatibility. New code should use *ServerProxy*.

在 3.5 版的變更: 加入 *context* 引數。

在 3.6 版的變更: Added support of type tags with prefixes (e.g. `ex:nil`). Added support of unmarshalling additional types used by Apache XML-RPC implementation for numerics: `i1`, `i2`, `i8`, `biginteger`, `float` and `bigdecimal`. See <https://ws.apache.org/xmlrpc/types.html> for a description.

也參考:

XML-RPC HOWTO

A good description of XML-RPC operation and client software in several languages. Contains pretty much everything an XML-RPC client developer needs to know.

XML-RPC Introspection

Describes the XML-RPC protocol extension for introspection.

XML-RPC Specification

The official specification.

21.21.1 ServerProxy 物件

A *ServerProxy* instance has a method corresponding to each remote procedure call accepted by the XML-RPC server. Calling the method performs an RPC, dispatched by both name and argument signature (e.g. the same method name can be overloaded with multiple argument signatures). The RPC finishes by returning a value, which may be either returned data in a conformant type or a *Fault* or *ProtocolError* object indicating an error.

Servers that support the XML introspection API support some common methods grouped under the reserved `system` attribute:

`ServerProxy.system.listMethods()`

This method returns a list of strings, one for each (non-system) method supported by the XML-RPC server.

`ServerProxy.system.methodSignature(name)`

This method takes one parameter, the name of a method implemented by the XML-RPC server. It returns an array of possible signatures for this method. A signature is an array of types. The first of these types is the return type of the method, the rest are parameters.

Because multiple signatures (ie. overloading) is permitted, this method returns a list of signatures rather than a singleton.

Signatures themselves are restricted to the top level parameters expected by a method. For instance if a method expects one array of structs as a parameter, and it returns a string, its signature is simply "string, array". If it expects three integers and returns a string, its signature is "string, int, int, int".

If no signature is defined for the method, a non-array value is returned. In Python this means that the type of the returned value will be something other than list.

`ServerProxy.system.methodHelp(name)`

This method takes one parameter, the name of a method implemented by the XML-RPC server. It returns a documentation string describing the use of that method. If no such string is available, an empty string is returned. The documentation string may contain HTML markup.

在 3.5 版的變更: Instances of *ServerProxy* support the *context manager* protocol for closing the underlying transport.

A working example follows. The server code:

```
from xmlrpc.server import SimpleXMLRPCServer

def is_even(n):
    return n % 2 == 0

server = SimpleXMLRPCServer(("localhost", 8000))
print("Listening on port 8000...")
server.register_function(is_even, "is_even")
server.serve_forever()
```

The client code for the preceding server:

```
import xmlrpc.client

with xmlrpc.client.ServerProxy("http://localhost:8000/") as proxy:
    print("3 is even: %s" % str(proxy.is_even(3)))
    print("100 is even: %s" % str(proxy.is_even(100)))
```

21.21.2 日期時間物件

class xmlrpc.client.DateTime

This class may be initialized with seconds since the epoch, a time tuple, an ISO 8601 time/date string, or a `datetime.datetime` instance. It has the following methods, supported mainly for internal use by the marshalling/unmarshalling code:

decode (*string*)

Accept a string as the instance's new time value.

encode (*out*)

Write the XML-RPC encoding of this `DateTime` item to the *out* stream object.

It also supports certain of Python's built-in operators through `rich comparison` and `__repr__()` methods.

A working example follows. The server code:

```
import datetime
from xmlrpc.server import SimpleXMLRPCServer
import xmlrpc.client

def today():
    today = datetime.datetime.today()
    return xmlrpc.client.DateTime(today)

server = SimpleXMLRPCServer(("localhost", 8000))
print("Listening on port 8000...")
server.register_function(today, "today")
server.serve_forever()
```

The client code for the preceding server:

```
import xmlrpc.client
import datetime

proxy = xmlrpc.client.ServerProxy("http://localhost:8000/")

today = proxy.today()
# convert the ISO8601 string to a datetime object
converted = datetime.datetime.strptime(today.value, "%Y%m%dT%H:%M:%S")
print("Today: %s" % converted.strftime("%d.%m.%Y, %H:%M"))
```

21.21.3 Binary Objects

class xmlrpc.client.Binary

This class may be initialized from bytes data (which may include NULs). The primary access to the content of a `Binary` object is provided by an attribute:

data

The binary data encapsulated by the `Binary` instance. The data is provided as a `bytes` object.

`Binary` objects have the following methods, supported mainly for internal use by the marshalling/unmarshalling code:

decode (*bytes*)

Accept a base64 `bytes` object and decode it as the instance's new data.

encode (*out*)

Write the XML-RPC base 64 encoding of this binary item to the *out* stream object.

The encoded data will have newlines every 76 characters as per [RFC 2045 section 6.8](#), which was the de facto standard base64 specification when the XML-RPC spec was written.

It also supports certain of Python's built-in operators through `__eq__()` and `__ne__()` methods.

Example usage of the binary objects. We're going to transfer an image over XMLRPC:

```
from xmlrpc.server import SimpleXMLRPCServer
import xmlrpc.client

def python_logo():
    with open("python_logo.jpg", "rb") as handle:
        return xmlrpc.client.Binary(handle.read())

server = SimpleXMLRPCServer(("localhost", 8000))
print("Listening on port 8000...")
server.register_function(python_logo, 'python_logo')

server.serve_forever()
```

The client gets the image and saves it to a file:

```
import xmlrpc.client

proxy = xmlrpc.client.ServerProxy("http://localhost:8000/")
with open("fetched_python_logo.jpg", "wb") as handle:
    handle.write(proxy.python_logo().data)
```

21.21.4 Fault Objects

`class xmlrpc.client.Fault`

A *Fault* object encapsulates the content of an XML-RPC fault tag. Fault objects have the following attributes:

faultCode

An int indicating the fault type.

faultString

A string containing a diagnostic message associated with the fault.

In the following example we're going to intentionally cause a *Fault* by returning a complex type object. The server code:

```
from xmlrpc.server import SimpleXMLRPCServer

# A marshalling error is going to occur because we're returning a
# complex number
def add(x, y):
    return x+y+0j

server = SimpleXMLRPCServer(("localhost", 8000))
print("Listening on port 8000...")
server.register_function(add, 'add')

server.serve_forever()
```

The client code for the preceding server:

```
import xmlrpc.client

proxy = xmlrpc.client.ServerProxy("http://localhost:8000/")
try:
    proxy.add(2, 5)
except xmlrpc.client.Fault as err:
    print("A fault occurred")
    print("Fault code: %d" % err.faultCode)
    print("Fault string: %s" % err.faultString)
```

21.21.5 ProtocolError 物件

class `xmlrpc.client.ProtocolError`

A *ProtocolError* object describes a protocol error in the underlying transport layer (such as a 404 'not found' error if the server named by the URI does not exist). It has the following attributes:

url

The URI or URL that triggered the error.

errcode

The error code.

errmsg

The error message or diagnostic string.

headers

A dict containing the headers of the HTTP/HTTPS request that triggered the error.

In the following example we're going to intentionally cause a *ProtocolError* by providing an invalid URI:

```
import xmlrpc.client

# create a ServerProxy with a URI that doesn't respond to XMLRPC requests
proxy = xmlrpc.client.ServerProxy("http://google.com/")

try:
    proxy.some_method()
except xmlrpc.client.ProtocolError as err:
    print("A protocol error occurred")
    print("URL: %s" % err.url)
    print("HTTP/HTTPS headers: %s" % err.headers)
    print("Error code: %d" % err.errcode)
    print("Error message: %s" % err.errmsg)
```

21.21.6 MultiCall 物件

The *MultiCall* object provides a way to encapsulate multiple calls to a remote server into a single request¹.

class `xmlrpc.client.MultiCall` (*server*)

Create an object used to boxcar method calls. *server* is the eventual target of the call. Calls can be made to the result object, but they will immediately return `None`, and only store the call name and parameters in the *MultiCall* object. Calling the object itself causes all stored calls to be transmitted as a single `system.multicall` request. The result of this call is a *generator*; iterating over this generator yields the individual results.

A usage example of this class follows. The server code:

¹ This approach has been first presented in a [discussion on xmlrpc.com](#).

```

from xmlrpc.server import SimpleXMLRPCServer

def add(x, y):
    return x + y

def subtract(x, y):
    return x - y

def multiply(x, y):
    return x * y

def divide(x, y):
    return x // y

# A simple server with simple arithmetic functions
server = SimpleXMLRPCServer(("localhost", 8000))
print("Listening on port 8000...")
server.register_multicall_functions()
server.register_function(add, 'add')
server.register_function(subtract, 'subtract')
server.register_function(multiply, 'multiply')
server.register_function(divide, 'divide')
server.serve_forever()

```

The client code for the preceding server:

```

import xmlrpc.client

proxy = xmlrpc.client.ServerProxy("http://localhost:8000/")
multicall = xmlrpc.client.MultiCall(proxy)
multicall.add(7, 3)
multicall.subtract(7, 3)
multicall.multiply(7, 3)
multicall.divide(7, 3)
result = multicall()

print("7+3=%d, 7-3=%d, 7*3=%d, 7//3=%d" % tuple(result))

```

21.21.7 Convenience Functions

`xmlrpc.client.dumps` (*params*, *methodname=None*, *methodresponse=None*, *encoding=None*, *allow_none=False*)

Convert *params* into an XML-RPC request, or into a response if *methodresponse* is true. *params* can be either a tuple of arguments or an instance of the `Fault` exception class. If *methodresponse* is true, only a single value can be returned, meaning that *params* must be of length 1. *encoding*, if supplied, is the encoding to use in the generated XML; the default is UTF-8. Python's `None` value cannot be used in standard XML-RPC; to allow using it via an extension, provide a true value for *allow_none*.

`xmlrpc.client.loads` (*data*, *use_datetime=False*, *use_builtin_types=False*)

Convert an XML-RPC request or response into Python objects, a (*params*, *methodname*). *params* is a tuple of argument; *methodname* is a string, or `None` if no method name is present in the packet. If the XML-RPC packet represents a fault condition, this function will raise a `Fault` exception. The *use_builtin_types* flag can be used to cause date/time values to be presented as `datetime.datetime` objects and binary data to be presented as `bytes` objects; this flag is false by default.

The obsolete *use_datetime* flag is similar to *use_builtin_types* but it applies only to date/time values.

在 3.3 版的變更: 新增 *use_builtin_types* 旗標。

21.21.8 Example of Client Usage

```
# simple test program (from the XML-RPC specification)
from xmlrpc.client import ServerProxy, Error

# server = ServerProxy("http://localhost:8000") # local server
with ServerProxy("http://betty.userland.com") as proxy:

    print(proxy)

    try:
        print(proxy.examples.getStateName(41))
    except Error as v:
        print("ERROR", v)
```

To access an XML-RPC server through a HTTP proxy, you need to define a custom transport. The following example shows how:

```
import http.client
import xmlrpc.client

class ProxiedTransport(xmlrpc.client.Transport):

    def set_proxy(self, host, port=None, headers=None):
        self.proxy = host, port
        self.proxy_headers = headers

    def make_connection(self, host):
        connection = http.client.HTTPConnection(*self.proxy)
        connection.set_tunnel(host, headers=self.proxy_headers)
        self._connection = host, connection
        return connection

transport = ProxiedTransport()
transport.set_proxy('proxy-server', 8080)
server = xmlrpc.client.ServerProxy('http://betty.userland.com',
    ↪transport=transport)
print(server.examples.getStateName(41))
```

21.21.9 Example of Client and Server Usage

See *SimpleXMLRPCServer* 範例.

解

21.22 xmlrpc.server --- Basic XML-RPC servers

原始碼: `Lib/xmlrpc/server.py`

The `xmlrpc.server` module provides a basic server framework for XML-RPC servers written in Python. Servers can either be free standing, using *SimpleXMLRPCServer*, or embedded in a CGI environment, using *CGIXMLRPCRequestHandler*.

警告: The `xmlrpc.server` module is not secure against maliciously constructed data. If you need to parse untrusted or unauthenticated data see *XML vulnerabilities*.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

```
class xmlrpc.server.SimpleXMLRPCServer (addr, requestHandler=SimpleXMLRPCRequestHandler,
                                         logRequests=True, allow_none=False, encoding=None,
                                         bind_and_activate=True, use_builtin_types=False)
```

Create a new server instance. This class provides methods for registration of functions that can be called by the XML-RPC protocol. The `requestHandler` parameter should be a factory for request handler instances; it defaults to `SimpleXMLRPCRequestHandler`. The `addr` and `requestHandler` parameters are passed to the `socketserver.TCPServer` constructor. If `logRequests` is true (the default), requests will be logged; setting this parameter to false will turn off logging. The `allow_none` and `encoding` parameters are passed on to `xmlrpc.client` and control the XML-RPC responses that will be returned from the server. The `bind_and_activate` parameter controls whether `server_bind()` and `server_activate()` are called immediately by the constructor; it defaults to true. Setting it to false allows code to manipulate the `allow_reuse_address` class variable before the address is bound. The `use_builtin_types` parameter is passed to the `loads()` function and controls which types are processed when date/times values or binary data are received; it defaults to false.

在 3.3 版的變更: The `use_builtin_types` flag was added.

```
class xmlrpc.server.CGIXMLRPCRequestHandler (allow_none=False, encoding=None,
                                              use_builtin_types=False)
```

Create a new instance to handle XML-RPC requests in a CGI environment. The `allow_none` and `encoding` parameters are passed on to `xmlrpc.client` and control the XML-RPC responses that will be returned from the server. The `use_builtin_types` parameter is passed to the `loads()` function and controls which types are processed when date/times values or binary data are received; it defaults to false.

在 3.3 版的變更: The `use_builtin_types` flag was added.

```
class xmlrpc.server.SimpleXMLRPCRequestHandler
```

Create a new request handler instance. This request handler supports POST requests and modifies logging so that the `logRequests` parameter to the `SimpleXMLRPCServer` constructor parameter is honored.

21.22.1 SimpleXMLRPCServer 物件

The `SimpleXMLRPCServer` class is based on `socketserver.TCPServer` and provides a means of creating simple, stand alone XML-RPC servers.

```
SimpleXMLRPCServer.register_function (function=None, name=None)
```

Register a function that can respond to XML-RPC requests. If `name` is given, it will be the method name associated with `function`, otherwise `function.__name__` will be used. `name` is a string, and may contain characters not legal in Python identifiers, including the period character.

This method can also be used as a decorator. When used as a decorator, `name` can only be given as a keyword argument to register `function` under `name`. If no `name` is given, `function.__name__` will be used.

在 3.7 版的變更: `register_function()` 也可被當作裝飾器使用。

```
SimpleXMLRPCServer.register_instance (instance, allow_dotted_names=False)
```

Register an object which is used to expose method names which have not been registered using `register_function()`. If `instance` contains a `_dispatch()` method, it is called with the requested method name and the parameters from the request. Its API is `def _dispatch(self, method, params)` (note that `params` does not represent a variable argument list). If it calls an underlying function to perform its task, that function is called as `func(*params)`, expanding the parameter list. The return value from `_dispatch()` is returned to the client as the result. If `instance` does not have a `_dispatch()` method, it is searched for an attribute matching the name of the requested method.

If the optional `allow_dotted_names` argument is true and the instance does not have a `_dispatch()` method, then if the requested method name contains periods, each component of the method name is searched for

individually, with the effect that a simple hierarchical search is performed. The value found from this search is then called with the parameters from the request, and the return value is passed back to the client.

警告: Enabling the `allow_dotted_names` option allows intruders to access your module's global variables and may allow intruders to execute arbitrary code on your machine. Only use this option on a secure, closed network.

`SimpleXMLRPCServer.register_introspection_functions()`

Registers the XML-RPC introspection functions `system.listMethods`, `system.methodHelp` and `system.methodSignature`.

`SimpleXMLRPCServer.register_multicall_functions()`

Registers the XML-RPC multicall function `system.multicall`.

`SimpleXMLRPCRequestHandler.rpc_paths`

An attribute value that must be a tuple listing valid path portions of the URL for receiving XML-RPC requests. Requests posted to other paths will result in a 404 "no such page" HTTP error. If this tuple is empty, all paths will be considered valid. The default value is `('/', '/RPC2')`.

SimpleXMLRPCServer 范例

Server code:

```
from xmlrpc.server import SimpleXMLRPCServer
from xmlrpc.server import SimpleXMLRPCRequestHandler

# Restrict to a particular path.
class RequestHandler(SimpleXMLRPCRequestHandler):
    rpc_paths = ('/RPC2',)

# Create server
with SimpleXMLRPCServer(('localhost', 8000),
                        requestHandler=RequestHandler) as server:
    server.register_introspection_functions()

    # Register pow() function; this will use the value of
    # pow.__name__ as the name, which is just 'pow'.
    server.register_function(pow)

    # Register a function under a different name
    def adder_function(x, y):
        return x + y
    server.register_function(adder_function, 'add')

    # Register an instance; all the methods of the instance are
    # published as XML-RPC methods (in this case, just 'mul').
    class MyFuncs:
        def mul(self, x, y):
            return x * y

    server.register_instance(MyFuncs())

# Run the server's main loop
server.serve_forever()
```

The following client code will call the methods made available by the preceding server:

```
import xmlrpc.client
```

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```
s = xmlrpc.client.ServerProxy('http://localhost:8000')
print(s.pow(2,3))  # Returns 2**3 = 8
print(s.add(2,3))  # Returns 5
print(s.mul(5,2))  # Returns 5*2 = 10

# Print list of available methods
print(s.system.listMethods())
```

`register_function()` can also be used as a decorator. The previous server example can register functions in a decorator way:

```
from xmlrpc.server import SimpleXMLRPCServer
from xmlrpc.server import SimpleXMLRPCRequestHandler

class RequestHandler(SimpleXMLRPCRequestHandler):
    rpc_paths = ('/RPC2',)

with SimpleXMLRPCServer(('localhost', 8000),
                        requestHandler=RequestHandler) as server:
    server.register_introspection_functions()

    # Register pow() function; this will use the value of
    # pow.__name__ as the name, which is just 'pow'.
    server.register_function(pow)

    # Register a function under a different name, using
    # register_function as a decorator. *name* can only be given
    # as a keyword argument.
    @server.register_function(name='add')
    def adder_function(x, y):
        return x + y

    # Register a function under function.__name__.
    @server.register_function
    def mul(x, y):
        return x * y

    server.serve_forever()
```

The following example included in the `Lib/xmlrpc/server.py` module shows a server allowing dotted names and registering a multicall function.

警告: Enabling the `allow_dotted_names` option allows intruders to access your module's global variables and may allow intruders to execute arbitrary code on your machine. Only use this example only within a secure, closed network.

```
import datetime

class ExampleService:
    def getData(self):
        return '42'

    class currentTime:
        @staticmethod
        def getCurrentTime():
            return datetime.datetime.now()

with SimpleXMLRPCServer(("localhost", 8000)) as server:
    server.register_function(pow)
```

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```

server.register_function(lambda x,y: x+y, 'add')
server.register_instance(ExampleService(), allow_dotted_names=True)
server.register_multicall_functions()
print('Serving XML-RPC on localhost port 8000')
try:
    server.serve_forever()
except KeyboardInterrupt:
    print("\nKeyboard interrupt received, exiting.")
    sys.exit(0)

```

This ExampleService demo can be invoked from the command line:

```
python -m xmlrpc.server
```

The client that interacts with the above server is included in Lib/xmlrpc/client.py:

```

server = ServerProxy("http://localhost:8000")

try:
    print(server.currentTime.getCurrentTime())
except Error as v:
    print("ERROR", v)

multi = MultiCall(server)
multi.getData()
multi.pow(2,9)
multi.add(1,2)
try:
    for response in multi():
        print(response)
except Error as v:
    print("ERROR", v)

```

This client which interacts with the demo XMLRPC server can be invoked as:

```
python -m xmlrpc.client
```

21.22.2 CGIXMLRPCRequestHandler

The *CGIXMLRPCRequestHandler* class can be used to handle XML-RPC requests sent to Python CGI scripts.

CGIXMLRPCRequestHandler.register_function (*function=None, name=None*)

Register a function that can respond to XML-RPC requests. If *name* is given, it will be the method name associated with *function*, otherwise *function.__name__* will be used. *name* is a string, and may contain characters not legal in Python identifiers, including the period character.

This method can also be used as a decorator. When used as a decorator, *name* can only be given as a keyword argument to register *function* under *name*. If no *name* is given, *function.__name__* will be used.

在 3.7 版的變更: *register_function()* 也可被當作裝飾器使用。

CGIXMLRPCRequestHandler.register_instance (*instance*)

Register an object which is used to expose method names which have not been registered using *register_function()*. If *instance* contains a *_dispatch()* method, it is called with the requested method name and the parameters from the request; the return value is returned to the client as the result. If *instance* does not have a *_dispatch()* method, it is searched for an attribute matching the name of the requested method; if the requested method name contains periods, each component of the method name is searched for individually, with the effect that a simple hierarchical search is performed. The value found from this search is then called with the parameters from the request, and the return value is passed back to the client.

`CGIXMLRPCRequestHandler.register_introspection_functions()`

Register the XML-RPC introspection functions `system.listMethods`, `system.methodHelp` and `system.methodSignature`.

`CGIXMLRPCRequestHandler.register_multicall_functions()`

Register the XML-RPC multicall function `system.multicall`.

`CGIXMLRPCRequestHandler.handle_request(request_text=None)`

Handle an XML-RPC request. If `request_text` is given, it should be the POST data provided by the HTTP server, otherwise the contents of `stdin` will be used.

範例:

```
class MyFuncs:
    def mul(self, x, y):
        return x * y

handler = CGIXMLRPCRequestHandler()
handler.register_function(pow)
handler.register_function(lambda x,y: x+y, 'add')
handler.register_introspection_functions()
handler.register_instance(MyFuncs())
handler.handle_request()
```

21.22.3 Documenting XMLRPC server

These classes extend the above classes to serve HTML documentation in response to HTTP GET requests. Servers can either be free standing, using [`DocXMLRPCServer`](#), or embedded in a CGI environment, using [`DocCGIXMLRPCRequestHandler`](#).

class `xmlrpc.server.DocXMLRPCServer` (*addr*, *requestHandler=DocXMLRPCRequestHandler*, *logRequests=True*, *allow_none=False*, *encoding=None*, *bind_and_activate=True*, *use_builtin_types=True*)

Create a new server instance. All parameters have the same meaning as for [`SimpleXMLRPCServer`](#); *requestHandler* defaults to [`DocXMLRPCRequestHandler`](#).

在 3.3 版的變更: The *use_builtin_types* flag was added.

class `xmlrpc.server.DocCGIXMLRPCRequestHandler`

Create a new instance to handle XML-RPC requests in a CGI environment.

class `xmlrpc.server.DocXMLRPCRequestHandler`

Create a new request handler instance. This request handler supports XML-RPC POST requests, documentation GET requests, and modifies logging so that the *logRequests* parameter to the [`DocXMLRPCServer`](#) constructor parameter is honored.

21.22.4 DocXMLRPCServer 物件

The [`DocXMLRPCServer`](#) class is derived from [`SimpleXMLRPCServer`](#) and provides a means of creating self-documenting, stand alone XML-RPC servers. HTTP POST requests are handled as XML-RPC method calls. HTTP GET requests are handled by generating pydoc-style HTML documentation. This allows a server to provide its own web-based documentation.

`DocXMLRPCServer.set_server_title(server_title)`

Set the title used in the generated HTML documentation. This title will be used inside the HTML "title" element.

`DocXMLRPCServer.set_server_name(server_name)`

Set the name used in the generated HTML documentation. This name will appear at the top of the generated documentation inside a "h1" element.

`DocXMLRPCServer.set_server_documentation(server_documentation)`

Set the description used in the generated HTML documentation. This description will appear as a paragraph, below the server name, in the documentation.

21.22.5 DocCGIXMLRPCRequestHandler

The `DocCGIXMLRPCRequestHandler` class is derived from `CGIXMLRPCRequestHandler` and provides a means of creating self-documenting, XML-RPC CGI scripts. HTTP POST requests are handled as XML-RPC method calls. HTTP GET requests are handled by generating pydoc-style HTML documentation. This allows a server to provide its own web-based documentation.

`DocCGIXMLRPCRequestHandler.set_server_title(server_title)`

Set the title used in the generated HTML documentation. This title will be used inside the HTML "title" element.

`DocCGIXMLRPCRequestHandler.set_server_name(server_name)`

Set the name used in the generated HTML documentation. This name will appear at the top of the generated documentation inside a "h1" element.

`DocCGIXMLRPCRequestHandler.set_server_documentation(server_documentation)`

Set the description used in the generated HTML documentation. This description will appear as a paragraph, below the server name, in the documentation.

21.23 ipaddress --- IPv4/IPv6 manipulation library

原始碼: [Lib/ipaddress.py](#)

`ipaddress` provides the capabilities to create, manipulate and operate on IPv4 and IPv6 addresses and networks.

The functions and classes in this module make it straightforward to handle various tasks related to IP addresses, including checking whether or not two hosts are on the same subnet, iterating over all hosts in a particular subnet, checking whether or not a string represents a valid IP address or network definition, and so on.

This is the full module API reference—for an overview and introduction, see `ipaddress-howto`.

在 3.3 版新加入.

21.23.1 Convenience factory functions

The `ipaddress` module provides factory functions to conveniently create IP addresses, networks and interfaces:

`ipaddress.ip_address(address)`

Return an `IPv4Address` or `IPv6Address` object depending on the IP address passed as argument. Either IPv4 or IPv6 addresses may be supplied; integers less than 2^{32} will be considered to be IPv4 by default. A `ValueError` is raised if `address` does not represent a valid IPv4 or IPv6 address.

```
>>> ipaddress.ip_address('192.168.0.1')
IPv4Address('192.168.0.1')
>>> ipaddress.ip_address('2001:db8::')
IPv6Address('2001:db8::')
```

`ipaddress.ip_network(address, strict=True)`

Return an *IPv4Network* or *IPv6Network* object depending on the IP address passed as argument. *address* is a string or integer representing the IP network. Either IPv4 or IPv6 networks may be supplied; integers less than 2^{32} will be considered to be IPv4 by default. *strict* is passed to *IPv4Network* or *IPv6Network* constructor. A *ValueError* is raised if *address* does not represent a valid IPv4 or IPv6 address, or if the network has host bits set.

```
>>> ipaddress.ip_network('192.168.0.0/28')
IPv4Network('192.168.0.0/28')
```

`ipaddress.ip_interface(address)`

Return an *IPv4Interface* or *IPv6Interface* object depending on the IP address passed as argument. *address* is a string or integer representing the IP address. Either IPv4 or IPv6 addresses may be supplied; integers less than 2^{32} will be considered to be IPv4 by default. A *ValueError* is raised if *address* does not represent a valid IPv4 or IPv6 address.

One downside of these convenience functions is that the need to handle both IPv4 and IPv6 formats means that error messages provide minimal information on the precise error, as the functions don't know whether the IPv4 or IPv6 format was intended. More detailed error reporting can be obtained by calling the appropriate version specific class constructors directly.

21.23.2 IP Addresses

Address objects

The *IPv4Address* and *IPv6Address* objects share a lot of common attributes. Some attributes that are only meaningful for IPv6 addresses are also implemented by *IPv4Address* objects, in order to make it easier to write code that handles both IP versions correctly. Address objects are *hashable*, so they can be used as keys in dictionaries.

class `ipaddress.IPv4Address(address)`

Construct an IPv4 address. An *AddressValueError* is raised if *address* is not a valid IPv4 address.

The following constitutes a valid IPv4 address:

1. A string in decimal-dot notation, consisting of four decimal integers in the inclusive range 0--255, separated by dots (e.g. `192.168.0.1`). Each integer represents an octet (byte) in the address. Leading zeroes are not tolerated to prevent confusion with octal notation.
2. An integer that fits into 32 bits.
3. An integer packed into a *bytes* object of length 4 (most significant octet first).

```
>>> ipaddress.IPv4Address('192.168.0.1')
IPv4Address('192.168.0.1')
>>> ipaddress.IPv4Address(3232235521)
IPv4Address('192.168.0.1')
>>> ipaddress.IPv4Address(b'\xC0\xA8\x00\x01')
IPv4Address('192.168.0.1')
```

在 3.8 版的變更: Leading zeros are tolerated, even in ambiguous cases that look like octal notation.

在 3.9.5 版的變更: Leading zeros are no longer tolerated and are treated as an error. IPv4 address strings are now parsed as strict as glibc *inet_pton()*.

version

The appropriate version number: 4 for IPv4, 6 for IPv6.

max_prefixlen

The total number of bits in the address representation for this version: 32 for IPv4, 128 for IPv6.


```

>>> format(ipaddress.IPv4Address('192.168.0.1'))
'192.168.0.1'
>>> '{:#b}'.format(ipaddress.IPv4Address('192.168.0.1'))
'0b110000001010100000000000000001'
>>> f'{ipaddress.IPv6Address("2001:db8::1000"):s}'
'2001:db8::1000'
>>> format(ipaddress.IPv6Address('2001:db8::1000'), '_X')
'2001_0DB8_0000_0000_0000_0000_1000'
>>> '{:#_n}'.format(ipaddress.IPv6Address('2001:db8::1000'))
'0x2001_0db8_0000_0000_0000_0000_1000'

```

在 3.9 版新加入.

class `ipaddress.IPv6Address` (*address*)

Construct an IPv6 address. An *AddressValueError* is raised if *address* is not a valid IPv6 address.

The following constitutes a valid IPv6 address:

1. A string consisting of eight groups of four hexadecimal digits, each group representing 16 bits. The groups are separated by colons. This describes an *exploded* (longhand) notation. The string can also be *compressed* (shorthand notation) by various means. See [RFC 4291](#) for details. For example, "0000:0000:0000:0000:0000:0abc:0007:0def" can be compressed to "::abc:7:def".

Optionally, the string may also have a scope zone ID, expressed with a suffix `%scope_id`. If present, the scope ID must be non-empty, and may not contain `%`. See [RFC 4007](#) for details. For example, `fe80::1234%1` might identify address `fe80::1234` on the first link of the node.

2. An integer that fits into 128 bits.
3. An integer packed into a *bytes* object of length 16, big-endian.

```

>>> ipaddress.IPv6Address('2001:db8::1000')
IPv6Address('2001:db8::1000')
>>> ipaddress.IPv6Address('ff02::5678%1')
IPv6Address('ff02::5678%1')

```

compressed

The short form of the address representation, with leading zeroes in groups omitted and the longest sequence of groups consisting entirely of zeroes collapsed to a single empty group.

This is also the value returned by `str(addr)` for IPv6 addresses.

exploded

The long form of the address representation, with all leading zeroes and groups consisting entirely of zeroes included.

For the following attributes and methods, see the corresponding documentation of the *IPv4Address* class:

packed

reverse_pointer

version

max_prefixlen

is_multicast

is_private

is_global

is_unspecified

is_reserved

is_loopback

is_link_local

在 3.4 版新加入: `is_global`

is_site_local

True if the address is reserved for site-local usage. Note that the site-local address space has been deprecated by [RFC 3879](#). Use `is_private` to test if this address is in the space of unique local addresses as defined by [RFC 4193](#).

ipv4_mapped

For addresses that appear to be IPv4 mapped addresses (starting with `::FFFF/96`), this property will report the embedded IPv4 address. For any other address, this property will be `None`.

scope_id

For scoped addresses as defined by [RFC 4007](#), this property identifies the particular zone of the address's scope that the address belongs to, as a string. When no scope zone is specified, this property will be `None`.

sixtofour

For addresses that appear to be 6to4 addresses (starting with `2002::/16`) as defined by [RFC 3056](#), this property will report the embedded IPv4 address. For any other address, this property will be `None`.

teredo

For addresses that appear to be Teredo addresses (starting with `2001::/32`) as defined by [RFC 4380](#), this property will report the embedded (server, client) IP address pair. For any other address, this property will be `None`.

`IPv6Address.__format__(fmt)`

Refer to the corresponding method documentation in [IPv4Address](#).

在 3.9 版新加入.

Conversion to Strings and Integers

To interoperate with networking interfaces such as the `socket` module, addresses must be converted to strings or integers. This is handled using the `str()` and `int()` builtin functions:

```
>>> str(ipaddress.IPv4Address('192.168.0.1'))
'192.168.0.1'
>>> int(ipaddress.IPv4Address('192.168.0.1'))
3232235521
>>> str(ipaddress.IPv6Address('::1'))
 '::1'
>>> int(ipaddress.IPv6Address('::1'))
1
```

Note that IPv6 scoped addresses are converted to integers without scope zone ID.

Operators

Address objects support some operators. Unless stated otherwise, operators can only be applied between compatible objects (i.e. IPv4 with IPv4, IPv6 with IPv6).

Comparison operators

Address objects can be compared with the usual set of comparison operators. Same IPv6 addresses with different scope zone IDs are not equal. Some examples:

```
>>> IPv4Address('127.0.0.2') > IPv4Address('127.0.0.1')
True
>>> IPv4Address('127.0.0.2') == IPv4Address('127.0.0.1')
False
>>> IPv4Address('127.0.0.2') != IPv4Address('127.0.0.1')
True
>>> IPv6Address('fe80::1234') == IPv6Address('fe80::1234%1')
False
>>> IPv6Address('fe80::1234%1') != IPv6Address('fe80::1234%2')
True
```

Arithmetic operators

Integers can be added to or subtracted from address objects. Some examples:

```
>>> IPv4Address('127.0.0.2') + 3
IPv4Address('127.0.0.5')
>>> IPv4Address('127.0.0.2') - 3
IPv4Address('126.255.255.255')
>>> IPv4Address('255.255.255.255') + 1
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ipaddress.AddressValueError: 4294967296 (>= 2**32) is not permitted as an IPv4_
↳address
```

21.23.3 IP Network definitions

The *IPv4Network* and *IPv6Network* objects provide a mechanism for defining and inspecting IP network definitions. A network definition consists of a *mask* and a *network address*, and as such defines a range of IP addresses that equal the network address when masked (binary AND) with the mask. For example, a network definition with the mask 255.255.255.0 and the network address 192.168.1.0 consists of IP addresses in the inclusive range 192.168.1.0 to 192.168.1.255.

Prefix, net mask and host mask

There are several equivalent ways to specify IP network masks. A *prefix* /<nbits> is a notation that denotes how many high-order bits are set in the network mask. A *net mask* is an IP address with some number of high-order bits set. Thus the prefix /24 is equivalent to the net mask 255.255.255.0 in IPv4, or ffff:fff0:: in IPv6. In addition, a *host mask* is the logical inverse of a *net mask*, and is sometimes used (for example in Cisco access control lists) to denote a network mask. The host mask equivalent to /24 in IPv4 is 0.0.0.255.

Network objects

All attributes implemented by address objects are implemented by network objects as well. In addition, network objects implement additional attributes. All of these are common between *IPv4Network* and *IPv6Network*, so to avoid duplication they are only documented for *IPv4Network*. Network objects are *hashable*, so they can be used as keys in dictionaries.

class `ipaddress.IPv4Network` (*address*, *strict=True*)

Construct an IPv4 network definition. *address* can be one of the following:

1. A string consisting of an IP address and an optional mask, separated by a slash (/). The IP address is the network address, and the mask can be either a single number, which means it's a *prefix*, or a string representation of an IPv4 address. If it's the latter, the mask is interpreted as a *net mask* if it starts with a non-zero field, or as a *host mask* if it starts with a zero field, with the single exception of an all-zero mask which is treated as a *net mask*. If no mask is provided, it's considered to be /32.

For example, the following *address* specifications are equivalent: 192.168.1.0/24, 192.168.1.0/255.255.255.0 and 192.168.1.0/0.0.0.255.

2. An integer that fits into 32 bits. This is equivalent to a single-address network, with the network address being *address* and the mask being /32.
3. An integer packed into a *bytes* object of length 4, big-endian. The interpretation is similar to an integer *address*.
4. A two-tuple of an address description and a netmask, where the address description is either a string, a 32-bits integer, a 4-bytes packed integer, or an existing *IPv4Address* object; and the netmask is either an integer representing the prefix length (e.g. 24) or a string representing the prefix mask (e.g. 255.255.255.0).

An *AddressValueError* is raised if *address* is not a valid IPv4 address. A *NetmaskValueError* is raised if the mask is not valid for an IPv4 address.

If *strict* is *True* and host bits are set in the supplied address, then *ValueError* is raised. Otherwise, the host bits are masked out to determine the appropriate network address.

Unless stated otherwise, all network methods accepting other network/address objects will raise *TypeError* if the argument's IP version is incompatible to *self*.

在 3.5 版的變更: Added the two-tuple form for the *address* constructor parameter.

version

max_prefixlen

Refer to the corresponding attribute documentation in *IPv4Address*.

is_multicast

is_private

is_unspecified

is_reserved

is_loopback

is_link_local

These attributes are true for the network as a whole if they are true for both the network address and the broadcast address.

network_address

The network address for the network. The network address and the prefix length together uniquely define a network.

broadcast_address

The broadcast address for the network. Packets sent to the broadcast address should be received by every host on the network.

hostmask

The host mask, as an *IPv4Address* object.

netmask

The net mask, as an *IPv4Address* object.

with_prefixlen**compressed****exploded**

A string representation of the network, with the mask in prefix notation.

`with_prefixlen` and `compressed` are always the same as `str(network)`. `exploded` uses the exploded form the network address.

with_netmask

A string representation of the network, with the mask in net mask notation.

with_hostmask

A string representation of the network, with the mask in host mask notation.

num_addresses

The total number of addresses in the network.

prefixlen

Length of the network prefix, in bits.

hosts()

Returns an iterator over the usable hosts in the network. The usable hosts are all the IP addresses that belong to the network, except the network address itself and the network broadcast address. For networks with a mask length of 31, the network address and network broadcast address are also included in the result. Networks with a mask of 32 will return a list containing the single host address.

```
>>> list(ip_network('192.0.2.0/29').hosts())
[IPv4Address('192.0.2.1'), IPv4Address('192.0.2.2'),
 IPv4Address('192.0.2.3'), IPv4Address('192.0.2.4'),
 IPv4Address('192.0.2.5'), IPv4Address('192.0.2.6')]
>>> list(ip_network('192.0.2.0/31').hosts())
[IPv4Address('192.0.2.0'), IPv4Address('192.0.2.1')]
>>> list(ip_network('192.0.2.1/32').hosts())
[IPv4Address('192.0.2.1')]
```

overlaps(*other*)

True if this network is partly or wholly contained in *other* or *other* is wholly contained in this network.

address_exclude(*network*)

Computes the network definitions resulting from removing the given *network* from this one. Returns an iterator of network objects. Raises *ValueError* if *network* is not completely contained in this network.

```
>>> n1 = ip_network('192.0.2.0/28')
>>> n2 = ip_network('192.0.2.1/32')
>>> list(n1.address_exclude(n2))
[IPv4Network('192.0.2.8/29'), IPv4Network('192.0.2.4/30'),
 IPv4Network('192.0.2.2/31'), IPv4Network('192.0.2.0/32')]
```

subnets (*prefixlen_diff=1, new_prefix=None*)

The subnets that join to make the current network definition, depending on the argument values. *prefixlen_diff* is the amount our prefix length should be increased by. *new_prefix* is the desired new prefix of the subnets; it must be larger than our prefix. One and only one of *prefixlen_diff* and *new_prefix* must be set. Returns an iterator of network objects.

```
>>> list(ip_network('192.0.2.0/24').subnets())
[IPv4Network('192.0.2.0/25'), IPv4Network('192.0.2.128/25')]
>>> list(ip_network('192.0.2.0/24').subnets(prefixlen_diff=2))
[IPv4Network('192.0.2.0/26'), IPv4Network('192.0.2.64/26'),
 IPv4Network('192.0.2.128/26'), IPv4Network('192.0.2.192/26')]
>>> list(ip_network('192.0.2.0/24').subnets(new_prefix=26))
[IPv4Network('192.0.2.0/26'), IPv4Network('192.0.2.64/26'),
 IPv4Network('192.0.2.128/26'), IPv4Network('192.0.2.192/26')]
>>> list(ip_network('192.0.2.0/24').subnets(new_prefix=23))
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
    raise ValueError('new prefix must be longer')
ValueError: new prefix must be longer
>>> list(ip_network('192.0.2.0/24').subnets(new_prefix=25))
[IPv4Network('192.0.2.0/25'), IPv4Network('192.0.2.128/25')]
```

supernet (*prefixlen_diff=1, new_prefix=None*)

The supernet containing this network definition, depending on the argument values. *prefixlen_diff* is the amount our prefix length should be decreased by. *new_prefix* is the desired new prefix of the supernet; it must be smaller than our prefix. One and only one of *prefixlen_diff* and *new_prefix* must be set. Returns a single network object.

```
>>> ip_network('192.0.2.0/24').supernet()
IPv4Network('192.0.2.0/23')
>>> ip_network('192.0.2.0/24').supernet(prefixlen_diff=2)
IPv4Network('192.0.0.0/22')
>>> ip_network('192.0.2.0/24').supernet(new_prefix=20)
IPv4Network('192.0.0.0/20')
```

subnet_of (*other*)

Return True if this network is a subnet of *other*.

```
>>> a = ip_network('192.168.1.0/24')
>>> b = ip_network('192.168.1.128/30')
>>> b.subnet_of(a)
True
```

在 3.7 版新加入。

supernet_of (*other*)

Return True if this network is a supernet of *other*.

```
>>> a = ip_network('192.168.1.0/24')
>>> b = ip_network('192.168.1.128/30')
>>> a.supernet_of(b)
True
```

在 3.7 版新加入。

compare_networks (*other*)

Compare this network to *other*. In this comparison only the network addresses are considered; host bits aren't. Returns either -1, 0 or 1.

```
>>> ip_network('192.0.2.1/32').compare_networks(ip_network('192.0.2.2/32'))
-1
```

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```

>>> ip_network('192.0.2.1/32').compare_networks(ip_network('192.0.2.0/32'))
1
>>> ip_network('192.0.2.1/32').compare_networks(ip_network('192.0.2.1/32'))
0

```

在 3.7 版之後被用: It uses the same ordering and comparison algorithm as "<", "==", and ">"

class `ipaddress.IPv6Network` (*address*, *strict=True*)

Construct an IPv6 network definition. *address* can be one of the following:

1. A string consisting of an IP address and an optional prefix length, separated by a slash (/). The IP address is the network address, and the prefix length must be a single number, the *prefix*. If no prefix length is provided, it's considered to be /128.

Note that currently expanded netmasks are not supported. That means `2001:db00::0/24` is a valid argument while `2001:db00::0/ffff:ff00::` is not.

2. An integer that fits into 128 bits. This is equivalent to a single-address network, with the network address being *address* and the mask being /128.
3. An integer packed into a *bytes* object of length 16, big-endian. The interpretation is similar to an integer *address*.
4. A two-tuple of an address description and a netmask, where the address description is either a string, a 128-bits integer, a 16-bytes packed integer, or an existing IPv6Address object; and the netmask is an integer representing the prefix length.

An *AddressValueError* is raised if *address* is not a valid IPv6 address. A *NetmaskValueError* is raised if the mask is not valid for an IPv6 address.

If *strict* is *True* and host bits are set in the supplied address, then *ValueError* is raised. Otherwise, the host bits are masked out to determine the appropriate network address.

在 3.5 版的變更: Added the two-tuple form for the *address* constructor parameter.

version

max_prefixlen

is_multicast

is_private

is_unspecified

is_reserved

is_loopback

is_link_local

network_address

broadcast_address

hostmask

netmask

with_prefixlen

compressed

exploded

with_netmask

with_hostmask

num_addresses

prefixlen

hosts()

Returns an iterator over the usable hosts in the network. The usable hosts are all the IP addresses that belong to the network, except the Subnet-Router anycast address. For networks with a mask length of 127, the Subnet-Router anycast address is also included in the result. Networks with a mask of 128 will return a list containing the single host address.

overlaps() (*other*)

address_exclude() (*network*)

subnets() (*prefixlen_diff=1, new_prefix=None*)

supernet() (*prefixlen_diff=1, new_prefix=None*)

subnet_of() (*other*)

supernet_of() (*other*)

compare_networks() (*other*)

Refer to the corresponding attribute documentation in [IPv4Network](#).

is_site_local

This attribute is true for the network as a whole if it is true for both the network address and the broadcast address.

Operators

Network objects support some operators. Unless stated otherwise, operators can only be applied between compatible objects (i.e. IPv4 with IPv4, IPv6 with IPv6).

Logical operators

Network objects can be compared with the usual set of logical operators. Network objects are ordered first by network address, then by net mask.

Iteration

Network objects can be iterated to list all the addresses belonging to the network. For iteration, *all* hosts are returned, including unusable hosts (for usable hosts, use the `hosts()` method). An example:

```
>>> for addr in IPv4Network('192.0.2.0/28'):
...     addr
...
IPv4Address('192.0.2.0')
IPv4Address('192.0.2.1')
IPv4Address('192.0.2.2')
IPv4Address('192.0.2.3')
IPv4Address('192.0.2.4')
IPv4Address('192.0.2.5')
IPv4Address('192.0.2.6')
```

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```
IPv4Address('192.0.2.7')
IPv4Address('192.0.2.8')
IPv4Address('192.0.2.9')
IPv4Address('192.0.2.10')
IPv4Address('192.0.2.11')
IPv4Address('192.0.2.12')
IPv4Address('192.0.2.13')
IPv4Address('192.0.2.14')
IPv4Address('192.0.2.15')
```

Networks as containers of addresses

Network objects can act as containers of addresses. Some examples:

```
>>> IPv4Network('192.0.2.0/28')[0]
IPv4Address('192.0.2.0')
>>> IPv4Network('192.0.2.0/28')[15]
IPv4Address('192.0.2.15')
>>> IPv4Address('192.0.2.6') in IPv4Network('192.0.2.0/28')
True
>>> IPv4Address('192.0.3.6') in IPv4Network('192.0.2.0/28')
False
```

21.23.4 Interface objects

Interface objects are *hashable*, so they can be used as keys in dictionaries.

class `ipaddress.IPv4Interface` (*address*)

Construct an IPv4 interface. The meaning of *address* is as in the constructor of *IPv4Network*, except that arbitrary host addresses are always accepted.

IPv4Interface is a subclass of *IPv4Address*, so it inherits all the attributes from that class. In addition, the following attributes are available:

ip

The address (*IPv4Address*) without network information.

```
>>> interface = IPv4Interface('192.0.2.5/24')
>>> interface.ip
IPv4Address('192.0.2.5')
```

network

The network (*IPv4Network*) this interface belongs to.

```
>>> interface = IPv4Interface('192.0.2.5/24')
>>> interface.network
IPv4Network('192.0.2.0/24')
```

with_prefixlen

A string representation of the interface with the mask in prefix notation.

```
>>> interface = IPv4Interface('192.0.2.5/24')
>>> interface.with_prefixlen
'192.0.2.5/24'
```

with_netmask

A string representation of the interface with the network as a net mask.

```
>>> interface = IPv4Interface('192.0.2.5/24')
>>> interface.with_netmask
'192.0.2.5/255.255.255.0'
```

with_hostmask

A string representation of the interface with the network as a host mask.

```
>>> interface = IPv4Interface('192.0.2.5/24')
>>> interface.with_hostmask
'192.0.2.5/0.0.0.255'
```

class `ipaddress.IPv6Interface` (*address*)

Construct an IPv6 interface. The meaning of *address* is as in the constructor of *IPv6Network*, except that arbitrary host addresses are always accepted.

IPv6Interface is a subclass of *IPv6Address*, so it inherits all the attributes from that class. In addition, the following attributes are available:

ip

network

with_prefixlen

with_netmask

with_hostmask

Refer to the corresponding attribute documentation in *IPv4Interface*.

Operators

Interface objects support some operators. Unless stated otherwise, operators can only be applied between compatible objects (i.e. IPv4 with IPv4, IPv6 with IPv6).

Logical operators

Interface objects can be compared with the usual set of logical operators.

For equality comparison (`==` and `!=`), both the IP address and network must be the same for the objects to be equal. An interface will not compare equal to any address or network object.

For ordering (`<`, `>`, etc) the rules are different. Interface and address objects with the same IP version can be compared, and the address objects will always sort before the interface objects. Two interface objects are first compared by their networks and, if those are the same, then by their IP addresses.

21.23.5 Other Module Level Functions

The module also provides the following module level functions:

ipaddress.v4_int_to_packed (*address*)

Represent an address as 4 packed bytes in network (big-endian) order. *address* is an integer representation of an IPv4 IP address. A *ValueError* is raised if the integer is negative or too large to be an IPv4 IP address.

```
>>> ipaddress.ip_address(3221225985)
IPv4Address('192.0.2.1')
>>> ipaddress.v4_int_to_packed(3221225985)
b'\xc0\x00\x02\x01'
```

`ipaddress.v6_int_to_packed(address)`

Represent an address as 16 packed bytes in network (big-endian) order. *address* is an integer representation of an IPv6 IP address. A *ValueError* is raised if the integer is negative or too large to be an IPv6 IP address.

`ipaddress.summarize_address_range(first, last)`

Return an iterator of the summarized network range given the first and last IP addresses. *first* is the first *IPv4Address* or *IPv6Address* in the range and *last* is the last *IPv4Address* or *IPv6Address* in the range. A *TypeError* is raised if *first* or *last* are not IP addresses or are not of the same version. A *ValueError* is raised if *last* is not greater than *first* or if *first* address version is not 4 or 6.

```
>>> [ipaddr for ipaddr in ipaddress.summarize_address_range(
...     ipaddress.IPv4Address('192.0.2.0'),
...     ipaddress.IPv4Address('192.0.2.130'))]
[IPv4Network('192.0.2.0/25'), IPv4Network('192.0.2.128/31'), IPv4Network('192.
→0.2.130/32')]
```

`ipaddress.collapse_addresses(addresses)`

Return an iterator of the collapsed *IPv4Network* or *IPv6Network* objects. *addresses* is an iterator of *IPv4Network* or *IPv6Network* objects. A *TypeError* is raised if *addresses* contains mixed version objects.

```
>>> [ipaddr for ipaddr in
... ipaddress.collapse_addresses([ipaddress.IPv4Network('192.0.2.0/25'),
... ipaddress.IPv4Network('192.0.2.128/25')])]
[IPv4Network('192.0.2.0/24')]
```

`ipaddress.get_mixed_type_key(obj)`

Return a key suitable for sorting between networks and addresses. Address and Network objects are not sortable by default; they're fundamentally different, so the expression:

```
IPv4Address('192.0.2.0') <= IPv4Network('192.0.2.0/24')
```

doesn't make sense. There are some times however, where you may wish to have *ipaddress* sort these anyway. If you need to do this, you can use this function as the *key* argument to *sorted()*.

obj is either a network or address object.

21.23.6 Custom Exceptions

To support more specific error reporting from class constructors, the module defines the following exceptions:

exception `ipaddress.AddressValueError` (*ValueError*)

Any value error related to the address.

exception `ipaddress.NetmaskValueError` (*ValueError*)

Any value error related to the net mask.

此章節所描述的模組 (module) 實作了多種在多媒體服務中相當有用的演算法和介面，[☞](#)可在安裝時[☞](#)定是否要使用它們。以下[☞](#)綜述：

22.1 wave --- Read and write WAV files

原始碼：[Lib/wave.py](#)

The `wave` module provides a convenient interface to the Waveform Audio "WAVE" (or "WAV") file format. Only files using `WAVE_FORMAT_PCM` are supported. Note that this does not include files using `WAVE_FORMAT_EXTENSIBLE` even if the subformat is PCM.

The `wave` module defines the following function and exception:

`wave.open(file, mode=None)`

If `file` is a string, open the file by that name, otherwise treat it as a file-like object. `mode` can be:

`'rb'`

Read only mode.

`'wb'`

Write only mode.

Note that it does not allow read/write WAV files.

A `mode` of `'rb'` returns a `Wave_read` object, while a `mode` of `'wb'` returns a `Wave_write` object. If `mode` is omitted and a file-like object is passed as `file`, `file.mode` is used as the default value for `mode`.

If you pass in a file-like object, the wave object will not close it when its `close()` method is called; it is the caller's responsibility to close the file object.

The `open()` function may be used in a `with` statement. When the `with` block completes, the `Wave_read.close()` or `Wave_write.close()` method is called.

在 3.4 版的變更: Added support for unseekable files.

exception `wave.Error`

An error raised when something is impossible because it violates the WAV specification or hits an implementation deficiency.

22.1.1 Wave_read 物件

class `wave.Wave_read`

Read a WAV file.

Wave_read objects, as returned by `open()`, have the following methods:

close()

Close the stream if it was opened by `wave`, and make the instance unusable. This is called automatically on object collection.

getnchannels()

Returns number of audio channels (1 for mono, 2 for stereo).

getsampwidth()

Returns sample width in bytes.

getframerate()

Returns sampling frequency.

getnframes()

Returns number of audio frames.

getcomptype()

Returns compression type ('NONE' is the only supported type).

getcompname()

Human-readable version of `getcomptype()`. Usually 'not compressed' parallels 'NONE'.

getparams()

Returns a `namedtuple()` (nchannels, sampwidth, framerate, nframes, comptype, compname), equivalent to output of the `get*()` methods.

readframes(n)

Reads and returns at most *n* frames of audio, as a `bytes` object.

rewind()

Rewind the file pointer to the beginning of the audio stream.

The following two methods are defined for compatibility with the `aifc` module, and don't do anything interesting.

getmarkers()

Returns `None`.

getmark(id)

Raise an error.

The following two methods define a term "position" which is compatible between them, and is otherwise implementation dependent.

setpos(pos)

Set the file pointer to the specified position.

tell()

Return current file pointer position.

22.1.2 Wave_write 物件

class `wave.Wave_write`

Write a WAV file.

Wave_write objects, as returned by `open()`.

For seekable output streams, the `wave` header will automatically be updated to reflect the number of frames actually written. For unseekable streams, the `nframes` value must be accurate when the first frame data is written. An accurate `nframes` value can be achieved either by calling `setnframes()` or `setparams()` with the number of frames that will be written before `close()` is called and then using `writeframesraw()` to write the frame data, or by calling `writeframes()` with all of the frame data to be written. In the latter case `writeframes()` will calculate the number of frames in the data and set `nframes` accordingly before writing the frame data.

在 3.4 版的變更: Added support for unseekable files.

Wave_write objects have the following methods:

close()

Make sure `nframes` is correct, and close the file if it was opened by `wave`. This method is called upon object collection. It will raise an exception if the output stream is not seekable and `nframes` does not match the number of frames actually written.

setnchannels(n)

Set the number of channels.

setsampwidth(n)

Set the sample width to `n` bytes.

setframerate(n)

Set the frame rate to `n`.

在 3.2 版的變更: A non-integral input to this method is rounded to the nearest integer.

setnframes(n)

Set the number of frames to `n`. This will be changed later if the number of frames actually written is different (this update attempt will raise an error if the output stream is not seekable).

setcomptype(type, name)

Set the compression type and description. At the moment, only compression type `NONE` is supported, meaning no compression.

setparams(tuple)

The `tuple` should be `(nchannels, sampwidth, framerate, nframes, comptype, compname)`, with values valid for the `set*()` methods. Sets all parameters.

tell()

Return current position in the file, with the same disclaimer for the `Wave_read.tell()` and `Wave_read.setpos()` methods.

writeframesraw(data)

Write audio frames, without correcting `nframes`.

在 3.4 版的變更: Any *bytes-like object* is now accepted.

writeframes(data)

Write audio frames and make sure `nframes` is correct. It will raise an error if the output stream is not seekable and the total number of frames that have been written after `data` has been written does not match the previously set value for `nframes`.

在 3.4 版的變更: Any *bytes-like object* is now accepted.

Note that it is invalid to set any parameters after calling `writeframes()` or `writeframesraw()`, and any attempt to do so will raise `wave.Error`.

22.2 colorsys --- 色系統間的轉

原始碼: [Lib/colors.py](#)

`colorsys` 模組 (module) 定義了電腦顯示器所用的 RGB (紅藍) 色彩空間與三種其他色彩座標系統: YIQ、HLS (色相、亮度、飽和度) 和 HSV (色相、飽和度、明度) 所表示的色值之間的雙向轉。所有這些色彩空間的座標都使用浮點數值 (floating point) 來表示。在 YIQ 空間中, Y 座標值 0 和 1 之間, 而 I 和 Q 座標均可以正數或負數。在所有其他空間中, 座標值均 0 和 1 之間。

也參考:

有關色彩空間的更多資訊請見 <https://poynton.ca/ColorFAQ.html> 和 <https://www.cambridgeincolour.com/tutorials/color-spaces.htm>。

`colorsys` 模組定義了以下函式:

`colorsys.rgb_to_yiq(r, g, b)`

將色自 RGB 座標轉至 YIQ 座標。

`colorsys.yiq_to_rgb(y, i, q)`

將色自 YIQ 座標轉至 RGB 座標。

`colorsys.rgb_to_hls(r, g, b)`

將色自 RGB 座標轉至 HLS 座標。

`colorsys.hls_to_rgb(h, l, s)`

將色自 HLS 座標轉至 RGB 座標。

`colorsys.rgb_to_hsv(r, g, b)`

將色自 RGB 座標轉至 HSV 座標。

`colorsys.hsv_to_rgb(h, s, v)`

將色自 HSV 座標轉至 RGB 座標。

範例:

```
>>> import colorsys
>>> colorsys.rgb_to_hsv(0.2, 0.4, 0.4)
(0.5, 0.5, 0.4)
>>> colorsys.hsv_to_rgb(0.5, 0.5, 0.4)
(0.2, 0.4, 0.4)
```


The modules described in this chapter help you write software that is independent of language and locale by providing mechanisms for selecting a language to be used in program messages or by tailoring output to match local conventions.

The list of modules described in this chapter is:

23.1 gettext --- Multilingual internationalization services

原始碼: [Lib/gettext.py](#)

The `gettext` module provides internationalization (I18N) and localization (L10N) services for your Python modules and applications. It supports both the GNU **gettext** message catalog API and a higher level, class-based API that may be more appropriate for Python files. The interface described below allows you to write your module and application messages in one natural language, and provide a catalog of translated messages for running under different natural languages.

Some hints on localizing your Python modules and applications are also given.

23.1.1 GNU gettext API

The `gettext` module defines the following API, which is very similar to the GNU **gettext** API. If you use this API you will affect the translation of your entire application globally. Often this is what you want if your application is monolingual, with the choice of language dependent on the locale of your user. If you are localizing a Python module, or if your application needs to switch languages on the fly, you probably want to use the class-based API instead.

`gettext`.**bindtextdomain** (*domain*, *localedir*=None)

Bind the *domain* to the locale directory *localedir*. More concretely, `gettext` will look for binary `.mo` files for the given domain using the path (on Unix): `localedir/language/LC_MESSAGES/domain.mo`, where *language* is searched for in the environment variables `LANGUAGE`, `LC_ALL`, `LC_MESSAGES`, and `LANG` respectively.

If *localedir* is omitted or `None`, then the current binding for *domain* is returned.¹

¹ The default locale directory is system dependent; for example, on Red Hat Linux it is `/usr/share/locale`, but on Solaris it is `/usr/lib/locale`. The `gettext` module does not try to support these system dependent defaults; instead its default is `sys.base_prefix/`

`gettext.textdomain (domain=None)`

Change or query the current global domain. If *domain* is `None`, then the current global domain is returned, otherwise the global domain is set to *domain*, which is returned.

`gettext.gettext (message)`

Return the localized translation of *message*, based on the current global domain, language, and locale directory. This function is usually aliased as `_()` in the local namespace (see examples below).

`gettext.dgettext (domain, message)`

Like `gettext()`, but look the message up in the specified *domain*.

`gettext.ngettext (singular, plural, n)`

Like `gettext()`, but consider plural forms. If a translation is found, apply the plural formula to *n*, and return the resulting message (some languages have more than two plural forms). If no translation is found, return *singular* if *n* is 1; return *plural* otherwise.

The Plural formula is taken from the catalog header. It is a C or Python expression that has a free variable *n*; the expression evaluates to the index of the plural in the catalog. See [the GNU gettext documentation](#) for the precise syntax to be used in `.po` files and the formulas for a variety of languages.

`gettext.dngettext (domain, singular, plural, n)`

Like `ngettext()`, but look the message up in the specified *domain*.

`gettext.pgettext (context, message)`

`gettext.dpgettext (domain, context, message)`

`gettext.npgettext (context, singular, plural, n)`

`gettext.dnpgettext (domain, context, singular, plural, n)`

Similar to the corresponding functions without the `p` in the prefix (that is, `gettext()`, `dgettext()`, `ngettext()`, `dngettext()`), but the translation is restricted to the given message *context*.

在 3.8 版新加入。

Note that GNU **gettext** also defines a `dcgettext()` method, but this was deemed not useful and so it is currently unimplemented.

Here's an example of typical usage for this API:

```
import gettext
gettext.bindtextdomain('myapplication', '/path/to/my/language/directory')
gettext.textdomain('myapplication')
_ = gettext.gettext
# ...
print(_('This is a translatable string.'))
```

23.1.2 Class-based API

The class-based API of the `gettext` module gives you more flexibility and greater convenience than the GNU **gettext** API. It is the recommended way of localizing your Python applications and modules. `gettext` defines a `GNUTranslations` class which implements the parsing of GNU `.mo` format files, and has methods for returning strings. Instances of this class can also install themselves in the built-in namespace as the function `_()`.

`gettext.find (domain, loaledir=None, languages=None, all=False)`

This function implements the standard `.mo` file search algorithm. It takes a *domain*, identical to what `textdomain()` takes. Optional *loaledir* is as in `bindtextdomain()`. Optional *languages* is a list of strings, where each string is a language code.

share/locale (see `sys.base_prefix`). For this reason, it is always best to call `bindtextdomain()` with an explicit absolute path at the start of your application.

If *localedir* is not given, then the default system locale directory is used.² If *languages* is not given, then the following environment variables are searched: `LANGUAGE`, `LC_ALL`, `LC_MESSAGES`, and `LANG`. The first one returning a non-empty value is used for the *languages* variable. The environment variables should contain a colon separated list of languages, which will be split on the colon to produce the expected list of language code strings.

find() then expands and normalizes the languages, and then iterates through them, searching for an existing file built of these components:

```
localedir/language/LC_MESSAGES/domain.mo
```

The first such file name that exists is returned by *find()*. If no such file is found, then `None` is returned. If *all* is given, it returns a list of all file names, in the order in which they appear in the languages list or the environment variables.

```
gettext.translation(domain, localedir=None, languages=None, class_=None, fallback=False)
```

Return a `*Translations` instance based on the *domain*, *localedir*, and *languages*, which are first passed to *find()* to get a list of the associated `.mo` file paths. Instances with identical `.mo` file names are cached. The actual class instantiated is *class_* if provided, otherwise `GNUTranslations`. The class's constructor must take a single *file object* argument.

If multiple files are found, later files are used as fallbacks for earlier ones. To allow setting the fallback, `copy.copy()` is used to clone each translation object from the cache; the actual instance data is still shared with the cache.

If no `.mo` file is found, this function raises `OSError` if *fallback* is false (which is the default), and returns a `NullTranslations` instance if *fallback* is true.

在 3.3 版的變更: `IOError` used to be raised, it is now an alias of `OSError`.

在 3.11 版的變更: `codeset` 參數被移除。

```
gettext.install(domain, localedir=None, *, names=None)
```

This installs the function `_()` in Python's builtins namespace, based on *domain* and *localedir* which are passed to the function *translation()*.

For the *names* parameter, please see the description of the translation object's *install()* method.

As seen below, you usually mark the strings in your application that are candidates for translation, by wrapping them in a call to the `_()` function, like this:

```
print(_('This string will be translated.'))
```

For convenience, you want the `_()` function to be installed in Python's builtins namespace, so it is easily accessible in all modules of your application.

在 3.11 版的變更: *names* is now a keyword-only parameter.

The NullTranslations class

Translation classes are what actually implement the translation of original source file message strings to translated message strings. The base class used by all translation classes is `NullTranslations`; this provides the basic interface you can use to write your own specialized translation classes. Here are the methods of `NullTranslations`:

```
class gettext.NullTranslations(fp=None)
```

Takes an optional *file object* *fp*, which is ignored by the base class. Initializes "protected" instance variables `_info` and `_charset` which are set by derived classes, as well as `_fallback`, which is set through *add_fallback()*. It then calls `self._parse(fp)` if *fp* is not `None`.

² 請見上方 *bindtextdomain()* 之 解。

_parse (*fp*)

No-op in the base class, this method takes file object *fp*, and reads the data from the file, initializing its message catalog. If you have an unsupported message catalog file format, you should override this method to parse your format.

add_fallback (*fallback*)

Add *fallback* as the fallback object for the current translation object. A translation object should consult the fallback if it cannot provide a translation for a given message.

gettext (*message*)

If a fallback has been set, forward `gettext()` to the fallback. Otherwise, return *message*. Overridden in derived classes.

ngettext (*singular*, *plural*, *n*)

If a fallback has been set, forward `ngettext()` to the fallback. Otherwise, return *singular* if *n* is 1; return *plural* otherwise. Overridden in derived classes.

pgettext (*context*, *message*)

If a fallback has been set, forward `pgettext()` to the fallback. Otherwise, return the translated message. Overridden in derived classes.

在 3.8 版新加入。

npgettext (*context*, *singular*, *plural*, *n*)

If a fallback has been set, forward `npgettext()` to the fallback. Otherwise, return the translated message. Overridden in derived classes.

在 3.8 版新加入。

info ()

Return a dictionary containing the metadata found in the message catalog file.

charset ()

Return the encoding of the message catalog file.

install (*names=None*)

This method installs `gettext()` into the built-in namespace, binding it to `_`.

If the *names* parameter is given, it must be a sequence containing the names of functions you want to install in the builtins namespace in addition to `_()`. Supported names are 'gettext', 'ngettext', 'pgettext', and 'npgettext'.

Note that this is only one way, albeit the most convenient way, to make the `_()` function available to your application. Because it affects the entire application globally, and specifically the built-in namespace, localized modules should never install `_()`. Instead, they should use this code to make `_()` available to their module:

```
import gettext
t = gettext.translation('mymodule', ...)
_ = t.gettext
```

This puts `_()` only in the module's global namespace and so only affects calls within this module.

在 3.8 版的變更: 新增 'pgettext' 與 'npgettext'。

The GNUTranslations class

The `gettext` module provides one additional class derived from `NullTranslations`: `GNUTranslations`. This class overrides `_parse()` to enable reading GNU `gettext` format `.mo` files in both big-endian and little-endian format.

`GNUTranslations` parses optional metadata out of the translation catalog. It is convention with GNU `gettext` to include metadata as the translation for the empty string. This metadata is in RFC 822-style `key: value` pairs, and should contain the `Project-Id-Version` key. If the key `Content-Type` is found, then the `charset` property is used to initialize the "protected" `_charset` instance variable, defaulting to `None` if not found. If the charset encoding is specified, then all message ids and message strings read from the catalog are converted to Unicode using this encoding, else ASCII is assumed.

Since message ids are read as Unicode strings too, all `*gettext()` methods will assume message ids as Unicode strings, not byte strings.

The entire set of key/value pairs are placed into a dictionary and set as the "protected" `_info` instance variable.

If the `.mo` file's magic number is invalid, the major version number is unexpected, or if other problems occur while reading the file, instantiating a `GNUTranslations` class can raise `OSError`.

`class gettext.GNUTranslations`

The following methods are overridden from the base class implementation:

`gettext(message)`

Look up the *message* id in the catalog and return the corresponding message string, as a Unicode string. If there is no entry in the catalog for the *message* id, and a fallback has been set, the look up is forwarded to the fallback's `gettext()` method. Otherwise, the *message* id is returned.

`ngettext(singular, plural, n)`

Do a plural-forms lookup of a message id. *singular* is used as the message id for purposes of lookup in the catalog, while *n* is used to determine which plural form to use. The returned message string is a Unicode string.

If the message id is not found in the catalog, and a fallback is specified, the request is forwarded to the fallback's `ngettext()` method. Otherwise, when *n* is 1 *singular* is returned, and *plural* is returned in all other cases.

以下是個範例：

```
n = len(os.listdir('.'))
cat = GNUTranslations(somefile)
message = cat.ngettext(
    'There is %(num)d file in this directory',
    'There are %(num)d files in this directory',
    n) % {'num': n}
```

`pgettext(context, message)`

Look up the *context* and *message* id in the catalog and return the corresponding message string, as a Unicode string. If there is no entry in the catalog for the *message* id and *context*, and a fallback has been set, the look up is forwarded to the fallback's `pgettext()` method. Otherwise, the *message* id is returned.

在 3.8 版新加入。

`npgettext(context, singular, plural, n)`

Do a plural-forms lookup of a message id. *singular* is used as the message id for purposes of lookup in the catalog, while *n* is used to determine which plural form to use.

If the message id for *context* is not found in the catalog, and a fallback is specified, the request is forwarded to the fallback's `npgettext()` method. Otherwise, when *n* is 1 *singular* is returned, and *plural* is returned in all other cases.

在 3.8 版新加入。

Solaris message catalog support

The Solaris operating system defines its own binary `.mo` file format, but since no documentation can be found on this format, it is not supported at this time.

The Catalog constructor

GNOME uses a version of the `gettext` module by James Henstridge, but this version has a slightly different API. Its documented usage was:

```
import gettext
cat = gettext.Catalog(domain, localedir)
_ = cat.gettext
print(_('hello world'))
```

For compatibility with this older module, the function `Catalog()` is an alias for the `translation()` function described above.

One difference between this module and Henstridge's: his catalog objects supported access through a mapping API, but this appears to be unused and so is not currently supported.

23.1.3 Internationalizing your programs and modules

Internationalization (I18N) refers to the operation by which a program is made aware of multiple languages. Localization (L10N) refers to the adaptation of your program, once internationalized, to the local language and cultural habits. In order to provide multilingual messages for your Python programs, you need to take the following steps:

1. prepare your program or module by specially marking translatable strings
2. run a suite of tools over your marked files to generate raw messages catalogs
3. create language-specific translations of the message catalogs
4. use the `gettext` module so that message strings are properly translated

In order to prepare your code for I18N, you need to look at all the strings in your files. Any string that needs to be translated should be marked by wrapping it in `_('...')` --- that is, a call to the function `_`. For example:

```
filename = 'mylog.txt'
message = _('writing a log message')
with open(filename, 'w') as fp:
    fp.write(message)
```

In this example, the string `'writing a log message'` is marked as a candidate for translation, while the strings `'mylog.txt'` and `'w'` are not.

There are a few tools to extract the strings meant for translation. The original GNU `gettext` only supported C or C++ source code but its extended version `xgettext` scans code written in a number of languages, including Python, to find strings marked as translatable. `Babel` is a Python internationalization library that includes a `pybabel` script to extract and compile message catalogs. François Pinard's program called `xpot` does a similar job and is available as part of his `po-utils` package.

(Python also includes pure-Python versions of these programs, called `pygettext.py` and `msgfmt.py`; some Python distributions will install them for you. `pygettext.py` is similar to `xgettext`, but only understands Python source code and cannot handle other programming languages such as C or C++. `pygettext.py` supports a command-line interface similar to `xgettext`; for details on its use, run `pygettext.py --help`. `msgfmt.py` is binary compatible with GNU `msgfmt`. With these two programs, you may not need the GNU `gettext` package to internationalize your Python applications.)

`xgettext`, `pygettext`, and similar tools generate `.po` files that are message catalogs. They are structured human-readable files that contain every marked string in the source code, along with a placeholder for the translated versions of these strings.

Copies of these `.po` files are then handed over to the individual human translators who write translations for every supported natural language. They send back the completed language-specific versions as a `<language-name>.po` file that's compiled into a machine-readable `.mo` binary catalog file using the `msgfmt` program. The `.mo` files are used by the `gettext` module for the actual translation processing at run-time.

How you use the `gettext` module in your code depends on whether you are internationalizing a single module or your entire application. The next two sections will discuss each case.

Localizing your module

If you are localizing your module, you must take care not to make global changes, e.g. to the built-in namespace. You should not use the GNU `gettext` API but instead the class-based API.

Let's say your module is called "spam" and the module's various natural language translation `.mo` files reside in `/usr/share/locale` in GNU `gettext` format. Here's what you would put at the top of your module:

```
import gettext
t = gettext.translation('spam', '/usr/share/locale')
_ = t.gettext
```

Localizing your application

If you are localizing your application, you can install the `_()` function globally into the built-in namespace, usually in the main driver file of your application. This will let all your application-specific files just use `_('...')` without having to explicitly install it in each file.

In the simple case then, you need only add the following bit of code to the main driver file of your application:

```
import gettext
gettext.install('myapplication')
```

If you need to set the locale directory, you can pass it into the `install()` function:

```
import gettext
gettext.install('myapplication', '/usr/share/locale')
```

Changing languages on the fly

If your program needs to support many languages at the same time, you may want to create multiple translation instances and then switch between them explicitly, like so:

```
import gettext

lang1 = gettext.translation('myapplication', languages=['en'])
lang2 = gettext.translation('myapplication', languages=['fr'])
lang3 = gettext.translation('myapplication', languages=['de'])

# start by using language1
lang1.install()

# ... time goes by, user selects language 2
lang2.install()

# ... more time goes by, user selects language 3
lang3.install()
```

Deferred translations

In most coding situations, strings are translated where they are coded. Occasionally however, you need to mark strings for translation, but defer actual translation until later. A classic example is:

```
animals = ['mollusk',
           'albatross',
           'rat',
           'penguin',
           'python', ]

# ...
for a in animals:
    print(a)
```

Here, you want to mark the strings in the `animals` list as being translatable, but you don't actually want to translate them until they are printed.

Here is one way you can handle this situation:

```
def _(message): return message

animals = [_('mollusk'),
           _('albatross'),
           _('rat'),
           _('penguin'),
           _('python'), ]

del _

# ...
for a in animals:
    print(_(a))
```

This works because the dummy definition of `_()` simply returns the string unchanged. And this dummy definition will temporarily override any definition of `_()` in the built-in namespace (until the `del` command). Take care, though if you have a previous definition of `_()` in the local namespace.

Note that the second use of `_()` will not identify "a" as being translatable to the `gettext` program, because the parameter is not a string literal.

Another way to handle this is with the following example:

```
def N_(message): return message

animals = [N_('mollusk'),
           N_('albatross'),
           N_('rat'),
           N_('penguin'),
           N_('python'), ]

# ...
for a in animals:
    print(_(a))
```

In this case, you are marking translatable strings with the function `N_()`, which won't conflict with any definition of `_()`. However, you will need to teach your message extraction program to look for translatable strings marked with `N_()`. `xgettext`, `pygettext`, `pybabel extract`, and `xpot` all support this through the use of the `-k` command-line switch. The choice of `N_()` here is totally arbitrary; it could have just as easily been `MarkThisStringForTranslation()`.

23.1.4 致謝

The following people contributed code, feedback, design suggestions, previous implementations, and valuable experience to the creation of this module:

- Peter Funk
- James Henstridge
- Juan David Ibáñez Palomar
- Marc-André Lemburg
- Martin von Löwis
- François Pinard
- Barry Warsaw
- Gustavo Niemeyer

解 F

23.2 locale --- Internationalization services

原始碼: [Lib/locale.py](#)

The `locale` module opens access to the POSIX locale database and functionality. The POSIX locale mechanism allows programmers to deal with certain cultural issues in an application, without requiring the programmer to know all the specifics of each country where the software is executed.

The `locale` module is implemented on top of the `_locale` module, which in turn uses an ANSI C locale implementation if available.

The `locale` module defines the following exception and functions:

exception `locale.Error`

Exception raised when the locale passed to `setlocale()` is not recognized.

`locale.setlocale(category, locale=None)`

If `locale` is given and not `None`, `setlocale()` modifies the locale setting for the `category`. The available categories are listed in the data description below. `locale` may be a string, or an iterable of two strings (language code and encoding). If it's an iterable, it's converted to a locale name using the locale aliasing engine. An empty string specifies the user's default settings. If the modification of the locale fails, the exception `Error` is raised. If successful, the new locale setting is returned.

If `locale` is omitted or `None`, the current setting for `category` is returned.

`setlocale()` is not thread-safe on most systems. Applications typically start with a call of

```
import locale
locale.setlocale(locale.LC_ALL, '')
```

This sets the locale for all categories to the user's default setting (typically specified in the `LANG` environment variable). If the locale is not changed thereafter, using multithreading should not cause problems.

`locale.localeconv()`

Returns the database of the local conventions as a dictionary. This dictionary has the following strings as keys:

Category	Key	Meaning
LC_NUMERIC	'decimal_point'	Decimal point character.
	'grouping'	Sequence of numbers specifying which relative positions the 'thousands_sep' is expected. If the sequence is terminated with CHAR_MAX, no further grouping is performed. If the sequence terminates with a 0, the last group size is repeatedly used.
LC_MONETARY	'thousands_sep'	Character used between groups.
	'int_curr_symbol'	International currency symbol.
	'currency_symbol'	Local currency symbol.
	'p_cs_precedes/n_cs_precedes'	Whether the currency symbol precedes the value (for positive resp. negative values).
	'p_sep_by_space/n_sep_by_space'	Whether the currency symbol is separated from the value by a space (for positive resp. negative values).
	'mon_decimal_point'	Decimal point used for monetary values.
	'frac_digits'	Number of fractional digits used in local formatting of monetary values.
	'int_frac_digits'	Number of fractional digits used in international formatting of monetary values.
	'mon_thousands_sep'	Group separator used for monetary values.
	'mon_grouping'	Equivalent to 'grouping', used for monetary values.
	'positive_sign'	Symbol used to annotate a positive monetary value.
	'negative_sign'	Symbol used to annotate a negative monetary value.
	'p_sign_posn/n_sign_posn'	The position of the sign (for positive resp. negative values), see below.

All numeric values can be set to CHAR_MAX to indicate that there is no value specified in this locale.

The possible values for 'p_sign_posn' and 'n_sign_posn' are given below.

Value	Explanation
0	Currency and value are surrounded by parentheses.
1	The sign should precede the value and currency symbol.
2	The sign should follow the value and currency symbol.
3	The sign should immediately precede the value.
4	The sign should immediately follow the value.
CHAR_MAX	Nothing is specified in this locale.

The function temporarily sets the LC_CTYPE locale to the LC_NUMERIC locale or the LC_MONETARY locale if locales are different and numeric or monetary strings are non-ASCII. This temporary change affects other

threads.

在 3.7 版的變更: The function now temporarily sets the `LC_CTYPE` locale to the `LC_NUMERIC` locale in some cases.

`locale.nl_langinfo (option)`

Return some locale-specific information as a string. This function is not available on all systems, and the set of possible options might also vary across platforms. The possible argument values are numbers, for which symbolic constants are available in the `locale` module.

The `nl_langinfo()` function accepts one of the following keys. Most descriptions are taken from the corresponding description in the GNU C library.

`locale.CODESET`

Get a string with the name of the character encoding used in the selected locale.

`locale.D_T_FMT`

Get a string that can be used as a format string for `time.strftime()` to represent date and time in a locale-specific way.

`locale.D_FMT`

Get a string that can be used as a format string for `time.strftime()` to represent a date in a locale-specific way.

`locale.T_FMT`

Get a string that can be used as a format string for `time.strftime()` to represent a time in a locale-specific way.

`locale.T_FMT_AMPM`

Get a format string for `time.strftime()` to represent time in the am/pm format.

`locale.DAY_1`

`locale.DAY_2`

`locale.DAY_3`

`locale.DAY_4`

`locale.DAY_5`

`locale.DAY_6`

`locale.DAY_7`

Get the name of the n-th day of the week.

備F: This follows the US convention of `DAY_1` being Sunday, not the international convention (ISO 8601) that Monday is the first day of the week.

`locale.ABDAY_1`

`locale.ABDAY_2`

`locale.ABDAY_3`

`locale.ABDAY_4`

`locale.ABDAY_5`

`locale.ABDAY_6`

`locale.ABDAY_7`

Get the abbreviated name of the n-th day of the week.

`locale.MON_1`

`locale.MON_2`

`locale.MON_3`

`locale.MON_4`

`locale.MON_5`

`locale.MON_6`
`locale.MON_7`
`locale.MON_8`
`locale.MON_9`
`locale.MON_10`
`locale.MON_11`
`locale.MON_12`

Get the name of the n-th month.

`locale.ABMON_1`
`locale.ABMON_2`
`locale.ABMON_3`
`locale.ABMON_4`
`locale.ABMON_5`
`locale.ABMON_6`
`locale.ABMON_7`
`locale.ABMON_8`
`locale.ABMON_9`
`locale.ABMON_10`
`locale.ABMON_11`
`locale.ABMON_12`

Get the abbreviated name of the n-th month.

`locale.RADIXCHAR`

Get the radix character (decimal dot, decimal comma, etc.).

`locale.THOUSEP`

Get the separator character for thousands (groups of three digits).

`locale.YESEXPR`

Get a regular expression that can be used with the `regex` function to recognize a positive response to a yes/no question.

`locale.NOEXPR`

Get a regular expression that can be used with the `regex(3)` function to recognize a negative response to a yes/no question.

備 F: The regular expressions for `YESEXPR` and `NOEXPR` use syntax suitable for the `regex` function from the C library, which might differ from the syntax used in *re*.

`locale.CRNCYSTR`

Get the currency symbol, preceded by “-” if the symbol should appear before the value, “+” if the symbol should appear after the value, or “.” if the symbol should replace the radix character.

`locale.ERA`

Get a string that represents the era used in the current locale.

Most locales do not define this value. An example of a locale which does define this value is the Japanese one. In Japan, the traditional representation of dates includes the name of the era corresponding to the then-emperor’s reign.

Normally it should not be necessary to use this value directly. Specifying the E modifier in their format strings causes the `time.strftime()` function to use this information. The format of the returned string is not specified, and therefore you should not assume knowledge of it on different systems.

`locale.ERA_D_T_FMT`

Get a format string for `time.strftime()` to represent date and time in a locale-specific era-based way.

`locale.ERA_D_FMT`

Get a format string for `time.strftime()` to represent a date in a locale-specific era-based way.

`locale.ERA_T_FMT`

Get a format string for `time.strftime()` to represent a time in a locale-specific era-based way.

`locale.ALT_DIGITS`

Get a representation of up to 100 values used to represent the values 0 to 99.

`locale.getdefaultlocale([envvars])`

Tries to determine the default locale settings and returns them as a tuple of the form (language code, encoding).

According to POSIX, a program which has not called `setlocale(LC_ALL, '')` runs using the portable 'C' locale. Calling `setlocale(LC_ALL, '')` lets it use the default locale as defined by the LANG variable. Since we do not want to interfere with the current locale setting we thus emulate the behavior in the way described above.

To maintain compatibility with other platforms, not only the LANG variable is tested, but a list of variables given as `envvars` parameter. The first found to be defined will be used. `envvars` defaults to the search path used in GNU gettext; it must always contain the variable name 'LANG'. The GNU gettext search path contains 'LC_ALL', 'LC_CTYPE', 'LANG' and 'LANGUAGE', in that order.

Except for the code 'C', the language code corresponds to [RFC 1766](#). *language code* and *encoding* may be None if their values cannot be determined.

自從版本 3.11 後不推薦使用，將會自版本 3.15 中移除。

`locale.getlocale(category=LC_CTYPE)`

Returns the current setting for the given locale category as sequence containing *language code*, *encoding*. *category* may be one of the LC_* values except LC_ALL. It defaults to LC_CTYPE.

Except for the code 'C', the language code corresponds to [RFC 1766](#). *language code* and *encoding* may be None if their values cannot be determined.

`locale.getpreferredencoding(do_setlocale=True)`

Return the *locale encoding* used for text data, according to user preferences. User preferences are expressed differently on different systems, and might not be available programmatically on some systems, so this function only returns a guess.

On some systems, it is necessary to invoke `setlocale()` to obtain the user preferences, so this function is not thread-safe. If invoking `setlocale` is not necessary or desired, `do_setlocale` should be set to False.

On Android or if the *Python UTF-8 Mode* is enabled, always return 'utf-8', the *locale encoding* and the `do_setlocale` argument are ignored.

The Python preinitialization configures the LC_CTYPE locale. See also the *filesystem encoding and error handler*.

在 3.7 版的變更: The function now always returns "utf-8" on Android or if the *Python UTF-8 Mode* is enabled.

`locale.getencoding()`

Get the current *locale encoding*:

- On Android and VxWorks, return "utf-8".
- On Unix, return the encoding of the current LC_CTYPE locale. Return "utf-8" if `nl_langinfo(CODESET)` returns an empty string; for example, if the current LC_CTYPE locale is not supported.
- On Windows, return the ANSI code page.

The Python preinitialization configures the `LC_CTYPE` locale. See also the *filesystem encoding and error handler*.

This function is similar to `getpreferredencoding(False)` except this function ignores the *Python UTF-8 Mode*.

在 3.11 版新加入.

`locale.normalize(localename)`

Returns a normalized locale code for the given locale name. The returned locale code is formatted for use with `setlocale()`. If normalization fails, the original name is returned unchanged.

If the given encoding is not known, the function defaults to the default encoding for the locale code just like `setlocale()`.

`locale.resetlocale(category=LC_ALL)`

Sets the locale for *category* to the default setting.

The default setting is determined by calling `getdefaultlocale()`. *category* defaults to `LC_ALL`.

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。.

`locale.strcoll(string1, string2)`

Compares two strings according to the current `LC_COLLATE` setting. As any other compare function, returns a negative, or a positive value, or 0, depending on whether *string1* collates before or after *string2* or is equal to it.

`locale.strxfrm(string)`

Transforms a string to one that can be used in locale-aware comparisons. For example, `strxfrm(s1) < strxfrm(s2)` is equivalent to `strcoll(s1, s2) < 0`. This function can be used when the same string is compared repeatedly, e.g. when collating a sequence of strings.

`locale.format_string(format, val, grouping=False, monetary=False)`

Formats a number *val* according to the current `LC_NUMERIC` setting. The format follows the conventions of the `%` operator. For floating point values, the decimal point is modified if appropriate. If *grouping* is `True`, also takes the grouping into account.

If *monetary* is `true`, the conversion uses monetary thousands separator and grouping strings.

Processes formatting specifiers as in `format % val`, but takes the current locale settings into account.

在 3.7 版的變更: The *monetary* keyword parameter was added.

`locale.format(format, val, grouping=False, monetary=False)`

Please note that this function works like `format_string()` but will only work for exactly one `%char` specifier. For example, `'%f'` and `'%.0f'` are both valid specifiers, but `'%f KiB'` is not.

For whole format strings, use `format_string()`.

在 3.7 版之後被 用: Use `format_string()` instead.

`locale.currency(val, symbol=True, grouping=False, international=False)`

Formats a number *val* according to the current `LC_MONETARY` settings.

The returned string includes the currency symbol if *symbol* is `true`, which is the default. If *grouping* is `True` (which is not the default), grouping is done with the value. If *international* is `True` (which is not the default), the international currency symbol is used.

備 註: This function will not work with the 'C' locale, so you have to set a locale via `setlocale()` first.

`locale.str(float)`

Formats a floating point number using the same format as the built-in function `str(float)`, but takes the decimal point into account.

`locale.delocalize(string)`

Converts a string into a normalized number string, following the `LC_NUMERIC` settings.

在 3.5 版新加入。

`locale.localize(string, grouping=False, monetary=False)`

Converts a normalized number string into a formatted string following the `LC_NUMERIC` settings.

在 3.10 版新加入。

`locale.atof(string, func=float)`

Converts a string to a number, following the `LC_NUMERIC` settings, by calling `func` on the result of calling `delocalize()` on `string`.

`locale.atoi(string)`

Converts a string to an integer, following the `LC_NUMERIC` conventions.

`locale.LC_CTYPE`

Locale category for the character type functions. Most importantly, this category defines the text encoding, i.e. how bytes are interpreted as Unicode codepoints. See [PEP 538](#) and [PEP 540](#) for how this variable might be automatically coerced to `C.UTF-8` to avoid issues created by invalid settings in containers or incompatible settings passed over remote SSH connections.

Python doesn't internally use locale-dependent character transformation functions from `ctype.h`. Instead, an internal `pyctype.h` provides locale-independent equivalents like `Py_TOLOWER`.

`locale.LC_COLLATE`

Locale category for sorting strings. The functions `strcoll()` and `strxfrm()` of the `locale` module are affected.

`locale.LC_TIME`

Locale category for the formatting of time. The function `time.strftime()` follows these conventions.

`locale.LC_MONETARY`

Locale category for formatting of monetary values. The available options are available from the `localeconv()` function.

`locale.LC_MESSAGES`

Locale category for message display. Python currently does not support application specific locale-aware messages. Messages displayed by the operating system, like those returned by `os.strerror()` might be affected by this category.

This value may not be available on operating systems not conforming to the POSIX standard, most notably Windows.

`locale.LC_NUMERIC`

Locale category for formatting numbers. The functions `format()`, `atoi()`, `atof()` and `str()` of the `locale` module are affected by that category. All other numeric formatting operations are not affected.

`locale.LC_ALL`

Combination of all locale settings. If this flag is used when the locale is changed, setting the locale for all categories is attempted. If that fails for any category, no category is changed at all. When the locale is retrieved using this flag, a string indicating the setting for all categories is returned. This string can be later used to restore the settings.

`locale.CHAR_MAX`

This is a symbolic constant used for different values returned by `localeconv()`.

範例：

```
>>> import locale
>>> loc = locale.getlocale() # get current locale
# use German locale; name might vary with platform
```

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(繼續上一頁)

```
>>> locale.setlocale(locale.LC_ALL, 'de_DE')
>>> locale.strcoll('f\xee4n', 'foo') # compare a string containing an umlaut
>>> locale.setlocale(locale.LC_ALL, '') # use user's preferred locale
>>> locale.setlocale(locale.LC_ALL, 'C') # use default (C) locale
>>> locale.setlocale(locale.LC_ALL, loc) # restore saved locale
```

23.2.1 Background, details, hints, tips and caveats

The C standard defines the locale as a program-wide property that may be relatively expensive to change. On top of that, some implementations are broken in such a way that frequent locale changes may cause core dumps. This makes the locale somewhat painful to use correctly.

Initially, when a program is started, the locale is the C locale, no matter what the user's preferred locale is. There is one exception: the `LC_CTYPE` category is changed at startup to set the current locale encoding to the user's preferred locale encoding. The program must explicitly say that it wants the user's preferred locale settings for other categories by calling `setlocale(LC_ALL, '')`.

It is generally a bad idea to call `setlocale()` in some library routine, since as a side effect it affects the entire program. Saving and restoring it is almost as bad: it is expensive and affects other threads that happen to run before the settings have been restored.

If, when coding a module for general use, you need a locale independent version of an operation that is affected by the locale (such as certain formats used with `time.strftime()`), you will have to find a way to do it without using the standard library routine. Even better is convincing yourself that using locale settings is okay. Only as a last resort should you document that your module is not compatible with non-C locale settings.

The only way to perform numeric operations according to the locale is to use the special functions defined by this module: `atof()`, `atoi()`, `format()`, `str()`.

There is no way to perform case conversions and character classifications according to the locale. For (Unicode) text strings these are done according to the character value only, while for byte strings, the conversions and classifications are done according to the ASCII value of the byte, and bytes whose high bit is set (i.e., non-ASCII bytes) are never converted or considered part of a character class such as letter or whitespace.

23.2.2 For extension writers and programs that embed Python

Extension modules should never call `setlocale()`, except to find out what the current locale is. But since the return value can only be used portably to restore it, that is not very useful (except perhaps to find out whether or not the locale is C).

When Python code uses the `locale` module to change the locale, this also affects the embedding application. If the embedding application doesn't want this to happen, it should remove the `_locale` extension module (which does all the work) from the table of built-in modules in the `config.c` file, and make sure that the `_locale` module is not accessible as a shared library.

23.2.3 Access to message catalogs

`locale.gettext(msg)`

`locale.dgettext(domain, msg)`

`locale.dcgettext(domain, msg, category)`

`locale.textdomain(domain)`

`locale.bindtextdomain(domain, dir)`

`locale.bind_textdomain_codeset` (*domain*, *codeset*)

The `locale` module exposes the C library's `gettext` interface on systems that provide this interface. It consists of the functions `gettext()`, `dgettext()`, `dcgettext()`, `textdomain()`, `bindtextdomain()`, and `bind_textdomain_codeset()`. These are similar to the same functions in the `gettext` module, but use the C library's binary format for message catalogs, and the C library's search algorithms for locating message catalogs.

Python applications should normally find no need to invoke these functions, and should use `gettext` instead. A known exception to this rule are applications that link with additional C libraries which internally invoke C functions `gettext` or `dcgettext`. For these applications, it may be necessary to bind the text domain, so that the libraries can properly locate their message catalogs.

The modules described in this chapter are frameworks that will largely dictate the structure of your program. Currently the modules described here are all oriented toward writing command-line interfaces.

The full list of modules described in this chapter is:

24.1 turtle --- 龜圖學

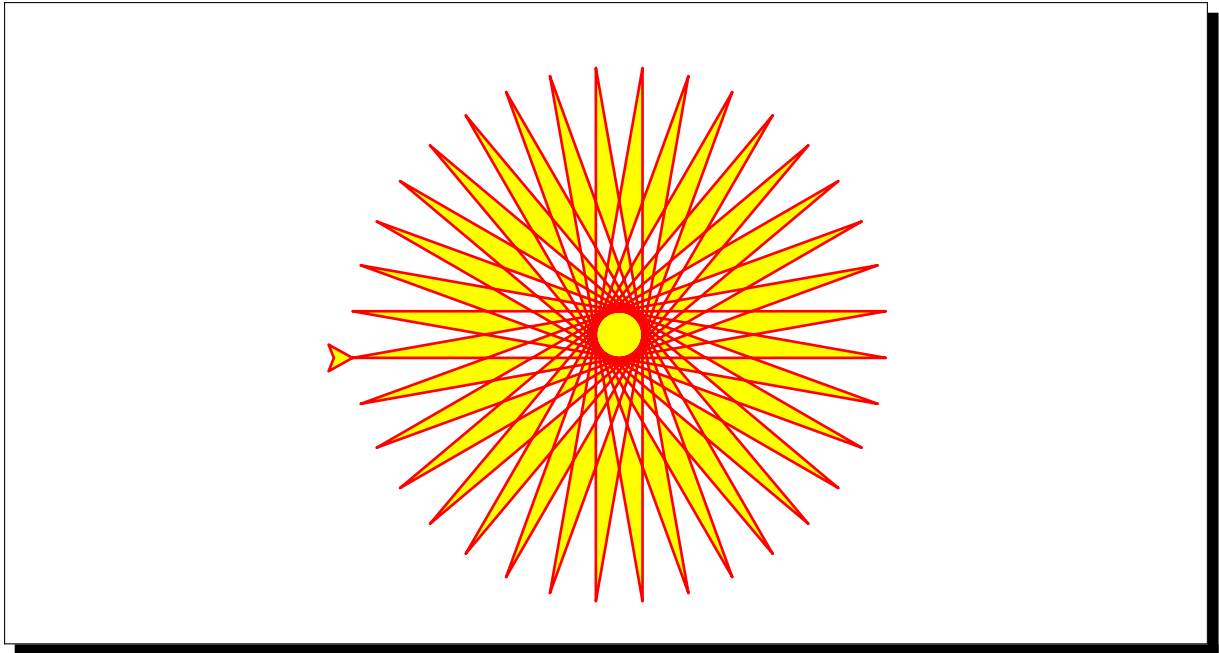
原始碼: [Lib/turtle.py](#)

24.1.1 介紹

Turtle graphics is an implementation of [the popular geometric drawing tools introduced in Logo](#), developed by Wally Feurzeig, Seymour Papert and Cynthia Solomon in 1967.

Turtle star

龜可以使用重疊簡單動作之程式來畫出複雜的形狀。



In Python, turtle graphics provides a representation of a physical “turtle” (a little robot with a pen) that draws on a sheet of paper on the floor.

It’s an effective and well-proven way for learners to encounter programming concepts and interaction with software, as it provides instant, visible feedback. It also provides convenient access to graphical output in general.

Turtle drawing was originally created as an educational tool, to be used by teachers in the classroom. For the programmer who needs to produce some graphical output it can be a way to do that without the overhead of introducing more complex or external libraries into their work.

24.1.2 Tutorial

New users should start here. In this tutorial we’ll explore some of the basics of turtle drawing.

Starting a turtle environment

In a Python shell, import all the objects of the `turtle` module:

```
from turtle import *
```

If you run into a No module named ‘`_tkinter`’ error, you’ll have to install the *Tk interface package* on your system.

Basic drawing

Send the turtle forward 100 steps:

```
forward(100)
```

You should see (most likely, in a new window on your display) a line drawn by the turtle, heading East. Change the direction of the turtle, so that it turns 120 degrees left (anti-clockwise):

```
left(120)
```

Let’s continue by drawing a triangle:

```
forward(100)
left(120)
forward(100)
```

Notice how the turtle, represented by an arrow, points in different directions as you steer it.

Experiment with those commands, and also with `backward()` and `right()`.

Pen control

Try changing the color - for example, `color('blue')` - and width of the line - for example, `width(3)` - and then drawing again.

You can also move the turtle around without drawing, by lifting up the pen: `up()` before moving. To start drawing again, use `down()`.

The turtle's position

Send your turtle back to its starting-point (useful if it has disappeared off-screen):

```
home()
```

The home position is at the center of the turtle's screen. If you ever need to know them, get the turtle's x-y co-ordinates with:

```
pos()
```

Home is at (0, 0).

And after a while, it will probably help to clear the window so we can start anew:

```
clearscreen()
```

Making algorithmic patterns

Using loops, it's possible to build up geometric patterns:

```
for steps in range(100):
    for c in ('blue', 'red', 'green'):
        color(c)
        forward(steps)
        right(30)
```

- which of course, are limited only by the imagination!

Let's draw the star shape at the top of this page. We want red lines, filled in with yellow:

```
color('red')
fillcolor('yellow')
```

Just as `up()` and `down()` determine whether lines will be drawn, filling can be turned on and off:

```
begin_fill()
```

Next we'll create a loop:

```
while True:
    forward(200)
    left(170)
    if abs(pos()) < 1:
        break
```

`abs(pos()) < 1` is a good way to know when the turtle is back at its home position.

Finally, complete the filling:

```
end_fill()
```

(Note that filling only actually takes place when you give the `end_fill()` command.)

24.1.3 How to...

This section covers some typical turtle use-cases and approaches.

Get started as quickly as possible

One of the joys of turtle graphics is the immediate, visual feedback that's available from simple commands - it's an excellent way to introduce children to programming ideas, with a minimum of overhead (not just children, of course).

The turtle module makes this possible by exposing all its basic functionality as functions, available with `from turtle import *`. The [turtle graphics tutorial](#) covers this approach.

It's worth noting that many of the turtle commands also have even more terse equivalents, such as `fd()` for `forward()`. These are especially useful when working with learners for whom typing is not a skill.

You'll need to have the *Tk interface package* installed on your system for turtle graphics to work. Be warned that this is not always straightforward, so check this in advance if you're planning to use turtle graphics with a learner.

Use the turtle module namespace

Using `from turtle import *` is convenient - but be warned that it imports a rather large collection of objects, and if you're doing anything but turtle graphics you run the risk of a name conflict (this becomes even more an issue if you're using turtle graphics in a script where other modules might be imported).

The solution is to use `import turtle` - `fd()` becomes `turtle.fd()`, `width()` becomes `turtle.width()` and so on. (If typing "turtle" over and over again becomes tedious, use for example `import turtle as t` instead.)

Use turtle graphics in a script

It's recommended to use the `turtle` module namespace as described immediately above, for example:

```
import turtle as t
from random import random

for i in range(100):
    steps = int(random() * 100)
    angle = int(random() * 360)
    t.right(angle)
    t.fd(steps)
```

Another step is also required though - as soon as the script ends, Python will also close the turtle's window. Add:

```
t.mainloop()
```

to the end of the script. The script will now wait to be dismissed and will not exit until it is terminated, for example by closing the turtle graphics window.

Use object-oriented turtle graphics

也參考:

Explanation of the object-oriented interface

Other than for very basic introductory purposes, or for trying things out as quickly as possible, it's more usual and much more powerful to use the object-oriented approach to turtle graphics. For example, this allows multiple turtles on screen at once.

In this approach, the various turtle commands are methods of objects (mostly of `Turtle` objects). You *can* use the object-oriented approach in the shell, but it would be more typical in a Python script.

The example above then becomes:

```
from turtle import Turtle
from random import random

t = Turtle()
for i in range(100):
    steps = int(random() * 100)
    angle = int(random() * 360)
    t.right(angle)
    t.fd(steps)

t.screen.mainloop()
```

Note the last line. `t.screen` is an instance of the *Screen* that a `Turtle` instance exists on; it's created automatically along with the turtle.

The turtle's screen can be customised, for example:

```
t.screen.title('Object-oriented turtle demo')
t.screen.bgcolor("orange")
```

24.1.4 Turtle graphics reference

備F: In the following documentation the argument list for functions is given. Methods, of course, have the additional first argument *self* which is omitted here.

Turtle methods

Turtle motion

Move and draw

```
forward() | fd()
backward() | bk() | back()
right() | rt()
left() | lt()
goto() | setpos() | setposition()
setx()
```

```
sety()  
setheading() | seth()  
home()  
circle()  
dot()  
stamp()  
clearstamp()  
clearstamps()  
undo()  
speed()
```

Tell Turtle's state

```
position() | pos()  
towards()  
xcor()  
ycor()  
heading()  
distance()
```

Setting and measurement

```
degrees()  
radians()
```

Pen control**Drawing state**

```
pendown() | pd() | down()  
penup() | pu() | up()  
pensize() | width()  
pen()  
isdown()
```

Color control

```
color()  
pencolor()  
fillcolor()
```

Filling

```
filling()  
begin_fill()  
end_fill()
```

More drawing control

```
reset()  
clear()  
write()
```

Turtle state**Visibility**

```
showturtle() | st()  
hideturtle() | ht()  
isvisible()
```

Appearance


```

    shape()
    resizemode()
    shapeseize() | turtlesize()
    shearfactor()
    settiltangle()
    tiltangle()
    tilt()
    shapetransform()
    get_shapepoly()

```

Using events

```

    onclick()
    onrelease()
    ondrag()

```

Special Turtle methods

```

    begin_poly()
    end_poly()
    get_poly()
    clone()
    getturtle() | getpen()
    getscreen()
    setundobuffer()
    undobufferentries()

```

Methods of TurtleScreen/Screen**Window control**

```

    bgcolor()
    bgpic()
    clearscreen()
    resetscreen()
    screensize()
    setworldcoordinates()

```

Animation control

```

    delay()
    tracer()
    update()

```

Using screen events

```

    listen()
    onkey() | onkeyrelease()
    onkeypress()
    onclick() | onscreenclick()
    ontimer()
    mainloop() | done()

```

Settings and special methods

```

    mode()
    colormode()
    getcanvas()

```

```
getshapes()
register_shape() | addshape()
turtles()
window_height()
window_width()
```

Input methods

```
textinput()
numinput()
```

Methods specific to Screen

```
bye()
exitonclick()
setup()
title()
```

24.1.5 Methods of RawTurtle/Turtle and corresponding functions

Most of the examples in this section refer to a Turtle instance called `turtle`.

Turtle motion

```
turtle.forward(distance)
turtle.fd(distance)
```

参数

distance -- a number (integer or float)

Move the turtle forward by the specified *distance*, in the direction the turtle is headed.

```
>>> turtle.position()
(0.00,0.00)
>>> turtle.forward(25)
>>> turtle.position()
(25.00,0.00)
>>> turtle.forward(-75)
>>> turtle.position()
(-50.00,0.00)
```

```
turtle.back(distance)
turtle.bk(distance)
turtle.backward(distance)
```

参数

distance -- a number

Move the turtle backward by *distance*, opposite to the direction the turtle is headed. Do not change the turtle's heading.

```
>>> turtle.position()
(0.00,0.00)
>>> turtle.backward(30)
>>> turtle.position()
(-30.00,0.00)
```

```
turtle.right(angle)
```

`turtle.rt(angle)`

參數

angle -- a number (integer or float)

Turn turtle right by *angle* units. (Units are by default degrees, but can be set via the `degrees()` and `radians()` functions.) Angle orientation depends on the turtle mode, see `mode()`.

```
>>> turtle.heading()
22.0
>>> turtle.right(45)
>>> turtle.heading()
337.0
```

`turtle.left(angle)`

`turtle.lt(angle)`

參數

angle -- a number (integer or float)

Turn turtle left by *angle* units. (Units are by default degrees, but can be set via the `degrees()` and `radians()` functions.) Angle orientation depends on the turtle mode, see `mode()`.

```
>>> turtle.heading()
22.0
>>> turtle.left(45)
>>> turtle.heading()
67.0
```

`turtle.goto(x, y=None)`

`turtle.setpos(x, y=None)`

`turtle.setposition(x, y=None)`

參數

- ***x*** -- a number or a pair/vector of numbers
- ***y*** -- a number or None

If *y* is None, *x* must be a pair of coordinates or a `Vec2D` (e.g. as returned by `pos()`).

Move turtle to an absolute position. If the pen is down, draw line. Do not change the turtle's orientation.

```
>>> tp = turtle.pos()
>>> tp
(0.00, 0.00)
>>> turtle.setpos(60, 30)
>>> turtle.pos()
(60.00, 30.00)
>>> turtle.setpos((20, 80))
>>> turtle.pos()
(20.00, 80.00)
>>> turtle.setpos(tp)
>>> turtle.pos()
(0.00, 0.00)
```

`turtle.setx(x)`

參數

x -- a number (integer or float)

Set the turtle's first coordinate to *x*, leave second coordinate unchanged.

```
>>> turtle.position()
(0.00, 240.00)
>>> turtle.setx(10)
>>> turtle.position()
(10.00, 240.00)
```

`turtle.sety(y)`

參數

y -- a number (integer or float)

Set the turtle's second coordinate to *y*, leave first coordinate unchanged.

```
>>> turtle.position()
(0.00, 40.00)
>>> turtle.sety(-10)
>>> turtle.position()
(0.00, -10.00)
```

`turtle.setheading(to_angle)`

`turtle.seth(to_angle)`

參數

to_angle -- a number (integer or float)

Set the orientation of the turtle to *to_angle*. Here are some common directions in degrees:

standard mode	logo mode
0 - east	0 - north
90 - north	90 - east
180 - west	180 - south
270 - south	270 - west

```
>>> turtle.setheading(90)
>>> turtle.heading()
90.0
```

`turtle.home()`

Move turtle to the origin -- coordinates (0,0) -- and set its heading to its start-orientation (which depends on the mode, see [mode\(\)](#)).

```
>>> turtle.heading()
90.0
>>> turtle.position()
(0.00, -10.00)
>>> turtle.home()
>>> turtle.position()
(0.00, 0.00)
>>> turtle.heading()
0.0
```

`turtle.circle(radius, extent=None, steps=None)`

參數

- **radius** -- a number
- **extent** -- a number (or None)
- **steps** -- an integer (or None)

Draw a circle with given *radius*. The center is *radius* units left of the turtle; *extent* -- an angle -- determines which part of the circle is drawn. If *extent* is not given, draw the entire circle. If *extent* is not a full circle, one endpoint of the arc is the current pen position. Draw the arc in counterclockwise direction if *radius* is positive, otherwise in clockwise direction. Finally the direction of the turtle is changed by the amount of *extent*.

As the circle is approximated by an inscribed regular polygon, *steps* determines the number of steps to use. If not given, it will be calculated automatically. May be used to draw regular polygons.

```
>>> turtle.home()
>>> turtle.position()
(0.00,0.00)
>>> turtle.heading()
0.0
>>> turtle.circle(50)
>>> turtle.position()
(-0.00,0.00)
>>> turtle.heading()
0.0
>>> turtle.circle(120, 180) # draw a semicircle
>>> turtle.position()
(0.00,240.00)
>>> turtle.heading()
180.0
```

`turtle.dot (size=None, *color)`

參數

- **size** -- an integer ≥ 1 (if given)
- **color** -- a colorstring or a numeric color tuple

Draw a circular dot with diameter *size*, using *color*. If *size* is not given, the maximum of pensize+4 and 2*pensize is used.

```
>>> turtle.home()
>>> turtle.dot()
>>> turtle.fd(50); turtle.dot(20, "blue"); turtle.fd(50)
>>> turtle.position()
(100.00,-0.00)
>>> turtle.heading()
0.0
```

`turtle.stamp()`

Stamp a copy of the turtle shape onto the canvas at the current turtle position. Return a `stamp_id` for that stamp, which can be used to delete it by calling `clearstamp(stamp_id)`.

```
>>> turtle.color("blue")
>>> turtle.stamp()
11
>>> turtle.fd(50)
```

`turtle.clearstamp (stampid)`

參數

stampid -- an integer, must be return value of previous `stamp()` call

Delete stamp with given *stampid*.

```
>>> turtle.position()
(150.00,-0.00)
>>> turtle.color("blue")
>>> astamp = turtle.stamp()
```

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```
>>> turtle.fd(50)
>>> turtle.position()
(200.00,-0.00)
>>> turtle.clearstamp(astamp)
>>> turtle.position()
(200.00,-0.00)
```

`turtle.clearstamps` (*n=None*)

參數

n -- an integer (or None)

Delete all or first/last *n* of turtle's stamps. If *n* is None, delete all stamps, if *n* > 0 delete first *n* stamps, else if *n* < 0 delete last *n* stamps.

```
>>> for i in range(8):
...     turtle.stamp(); turtle.fd(30)
13
14
15
16
17
18
19
20
>>> turtle.clearstamps(2)
>>> turtle.clearstamps(-2)
>>> turtle.clearstamps()
```

`turtle.undo` ()

Undo (repeatedly) the last turtle action(s). Number of available undo actions is determined by the size of the undobuffer.

```
>>> for i in range(4):
...     turtle.fd(50); turtle.lt(80)
...
>>> for i in range(8):
...     turtle.undo()
```

`turtle.speed` (*speed=None*)

參數

speed -- an integer in the range 0..10 or a speedstring (see below)

Set the turtle's speed to an integer value in the range 0..10. If no argument is given, return current speed.

If input is a number greater than 10 or smaller than 0.5, speed is set to 0. Speedstrings are mapped to speed-values as follows:

- "fastest": 0
- "fast": 10
- "normal": 6
- "slow": 3
- "slowest": 1

Speeds from 1 to 10 enforce increasingly faster animation of line drawing and turtle turning.

Attention: *speed* = 0 means that *no* animation takes place. forward/back makes turtle jump and likewise left/right make the turtle turn instantly.

```
>>> turtle.speed()
3
>>> turtle.speed('normal')
>>> turtle.speed()
6
>>> turtle.speed(9)
>>> turtle.speed()
9
```

Tell Turtle's state

`turtle.position()`

`turtle.pos()`

Return the turtle's current location (x,y) (as a *Vec2D* vector).

```
>>> turtle.pos()
(440.00, -0.00)
```

`turtle.towards(x, y=None)`

參數

- **x** -- a number or a pair/vector of numbers or a turtle instance
- **y** -- a number if *x* is a number, else None

Return the angle between the line from turtle position to position specified by (x,y), the vector or the other turtle. This depends on the turtle's start orientation which depends on the mode - "standard"/"world" or "logo".

```
>>> turtle.goto(10, 10)
>>> turtle.towards(0,0)
225.0
```

`turtle.xcor()`

Return the turtle's x coordinate.

```
>>> turtle.home()
>>> turtle.left(50)
>>> turtle.forward(100)
>>> turtle.pos()
(64.28, 76.60)
>>> print(round(turtle.xcor(), 5))
64.27876
```

`turtle.ycor()`

Return the turtle's y coordinate.

```
>>> turtle.home()
>>> turtle.left(60)
>>> turtle.forward(100)
>>> print(turtle.pos())
(50.00, 86.60)
>>> print(round(turtle.ycor(), 5))
86.60254
```

`turtle.heading()`

Return the turtle's current heading (value depends on the turtle mode, see *mode()*).

```
>>> turtle.home()
>>> turtle.left(67)
>>> turtle.heading()
67.0
```

`turtle.distance(x, y=None)`

參數

- **x** -- a number or a pair/vector of numbers or a turtle instance
- **y** -- a number if *x* is a number, else None

Return the distance from the turtle to (x,y), the given vector, or the given other turtle, in turtle step units.

```
>>> turtle.home()
>>> turtle.distance(30,40)
50.0
>>> turtle.distance((30,40))
50.0
>>> joe = Turtle()
>>> joe.forward(77)
>>> turtle.distance(joe)
77.0
```

Settings for measurement

`turtle.degrees(fullcircle=360.0)`

參數

fullcircle -- a number

Set angle measurement units, i.e. set number of "degrees" for a full circle. Default value is 360 degrees.

```
>>> turtle.home()
>>> turtle.left(90)
>>> turtle.heading()
90.0

Change angle measurement unit to grad (also known as gon,
grade, or gradian and equals 1/100-th of the right angle.)
>>> turtle.degrees(400.0)
>>> turtle.heading()
100.0
>>> turtle.degrees(360)
>>> turtle.heading()
90.0
```

`turtle.radians()`

Set the angle measurement units to radians. Equivalent to `degrees(2*math.pi)`.

```
>>> turtle.home()
>>> turtle.left(90)
>>> turtle.heading()
90.0
>>> turtle.radians()
>>> turtle.heading()
1.5707963267948966
```


Pen control

Drawing state

```
turtle.pendown()
```

```
turtle.pd()
```

```
turtle.down()
```

Pull the pen down -- drawing when moving.

```
turtle.penup()
```

```
turtle.pu()
```

```
turtle.up()
```

Pull the pen up -- no drawing when moving.

```
turtle.pensize(width=None)
```

```
turtle.width(width=None)
```

參數

width -- a positive number

Set the line thickness to *width* or return it. If *resizemode* is set to "auto" and *turtleshape* is a polygon, that polygon is drawn with the same line thickness. If no argument is given, the current pensize is returned.

```
>>> turtle.pensize()
1
>>> turtle.pensize(10)    # from here on lines of width 10 are drawn
```

```
turtle.pen(pen=None, **pendict)
```

參數

- **pen** -- a dictionary with some or all of the below listed keys
- **pendict** -- one or more keyword-arguments with the below listed keys as keywords

Return or set the pen's attributes in a "pen-dictionary" with the following key/value pairs:

- "shown": True/False
- "pendown": True/False
- "pencolor": color-string or color-tuple
- "fillcolor": color-string or color-tuple
- "pensize": positive number
- "speed": number in range 0..10
- "resizemode": "auto" or "user" or "noresize"
- "stretchfactor": (positive number, positive number)
- "outline": positive number
- "tilt": number

This dictionary can be used as argument for a subsequent call to `pen()` to restore the former pen-state. Moreover one or more of these attributes can be provided as keyword-arguments. This can be used to set several pen attributes in one statement.

```
>>> turtle.pen(fillcolor="black", pencolor="red", pensize=10)
>>> sorted(turtle.pen().items())
[('fillcolor', 'black'), ('outline', 1), ('pencolor', 'red'),
 ('pendown', True), ('pensize', 10), ('resizemode', 'noresize'),
```

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```

('shearfactor', 0.0), ('shown', True), ('speed', 9),
('stretchfactor', (1.0, 1.0)), ('tilt', 0.0)]
>>> penstate=turtle.pen()
>>> turtle.color("yellow", "")
>>> turtle.penup()
>>> sorted(turtle.pen().items())[:3]
[('fillcolor', ''), ('outline', 1), ('pencolor', 'yellow')]
>>> turtle.pen(penstate, fillcolor="green")
>>> sorted(turtle.pen().items())[:3]
[('fillcolor', 'green'), ('outline', 1), ('pencolor', 'red')]

```

`turtle.isdown()`

Return True if pen is down, False if it's up.

```

>>> turtle.penup()
>>> turtle.isdown()
False
>>> turtle.pendown()
>>> turtle.isdown()
True

```

Color control

`turtle.pencolor(*args)`

Return or set the pencolor.

Four input formats are allowed:

`pencolor()`

Return the current pencolor as color specification string or as a tuple (see example). May be used as input to another color/pencolor/fillcolor call.

`pencolor(colorstring)`

Set pencolor to *colorstring*, which is a Tk color specification string, such as "red", "yellow", or "#33cc8c".

`pencolor(r, g, b)`

Set pencolor to the RGB color represented by the tuple of *r*, *g*, and *b*. Each of *r*, *g*, and *b* must be in the range 0..colormode, where colormode is either 1.0 or 255 (see `colormode()`).

`pencolor(r, g, b)`

Set pencolor to the RGB color represented by *r*, *g*, and *b*. Each of *r*, *g*, and *b* must be in the range 0..colormode.

If `turtleshape` is a polygon, the outline of that polygon is drawn with the newly set pencolor.

```

>>> colormode()
1.0
>>> turtle.pencolor()
'red'
>>> turtle.pencolor("brown")
>>> turtle.pencolor()
'brown'
>>> tup = (0.2, 0.8, 0.55)
>>> turtle.pencolor(tup)
>>> turtle.pencolor()
(0.2, 0.8, 0.5490196078431373)
>>> colormode(255)
>>> turtle.pencolor()
(51.0, 204.0, 140.0)

```

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```
>>> turtle.pencolor('#32c18f')
>>> turtle.pencolor()
(50.0, 193.0, 143.0)
```

`turtle.fillcolor(*args)`

Return or set the fillcolor.

Four input formats are allowed:

fillcolor()

Return the current fillcolor as color specification string, possibly in tuple format (see example). May be used as input to another color/pencolor/fillcolor call.

fillcolor(colorstring)

Set fillcolor to *colorstring*, which is a Tk color specification string, such as "red", "yellow", or "#33cc8c".

fillcolor(r, g, b)

Set fillcolor to the RGB color represented by the tuple of *r*, *g*, and *b*. Each of *r*, *g*, and *b* must be in the range 0..colormode, where colormode is either 1.0 or 255 (see `colormode()`).

fillcolor(r, g, b)

Set fillcolor to the RGB color represented by *r*, *g*, and *b*. Each of *r*, *g*, and *b* must be in the range 0..colormode.

If turtleshape is a polygon, the interior of that polygon is drawn with the newly set fillcolor.

```
>>> turtle.fillcolor("violet")
>>> turtle.fillcolor()
'violet'
>>> turtle.pencolor()
(50.0, 193.0, 143.0)
>>> turtle.fillcolor((50, 193, 143)) # Integers, not floats
>>> turtle.fillcolor()
(50.0, 193.0, 143.0)
>>> turtle.fillcolor('#ffffff')
>>> turtle.fillcolor()
(255.0, 255.0, 255.0)
```

`turtle.color(*args)`

Return or set pencolor and fillcolor.

Several input formats are allowed. They use 0 to 3 arguments as follows:

color()

Return the current pencolor and the current fillcolor as a pair of color specification strings or tuples as returned by `pencolor()` and `fillcolor()`.

color(colorstring), color(r, g, b), color(r, g, b)

Inputs as in `pencolor()`, set both, fillcolor and pencolor, to the given value.

color(colorstring1, colorstring2), color(r1, g1, b1), (r2, g2, b2))

Equivalent to `pencolor(colorstring1)` and `fillcolor(colorstring2)` and analogously if the other input format is used.

If turtleshape is a polygon, outline and interior of that polygon is drawn with the newly set colors.

```
>>> turtle.color("red", "green")
>>> turtle.color()
('red', 'green')
>>> color("#285078", "#a0c8f0")
>>> color()
((40.0, 80.0, 120.0), (160.0, 200.0, 240.0))
```

See also: Screen method `colormode()`.

Filling

`turtle.filling()`

Return fillstate (True if filling, False else).

```
>>> turtle.begin_fill()
>>> if turtle.filling():
...     turtle.pensize(5)
... else:
...     turtle.pensize(3)
```

`turtle.begin_fill()`

To be called just before drawing a shape to be filled.

`turtle.end_fill()`

Fill the shape drawn after the last call to `begin_fill()`.

Whether or not overlap regions for self-intersecting polygons or multiple shapes are filled depends on the operating system graphics, type of overlap, and number of overlaps. For example, the Turtle star above may be either all yellow or have some white regions.

```
>>> turtle.color("black", "red")
>>> turtle.begin_fill()
>>> turtle.circle(80)
>>> turtle.end_fill()
```

More drawing control

`turtle.reset()`

Delete the turtle's drawings from the screen, re-center the turtle and set variables to the default values.

```
>>> turtle.goto(0,-22)
>>> turtle.left(100)
>>> turtle.position()
(0.00,-22.00)
>>> turtle.heading()
100.0
>>> turtle.reset()
>>> turtle.position()
(0.00,0.00)
>>> turtle.heading()
0.0
```

`turtle.clear()`

Delete the turtle's drawings from the screen. Do not move turtle. State and position of the turtle as well as drawings of other turtles are not affected.

`turtle.write(arg, move=False, align='left', font=('Arial', 8, 'normal'))`

參數

- **arg** -- object to be written to the TurtleScreen
- **move** -- True/False
- **align** -- one of the strings "left", "center" or "right"
- **font** -- a triple (fontname, fontsize, fonttype)

Write text - the string representation of *arg* - at the current turtle position according to *align* ("left", "center" or "right") and with the given font. If *move* is true, the pen is moved to the bottom-right corner of the text. By default, *move* is False.

```
>>> turtle.write("Home = ", True, align="center")
>>> turtle.write((0,0), True)
```

Turtle state

Visibility

`turtle.hideturtle()`

`turtle.ht()`

Make the turtle invisible. It's a good idea to do this while you're in the middle of doing some complex drawing, because hiding the turtle speeds up the drawing observably.

```
>>> turtle.hideturtle()
```

`turtle.showturtle()`

`turtle.st()`

Make the turtle visible.

```
>>> turtle.showturtle()
```

`turtle.isvisible()`

Return True if the Turtle is shown, False if it's hidden.

```
>>> turtle.hideturtle()
>>> turtle.isvisible()
False
>>> turtle.showturtle()
>>> turtle.isvisible()
True
```

Appearance

`turtle.shape(name=None)`

参数

name -- a string which is a valid shapename

Set turtle shape to shape with given *name* or, if name is not given, return name of current shape. Shape with *name* must exist in the TurtleScreen's shape dictionary. Initially there are the following polygon shapes: "arrow", "turtle", "circle", "square", "triangle", "classic". To learn about how to deal with shapes see Screen method [register_shape\(\)](#).

```
>>> turtle.shape()
'classic'
>>> turtle.shape("turtle")
>>> turtle.shape()
'turtle'
```

`turtle.resizemode(rmode=None)`

参数

rmode -- one of the strings "auto", "user", "noresize"

Set `resizemode` to one of the values: "auto", "user", "noresize". If *rmode* is not given, return current `resizemode`. Different `resizemodes` have the following effects:

- "auto": adapts the appearance of the turtle corresponding to the value of `pensize`.
- "user": adapts the appearance of the turtle according to the values of `stretchfactor` and `outlinewidth` (outline), which are set by `shapesize()`.
- "noresize": no adaption of the turtle's appearance takes place.

`resizemode("user")` is called by `shapesize()` when used with arguments.

```
>>> turtle.resizemode()
'noresize'
>>> turtle.resizemode("auto")
>>> turtle.resizemode()
'auto'
```

`turtle.shapesize(stretch_wid=None, stretch_len=None, outline=None)`

`turtle.turtlesize(stretch_wid=None, stretch_len=None, outline=None)`

参数

- **stretch_wid** -- positive number
- **stretch_len** -- positive number
- **outline** -- positive number

Return or set the pen's attributes x/y-stretchfactors and/or outline. Set `resizemode` to "user". If and only if `resizemode` is set to "user", the turtle will be displayed stretched according to its stretchfactors: *stretch_wid* is stretchfactor perpendicular to its orientation, *stretch_len* is stretchfactor in direction of its orientation, *outline* determines the width of the shape's outline.

```
>>> turtle.shapesize()
(1.0, 1.0, 1)
>>> turtle.resizemode("user")
>>> turtle.shapesize(5, 5, 12)
>>> turtle.shapesize()
(5, 5, 12)
>>> turtle.shapesize(outline=8)
>>> turtle.shapesize()
(5, 5, 8)
```

`turtle.shearfactor(shear=None)`

参数

shear -- number (optional)

Set or return the current `shearfactor`. Shear the `turtleshape` according to the given `shearfactor` `shear`, which is the tangent of the shear angle. Do *not* change the turtle's heading (direction of movement). If `shear` is not given: return the current `shearfactor`, i. e. the tangent of the shear angle, by which lines parallel to the heading of the turtle are sheared.

```
>>> turtle.shape("circle")
>>> turtle.shapesize(5,2)
>>> turtle.shearfactor(0.5)
>>> turtle.shearfactor()
0.5
```

`turtle.tilt(angle)`

参数

angle -- a number

Rotate the turtleshape by *angle* from its current tilt-angle, but do *not* change the turtle's heading (direction of movement).

```
>>> turtle.reset()
>>> turtle.shape("circle")
>>> turtle.shapesize(5,2)
>>> turtle.tilt(30)
>>> turtle.fd(50)
>>> turtle.tilt(30)
>>> turtle.fd(50)
```

`turtle.settiltangle(angle)`

参数

angle -- a number

Rotate the turtleshape to point in the direction specified by *angle*, regardless of its current tilt-angle. Do *not* change the turtle's heading (direction of movement).

```
>>> turtle.reset()
>>> turtle.shape("circle")
>>> turtle.shapesize(5,2)
>>> turtle.settiltangle(45)
>>> turtle.fd(50)
>>> turtle.settiltangle(-45)
>>> turtle.fd(50)
```

在 3.1 版之後被弃用。

`turtle.tiltangle(angle=None)`

参数

angle -- a number (optional)

Set or return the current tilt-angle. If *angle* is given, rotate the turtleshape to point in the direction specified by *angle*, regardless of its current tilt-angle. Do *not* change the turtle's heading (direction of movement). If *angle* is not given: return the current tilt-angle, i. e. the angle between the orientation of the turtleshape and the heading of the turtle (its direction of movement).

```
>>> turtle.reset()
>>> turtle.shape("circle")
>>> turtle.shapesize(5,2)
>>> turtle.tilt(45)
>>> turtle.tiltangle()
45.0
```

`turtle.shapetransform(t11=None, t12=None, t21=None, t22=None)`

参数

- **t11** -- a number (optional)
- **t12** -- a number (optional)
- **t21** -- a number (optional)
- **t22** -- a number (optional)

Set or return the current transformation matrix of the turtle shape.

If none of the matrix elements are given, return the transformation matrix as a tuple of 4 elements. Otherwise set the given elements and transform the turtleshape according to the matrix consisting of first row *t11*, *t12* and second row *t21*, *t22*. The determinant $t11 * t22 - t12 * t21$ must not be zero, otherwise an error is raised. Modify stretchfactor, shearfactor and tiltangle according to the given matrix.

```
>>> turtle = Turtle()
>>> turtle.shape("square")
>>> turtle.shapesize(4,2)
>>> turtle.shearfactor(-0.5)
>>> turtle.shapetransform()
(4.0, -1.0, -0.0, 2.0)
```

`turtle.get_shapepoly()`

Return the current shape polygon as tuple of coordinate pairs. This can be used to define a new shape or components of a compound shape.

```
>>> turtle.shape("square")
>>> turtle.shapetransform(4, -1, 0, 2)
>>> turtle.get_shapepoly()
((50, -20), (30, 20), (-50, 20), (-30, -20))
```

Using events

`turtle.onclick(fun, btn=1, add=None)`

參數

- **fun** -- a function with two arguments which will be called with the coordinates of the clicked point on the canvas
- **btn** -- number of the mouse-button, defaults to 1 (left mouse button)
- **add** -- True or False -- if True, a new binding will be added, otherwise it will replace a former binding

Bind *fun* to mouse-click events on this turtle. If *fun* is None, existing bindings are removed. Example for the anonymous turtle, i.e. the procedural way:

```
>>> def turn(x, y):
...     left(180)
...
>>> onclick(turn)    # Now clicking into the turtle will turn it.
>>> onclick(None)    # event-binding will be removed
```

`turtle.onrelease(fun, btn=1, add=None)`

參數

- **fun** -- a function with two arguments which will be called with the coordinates of the clicked point on the canvas
- **btn** -- number of the mouse-button, defaults to 1 (left mouse button)
- **add** -- True or False -- if True, a new binding will be added, otherwise it will replace a former binding

Bind *fun* to mouse-button-release events on this turtle. If *fun* is None, existing bindings are removed.

```
>>> class MyTurtle(Turtle):
...     def glow(self, x, y):
...         self.fillcolor("red")
...     def unglow(self, x, y):
...         self.fillcolor("")
...
>>> turtle = MyTurtle()
>>> turtle.onclick(turtle.glow)    # clicking on turtle turns fillcolor red,
>>> turtle.onrelease(turtle.unglow) # releasing turns it to transparent.
```


`turtle.ondrag` (*fun*, *btn=1*, *add=None*)

參數

- **fun** -- a function with two arguments which will be called with the coordinates of the clicked point on the canvas
- **btn** -- number of the mouse-button, defaults to 1 (left mouse button)
- **add** -- True or False -- if True, a new binding will be added, otherwise it will replace a former binding

Bind *fun* to mouse-move events on this turtle. If *fun* is `None`, existing bindings are removed.

Remark: Every sequence of mouse-move-events on a turtle is preceded by a mouse-click event on that turtle.

```
>>> turtle.ondrag(turtle.goto)
```

Subsequently, clicking and dragging the Turtle will move it across the screen thereby producing handdrawings (if pen is down).

Special Turtle methods

`turtle.begin_poly` ()

Start recording the vertices of a polygon. Current turtle position is first vertex of polygon.

`turtle.end_poly` ()

Stop recording the vertices of a polygon. Current turtle position is last vertex of polygon. This will be connected with the first vertex.

`turtle.get_poly` ()

Return the last recorded polygon.

```
>>> turtle.home()
>>> turtle.begin_poly()
>>> turtle.fd(100)
>>> turtle.left(20)
>>> turtle.fd(30)
>>> turtle.left(60)
>>> turtle.fd(50)
>>> turtle.end_poly()
>>> p = turtle.get_poly()
>>> register_shape("myFavouriteShape", p)
```

`turtle.clone` ()

Create and return a clone of the turtle with same position, heading and turtle properties.

```
>>> mick = Turtle()
>>> joe = mick.clone()
```

`turtle.getturtle` ()

`turtle.getpen` ()

Return the Turtle object itself. Only reasonable use: as a function to return the "anonymous turtle":

```
>>> pet = getturtle()
>>> pet.fd(50)
>>> pet
<turtle.Turtle object at 0x...>
```

`turtle.getscreen` ()

Return the `TurtleScreen` object the turtle is drawing on. `TurtleScreen` methods can then be called for that object.

```
>>> ts = turtle.getscreen()
>>> ts
<turtle._Screen object at 0x...>
>>> ts.bgcolor("pink")
```

`turtle.setundobuffer(size)`

參數

size -- an integer or None

Set or disable undobuffer. If *size* is an integer, an empty undobuffer of given size is installed. *size* gives the maximum number of turtle actions that can be undone by the `undo()` method/function. If *size* is None, the undobuffer is disabled.

```
>>> turtle.setundobuffer(42)
```

`turtle.undobufferentries()`

Return number of entries in the undobuffer.

```
>>> while undobufferentries():
...     undo()
```

Compound shapes

To use compound turtle shapes, which consist of several polygons of different color, you must use the helper class *Shape* explicitly as described below:

1. Create an empty Shape object of type "compound".
2. Add as many components to this object as desired, using the `addcomponent()` method.

舉例來F:

```
>>> s = Shape("compound")
>>> poly1 = ((0,0), (10,-5), (0,10), (-10,-5))
>>> s.addcomponent(poly1, "red", "blue")
>>> poly2 = ((0,0), (10,-5), (-10,-5))
>>> s.addcomponent(poly2, "blue", "red")
```

3. Now add the Shape to the Screen's shapelist and use it:

```
>>> register_shape("myshape", s)
>>> shape("myshape")
```

備F: The *Shape* class is used internally by the `register_shape()` method in different ways. The application programmer has to deal with the Shape class *only* when using compound shapes like shown above!

24.1.6 Methods of TurtleScreen/Screen and corresponding functions

Most of the examples in this section refer to a TurtleScreen instance called `screen`.

Window control

`turtle.bgcolor(*args)`

参数

args -- a color string or three numbers in the range 0..colormode or a 3-tuple of such numbers

Set or return background color of the TurtleScreen.

```
>>> screen.bgcolor("orange")
>>> screen.bgcolor()
'orange'
>>> screen.bgcolor("#800080")
>>> screen.bgcolor()
(128.0, 0.0, 128.0)
```

`turtle.bgpic(picname=None)`

参数

picname -- a string, name of a gif-file or "nopic", or None

Set background image or return name of current backgroundimage. If *picname* is a filename, set the corresponding image as background. If *picname* is "nopic", delete background image, if present. If *picname* is None, return the filename of the current backgroundimage.

```
>>> screen.bgpic()
'nopic'
>>> screen.bgpic("landscape.gif")
>>> screen.bgpic()
"landscape.gif"
```

`turtle.clear()`

備註: This TurtleScreen method is available as a global function only under the name `clearscreen`. The global function `clear` is a different one derived from the Turtle method `clear`.

`turtle.clearscreen()`

Delete all drawings and all turtles from the TurtleScreen. Reset the now empty TurtleScreen to its initial state: white background, no background image, no event bindings and tracing on.

`turtle.reset()`

備註: This TurtleScreen method is available as a global function only under the name `resetscreen`. The global function `reset` is another one derived from the Turtle method `reset`.

`turtle.resetscreen()`

Reset all Turtles on the Screen to their initial state.

`turtle.screensize(canvwidth=None, canvheight=None, bg=None)`

参数

- **canvwidth** -- positive integer, new width of canvas in pixels
- **canvheight** -- positive integer, new height of canvas in pixels
- **bg** -- colorstring or color-tuple, new background color

If no arguments are given, return current (canvaswidth, canvasheight). Else resize the canvas the turtles are drawing on. Do not alter the drawing window. To observe hidden parts of the canvas, use the scrollbars. With this method, one can make visible those parts of a drawing which were outside the canvas before.

```
>>> screen.screensize()
(400, 300)
>>> screen.screensize(2000,1500)
>>> screen.screensize()
(2000, 1500)
```

e.g. to search for an erroneously escaped turtle ;-)

```
turtle.setworldcoordinates (llx, lly, urx, ury)
```

参数

- **llx** -- a number, x-coordinate of lower left corner of canvas
- **lly** -- a number, y-coordinate of lower left corner of canvas
- **urx** -- a number, x-coordinate of upper right corner of canvas
- **ury** -- a number, y-coordinate of upper right corner of canvas

Set up user-defined coordinate system and switch to mode "world" if necessary. This performs a `screen.reset()`. If mode "world" is already active, all drawings are redrawn according to the new coordinates.

ATTENTION: in user-defined coordinate systems angles may appear distorted.

```
>>> screen.reset()
>>> screen.setworldcoordinates(-50,-7.5,50,7.5)
>>> for _ in range(72):
...     left(10)
...
>>> for _ in range(8):
...     left(45); fd(2)    # a regular octagon
```

Animation control

```
turtle.delay (delay=None)
```

参数

delay -- positive integer

Set or return the drawing *delay* in milliseconds. (This is approximately the time interval between two consecutive canvas updates.) The longer the drawing delay, the slower the animation.

Optional argument:

```
>>> screen.delay()
10
>>> screen.delay(5)
>>> screen.delay()
5
```

```
turtle.tracer (n=None, delay=None)
```

参数

- **n** -- nonnegative integer
- **delay** -- nonnegative integer

Turn turtle animation on/off and set delay for update drawings. If *n* is given, only each *n*-th regular screen update is really performed. (Can be used to accelerate the drawing of complex graphics.) When called without arguments, returns the currently stored value of *n*. Second argument sets delay value (see `delay()`).

```
>>> screen.tracer(8, 25)
>>> dist = 2
>>> for i in range(200):
...     fd(dist)
...     rt(90)
...     dist += 2
```

`turtle.update()`

Perform a TurtleScreen update. To be used when tracer is turned off.

See also the RawTurtle/Turtle method `speed()`.

Using screen events

`turtle.listen(xdummy=None, ydummy=None)`

Set focus on TurtleScreen (in order to collect key-events). Dummy arguments are provided in order to be able to pass `listen()` to the onclick method.

`turtle.onkey(fun, key)`

`turtle.onkeyrelease(fun, key)`

參數

- **fun** -- a function with no arguments or None
- **key** -- a string: key (e.g. "a") or key-symbol (e.g. "space")

Bind *fun* to key-release event of key. If *fun* is None, event bindings are removed. Remark: in order to be able to register key-events, TurtleScreen must have the focus. (See method `listen()`.)

```
>>> def f():
...     fd(50)
...     lt(60)
...
>>> screen.onkey(f, "Up")
>>> screen.listen()
```

`turtle.onkeypress(fun, key=None)`

參數

- **fun** -- a function with no arguments or None
- **key** -- a string: key (e.g. "a") or key-symbol (e.g. "space")

Bind *fun* to key-press event of key if key is given, or to any key-press-event if no key is given. Remark: in order to be able to register key-events, TurtleScreen must have focus. (See method `listen()`.)

```
>>> def f():
...     fd(50)
...
>>> screen.onkey(f, "Up")
>>> screen.listen()
```

`turtle.onclick(fun, btn=1, add=None)`

`turtle.onscreenclick(fun, btn=1, add=None)`

參數

- **fun** -- a function with two arguments which will be called with the coordinates of the clicked point on the canvas
- **btn** -- number of the mouse-button, defaults to 1 (left mouse button)

- **add** -- True or False -- if True, a new binding will be added, otherwise it will replace a former binding

Bind *fun* to mouse-click events on this screen. If *fun* is None, existing bindings are removed.

Example for a TurtleScreen instance named *screen* and a Turtle instance named *turtle*:

```
>>> screen.onclick(turtle.goto) # Subsequently clicking into the TurtleScreen
↳ will
>>>                                     # make the turtle move to the clicked point.
>>> screen.onclick(None)           # remove event binding again
```

備 註: This TurtleScreen method is available as a global function only under the name `onscreenclick`. The global function `onclick` is another one derived from the Turtle method `onclick`.

`turtle.ontimer(fun, t=0)`

参数

- **fun** -- a function with no arguments
- **t** -- a number ≥ 0

Install a timer that calls *fun* after *t* milliseconds.

```
>>> running = True
>>> def f():
...     if running:
...         fd(50)
...         lt(60)
...         screen.ontimer(f, 250)
>>> f()    ### makes the turtle march around
>>> running = False
```

`turtle.mainloop()`

`turtle.done()`

Starts event loop - calling Tkinter's `mainloop` function. Must be the last statement in a turtle graphics program. Must *not* be used if a script is run from within IDLE in -n mode (No subprocess) - for interactive use of turtle graphics.

```
>>> screen.mainloop()
```

Input methods

`turtle.textinput(title, prompt)`

参数

- **title** -- string (字串)
- **prompt** -- string (字串)

Pop up a dialog window for input of a string. Parameter *title* is the title of the dialog window, *prompt* is a text mostly describing what information to input. Return the string input. If the dialog is canceled, return None.

```
>>> screen.textinput("NIM", "Name of first player:")
```

`turtle.numinput(title, prompt, default=None, minval=None, maxval=None)`

参数

- **title** -- string (字串)

- **prompt** -- string (字串)
- **default** -- number (optional)
- **minval** -- number (optional)
- **maxval** -- number (optional)

Pop up a dialog window for input of a number. title is the title of the dialog window, prompt is a text mostly describing what numerical information to input. default: default value, minval: minimum value for input, maxval: maximum value for input. The number input must be in the range minval .. maxval if these are given. If not, a hint is issued and the dialog remains open for correction. Return the number input. If the dialog is canceled, return None.

```
>>> screen.numinput("Poker", "Your stakes:", 1000, minval=10, maxval=10000)
```

Settings and special methods

`turtle.mode(mode=None)`

參數

mode -- one of the strings "standard", "logo" or "world"

Set turtle mode ("standard", "logo" or "world") and perform reset. If mode is not given, current mode is returned.

Mode "standard" is compatible with old `turtle`. Mode "logo" is compatible with most Logo turtle graphics. Mode "world" uses user-defined "world coordinates". **Attention:** in this mode angles appear distorted if x/y unit-ratio doesn't equal 1.

Mode	Initial turtle heading	positive angles
"standard"	to the right (east)	counterclockwise
"logo"	upward (north)	clockwise

```
>>> mode("logo")      # resets turtle heading to north
>>> mode()
'logo'
```

`turtle.colormode(cmode=None)`

參數

cmode -- one of the values 1.0 or 255

Return the colormode or set it to 1.0 or 255. Subsequently *r*, *g*, *b* values of color triples have to be in the range 0..*cmode*.

```
>>> screen.colormode(1)
>>> turtle.pencolor(240, 160, 80)
Traceback (most recent call last):
...
TurtleGraphicsError: bad color sequence: (240, 160, 80)
>>> screen.colormode()
1.0
>>> screen.colormode(255)
>>> screen.colormode()
255
>>> turtle.pencolor(240,160,80)
```

`turtle.getcanvas()`

Return the Canvas of this TurtleScreen. Useful for insiders who know what to do with a Tkinter Canvas.

```
>>> cv = screen.getcanvas()
>>> cv
<turtle.ScrolledCanvas object ...>
```

`turtle.getshapes()`

Return a list of names of all currently available turtle shapes.

```
>>> screen.getshapes()
['arrow', 'blank', 'circle', ..., 'turtle']
```

`turtle.register_shape(name, shape=None)`

`turtle.addshape(name, shape=None)`

There are three different ways to call this function:

- (1) *name* is the name of a gif-file and *shape* is `None`: Install the corresponding image shape.

```
>>> screen.register_shape("turtle.gif")
```

備 F: Image shapes *do not* rotate when turning the turtle, so they do not display the heading of the turtle!

- (2) *name* is an arbitrary string and *shape* is a tuple of pairs of coordinates: Install the corresponding polygon shape.

```
>>> screen.register_shape("triangle", ((5,-3), (0,5), (-5,-3)))
```

- (3) *name* is an arbitrary string and *shape* is a (compound) *Shape* object: Install the corresponding compound shape.

Add a turtle shape to TurtleScreen's shapelist. Only thusly registered shapes can be used by issuing the command `shape(shapename)`.

`turtle.turtles()`

Return the list of turtles on the screen.

```
>>> for turtle in screen.turtles():
...     turtle.color("red")
```

`turtle.window_height()`

Return the height of the turtle window.

```
>>> screen.window_height()
480
```

`turtle.window_width()`

Return the width of the turtle window.

```
>>> screen.window_width()
640
```


Methods specific to Screen, not inherited from TurtleScreen

`turtle.bye()`

Shut the turtlegraphics window.

`turtle.exitonclick()`

Bind `bye()` method to mouse clicks on the Screen.

If the value "using_IDLE" in the configuration dictionary is `False` (default value), also enter mainloop. Remark: If IDLE with the `-n` switch (no subprocess) is used, this value should be set to `True` in `turtle.cfg`. In this case IDLE's own mainloop is active also for the client script.

`turtle.setup(width=_CFG['width'], height=_CFG['height'], startx=_CFG['leftright'], starty=_CFG['topbottom'])`

Set the size and position of the main window. Default values of arguments are stored in the configuration dictionary and can be changed via a `turtle.cfg` file.

參數

- **width** -- if an integer, a size in pixels, if a float, a fraction of the screen; default is 50% of screen
- **height** -- if an integer, the height in pixels, if a float, a fraction of the screen; default is 75% of screen
- **startx** -- if positive, starting position in pixels from the left edge of the screen, if negative from the right edge, if `None`, center window horizontally
- **starty** -- if positive, starting position in pixels from the top edge of the screen, if negative from the bottom edge, if `None`, center window vertically

```
>>> screen.setup (width=200, height=200, startx=0, starty=0)
>>>                 # sets window to 200x200 pixels, in upper left of screen
>>> screen.setup (width=.75, height=0.5, startx=None, starty=None)
>>>                 # sets window to 75% of screen by 50% of screen and centers
```

`turtle.title(titlestring)`

參數

titlestring -- a string that is shown in the titlebar of the turtle graphics window

Set title of turtle window to *titlestring*.

```
>>> screen.title("Welcome to the turtle zoo!")
```

24.1.7 Public classes

`class turtle.RawTurtle (canvas)`

`class turtle.RawPen (canvas)`

參數

canvas -- a `tkinter.Canvas`, a *ScrolledCanvas* or a *TurtleScreen*

Create a turtle. The turtle has all methods described above as "methods of Turtle/RawTurtle".

`class turtle.Turtle`

Subclass of `RawTurtle`, has the same interface but draws on a default *Screen* object created automatically when needed for the first time.

`class turtle.TurtleScreen (cv)`

參數

cv -- a `tkinter.Canvas`

Provides screen oriented methods like `bgcolor()` etc. that are described above.

class `turtle.Screen`

Subclass of `TurtleScreen`, with *four methods added*.

class `turtle.ScrolledCanvas` (*master*)

參數

master -- some Tkinter widget to contain the `ScrolledCanvas`, i.e. a Tkinter-canvas with scrollbars added

Used by class `Screen`, which thus automatically provides a `ScrolledCanvas` as playground for the turtles.

class `turtle.Shape` (*type_*, *data*)

參數

type_ -- one of the strings "polygon", "image", "compound"

Data structure modeling shapes. The pair (*type_*, *data*) must follow this specification:

<i>type_</i>	<i>data</i>
"polygon"	a polygon-tuple, i.e. a tuple of pairs of coordinates
"image"	an image (in this form only used internally!)
"compound"	None (a compound shape has to be constructed using the <code>addcomponent()</code> method)

addcomponent (*poly*, *fill*, *outline=None*)

參數

- **poly** -- a polygon, i.e. a tuple of pairs of numbers
- **fill** -- a color the *poly* will be filled with
- **outline** -- a color for the poly's outline (if given)

例如:

```
>>> poly = ((0,0), (10,-5), (0,10), (-10,-5))
>>> s = Shape("compound")
>>> s.addcomponent(poly, "red", "blue")
>>> # ... add more components and then use register_shape()
```

請見 *Compound shapes*。

class `turtle.Vec2D` (*x*, *y*)

A two-dimensional vector class, used as a helper class for implementing turtle graphics. May be useful for turtle graphics programs too. Derived from tuple, so a vector is a tuple!

Provides (for *a*, *b* vectors, *k* number):

- *a* + *b* vector addition
- *a* - *b* vector subtraction
- *a* * *b* inner product
- *k* * *a* and *a* * *k* multiplication with scalar
- `abs(a)` absolute value of *a*
- `a.rotate(angle)` rotation

24.1.8 Explanation

A turtle object draws on a screen object, and there a number of key classes in the turtle object-oriented interface that can be used to create them and relate them to each other.

A *Turtle* instance will automatically create a *Screen* instance if one is not already present.

Turtle is a subclass of *RawTurtle*, which *doesn't* automatically create a drawing surface - a *canvas* will need to be provided or created for it. The *canvas* can be a `tkinter.Canvas`, *ScrolledCanvas* or *TurtleScreen*.

TurtleScreen is the basic drawing surface for a turtle. *Screen* is a subclass of *TurtleScreen*, and includes *some additional methods* for managing its appearance (including size and title) and behaviour. *TurtleScreen*'s constructor needs a `tkinter.Canvas` or a *ScrolledCanvas* as an argument.

The functional interface for turtle graphics uses the various methods of *Turtle* and *TurtleScreen/Screen*. Behind the scenes, a screen object is automatically created whenever a function derived from a *Screen* method is called. Similarly, a turtle object is automatically created whenever any of the functions derived from a *Turtle* method is called.

To use multiple turtles on a screen, the object-oriented interface must be used.

24.1.9 Help and configuration

How to use help

The public methods of the *Screen* and *Turtle* classes are documented extensively via docstrings. So these can be used as online-help via the Python help facilities:

- When using IDLE, tooltips show the signatures and first lines of the docstrings of typed in function-/method calls.
- Calling `help()` on methods or functions displays the docstrings:

```
>>> help(Screen.bgcolor)
Help on method bgcolor in module turtle:

bgcolor(self, *args) unbound turtle.Screen method
    Set or return backgroundcolor of the TurtleScreen.

    Arguments (if given): a color string or three numbers
    in the range 0..colormode or a 3-tuple of such numbers.

>>> screen.bgcolor("orange")
>>> screen.bgcolor()
"orange"
>>> screen.bgcolor(0.5,0,0.5)
>>> screen.bgcolor()
"#800080"

>>> help(Turtle.penup)
Help on method penup in module turtle:

penup(self) unbound turtle.Turtle method
    Pull the pen up -- no drawing when moving.

    Aliases: penup | pu | up

    No argument

>>> turtle.penup()
```

- The docstrings of the functions which are derived from methods have a modified form:

```
>>> help(bgcolor)
Help on function bgcolor in module turtle:

bgcolor(*args)
    Set or return backgroundcolor of the TurtleScreen.

    Arguments (if given): a color string or three numbers
    in the range 0..colormode or a 3-tuple of such numbers.

    Example::

    >>> bgcolor("orange")
    >>> bgcolor()
    "orange"
    >>> bgcolor(0.5,0,0.5)
    >>> bgcolor()
    "#800080"

>>> help(penup)
Help on function penup in module turtle:

penup()
    Pull the pen up -- no drawing when moving.

    Aliases: penup | pu | up

    No argument

    Example:
    >>> penup()
```

These modified docstrings are created automatically together with the function definitions that are derived from the methods at import time.

Translation of docstrings into different languages

There is a utility to create a dictionary the keys of which are the method names and the values of which are the docstrings of the public methods of the classes `Screen` and `Turtle`.

`turtle.write_docstringdict` (*filename*='turtle_docstringdict')

參數

filename -- a string, used as filename

Create and write docstring-dictionary to a Python script with the given filename. This function has to be called explicitly (it is not used by the turtle graphics classes). The docstring dictionary will be written to the Python script *filename.py*. It is intended to serve as a template for translation of the docstrings into different languages.

If you (or your students) want to use `turtle` with online help in your native language, you have to translate the docstrings and save the resulting file as e.g. `turtle_docstringdict_german.py`.

If you have an appropriate entry in your `turtle.cfg` file this dictionary will be read in at import time and will replace the original English docstrings.

At the time of this writing there are docstring dictionaries in German and in Italian. (Requests please to gingl@aon.at.)

How to configure Screen and Turtles

The built-in default configuration mimics the appearance and behaviour of the old turtle module in order to retain best possible compatibility with it.

If you want to use a different configuration which better reflects the features of this module or which better fits to your needs, e.g. for use in a classroom, you can prepare a configuration file `turtle.cfg` which will be read at import time and modify the configuration according to its settings.

The built in configuration would correspond to the following `turtle.cfg`:

```
width = 0.5
height = 0.75
leftright = None
topbottom = None
canvwidth = 400
canvheight = 300
mode = standard
colormode = 1.0
delay = 10
undobuffersize = 1000
shape = classic
pencolor = black
fillcolor = black
resizemode = noresize
visible = True
language = english
exampleturtle = turtle
examplescreen = screen
title = Python Turtle Graphics
using_IDLE = False
```

Short explanation of selected entries:

- The first four lines correspond to the arguments of the `Screen.setup` method.
- Line 5 and 6 correspond to the arguments of the method `Screen.screensize`.
- `shape` can be any of the built-in shapes, e.g: arrow, turtle, etc. For more info try `help(shape)`.
- If you want to use no fill color (i.e. make the turtle transparent), you have to write `fillcolor = ""` (but all nonempty strings must not have quotes in the cfg file).
- If you want to reflect the turtle its state, you have to use `resizemode = auto`.
- If you set e.g. `language = italian` the docstringdict `turtle_docstringdict_italian.py` will be loaded at import time (if present on the import path, e.g. in the same directory as `turtle`).
- The entries `exampleturtle` and `examplescreen` define the names of these objects as they occur in the docstrings. The transformation of method-docstrings to function-docstrings will delete these names from the docstrings.
- `using_IDLE`: Set this to `True` if you regularly work with IDLE and its `-n` switch ("no subprocess"). This will prevent `exitonclick()` to enter the mainloop.

There can be a `turtle.cfg` file in the directory where `turtle` is stored and an additional one in the current working directory. The latter will override the settings of the first one.

The `Lib/turtledemo` directory contains a `turtle.cfg` file. You can study it as an example and see its effects when running the demos (preferably not from within the demo-viewer).

24.1.10 `turtledemo` --- Demo scripts

The `turtledemo` package includes a set of demo scripts. These scripts can be run and viewed using the supplied demo viewer as follows:

```
python -m turtledemo
```

Alternatively, you can run the demo scripts individually. For example,

```
python -m turtledemo.bytedesign
```

The `turtledemo` package directory contains:

- A demo viewer `__main__.py` which can be used to view the sourcecode of the scripts and run them at the same time.
- Multiple scripts demonstrating different features of the `turtle` module. Examples can be accessed via the Examples menu. They can also be run standalone.
- A `turtle.cfg` file which serves as an example of how to write and use such files.

The demo scripts are:

Name	描述	Features
bytedesign	complex classical turtle graphics pattern	<code>tracer()</code> , <code>delay</code> , <code>update()</code>
chaos	graphs Verhulst dynamics, shows that computer's computations can generate results sometimes against the common sense expectations	world coordinates
clock	analog clock showing time of your computer	turtles as clock's hands, <code>ontimer</code>
colormixer	experiment with r, g, b	<code>ondrag()</code>
forest	3 breadth-first trees	randomization
fractalcurves	Hilbert & Koch curves	recursion
lindenmayer	ethnomathematics (indian kolams)	L-System
minimal_hanoi	Towers of Hanoi	Rectangular Turtles as Hanoi discs (shape, <code>shapeseize</code>)
nim	play the classical nim game with three heaps of sticks against the computer.	turtles as nimsticks, event driven (mouse, keyboard)
paint	super minimalistic drawing program	<code>onclick()</code>
peace	elementary	turtle: appearance and animation
penrose	aperiodic tiling with kites and darts	<code>stamp()</code>
planet_and_moon	simulation of gravitational system	compound shapes, <code>Vec2D</code>
rosette	a pattern from the wikipedia article on turtle graphics	<code>clone()</code> , <code>undo()</code>
round_dance	dancing turtles rotating pairwise in opposite direction	compound shapes, <code>clone</code> <code>shapeseize</code> , <code>tilt</code> , <code>get_shapepoly</code> , <code>update</code>
sorting_animate	visual demonstration of different sorting methods	simple alignment, randomization
tree	a (graphical) breadth first tree (using generators)	<code>clone()</code>
two_canvases	simple design	turtles on two canvases
yinyang	another elementary example	<code>circle()</code>

Have fun!

24.1.11 Changes since Python 2.6

- The methods `Turtle.tracer`, `Turtle.window_width` and `Turtle.window_height` have been eliminated. Methods with these names and functionality are now available only as methods of `Screen`. The functions derived from these remain available. (In fact already in Python 2.6 these methods were merely duplications of the corresponding `TurtleScreen/Screen` methods.)
- The method `Turtle.fill()` has been eliminated. The behaviour of `begin_fill()` and `end_fill()` have changed slightly: now every filling process must be completed with an `end_fill()` call.
- A method `Turtle.filling` has been added. It returns a boolean value: `True` if a filling process is under way, `False` otherwise. This behaviour corresponds to a `fill()` call without arguments in Python 2.6.

24.1.12 Changes since Python 3.0

- The `Turtle` methods `shearfactor()`, `shapetransform()` and `get_shapepoly()` have been added. Thus the full range of regular linear transforms is now available for transforming turtle shapes. `tiltangle()` has been enhanced in functionality: it now can be used to get or set the tilt angle. `settiltangle()` has been deprecated.
- The `Screen` method `onkeypress()` has been added as a complement to `onkey()`. As the latter binds actions to the key release event, an alias: `onkeyrelease()` was also added for it.
- The method `Screen.mainloop` has been added, so there is no longer a need to use the standalone `mainloop()` function when working with `Screen` and `Turtle` objects.
- Two input methods have been added: `Screen.textinput` and `Screen.numinput`. These pop up input dialogs and return strings and numbers respectively.
- Two example scripts `tdemo_nim.py` and `tdemo_round_dance.py` have been added to the `Lib/turtledemo` directory.

24.2 cmd --- Support for line-oriented command interpreters

原始碼: `Lib/cmd.py`

The `Cmd` class provides a simple framework for writing line-oriented command interpreters. These are often useful for test harnesses, administrative tools, and prototypes that will later be wrapped in a more sophisticated interface.

class `cmd.Cmd` (`completekey='tab'`, `stdin=None`, `stdout=None`)

A `Cmd` instance or subclass instance is a line-oriented interpreter framework. There is no good reason to instantiate `Cmd` itself; rather, it's useful as a superclass of an interpreter class you define yourself in order to inherit `Cmd`'s methods and encapsulate action methods.

The optional argument `completekey` is the `readline` name of a completion key; it defaults to `Tab`. If `completekey` is not `None` and `readline` is available, command completion is done automatically.

The optional arguments `stdin` and `stdout` specify the input and output file objects that the `Cmd` instance or subclass instance will use for input and output. If not specified, they will default to `sys.stdin` and `sys.stdout`.

If you want a given `stdin` to be used, make sure to set the instance's `use_rawinput` attribute to `False`, otherwise `stdin` will be ignored.

24.2.1 Cmd 物件

A *Cmd* instance has the following methods:

Cmd.cmdloop (*intro=None*)

Repeatedly issue a prompt, accept input, parse an initial prefix off the received input, and dispatch to action methods, passing them the remainder of the line as argument.

The optional argument is a banner or intro string to be issued before the first prompt (this overrides the *intro* class attribute).

If the *readline* module is loaded, input will automatically inherit **bash**-like history-list editing (e.g. Control-P scrolls back to the last command, Control-N forward to the next one, Control-F moves the cursor to the right non-destructively, Control-B moves the cursor to the left non-destructively, etc.).

An end-of-file on input is passed back as the string 'EOF'.

An interpreter instance will recognize a command name *foo* if and only if it has a method *do_foo()*. As a special case, a line beginning with the character '?' is dispatched to the method *do_help()*. As another special case, a line beginning with the character '!' is dispatched to the method *do_shell()* (if such a method is defined).

This method will return when the *postcmd()* method returns a true value. The *stop* argument to *postcmd()* is the return value from the command's corresponding *do_**() method.

If completion is enabled, completing commands will be done automatically, and completing of commands args is done by calling *complete_foo()* with arguments *text*, *line*, *begidx*, and *endidx*. *text* is the string prefix we are attempting to match: all returned matches must begin with it. *line* is the current input line with leading whitespace removed, *begidx* and *endidx* are the beginning and ending indexes of the prefix text, which could be used to provide different completion depending upon which position the argument is in.

Cmd.do_help (*arg*)

All subclasses of *Cmd* inherit a predefined *do_help()*. This method, called with an argument 'bar', invokes the corresponding method *help_bar()*, and if that is not present, prints the docstring of *do_bar()*, if available. With no argument, *do_help()* lists all available help topics (that is, all commands with corresponding *help_**() methods or commands that have docstrings), and also lists any undocumented commands.

Cmd.onecmd (*str*)

Interpret the argument as though it had been typed in response to the prompt. This may be overridden, but should not normally need to be; see the *precmd()* and *postcmd()* methods for useful execution hooks. The return value is a flag indicating whether interpretation of commands by the interpreter should stop. If there is a *do_**() method for the command *str*, the return value of that method is returned, otherwise the return value from the *default()* method is returned.

Cmd.emptyline ()

Method called when an empty line is entered in response to the prompt. If this method is not overridden, it repeats the last nonempty command entered.

Cmd.default (*line*)

Method called on an input line when the command prefix is not recognized. If this method is not overridden, it prints an error message and returns.

Cmd.completedefault (*text*, *line*, *begidx*, *endidx*)

Method called to complete an input line when no command-specific *complete_**() method is available. By default, it returns an empty list.

Cmd.columnize (*list*, *displaywidth=80*)

Method called to display a list of strings as a compact set of columns. Each column is only as wide as necessary. Columns are separated by two spaces for readability.

Cmd.precmd (line)

Hook method executed just before the command line *line* is interpreted, but after the input prompt is generated and issued. This method is a stub in *Cmd*; it exists to be overridden by subclasses. The return value is used as the command which will be executed by the *onecmd()* method; the *precmd()* implementation may re-write the command or simply return *line* unchanged.

Cmd.postcmd (stop, line)

Hook method executed just after a command dispatch is finished. This method is a stub in *Cmd*; it exists to be overridden by subclasses. *line* is the command line which was executed, and *stop* is a flag which indicates whether execution will be terminated after the call to *postcmd()*; this will be the return value of the *onecmd()* method. The return value of this method will be used as the new value for the internal flag which corresponds to *stop*; returning false will cause interpretation to continue.

Cmd.preloop ()

Hook method executed once when *cmdloop()* is called. This method is a stub in *Cmd*; it exists to be overridden by subclasses.

Cmd.postloop ()

Hook method executed once when *cmdloop()* is about to return. This method is a stub in *Cmd*; it exists to be overridden by subclasses.

Instances of *Cmd* subclasses have some public instance variables:

Cmd.prompt

The prompt issued to solicit input.

Cmd.identchars

The string of characters accepted for the command prefix.

Cmd.lastcmd

The last nonempty command prefix seen.

Cmd.cmdqueue

A list of queued input lines. The *cmdqueue* list is checked in *cmdloop()* when new input is needed; if it is nonempty, its elements will be processed in order, as if entered at the prompt.

Cmd.intro

A string to issue as an intro or banner. May be overridden by giving the *cmdloop()* method an argument.

Cmd.doc_header

The header to issue if the help output has a section for documented commands.

Cmd.misc_header

The header to issue if the help output has a section for miscellaneous help topics (that is, there are *help_*()* methods without corresponding *do_*()* methods).

Cmd.undoc_header

The header to issue if the help output has a section for undocumented commands (that is, there are *do_*()* methods without corresponding *help_*()* methods).

Cmd.ruler

The character used to draw separator lines under the help-message headers. If empty, no ruler line is drawn. It defaults to '='.

Cmd.use_rawinput

A flag, defaulting to true. If true, *cmdloop()* uses *input()* to display a prompt and read the next command; if false, *sys.stdout.write()* and *sys.stdin.readline()* are used. (This means that by importing *readline*, on systems that support it, the interpreter will automatically support **Emacs**-like line editing and command-history keystrokes.)

24.2.2 Cmd Example

The `cmd` module is mainly useful for building custom shells that let a user work with a program interactively.

This section presents a simple example of how to build a shell around a few of the commands in the `turtle` module.

Basic turtle commands such as `forward()` are added to a `Cmd` subclass with method named `do_forward()`. The argument is converted to a number and dispatched to the turtle module. The docstring is used in the help utility provided by the shell.

The example also includes a basic record and playback facility implemented with the `precmd()` method which is responsible for converting the input to lowercase and writing the commands to a file. The `do_playback()` method reads the file and adds the recorded commands to the `cmdqueue` for immediate playback:

```
import cmd, sys
from turtle import *

class TurtleShell(cmd.Cmd):
    intro = 'Welcome to the turtle shell.  Type help or ? to list commands.\n'
    prompt = '(turtle) '
    file = None

    # ----- basic turtle commands -----
    def do_forward(self, arg):
        'Move the turtle forward by the specified distance:  FORWARD 10'
        forward(*parse(arg))
    def do_right(self, arg):
        'Turn turtle right by given number of degrees:  RIGHT 20'
        right(*parse(arg))
    def do_left(self, arg):
        'Turn turtle left by given number of degrees:  LEFT 90'
        left(*parse(arg))
    def do_goto(self, arg):
        'Move turtle to an absolute position with changing orientation.  GOTO 100,
↪200'
        goto(*parse(arg))
    def do_home(self, arg):
        'Return turtle to the home position:  HOME'
        home()
    def do_circle(self, arg):
        'Draw circle with given radius an options extent and steps:  CIRCLE 50'
        circle(*parse(arg))
    def do_position(self, arg):
        'Print the current turtle position:  POSITION'
        print('Current position is %d %d\n' % position())
    def do_heading(self, arg):
        'Print the current turtle heading in degrees:  HEADING'
        print('Current heading is %d\n' % (heading(),))
    def do_color(self, arg):
        'Set the color:  COLOR BLUE'
        color(arg.lower())
    def do_undo(self, arg):
        'Undo (repeatedly) the last turtle action(s):  UNDO'
    def do_reset(self, arg):
        'Clear the screen and return turtle to center:  RESET'
        reset()
    def do_bye(self, arg):
        'Stop recording, close the turtle window, and exit:  BYE'
        print('Thank you for using Turtle')
        self.close()
        bye()
        return True
```

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```

# ----- record and playback -----
def do_record(self, arg):
    'Save future commands to filename:  RECORD rose.cmd'
    self.file = open(arg, 'w')
def do_playback(self, arg):
    'Playback commands from a file:  PLAYBACK rose.cmd'
    self.close()
    with open(arg) as f:
        self.cmdqueue.extend(f.read().splitlines())
def precmd(self, line):
    line = line.lower()
    if self.file and 'playback' not in line:
        print(line, file=self.file)
    return line
def close(self):
    if self.file:
        self.file.close()
        self.file = None

def parse(arg):
    'Convert a series of zero or more numbers to an argument tuple'
    return tuple(map(int, arg.split()))

if __name__ == '__main__':
    TurtleShell().cmdloop()

```

Here is a sample session with the turtle shell showing the help functions, using blank lines to repeat commands, and the simple record and playback facility:

```

Welcome to the turtle shell.  Type help or ? to list commands.

(turtle) ?

Documented commands (type help <topic>):
=====
bye      color      goto      home      playback  record    right
circle  forward  heading  left      position  reset     undo

(turtle) help forward
Move the turtle forward by the specified distance:  FORWARD 10
(turtle) record spiral.cmd
(turtle) position
Current position is 0 0

(turtle) heading
Current heading is 0

(turtle) reset
(turtle) circle 20
(turtle) right 30
(turtle) circle 40
(turtle) right 30
(turtle) circle 60
(turtle) right 30
(turtle) circle 80
(turtle) right 30
(turtle) circle 100
(turtle) right 30
(turtle) circle 120
(turtle) right 30
(turtle) circle 120

```

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```
(turtle) heading
Current heading is 180

(turtle) forward 100
(turtle)
(turtle) right 90
(turtle) forward 100
(turtle)
(turtle) right 90
(turtle) forward 400
(turtle) right 90
(turtle) forward 500
(turtle) right 90
(turtle) forward 400
(turtle) right 90
(turtle) forward 300
(turtle) playback spiral.cmd
Current position is 0 0

Current heading is 0

Current heading is 180

(turtle) bye
Thank you for using Turtle
```

24.3 shlex --- Simple lexical analysis

原始碼: [Lib/shlex.py](#)

The *shlex* class makes it easy to write lexical analyzers for simple syntaxes resembling that of the Unix shell. This will often be useful for writing minilanguages, (for example, in run control files for Python applications) or for parsing quoted strings.

The *shlex* module defines the following functions:

`shlex.split(s, comments=False, posix=True)`

Split the string *s* using shell-like syntax. If *comments* is *False* (the default), the parsing of comments in the given string will be disabled (setting the *commenters* attribute of the *shlex* instance to the empty string). This function operates in POSIX mode by default, but uses non-POSIX mode if the *posix* argument is false.

備註: Since the *split()* function instantiates a *shlex* instance, passing *None* for *s* will read the string to split from standard input.

在 3.9 版之後被註用: Passing *None* for *s* will raise an exception in future Python versions.

`shlex.join(split_command)`

Concatenate the tokens of the list *split_command* and return a string. This function is the inverse of *split()*.

```
>>> from shlex import join
>>> print(join(['echo', '-n', 'Multiple words']))
echo -n 'Multiple words'
```

The returned value is shell-escaped to protect against injection vulnerabilities (see *quote()*).

在 3.8 版新加入.

`shlex.quote(s)`

Return a shell-escaped version of the string *s*. The returned value is a string that can safely be used as one token in a shell command line, for cases where you cannot use a list.

警告: The `shlex` module is **only designed for Unix shells**.

The `quote()` function is not guaranteed to be correct on non-POSIX compliant shells or shells from other operating systems such as Windows. Executing commands quoted by this module on such shells can open up the possibility of a command injection vulnerability.

Consider using functions that pass command arguments with lists such as `subprocess.run()` with `shell=False`.

This idiom would be unsafe:

```
>>> filename = 'somefile; rm -rf ~'
>>> command = 'ls -l {}'.format(filename)
>>> print(command) # executed by a shell: boom!
ls -l somefile; rm -rf ~
```

`quote()` lets you plug the security hole:

```
>>> from shlex import quote
>>> command = 'ls -l {}'.format(quote(filename))
>>> print(command)
ls -l 'somefile; rm -rf ~'
>>> remote_command = 'ssh home {}'.format(quote(command))
>>> print(remote_command)
ssh home 'ls -l 'somefile; rm -rf ~'
```

The quoting is compatible with UNIX shells and with `split()`:

```
>>> from shlex import split
>>> remote_command = split(remote_command)
>>> remote_command
['ssh', 'home', 'ls -l 'somefile; rm -rf ~']
>>> command = split(remote_command[-1])
>>> command
['ls', '-l', 'somefile; rm -rf ~']
```

在 3.3 版新加入.

The `shlex` module defines the following class:

class `shlex.shlex` (*instream=None, infile=None, posix=False, punctuation_chars=False*)

A `shlex` instance or subclass instance is a lexical analyzer object. The initialization argument, if present, specifies where to read characters from. It must be a file-/stream-like object with `read()` and `readline()` methods, or a string. If no argument is given, input will be taken from `sys.stdin`. The second optional argument is a filename string, which sets the initial value of the `infile` attribute. If the `instream` argument is omitted or equal to `sys.stdin`, this second argument defaults to "stdin". The `posix` argument defines the operational mode: when `posix` is not true (default), the `shlex` instance will operate in compatibility mode. When operating in POSIX mode, `shlex` will try to be as close as possible to the POSIX shell parsing rules. The `punctuation_chars` argument provides a way to make the behaviour even closer to how real shells parse. This can take a number of values: the default value, `False`, preserves the behaviour seen under Python 3.5 and earlier. If set to `True`, then parsing of the characters `() ; <> | &` is changed: any run of these characters (considered punctuation characters) is returned as a single token. If set to a non-empty string of characters, those characters will be used as the punctuation characters. Any characters in the `wordchars` attribute that appear in `punctuation_chars` will be removed from `wordchars`. See *Improved Compatibility with Shells* for more information. `punctuation_chars` can be set only upon `shlex` instance creation and can't be modified later.

在 3.6 版的變更: 新增 *punctuation_chars* 參數。

也參考:

configparser 模組

Parser for configuration files similar to the Windows *.ini* files.

24.3.1 shlex 物件

A *shlex* instance has the following methods:

shlex.get_token()

Return a token. If tokens have been stacked using *push_token()*, pop a token off the stack. Otherwise, read one from the input stream. If reading encounters an immediate end-of-file, *eof* is returned (the empty string ('')) in non-POSIX mode, and *None* in POSIX mode).

shlex.push_token(str)

Push the argument onto the token stack.

shlex.read_token()

Read a raw token. Ignore the pushback stack, and do not interpret source requests. (This is not ordinarily a useful entry point, and is documented here only for the sake of completeness.)

shlex.sourcehook(filename)

When *shlex* detects a source request (see *source* below) this method is given the following token as argument, and expected to return a tuple consisting of a filename and an open file-like object.

Normally, this method first strips any quotes off the argument. If the result is an absolute pathname, or there was no previous source request in effect, or the previous source was a stream (such as *sys.stdin*), the result is left alone. Otherwise, if the result is a relative pathname, the directory part of the name of the file immediately before it on the source inclusion stack is prepended (this behavior is like the way the C preprocessor handles `#include "file.h"`).

The result of the manipulations is treated as a filename, and returned as the first component of the tuple, with *open()* called on it to yield the second component. (Note: this is the reverse of the order of arguments in instance initialization!)

This hook is exposed so that you can use it to implement directory search paths, addition of file extensions, and other namespace hacks. There is no corresponding 'close' hook, but a *shlex* instance will call the *close()* method of the sourced input stream when it returns EOF.

For more explicit control of source stacking, use the *push_source()* and *pop_source()* methods.

shlex.push_source(newstream, newfile=None)

Push an input source stream onto the input stack. If the filename argument is specified it will later be available for use in error messages. This is the same method used internally by the *sourcehook()* method.

shlex.pop_source()

Pop the last-pushed input source from the input stack. This is the same method used internally when the lexer reaches EOF on a stacked input stream.

shlex.error_leader(infile=None, lineno=None)

This method generates an error message leader in the format of a Unix C compiler error label; the format is `'"%s", line %d: '`, where the `%s` is replaced with the name of the current source file and the `%d` with the current input line number (the optional arguments can be used to override these).

This convenience is provided to encourage *shlex* users to generate error messages in the standard, parseable format understood by Emacs and other Unix tools.

Instances of *shlex* subclasses have some public instance variables which either control lexical analysis or can be used for debugging:

shlex.commenters

The string of characters that are recognized as comment beginners. All characters from the comment beginner to end of line are ignored. Includes just '#' by default.

shlex.wordchars

The string of characters that will accumulate into multi-character tokens. By default, includes all ASCII alphanumerics and underscore. In POSIX mode, the accented characters in the Latin-1 set are also included. If *punctuation_chars* is not empty, the characters `~-./*?=&`, which can appear in file-name specifications and command line parameters, will also be included in this attribute, and any characters which appear in *punctuation_chars* will be removed from *wordchars* if they are present there. If *whitespace_split* is set to `True`, this will have no effect.

shlex.whitespace

Characters that will be considered whitespace and skipped. Whitespace bounds tokens. By default, includes space, tab, linefeed and carriage-return.

shlex.escape

Characters that will be considered as escape. This will be only used in POSIX mode, and includes just '\ ' by default.

shlex.quotes

Characters that will be considered string quotes. The token accumulates until the same quote is encountered again (thus, different quote types protect each other as in the shell.) By default, includes ASCII single and double quotes.

shlex.escapedquotes

Characters in *quotes* that will interpret escape characters defined in *escape*. This is only used in POSIX mode, and includes just '"' by default.

shlex.whitespace_split

If `True`, tokens will only be split in whitespaces. This is useful, for example, for parsing command lines with *shlex*, getting tokens in a similar way to shell arguments. When used in combination with *punctuation_chars*, tokens will be split on whitespace in addition to those characters.

在 3.8 版的變更: The *punctuation_chars* attribute was made compatible with the *whitespace_split* attribute.

shlex.infile

The name of the current input file, as initially set at class instantiation time or stacked by later source requests. It may be useful to examine this when constructing error messages.

shlex.instream

The input stream from which this *shlex* instance is reading characters.

shlex.source

This attribute is `None` by default. If you assign a string to it, that string will be recognized as a lexical-level inclusion request similar to the *source* keyword in various shells. That is, the immediately following token will be opened as a filename and input will be taken from that stream until EOF, at which point the *close()* method of that stream will be called and the input source will again become the original input stream. Source requests may be stacked any number of levels deep.

shlex.debug

If this attribute is numeric and 1 or more, a *shlex* instance will print verbose progress output on its behavior. If you need to use this, you can read the module source code to learn the details.

shlex.lineno

Source line number (count of newlines seen so far plus one).

shlex.token

The token buffer. It may be useful to examine this when catching exceptions.

`shlex.eof`

Token used to determine end of file. This will be set to the empty string (`' '`), in non-POSIX mode, and to `None` in POSIX mode.

`shlex.punctuation_chars`

A read-only property. Characters that will be considered punctuation. Runs of punctuation characters will be returned as a single token. However, note that no semantic validity checking will be performed: for example, `'>>'` could be returned as a token, even though it may not be recognised as such by shells.

在 3.6 版新加入.

24.3.2 Parsing Rules

When operating in non-POSIX mode, `shlex` will try to obey to the following rules.

- Quote characters are not recognized within words (`Do"Not"Separate` is parsed as the single word `Do"Not"Separate`);
- Escape characters are not recognized;
- Enclosing characters in quotes preserve the literal value of all characters within the quotes;
- Closing quotes separate words (`"Do"Separate` is parsed as `"Do"` and `Separate`);
- If `whitespace_split` is `False`, any character not declared to be a word character, whitespace, or a quote will be returned as a single-character token. If it is `True`, `shlex` will only split words in whitespaces;
- EOF is signaled with an empty string (`' '`);
- It's not possible to parse empty strings, even if quoted.

When operating in POSIX mode, `shlex` will try to obey to the following parsing rules.

- Quotes are stripped out, and do not separate words (`"Do"Not"Separate"` is parsed as the single word `DoNotSeparate`);
- Non-quoted escape characters (e.g. `'\ '`) preserve the literal value of the next character that follows;
- Enclosing characters in quotes which are not part of *escapedquotes* (e.g. `"'"`) preserve the literal value of all characters within the quotes;
- Enclosing characters in quotes which are part of *escapedquotes* (e.g. `'"'`) preserves the literal value of all characters within the quotes, with the exception of the characters mentioned in *escape*. The escape characters retain its special meaning only when followed by the quote in use, or the escape character itself. Otherwise the escape character will be considered a normal character.
- EOF is signaled with a `None` value;
- Quoted empty strings (`' '`) are allowed.

24.3.3 Improved Compatibility with Shells

在 3.6 版新加入.

The `shlex` class provides compatibility with the parsing performed by common Unix shells like `bash`, `dash`, and `sh`. To take advantage of this compatibility, specify the `punctuation_chars` argument in the constructor. This defaults to `False`, which preserves pre-3.6 behaviour. However, if it is set to `True`, then parsing of the characters `() ; <> | &` is changed: any run of these characters is returned as a single token. While this is short of a full parser for shells (which would be out of scope for the standard library, given the multiplicity of shells out there), it does allow you to perform processing of command lines more easily than you could otherwise. To illustrate, you can see the difference in the following snippet:


```
>>> import shlex
>>> text = "a && b; c && d || e; f >'abc'; (def \"ghi\")"
>>> s = shlex.shlex(text, posix=True)
>>> s.whitespace_split = True
>>> list(s)
['a', '&&', 'b;', 'c', '&&', 'd', '||', 'e;', 'f', '>abc;', '(def', 'ghi)']
>>> s = shlex.shlex(text, posix=True, punctuation_chars=True)
>>> s.whitespace_split = True
>>> list(s)
['a', '&&', 'b', ';', 'c', '&&', 'd', '||', 'e', ';', 'f', '>', 'abc', ';',
 '(', 'def', 'ghi', ')']
```

Of course, tokens will be returned which are not valid for shells, and you'll need to implement your own error checks on the returned tokens.

Instead of passing `True` as the value for the `punctuation_chars` parameter, you can pass a string with specific characters, which will be used to determine which characters constitute punctuation. For example:

```
>>> import shlex
>>> s = shlex.shlex("a && b || c", punctuation_chars="|")
>>> list(s)
['a', '&&', 'b', '|', 'c']
```

備 注: When `punctuation_chars` is specified, the `wordchars` attribute is augmented with the characters `~-./*?=`. That is because these characters can appear in file names (including wildcards) and command-line arguments (e.g. `--color=auto`). Hence:

```
>>> import shlex
>>> s = shlex.shlex('~ /a && b-c --color=auto || d *.py?',
...                 punctuation_chars=True)
>>> list(s)
['~/a', '&&', 'b-c', '--color=auto', '||', 'd', '*.py?']
```

However, to match the shell as closely as possible, it is recommended to always use `posix` and `whitespace_split` when using `punctuation_chars`, which will negate `wordchars` entirely.

For best effect, `punctuation_chars` should be set in conjunction with `posix=True`. (Note that `posix=False` is the default for `shlex`.)

以 Tk 打造圖形使用者介面 (Graphical User Interfaces)

Tk/Tcl 長期以來一直是 Python 不可或缺的一部分。它提供了一個大且獨立於平台的視窗工具包，可供使用 *tkinter* 套件及其擴充套件 *tkinter.tix* 和 *tkinter.ttk* 模組的 Python 開發者使用。

tkinter 套件是 Tcl/Tk 之上的一個輕薄物件導向層。要使用 *tkinter*，你不需要編寫 Tcl 程式，但會需要查閱 Tk 文件和部份 Tcl 文件。*tkinter* 是一組將 Tk 小工具 (widget) 實作成 Python 類別的包裝器。

tkinter 的主要優點是速度快，而且通常與 Python 捆綁 (bundle) 在一起。儘管其標準文件不是很完整，但還是有些不錯的材料，包括：參考資料、教學、書籍等。*tkinter* 曾因其過時的外觀而聞所皆知，但這在 Tk 8.5 中得到了極大的改進。此外，還有許多其他你可能會感興趣的 GUI 函式庫。Python wiki 列出了幾個替代的 GUI 框架和工具。

25.1 tkinter --- Python interface to Tcl/Tk

原始碼：Lib/tkinter/__init__.py

The *tkinter* package ("Tk interface") is the standard Python interface to the Tcl/Tk GUI toolkit. Both Tk and *tkinter* are available on most Unix platforms, including macOS, as well as on Windows systems.

Running `python -m tkinter` from the command line should open a window demonstrating a simple Tk interface, letting you know that *tkinter* is properly installed on your system, and also showing what version of Tcl/Tk is installed, so you can read the Tcl/Tk documentation specific to that version.

Tkinter supports a range of Tcl/Tk versions, built either with or without thread support. The official Python binary release bundles Tcl/Tk 8.6 threaded. See the source code for the *_tkinter* module for more information about supported versions.

Tkinter is not a thin wrapper, but adds a fair amount of its own logic to make the experience more pythonic. This documentation will concentrate on these additions and changes, and refer to the official Tcl/Tk documentation for details that are unchanged.

備註：Tcl/Tk 8.5 (2007) introduced a modern set of themed user interface components along with a new API to use them. Both old and new APIs are still available. Most documentation you will find online still uses the old API and can be woefully outdated.

也參考：

- **TkDocs**

Extensive tutorial on creating user interfaces with Tkinter. Explains key concepts, and illustrates recommended approaches using the modern API.

- **Tkinter 8.5 reference: a GUI for Python**

Reference documentation for Tkinter 8.5 detailing available classes, methods, and options.

Tcl/Tk 相關資源：

- **Tk 指令**

Comprehensive reference to each of the underlying Tcl/Tk commands used by Tkinter.

- **Tcl/Tk 首頁**

Additional documentation, and links to Tcl/Tk core development.

書籍：

- **Modern Tkinter for Busy Python Developers**

由 Mark Roseman 所著。 (ISBN 978-1999149567)

- **Python GUI programming with Tkinter**

By Alan D. Moore. (ISBN 978-1788835886)

- **Programming Python**

由 Mark Lutz 所著；大部分 Tkinter 主題都有涵蓋。 (ISBN 978-0596158101)

- **Tcl and the Tk Toolkit (2nd edition)**

由 Tcl/Tk 發明者 John Ousterhout 與 Ken Jones 所著；不包含 Tkinter。 (ISBN 978-0321336330)

25.1.1 Architecture

Tcl/Tk is not a single library but rather consists of a few distinct modules, each with separate functionality and its own official documentation. Python's binary releases also ship an add-on module together with it.

Tcl

Tcl is a dynamic interpreted programming language, just like Python. Though it can be used on its own as a general-purpose programming language, it is most commonly embedded into C applications as a scripting engine or an interface to the Tk toolkit. The Tcl library has a C interface to create and manage one or more instances of a Tcl interpreter, run Tcl commands and scripts in those instances, and add custom commands implemented in either Tcl or C. Each interpreter has an event queue, and there are facilities to send events to it and process them. Unlike Python, Tcl's execution model is designed around cooperative multitasking, and Tkinter bridges this difference (see *Threading model* for details).

Tk

Tk is a [Tcl package](#) implemented in C that adds custom commands to create and manipulate GUI widgets. Each *Tk* object embeds its own Tcl interpreter instance with Tk loaded into it. Tk's widgets are very customizable, though at the cost of a dated appearance. Tk uses Tcl's event queue to generate and process GUI events.

Ttk

Themed Tk (Ttk) is a newer family of Tk widgets that provide a much better appearance on different platforms than many of the classic Tk widgets. Ttk is distributed as part of Tk, starting with Tk version 8.5. Python bindings are provided in a separate module, *tkinter.ttk*.

Internally, Tk and Ttk use facilities of the underlying operating system, i.e., Xlib on Unix/X11, Cocoa on macOS, GDI on Windows.

When your Python application uses a class in Tkinter, e.g., to create a widget, the *tkinter* module first assembles a Tcl/Tk command string. It passes that Tcl command string to an internal *_tkinter* binary module, which then calls the Tcl interpreter to evaluate it. The Tcl interpreter will then call into the Tk and/or Ttk packages, which will in turn make calls to Xlib, Cocoa, or GDI.

25.1.2 Tkinter Modules

Support for Tkinter is spread across several modules. Most applications will need the main `tkinter` module, as well as the `tkinter.ttk` module, which provides the modern themed widget set and API:

```
from tkinter import *
from tkinter import ttk
```

class `tkinter.Tk` (*screenName=None*, *baseName=None*, *className='Tk'*, *useTk=True*, *sync=False*, *use=None*)

Construct a toplevel Tk widget, which is usually the main window of an application, and initialize a Tcl interpreter for this widget. Each instance has its own associated Tcl interpreter.

The `Tk` class is typically instantiated using all default values. However, the following keyword arguments are currently recognized:

screenName

When given (as a string), sets the `DISPLAY` environment variable. (X11 only)

baseName

Name of the profile file. By default, *baseName* is derived from the program name (`sys.argv[0]`).

className

Name of the widget class. Used as a profile file and also as the name with which Tcl is invoked (*argv0* in *interp*).

useTk

If `True`, initialize the Tk subsystem. The `tkinter.Tcl()` function sets this to `False`.

sync

If `True`, execute all X server commands synchronously, so that errors are reported immediately. Can be used for debugging. (X11 only)

use

Specifies the *id* of the window in which to embed the application, instead of it being created as an independent toplevel window. *id* must be specified in the same way as the value for the `-use` option for toplevel widgets (that is, it has a form like that returned by `wininfo_id()`).

Note that on some platforms this will only work correctly if *id* refers to a Tk frame or toplevel that has its `-container` option enabled.

`Tk` reads and interprets profile files, named `.className.tcl` and `.baseName.tcl`, into the Tcl interpreter and calls `exec()` on the contents of `.className.py` and `.baseName.py`. The path for the profile files is the `HOME` environment variable or, if that isn't defined, then `os.curdir`.

tk

The Tk application object created by instantiating `Tk`. This provides access to the Tcl interpreter. Each widget that is attached the same instance of `Tk` has the same value for its `tk` attribute.

master

The widget object that contains this widget. For `Tk`, the *master* is `None` because it is the main window. The terms *master* and *parent* are similar and sometimes used interchangeably as argument names; however, calling `wininfo_parent()` returns a string of the widget name whereas *master* returns the object. *parent/child* reflects the tree-like relationship while *master/slave* reflects the container structure.

children

The immediate descendants of this widget as a *dict* with the child widget names as the keys and the child instance objects as the values.

`tkinter.Tcl` (*screenName=None*, *baseName=None*, *className='Tk'*, *useTk=False*)

The `Tcl()` function is a factory function which creates an object much like that created by the `Tk` class, except that it does not initialize the Tk subsystem. This is most often useful when driving the Tcl interpreter in an environment where one doesn't want to create extraneous toplevel windows, or where one cannot (such as

Unix/Linux systems without an X server). An object created by the `Tcl()` object can have a Toplevel window created (and the Tk subsystem initialized) by calling its `loadtk()` method.

The modules that provide Tk support include:

`tkinter`

Main Tkinter module.

`tkinter.colorchooser`

Dialog to let the user choose a color.

`tkinter.commondialog`

Base class for the dialogs defined in the other modules listed here.

`tkinter.filedialog`

Common dialogs to allow the user to specify a file to open or save.

`tkinter.font`

Utilities to help work with fonts.

`tkinter.messagebox`

Access to standard Tk dialog boxes.

`tkinter.scrolledtext`

Text widget with a vertical scroll bar built in.

`tkinter.simpledialog`

Basic dialogs and convenience functions.

`tkinter.ttk`

Themed widget set introduced in Tk 8.5, providing modern alternatives for many of the classic widgets in the main `tkinter` module.

Additional modules:

`_tkinter`

A binary module that contains the low-level interface to Tcl/Tk. It is automatically imported by the main `tkinter` module, and should never be used directly by application programmers. It is usually a shared library (or DLL), but might in some cases be statically linked with the Python interpreter.

`idlelib`

Python's Integrated Development and Learning Environment (IDLE). Based on `tkinter`.

`tkinter.constants`

Symbolic constants that can be used in place of strings when passing various parameters to Tkinter calls. Automatically imported by the main `tkinter` module.

`tkinter.dnd`

(experimental) Drag-and-drop support for `tkinter`. This will become deprecated when it is replaced with the Tk DND.

`tkinter.tix`

(deprecated) An older third-party Tcl/Tk package that adds several new widgets. Better alternatives for most can be found in `tkinter.ttk`.

`turtle`

Turtle graphics in a Tk window.

25.1.3 Tkinter Life Preserver

This section is not designed to be an exhaustive tutorial on either Tk or Tkinter. For that, refer to one of the external resources noted earlier. Instead, this section provides a very quick orientation to what a Tkinter application looks like, identifies foundational Tk concepts, and explains how the Tkinter wrapper is structured.

The remainder of this section will help you to identify the classes, methods, and options you'll need in your Tkinter application, and where to find more detailed documentation on them, including in the official Tcl/Tk reference manual.

A Hello World Program

We'll start by walking through a "Hello World" application in Tkinter. This isn't the smallest one we could write, but has enough to illustrate some key concepts you'll need to know.

```
from tkinter import *
from tkinter import ttk
root = Tk()
frm = ttk.Frame(root, padding=10)
frm.grid()
ttk.Label(frm, text="Hello World!").grid(column=0, row=0)
ttk.Button(frm, text="Quit", command=root.destroy).grid(column=1, row=0)
root.mainloop()
```

After the imports, the next line creates an instance of the `Tk` class, which initializes Tk and creates its associated Tcl interpreter. It also creates a toplevel window, known as the root window, which serves as the main window of the application.

The following line creates a frame widget, which in this case will contain a label and a button we'll create next. The frame is fit inside the root window.

The next line creates a label widget holding a static text string. The `grid()` method is used to specify the relative layout (position) of the label within its containing frame widget, similar to how tables in HTML work.

A button widget is then created, and placed to the right of the label. When pressed, it will call the `destroy()` method of the root window.

Finally, the `mainloop()` method puts everything on the display, and responds to user input until the program terminates.

Important Tk Concepts

Even this simple program illustrates the following key Tk concepts:

widgets

A Tkinter user interface is made up of individual *widgets*. Each widget is represented as a Python object, instantiated from classes like `ttk.Frame`, `ttk.Label`, and `ttk.Button`.

widget hierarchy

Widgets are arranged in a *hierarchy*. The label and button were contained within a frame, which in turn was contained within the root window. When creating each *child* widget, its *parent* widget is passed as the first argument to the widget constructor.

configuration options

Widgets have *configuration options*, which modify their appearance and behavior, such as the text to display in a label or button. Different classes of widgets will have different sets of options.

geometry management

Widgets aren't automatically added to the user interface when they are created. A *geometry manager* like `grid` controls where in the user interface they are placed.

event loop

Tkinter reacts to user input, changes from your program, and even refreshes the display only when actively running an *event loop*. If your program isn't running the event loop, your user interface won't update.

Understanding How Tkinter Wraps Tcl/Tk

When your application uses Tkinter's classes and methods, internally Tkinter is assembling strings representing Tcl/Tk commands, and executing those commands in the Tcl interpreter attached to your application's Tk instance.

Whether it's trying to navigate reference documentation, trying to find the right method or option, adapting some existing code, or debugging your Tkinter application, there are times that it will be useful to understand what those underlying Tcl/Tk commands look like.

To illustrate, here is the Tcl/Tk equivalent of the main part of the Tkinter script above.

```
ttk::frame .frm -padding 10
grid .frm
grid [ttk::label .frm.lbl -text "Hello World!"] -column 0 -row 0
grid [ttk::button .frm.btn -text "Quit" -command "destroy ."] -column 1 -row 0
```

Tcl's syntax is similar to many shell languages, where the first word is the command to be executed, with arguments to that command following it, separated by spaces. Without getting into too many details, notice the following:

- The commands used to create widgets (like `ttk::frame`) correspond to widget classes in Tkinter.
- Tcl widget options (like `-text`) correspond to keyword arguments in Tkinter.
- Widgets are referred to by a *pathname* in Tcl (like `.frm.btn`), whereas Tkinter doesn't use names but object references.
- A widget's place in the widget hierarchy is encoded in its (hierarchical) pathname, which uses a `.` (dot) as a path separator. The pathname for the root window is just `.` (dot). In Tkinter, the hierarchy is defined not by pathname but by specifying the parent widget when creating each child widget.
- Operations which are implemented as separate *commands* in Tcl (like `grid` or `destroy`) are represented as *methods* on Tkinter widget objects. As you'll see shortly, at other times Tcl uses what appear to be method calls on widget objects, which more closely mirror what would be used in Tkinter.

How do I...? What option does...?

If you're not sure how to do something in Tkinter, and you can't immediately find it in the tutorial or reference documentation you're using, there are a few strategies that can be helpful.

First, remember that the details of how individual widgets work may vary across different versions of both Tkinter and Tcl/Tk. If you're searching documentation, make sure it corresponds to the Python and Tcl/Tk versions installed on your system.

When searching for how to use an API, it helps to know the exact name of the class, option, or method that you're using. Introspection, either in an interactive Python shell or with `print()`, can help you identify what you need.

To find out what configuration options are available on any widget, call its `configure()` method, which returns a dictionary containing a variety of information about each object, including its default and current values. Use `keys()` to get just the names of each option.

```
btn = ttk.Button(frm, ...)
print(btn.configure().keys())
```

As most widgets have many configuration options in common, it can be useful to find out which are specific to a particular widget class. Comparing the list of options to that of a simpler widget, like a frame, is one way to do that.

```
print(set(btn.configure().keys()) - set(frm.configure().keys()))
```


Similarly, you can find the available methods for a widget object using the standard `dir()` function. If you try it, you'll see there are over 200 common widget methods, so again identifying those specific to a widget class is helpful.

```
print(dir(btn))
print(set(dir(btn)) - set(dir(frm)))
```

Navigating the Tcl/Tk Reference Manual

As noted, the official [Tk commands](#) reference manual (man pages) is often the most accurate description of what specific operations on widgets do. Even when you know the name of the option or method that you need, you may still have a few places to look.

While all operations in Tkinter are implemented as method calls on widget objects, you've seen that many Tcl/Tk operations appear as commands that take a widget pathname as its first parameter, followed by optional parameters, e.g.

```
destroy .
grid .frm.btn -column 0 -row 0
```

Others, however, look more like methods called on a widget object (in fact, when you create a widget in Tcl/Tk, it creates a Tcl command with the name of the widget pathname, with the first parameter to that command being the name of a method to call).

```
.frm.btn invoke
.frm.lbl configure -text "Goodbye"
```

In the official Tcl/Tk reference documentation, you'll find most operations that look like method calls on the man page for a specific widget (e.g., you'll find the `invoke()` method on the [ttk::button](#) man page), while functions that take a widget as a parameter often have their own man page (e.g., [grid](#)).

You'll find many common options and methods in the [options](#) or [ttk::widget](#) man pages, while others are found in the man page for a specific widget class.

You'll also find that many Tkinter methods have compound names, e.g., `wininfo_x()`, `wininfo_height()`, `wininfo_viewable()`. You'd find documentation for all of these in the [wininfo](#) man page.

備註: Somewhat confusingly, there are also methods on all Tkinter widgets that don't actually operate on the widget, but operate at a global scope, independent of any widget. Examples are methods for accessing the clipboard or the system bell. (They happen to be implemented as methods in the base `Widget` class that all Tkinter widgets inherit from).

25.1.4 Threading model

Python and Tcl/Tk have very different threading models, which [tkinter](#) tries to bridge. If you use threads, you may need to be aware of this.

A Python interpreter may have many threads associated with it. In Tcl, multiple threads can be created, but each thread has a separate Tcl interpreter instance associated with it. Threads can also create more than one interpreter instance, though each interpreter instance can be used only by the one thread that created it.

Each Tk object created by [tkinter](#) contains a Tcl interpreter. It also keeps track of which thread created that interpreter. Calls to [tkinter](#) can be made from any Python thread. Internally, if a call comes from a thread other than the one that created the Tk object, an event is posted to the interpreter's event queue, and when executed, the result is returned to the calling Python thread.

Tcl/Tk applications are normally event-driven, meaning that after initialization, the interpreter runs an event loop (i.e. `Tk.mainloop()`) and responds to events. Because it is single-threaded, event handlers must respond quickly, otherwise they will block other events from being processed. To avoid this, any long-running computations should

not run in an event handler, but are either broken into smaller pieces using timers, or run in another thread. This is different from many GUI toolkits where the GUI runs in a completely separate thread from all application code including event handlers.

If the Tcl interpreter is not running the event loop and processing events, any *tkinter* calls made from threads other than the one running the Tcl interpreter will fail.

A number of special cases exist:

- Tcl/Tk libraries can be built so they are not thread-aware. In this case, *tkinter* calls the library from the originating Python thread, even if this is different than the thread that created the Tcl interpreter. A global lock ensures only one call occurs at a time.
- While *tkinter* allows you to create more than one instance of a Tk object (with its own interpreter), all interpreters that are part of the same thread share a common event queue, which gets ugly fast. In practice, don't create more than one instance of Tk at a time. Otherwise, it's best to create them in separate threads and ensure you're running a thread-aware Tcl/Tk build.
- Blocking event handlers are not the only way to prevent the Tcl interpreter from reentering the event loop. It is even possible to run multiple nested event loops or abandon the event loop entirely. If you're doing anything tricky when it comes to events or threads, be aware of these possibilities.
- There are a few select *tkinter* functions that presently work only when called from the thread that created the Tcl interpreter.

25.1.5 Handy Reference

Setting Options

Options control things like the color and border width of a widget. Options can be set in three ways:

At object creation time, using keyword arguments

```
fred = Button(self, fg="red", bg="blue")
```

After object creation, treating the option name like a dictionary index

```
fred["fg"] = "red"
fred["bg"] = "blue"
```

Use the `config()` method to update multiple attrs subsequent to object creation

```
fred.config(fg="red", bg="blue")
```

For a complete explanation of a given option and its behavior, see the Tk man pages for the widget in question.

Note that the man pages list "STANDARD OPTIONS" and "WIDGET SPECIFIC OPTIONS" for each widget. The former is a list of options that are common to many widgets, the latter are the options that are idiosyncratic to that particular widget. The Standard Options are documented on the *options(3)* man page.

No distinction between standard and widget-specific options is made in this document. Some options don't apply to some kinds of widgets. Whether a given widget responds to a particular option depends on the class of the widget; buttons have a `command` option, labels do not.

The options supported by a given widget are listed in that widget's man page, or can be queried at runtime by calling the `config()` method without arguments, or by calling the `keys()` method on that widget. The return value of these calls is a dictionary whose key is the name of the option as a string (for example, `'relief'`) and whose values are 5-tuples.

Some options, like `bg` are synonyms for common options with long names (`bg` is shorthand for "background"). Passing the `config()` method the name of a shorthand option will return a 2-tuple, not 5-tuple. The 2-tuple passed back will contain the name of the synonym and the "real" option (such as `('bg', 'background')`).

Index	Meaning	範例
0	option name	'relief'
1	option name for database lookup	'relief'
2	option class for database lookup	'Relief'
3	default value	'raised'
4	current value	'groove'

範例:

```
>>> print(fred.config())
{'relief': ('relief', 'relief', 'Relief', 'raised', 'groove')}
```

Of course, the dictionary printed will include all the options available and their values. This is meant only as an example.

The Packer

The packer is one of Tk's geometry-management mechanisms. Geometry managers are used to specify the relative positioning of widgets within their container - their mutual *master*. In contrast to the more cumbersome *placer* (which is used less commonly, and we do not cover here), the packer takes qualitative relationship specification - *above*, *to the left of*, *filling*, etc - and works everything out to determine the exact placement coordinates for you.

The size of any *master* widget is determined by the size of the "slave widgets" inside. The packer is used to control where slave widgets appear inside the master into which they are packed. You can pack widgets into frames, and frames into other frames, in order to achieve the kind of layout you desire. Additionally, the arrangement is dynamically adjusted to accommodate incremental changes to the configuration, once it is packed.

Note that widgets do not appear until they have had their geometry specified with a geometry manager. It's a common early mistake to leave out the geometry specification, and then be surprised when the widget is created but nothing appears. A widget will appear only after it has had, for example, the packer's `pack()` method applied to it.

The `pack()` method can be called with keyword-option/value pairs that control where the widget is to appear within its container, and how it is to behave when the main application window is resized. Here are some examples:

```
fred.pack()                                # defaults to side = "top"
fred.pack(side="left")
fred.pack(expand=1)
```

Packer Options

For more extensive information on the packer and the options that it can take, see the man pages and page 183 of John Ousterhout's book.

anchor

Anchor type. Denotes where the packer is to place each slave in its parcel.

expand

Boolean, 0 or 1.

fill

Legal values: 'x', 'y', 'both', 'none'.

ipadx and ipady

A distance - designating internal padding on each side of the slave widget.

padx and pady

A distance - designating external padding on each side of the slave widget.

side

Legal values are: 'left', 'right', 'top', 'bottom'.

Coupling Widget Variables

The current-value setting of some widgets (like text entry widgets) can be connected directly to application variables by using special options. These options are `variable`, `textvariable`, `onvalue`, `offvalue`, and `value`. This connection works both ways: if the variable changes for any reason, the widget it's connected to will be updated to reflect the new value.

Unfortunately, in the current implementation of *tkinter* it is not possible to hand over an arbitrary Python variable to a widget through a `variable` or `textvariable` option. The only kinds of variables for which this works are variables that are subclassed from a class called `Variable`, defined in *tkinter*.

There are many useful subclasses of `Variable` already defined: `StringVar`, `IntVar`, `DoubleVar`, and `BooleanVar`. To read the current value of such a variable, call the `get()` method on it, and to change its value you call the `set()` method. If you follow this protocol, the widget will always track the value of the variable, with no further intervention on your part.

舉例來 F:

```
import tkinter as tk

class App(tk.Frame):
    def __init__(self, master):
        super().__init__(master)
        self.pack()

        self.entrythingy = tk.Entry()
        self.entrythingy.pack()

        # Create the application variable.
        self.contents = tk.StringVar()
        # Set it to some value.
        self.contents.set("this is a variable")
        # Tell the entry widget to watch this variable.
        self.entrythingy["textvariable"] = self.contents

        # Define a callback for when the user hits return.
        # It prints the current value of the variable.
        self.entrythingy.bind('<Key-Return>',
                               self.print_contents)

    def print_contents(self, event):
        print("Hi. The current entry content is:",
              self.contents.get())

root = tk.Tk()
myapp = App(root)
myapp.mainloop()
```

The Window Manager

In Tk, there is a utility command, `wm`, for interacting with the window manager. Options to the `wm` command allow you to control things like titles, placement, icon bitmaps, and the like. In *tkinter*, these commands have been implemented as methods on the `Wm` class. Toplevel widgets are subclassed from the `Wm` class, and so can call the `Wm` methods directly.

To get at the toplevel window that contains a given widget, you can often just refer to the widget's master. Of course if the widget has been packed inside of a frame, the master won't represent a toplevel window. To get at the toplevel window that contains an arbitrary widget, you can call the `_root()` method. This method begins with an underscore to denote the fact that this function is part of the implementation, and not an interface to Tk functionality.

以下是一些常見用法範例:

```
import tkinter as tk

class App(tk.Frame):
    def __init__(self, master=None):
        super().__init__(master)
        self.pack()

# create the application
myapp = App()

#
# here are method calls to the window manager class
#
myapp.master.title("My Do-Nothing Application")
myapp.master.maxsize(1000, 400)

# start the program
myapp.mainloop()
```

Tk Option Data Types

anchor

Legal values are points of the compass: "n", "ne", "e", "se", "s", "sw", "w", "nw", and also "center".

bitmap

There are eight built-in, named bitmaps: 'error', 'gray25', 'gray50', 'hourglass', 'info', 'questhead', 'question', 'warning'. To specify an X bitmap filename, give the full path to the file, preceded with an @, as in "@usr/contrib/bitmap/gumby.bit".

boolean

You can pass integers 0 or 1 or the strings "yes" or "no".

callback

This is any Python function that takes no arguments. For example:

```
def print_it():
    print("hi there")
fred["command"] = print_it
```

color

Colors can be given as the names of X colors in the rgb.txt file, or as strings representing RGB values in 4 bit: "#RGB", 8 bit: "#RRGGBB", 12 bit: "#RRRGGBBB", or 16 bit: "#RRRRGGGGBBBB" ranges, where R,G,B here represent any legal hex digit. See page 160 of Ousterhout's book for details.

cursor

The standard X cursor names from `cursorfont.h` can be used, without the `XC_` prefix. For example to get a hand cursor (`XC_hand2`), use the string "hand2". You can also specify a bitmap and mask file of your own. See page 179 of Ousterhout's book.

distance

Screen distances can be specified in either pixels or absolute distances. Pixels are given as numbers and absolute distances as strings, with the trailing character denoting units: *c* for centimetres, *i* for inches, *m* for millimetres, *p* for printer's points. For example, 3.5 inches is expressed as "3.5i".

font

Tk uses a list font name format, such as {courier 10 bold}. Font sizes with positive numbers are measured in points; sizes with negative numbers are measured in pixels.

geometry

This is a string of the form `widthxheight`, where `width` and `height` are measured in pixels for most widgets (in characters for widgets displaying text). For example: `fred["geometry"] = "200x100"`.

justify

Legal values are the strings: "left", "center", "right", and "fill".

region

This is a string with four space-delimited elements, each of which is a legal distance (see above). For example: "2 3 4 5" and "3i 2i 4.5i 2i" and "3c 2c 4c 10.43c" are all legal regions.

relief

Determines what the border style of a widget will be. Legal values are: "raised", "sunken", "flat", "groove", and "ridge".

scrollcommand

This is almost always the `set()` method of some scrollbar widget, but can be any widget method that takes a single argument.

wrap

Must be one of: "none", "char", or "word".

Bindings and Events

The `bind` method from the widget command allows you to watch for certain events and to have a callback function trigger when that event type occurs. The form of the `bind` method is:

```
def bind(self, sequence, func, add='')
```

where:

sequence (序列)

is a string that denotes the target kind of event. (See the `bind(3tk)` man page, and page 201 of John Ousterhout's book, *Tcl and the Tk Toolkit (2nd edition)*, for details).

func

is a Python function, taking one argument, to be invoked when the event occurs. An Event instance will be passed as the argument. (Functions deployed this way are commonly known as *callbacks*.)

add

is optional, either ' ' or '+ '. Passing an empty string denotes that this binding is to replace any other bindings that this event is associated with. Passing a '+' means that this function is to be added to the list of functions bound to this event type.

舉例來 F:

```
def turn_red(self, event):
    event.widget["activeforeground"] = "red"

self.button.bind("<Enter>", self.turn_red)
```

Notice how the widget field of the event is being accessed in the `turn_red()` callback. This field contains the widget that caught the X event. The following table lists the other event fields you can access, and how they are denoted in Tk, which can be useful when referring to the Tk man pages.

Tk	Tkinter Event Field	Tk	Tkinter Event Field
%f	focus	%A	char
%h	height	%E	send_event
%k	keycode	%K	keysym
%s	state	%N	keysym_num
%t	time	%T	type
%w	width	%W	widget
%x	x	%X	x_root
%y	y	%Y	y_root

The index Parameter

A number of widgets require "index" parameters to be passed. These are used to point at a specific place in a Text widget, or to particular characters in an Entry widget, or to particular menu items in a Menu widget.

Entry widget indexes (index, view index, etc.)

Entry widgets have options that refer to character positions in the text being displayed. You can use these *tkinter* functions to access these special points in text widgets:

Text widget indexes

The index notation for Text widgets is very rich and is best described in the Tk man pages.

Menu indexes (menu.invoke(), menu.entryconfig(), etc.)

Some options and methods for menus manipulate specific menu entries. Anytime a menu index is needed for an option or a parameter, you may pass in:

- an integer which refers to the numeric position of the entry in the widget, counted from the top, starting with 0;
- the string "active", which refers to the menu position that is currently under the cursor;
- the string "last" which refers to the last menu item;
- An integer preceded by @, as in @6, where the integer is interpreted as a y pixel coordinate in the menu's coordinate system;
- the string "none", which indicates no menu entry at all, most often used with menu.activate() to deactivate all entries, and finally,
- a text string that is pattern matched against the label of the menu entry, as scanned from the top of the menu to the bottom. Note that this index type is considered after all the others, which means that matches for menu items labelled last, active, or none may be interpreted as the above literals, instead.

Images

Images of different formats can be created through the corresponding subclass of *tkinter.Image*:

- *BitmapImage* for images in XBM format.
- *PhotoImage* for images in PGM, PPM, GIF and PNG formats. The latter is supported starting with Tk 8.6.

Either type of image is created through either the *file* or the *data* option (other options are available as well).

The image object can then be used wherever an *image* option is supported by some widget (e.g. labels, buttons, menus). In these cases, Tk will not keep a reference to the image. When the last Python reference to the image object is deleted, the image data is deleted as well, and Tk will display an empty box wherever the image was used.

也参考:

The *Pillow* package adds support for formats such as BMP, JPEG, TIFF, and WebP, among others.

25.1.6 File Handlers

Tk allows you to register and unregister a callback function which will be called from the Tk mainloop when I/O is possible on a file descriptor. Only one handler may be registered per file descriptor. Example code:

```
import tkinter
widget = tkinter.Tk()
mask = tkinter.READABLE | tkinter.WRITABLE
widget.tk.createfilehandler(file, mask, callback)
...
widget.tk.deletefilehandler(file)
```

This feature is not available on Windows.

Since you don't know how many bytes are available for reading, you may not want to use the `BufferedIOBase` or `TextIOBase` `read()` or `readline()` methods, since these will insist on reading a predefined number of bytes. For sockets, the `recv()` or `recvfrom()` methods will work fine; for other files, use raw reads or `os.read(file.fileno(), maxbytecount)`.

`Widget.tk.createfilehandler` (*file*, *mask*, *func*)

Registers the file handler callback function *func*. The *file* argument may either be an object with a `fileno()` method (such as a file or socket object), or an integer file descriptor. The *mask* argument is an ORed combination of any of the three constants below. The callback is called as follows:

```
callback(file, mask)
```

`Widget.tk.deletefilehandler` (*file*)

Unregisters a file handler.

`_tkinter.READABLE`

`_tkinter.WRITABLE`

`_tkinter.EXCEPTION`

Constants used in the *mask* arguments.

25.2 `tkinter.colorchooser` --- Color choosing dialog

原始碼: <Lib/tkinter/colorchooser.py>

The `tkinter.colorchooser` module provides the `Chooser` class as an interface to the native color picker dialog. `Chooser` implements a modal color choosing dialog window. The `Chooser` class inherits from the `Dialog` class.

class `tkinter.colorchooser.Chooser` (*master=None*, ***options*)

`tkinter.colorchooser.askcolor` (*color=None*, ***options*)

Create a color choosing dialog. A call to this method will show the window, wait for the user to make a selection, and return the selected color (or `None`) to the caller.

也參考:

`tkinter.commondialog` 模組

Tkinter standard dialog module

25.3 `tkinter.font` --- Tkinter font wrapper

原始碼: <Lib/tkinter/font.py>

The `tkinter.font` module provides the `Font` class for creating and using named fonts.

The different font weights and slants are:

`tkinter.font.NORMAL`

`tkinter.font.BOLD`

`tkinter.font.ITALIC`

`tkinter.font.ROMAN`

class `tkinter.font.Font` (*root=None, font=None, name=None, exists=False, **options*)

The *Font* class represents a named font. *Font* instances are given unique names and can be specified by their family, size, and style configuration. Named fonts are Tk's method of creating and identifying fonts as a single object, rather than specifying a font by its attributes with each occurrence.

引數:

font - font specifier tuple (family, size, options)

name - unique font name

exists - self points to existing named font if true

additional keyword options (ignored if *font* is specified):

family - font family i.e. Courier, Times

size - font size

If *size* is positive it is interpreted as size in points.

If *size* is a negative number its absolute value is treated as size in pixels.

weight - font emphasis (NORMAL, BOLD)

slant - ROMAN, ITALIC

underline - font underlining (0 - none, 1 - underline)

overstrike - font strikeout (0 - none, 1 - strikeout)

actual (*option=None, displayof=None*)

Return the attributes of the font.

cget (*option*)

Retrieve an attribute of the font.

config (***options*)

Modify attributes of the font.

copy ()

Return new instance of the current font.

measure (*text, displayof=None*)

Return amount of space the text would occupy on the specified display when formatted in the current font. If no display is specified then the main application window is assumed.

metrics (**options, **kw*)

Return font-specific data. Options include:

ascent - distance between baseline and highest point that a character of the font can occupy

descent - distance between baseline and lowest point that a character of the font can occupy

linespace - minimum vertical separation necessary between any two characters of the font that ensures no vertical overlap between lines.

fixed - 1 if font is fixed-width else 0

`tkinter.font.families` (*root=None, displayof=None*)

Return the different font families.

`tkinter.font.names` (*root=None*)

Return the names of defined fonts.

`tkinter.font.nametofont` (*name, root=None*)

Return a *Font* representation of a tk named font.

在 3.10 版的變更: 新增 *root* 參數。

25.4 Tkinter Dialogs

25.4.1 `tkinter.simpdialog` --- Standard Tkinter input dialogs

原始碼: [Lib/tkinter/simpdialog.py](#)

The `tkinter.simpdialog` module contains convenience classes and functions for creating simple modal dialogs to get a value from the user.

```
tkinter.simpdialog.askfloat (title, prompt, **kw)
tkinter.simpdialog.askinteger (title, prompt, **kw)
tkinter.simpdialog.askstring (title, prompt, **kw)
```

The above three functions provide dialogs that prompt the user to enter a value of the desired type.

```
class tkinter.simpdialog.Dialog (parent, title=None)
```

The base class for custom dialogs.

```
body (master)
```

Override to construct the dialog's interface and return the widget that should have initial focus.

```
buttonbox ()
```

Default behaviour adds OK and Cancel buttons. Override for custom button layouts.

25.4.2 `tkinter.filedialog` --- File selection dialogs

原始碼: [Lib/tkinter/filedialog.py](#)

The `tkinter.filedialog` module provides classes and factory functions for creating file/directory selection windows.

Native Load/Save Dialogs

The following classes and functions provide file dialog windows that combine a native look-and-feel with configuration options to customize behaviour. The following keyword arguments are applicable to the classes and functions listed below:

parent - the window to place the dialog on top of

title - the title of the window

initialdir - the directory that the dialog starts in

initialfile - the file selected upon opening of the dialog

filetypes - a sequence of (label, pattern) tuples, '*' wildcard is allowed

defaultextension - default extension to append to file (save dialogs)

multiple - when true, selection of multiple items is allowed

Static factory functions

The below functions when called create a modal, native look-and-feel dialog, wait for the user's selection, then return the selected value(s) or None to the caller.

```
tkinter.filedialog.askopenfile (mode='r', **options)
```

```
tkinter.filedialog.askopenfiles (mode='r', **options)
```

The above two functions create an *Open* dialog and return the opened file object(s) in read-only mode.

```
tkinter.filedialog.asksaveasfile (mode='w', **options)
```

Create a *SaveAs* dialog and return a file object opened in write-only mode.

```
tkinter.filedialog.askopenfilename (**options)
```

```
tkinter.filedialog.askopenfilenames (**options)
```

The above two functions create an *Open* dialog and return the selected filename(s) that correspond to existing file(s).

```
tkinter.filedialog.asksaveasfilename (**options)
```

Create a *SaveAs* dialog and return the selected filename.

```
tkinter.filedialog.askdirectory (**options)
```

Prompt user to select a directory.

Additional keyword option:

mustexist - determines if selection must be an existing directory.

```
class tkinter.filedialog.Open (master=None, **options)
```

```
class tkinter.filedialog.SaveAs (master=None, **options)
```

The above two classes provide native dialog windows for saving and loading files.

Convenience classes

The below classes are used for creating file/directory windows from scratch. These do not emulate the native look-and-feel of the platform.

```
class tkinter.filedialog.Directory (master=None, **options)
```

Create a dialog prompting the user to select a directory.

備 F: The *FileDialog* class should be subclassed for custom event handling and behaviour.

```
class tkinter.filedialog.FileDialog (master, title=None)
```

Create a basic file selection dialog.

```
cancel_command (event=None)
```

Trigger the termination of the dialog window.

```
dirs_double_event (event)
```

Event handler for double-click event on directory.

```
dirs_select_event (event)
```

Event handler for click event on directory.

```
files_double_event (event)
```

Event handler for double-click event on file.

```
files_select_event (event)
```

Event handler for single-click event on file.

filter_command (*event=None*)
Filter the files by directory.

get_filter ()
Retrieve the file filter currently in use.

get_selection ()
Retrieve the currently selected item.

go (*dir_or_file=os.curdir, pattern='*', default="", key=None*)
Render dialog and start event loop.

ok_event (*event*)
Exit dialog returning current selection.

quit (*how=None*)
Exit dialog returning filename, if any.

set_filter (*dir, pat*)
Set the file filter.

set_selection (*file*)
Update the current file selection to *file*.

class `tkinter.filedialog.LoadFileDialog` (*master, title=None*)
A subclass of `FileDialog` that creates a dialog window for selecting an existing file.

ok_command ()
Test that a file is provided and that the selection indicates an already existing file.

class `tkinter.filedialog.SaveFileDialog` (*master, title=None*)
A subclass of `FileDialog` that creates a dialog window for selecting a destination file.

ok_command ()
Test whether or not the selection points to a valid file that is not a directory. Confirmation is required if an already existing file is selected.

25.4.3 `tkinter.commondialog` --- Dialog window templates

原始碼: [Lib/tkinter/commondialog.py](#)

The `tkinter.commondialog` module provides the `Dialog` class that is the base class for dialogs defined in other supporting modules.

class `tkinter.commondialog.Dialog` (*master=None, **options*)

show (*color=None, **options*)
Render the Dialog window.

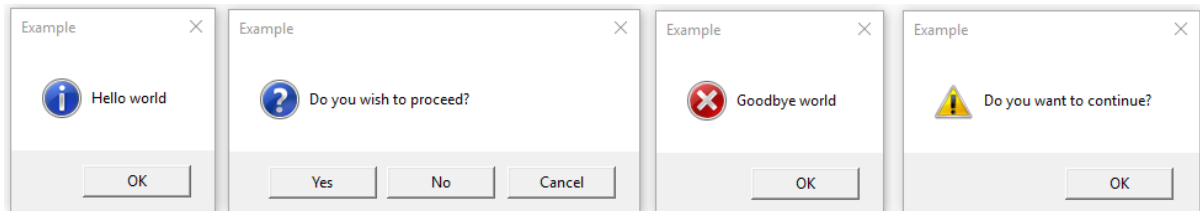
也參考:

`tkinter.messagebox` 模組、`tut-files`

25.5 tkinter.messagebox --- Tkinter message prompts

原始碼: [Lib/tkinter/messagebox.py](#)

The `tkinter.messagebox` module provides a template base class as well as a variety of convenience methods for commonly used configurations. The message boxes are modal and will return a subset of (`True`, `False`, `None`, `OK`, `CANCEL`, `YES`, `NO`) based on the user's selection. Common message box styles and layouts include but are not limited to:



class `tkinter.messagebox.Message` (*master=None*, ***options*)

Create a message window with an application-specified message, an icon and a set of buttons. Each of the buttons in the message window is identified by a unique symbolic name (see the *type* options).

The following options are supported:

command

Specifies the function to invoke when the user closes the dialog. The name of the button clicked by the user to close the dialog is passed as argument. This is only available on macOS.

default

Gives the *symbolic name* of the default button for this message window (`OK`, `CANCEL`, and so on). If this option is not specified, the first button in the dialog will be made the default.

detail

Specifies an auxiliary message to the main message given by the *message* option. The message detail will be presented beneath the main message and, where supported by the OS, in a less emphasized font than the main message.

icon

Specifies an *icon* to display. If this option is not specified, then the `INFO` icon will be displayed.

message

Specifies the message to display in this message box. The default value is an empty string.

parent

Makes the specified window the logical parent of the message box. The message box is displayed on top of its parent window.

title

Specifies a string to display as the title of the message box. This option is ignored on macOS, where platform guidelines forbid the use of a title on this kind of dialog.

type

Arranges for a *predefined set of buttons* to be displayed.

show (***options*)

Display a message window and wait for the user to select one of the buttons. Then return the symbolic name of the selected button. Keyword arguments can override options specified in the constructor.

Information message box

`tkinter.messagebox.showinfo` (*title=None*, *message=None*, ***options*)

Creates and displays an information message box with the specified title and message.

Warning message boxes

`tkinter.messagebox.showwarning` (*title=None, message=None, **options*)

Creates and displays a warning message box with the specified title and message.

`tkinter.messagebox.showerror` (*title=None, message=None, **options*)

Creates and displays an error message box with the specified title and message.

Question message boxes

`tkinter.messagebox.askquestion` (*title=None, message=None, *, type=YESNO, **options*)

Ask a question. By default shows buttons *YES* and *NO*. Returns the symbolic name of the selected button.

`tkinter.messagebox.askokcancel` (*title=None, message=None, **options*)

Ask if operation should proceed. Shows buttons *OK* and *CANCEL*. Returns *True* if the answer is ok and *False* otherwise.

`tkinter.messagebox.askretrycancel` (*title=None, message=None, **options*)

Ask if operation should be retried. Shows buttons *RETRY* and *CANCEL*. Return *True* if the answer is yes and *False* otherwise.

`tkinter.messagebox.askyesno` (*title=None, message=None, **options*)

Ask a question. Shows buttons *YES* and *NO*. Returns *True* if the answer is yes and *False* otherwise.

`tkinter.messagebox.askyesnocancel` (*title=None, message=None, **options*)

Ask a question. Shows buttons *YES*, *NO* and *CANCEL*. Return *True* if the answer is yes, *None* if cancelled, and *False* otherwise.

Symbolic names of buttons:

`tkinter.messagebox.ABORT` = *'abort'*

`tkinter.messagebox.RETRY` = *'retry'*

`tkinter.messagebox.IGNORE` = *'ignore'*

`tkinter.messagebox.OK` = *'ok'*

`tkinter.messagebox.CANCEL` = *'cancel'*

`tkinter.messagebox.YES` = *'yes'*

`tkinter.messagebox.NO` = *'no'*

Predefined sets of buttons:

`tkinter.messagebox.ABORTRETRYIGNORE` = *'abortretryignore'*

Displays three buttons whose symbolic names are *ABORT*, *RETRY* and *IGNORE*.

`tkinter.messagebox.OK` = *'ok'*

Displays one button whose symbolic name is *OK*.

`tkinter.messagebox.OKCANCEL` = *'okcancel'*

Displays two buttons whose symbolic names are *OK* and *CANCEL*.

`tkinter.messagebox.RETRYCANCEL` = *'retrycancel'*

Displays two buttons whose symbolic names are *RETRY* and *CANCEL*.

`tkinter.messagebox.YESNO` = *'yesno'*

Displays two buttons whose symbolic names are *YES* and *NO*.

`tkinter.messagebox.YESNOCANCEL` = *'yesnocancel'*

Displays three buttons whose symbolic names are *YES*, *NO* and *CANCEL*.

Icon images:

```
tkinter.messagebox.ERROR = 'error'
tkinter.messagebox.INFO = 'info'
tkinter.messagebox.QUESTION = 'question'
tkinter.messagebox.WARNING = 'warning'
```

25.6 tkinter.scrolledtext --- Scrolled Text Widget

原始碼: [Lib/tkinter/scrolledtext.py](#)

The `tkinter.scrolledtext` module provides a class of the same name which implements a basic text widget which has a vertical scroll bar configured to do the “right thing.” Using the `ScrolledText` class is a lot easier than setting up a text widget and scroll bar directly.

The text widget and scrollbar are packed together in a `Frame`, and the methods of the `Grid` and `Pack` geometry managers are acquired from the `Frame` object. This allows the `ScrolledText` widget to be used directly to achieve most normal geometry management behavior.

Should more specific control be necessary, the following attributes are available:

class `tkinter.scrolledtext.ScrolledText` (*master=None, **kw*)

frame

The frame which surrounds the text and scroll bar widgets.

vbar

The scroll bar widget.

25.7 tkinter.dnd --- Drag and drop support

原始碼: [Lib/tkinter/dnd.py](#)

備 F: This is experimental and due to be deprecated when it is replaced with the Tk DND.

The `tkinter.dnd` module provides drag-and-drop support for objects within a single application, within the same window or between windows. To enable an object to be dragged, you must create an event binding for it that starts the drag-and-drop process. Typically, you bind a `ButtonPress` event to a callback function that you write (see [Bindings and Events](#)). The function should call `dnd_start()`, where ‘source’ is the object to be dragged, and ‘event’ is the event that invoked the call (the argument to your callback function).

Selection of a target object occurs as follows:

1. Top-down search of area under mouse for target widget
 - Target widget should have a callable `dnd_accept` attribute
 - If `dnd_accept` is not present or returns `None`, search moves to parent widget
 - If no target widget is found, then the target object is `None`
2. Call to `<old_target>.dnd_leave(source, event)`
3. Call to `<new_target>.dnd_enter(source, event)`
4. Call to `<target>.dnd_commit(source, event)` to notify of drop
5. Call to `<source>.dnd_end(target, event)` to signal end of drag-and-drop

class `tkinter.dnd.DndHandler` (*source, event*)

The *DndHandler* class handles drag-and-drop events tracking Motion and ButtonRelease events on the root of the event widget.

cancel (*event=None*)

Cancel the drag-and-drop process.

finish (*event, commit=0*)

Execute end of drag-and-drop functions.

on_motion (*event*)

Inspect area below mouse for target objects while drag is performed.

on_release (*event*)

Signal end of drag when the release pattern is triggered.

`tkinter.dnd.dnd_start` (*source, event*)

Factory function for drag-and-drop process.

也參考:

Bindings and Events

25.8 `tkinter.ttk` --- Tk themed widgets

原始碼: [Lib/tkinter/ttk.py](#)

The *tkinter.ttk* module provides access to the Tk themed widget set, introduced in Tk 8.5. It provides additional benefits including anti-aliased font rendering under X11 and window transparency (requiring a composition window manager on X11).

The basic idea for *tkinter.ttk* is to separate, to the extent possible, the code implementing a widget's behavior from the code implementing its appearance.

也參考:

Tk Widget Styling Support

A document introducing theming support for Tk

25.8.1 Using Ttk

To start using Ttk, import its module:

```
from tkinter import ttk
```

To override the basic Tk widgets, the import should follow the Tk import:

```
from tkinter import *
from tkinter.ttk import *
```

That code causes several *tkinter.ttk* widgets (Button, Checkbutton, Entry, Frame, Label, LabelFrame, Menubutton, PanedWindow, Radiobutton, Scale and Scrollbar) to automatically replace the Tk widgets.

This has the direct benefit of using the new widgets which gives a better look and feel across platforms; however, the replacement widgets are not completely compatible. The main difference is that widget options such as "fg", "bg" and others related to widget styling are no longer present in Ttk widgets. Instead, use the *ttk.Style* class for improved styling effects.

也參考:

Converting existing applications to use Tile widgets

A monograph (using Tcl terminology) about differences typically encountered when moving applications to use the new widgets.

25.8.2 Ttk Widgets

Ttk comes with 18 widgets, twelve of which already existed in tkinter: `Button`, `Checkbutton`, `Entry`, `Frame`, `Label`, `LabelFrame`, `Menubutton`, `PanedWindow`, `Radiobutton`, `Scale`, `Scrollbar`, and `Spinbox`. The other six are new: `Combobox`, `Notebook`, `Progressbar`, `Separator`, `Sizegrip` and `Treeview`. And all them are subclasses of `Widget`.

Using the Ttk widgets gives the application an improved look and feel. As discussed above, there are differences in how the styling is coded.

Tk code:

```
l1 = tkinter.Label(text="Test", fg="black", bg="white")
l2 = tkinter.Label(text="Test", fg="black", bg="white")
```

Ttk code:

```
style = ttk.Style()
style.configure("BW.TLabel", foreground="black", background="white")

l1 = ttk.Label(text="Test", style="BW.TLabel")
l2 = ttk.Label(text="Test", style="BW.TLabel")
```

For more information about *TtkStyling*, see the *Style* class documentation.

25.8.3 Widget

`ttk.Widget` defines standard options and methods supported by Tk themed widgets and is not supposed to be directly instantiated.

Standard Options

All the `ttk` Widgets accept the following options:

Option	描述
class	Specifies the window class. The class is used when querying the option database for the window's other options, to determine the default bindtags for the window, and to select the widget's default layout and style. This option is read-only, and may only be specified when the window is created.
cursor	Specifies the mouse cursor to be used for the widget. If set to the empty string (the default), the cursor is inherited for the parent widget.
takefocus	Determines whether the window accepts the focus during keyboard traversal. 0, 1 or an empty string is returned. If 0 is returned, it means that the window should be skipped entirely during keyboard traversal. If 1, it means that the window should receive the input focus as long as it is viewable. And an empty string means that the traversal scripts make the decision about whether or not to focus on the window.
style	May be used to specify a custom widget style.

Scrollable Widget Options

The following options are supported by widgets that are controlled by a scrollbar.

Option	描述
xscrollcommand	Used to communicate with horizontal scrollbars. When the view in the widget's window change, the widget will generate a Tcl command based on the scrollcommand. Usually this option consists of the method <code>Scrollbar.set()</code> of some scrollbar. This will cause the scrollbar to be updated whenever the view in the window changes.
yscrollcommand	Used to communicate with vertical scrollbars. For some more information, see above.

Label Options

The following options are supported by labels, buttons and other button-like widgets.

Option	描述
text	Specifies a text string to be displayed inside the widget.
textvariable	Specifies a name whose value will be used in place of the text option resource.
underline	If set, specifies the index (0-based) of a character to underline in the text string. The underline character is used for mnemonic activation.
image	Specifies an image to display. This is a list of 1 or more elements. The first element is the default image name. The rest of the list if a sequence of statespec/value pairs as defined by <code>Style.map()</code> , specifying different images to use when the widget is in a particular state or a combination of states. All images in the list should have the same size.
compound (F合)	Specifies how to display the image relative to the text, in the case both text and images options are present. Valid values are: <ul style="list-style-type: none"> text: display text only image: display image only top, bottom, left, right: display image above, below, left of, or right of the text, respectively. none: the default. display the image if present, otherwise the text.
width	If greater than zero, specifies how much space, in character widths, to allocate for the text label, if less than zero, specifies a minimum width. If zero or unspecified, the natural width of the text label is used.

Compatibility Options

Option	描述
state	May be set to "normal" or "disabled" to control the "disabled" state bit. This is a write-only option: setting it changes the widget state, but the <code>Widget.state()</code> method does not affect this option.

Widget States

The widget state is a bitmap of independent state flags.

Flag	描述
active	The mouse cursor is over the widget and pressing a mouse button will cause some action to occur
disabled	Widget is disabled under program control
focus	Widget has keyboard focus
pressed	Widget is being pressed
selected	"On", "true", or "current" for things like Checkbuttons and radiobuttons
background	Windows and Mac have a notion of an "active" or foreground window. The <i>background</i> state is set for widgets in a background window, and cleared for those in the foreground window
readonly	Widget should not allow user modification
alternate	A widget-specific alternate display format
invalid	The widget's value is invalid

A state specification is a sequence of state names, optionally prefixed with an exclamation point indicating that the bit is off.

ttk.Widget

Besides the methods described below, the `ttk.Widget` supports the methods `tkinter.Widget.cget()` and `tkinter.Widget.configure()`.

class `tkinter.ttk.Widget`

identify (*x*, *y*)

Returns the name of the element at position *x* *y*, or the empty string if the point does not lie within any element.

x and *y* are pixel coordinates relative to the widget.

instate (*statespec*, *callback=None*, **args*, ***kw*)

Test the widget's state. If a callback is not specified, returns `True` if the widget state matches *statespec* and `False` otherwise. If callback is specified then it is called with *args* if widget state matches *statespec*.

state (*statespec=None*)

Modify or inquire widget state. If *statespec* is specified, sets the widget state according to it and return a new *statespec* indicating which flags were changed. If *statespec* is not specified, returns the currently enabled state flags.

statespec will usually be a list or a tuple.

25.8.4 Combobox

The `ttk.Combobox` widget combines a text field with a pop-down list of values. This widget is a subclass of `Entry`.

Besides the methods inherited from `Widget`: `Widget.cget()`, `Widget.configure()`, `Widget.identify()`, `Widget.instate()` and `Widget.state()`, and the following inherited from `Entry`: `Entry.bbox()`, `Entry.delete()`, `Entry.icursor()`, `Entry.index()`, `Entry.insert()`, `Entry.selection()`, `Entry.xview()`, it has some other methods, described at `ttk.Combobox`.

Options

This widget accepts the following specific options:

Option	描述
exportselection	Boolean value. If set, the widget selection is linked to the Window Manager selection (which can be returned by invoking <code>Misc.selection_get</code> , for example).
justify	Specifies how the text is aligned within the widget. One of "left", "center", or "right".
height	Specifies the height of the pop-down listbox, in rows.
postcommand	A script (possibly registered with <code>Misc.register</code>) that is called immediately before displaying the values. It may specify which values to display.
state	One of "normal", "readonly", or "disabled". In the "readonly" state, the value may not be edited directly, and the user can only selection of the values from the dropdown list. In the "normal" state, the text field is directly editable. In the "disabled" state, no interaction is possible.
textvariable	Specifies a name whose value is linked to the widget value. Whenever the value associated with that name changes, the widget value is updated, and vice versa. See <code>tkinter.StringVar</code> .
values	Specifies the list of values to display in the drop-down listbox.
width	Specifies an integer value indicating the desired width of the entry window, in average-size characters of the widget's font.

Virtual events

The combobox widgets generates a «**ComboboxSelected**» virtual event when the user selects an element from the list of values.

ttk.Combobox

```
class tkinter.ttk.Combobox

    current (newindex=None)
        If newindex is specified, sets the combobox value to the element position newindex. Otherwise, returns the index of the current value or -1 if the current value is not in the values list.

    get ()
        Returns the current value of the combobox.

    set (value)
        Sets the value of the combobox to value.
```

25.8.5 Spinbox

The `ttk.Spinbox` widget is a `ttk.Entry` enhanced with increment and decrement arrows. It can be used for numbers or lists of string values. This widget is a subclass of `Entry`.

Besides the methods inherited from `Widget`: `Widget.cget()`, `Widget.configure()`, `Widget.identify()`, `Widget.instate()` and `Widget.state()`, and the following inherited from `Entry`: `Entry.bbox()`, `Entry.delete()`, `Entry.icursor()`, `Entry.index()`, `Entry.insert()`, `Entry.xview()`, it has some other methods, described at `ttk.Spinbox`.

Options

This widget accepts the following specific options:

Option	描述
<code>from</code>	Float value. If set, this is the minimum value to which the decrement button will decrement. Must be spelled as <code>from_</code> when used as an argument, since <code>from</code> is a Python keyword.
<code>to</code>	Float value. If set, this is the maximum value to which the increment button will increment.
<code>increment</code>	Float value. Specifies the amount which the increment/decrement buttons change the value. Defaults to 1.0.
<code>values</code>	Sequence of string or float values. If specified, the increment/decrement buttons will cycle through the items in this sequence rather than incrementing or decrementing numbers.
<code>wrap</code>	Boolean value. If <code>True</code> , increment and decrement buttons will cycle from the <code>to</code> value to the <code>from</code> value or the <code>from</code> value to the <code>to</code> value, respectively.
<code>format</code>	String value. This specifies the format of numbers set by the increment/decrement buttons. It must be in the form <code>"%W.Pf"</code> , where <code>W</code> is the padded width of the value, <code>P</code> is the precision, and <code>'%'</code> and <code>'f'</code> are literal.
<code>command</code>	Python callable. Will be called with no arguments whenever either of the increment or decrement buttons are pressed.

Virtual events

The spinbox widget generates an «**Increment**» virtual event when the user presses <Up>, and a «**Decrement**» virtual event when the user presses <Down>.

ttk.Spinbox

```
class tkinter.ttk.Spinbox
```

```
    get ()
```

Returns the current value of the spinbox.

```
    set (value)
```

Sets the value of the spinbox to *value*.

25.8.6 Notebook

Ttk Notebook widget manages a collection of windows and displays a single one at a time. Each child window is associated with a tab, which the user may select to change the currently displayed window.

Options

This widget accepts the following specific options:

Option	描述
<code>height</code>	If present and greater than zero, specifies the desired height of the pane area (not including internal padding or tabs). Otherwise, the maximum height of all panes is used.
<code>padding</code>	Specifies the amount of extra space to add around the outside of the notebook. The padding is a list up to four length specifications left top right bottom. If fewer than four elements are specified, bottom defaults to top, right defaults to left, and top defaults to left.
<code>width</code>	If present and greater than zero, specified the desired width of the pane area (not including internal padding). Otherwise, the maximum width of all panes is used.

Tab Options

There are also specific options for tabs:

Option	描述
state	Either "normal", "disabled" or "hidden". If "disabled", then the tab is not selectable. If "hidden", then the tab is not shown.
sticky	Specifies how the child window is positioned within the pane area. Value is a string containing zero or more of the characters "n", "s", "e" or "w". Each letter refers to a side (north, south, east or west) that the child window will stick to, as per the <code>grid()</code> geometry manager.
padding	Specifies the amount of extra space to add between the notebook and this pane. Syntax is the same as for the option padding used by this widget.
text	Specifies a text to be displayed in the tab.
image	Specifies an image to display in the tab. See the option image described in <i>Widget</i> .
compound (F合)	Specifies how to display the image relative to the text, in the case both options text and image are present. See <i>Label Options</i> for legal values.
underline	Specifies the index (0-based) of a character to underline in the text string. The underlined character is used for mnemonic activation if <code>Notebook.enable_traversal()</code> is called.

Tab Identifiers

The `tab_id` present in several methods of `ttk.Notebook` may take any of the following forms:

- An integer between zero and the number of tabs
- The name of a child window
- A positional specification of the form "@x,y", which identifies the tab
- The literal string "current", which identifies the currently selected tab
- The literal string "end", which returns the number of tabs (only valid for `Notebook.index()`)

Virtual Events

This widget generates a «**NotebookTabChanged**» virtual event after a new tab is selected.

ttk.Notebook

class `tkinter.ttk.Notebook`

add (*child*, ***kw*)

Adds a new tab to the notebook.

If window is currently managed by the notebook but hidden, it is restored to its previous position.

可用的選項清單請見 *Tab Options*。

forget (*tab_id*)

Removes the tab specified by *tab_id*, unmaps and unmanages the associated window.

hide (*tab_id*)

Hides the tab specified by *tab_id*.

The tab will not be displayed, but the associated window remains managed by the notebook and its configuration remembered. Hidden tabs may be restored with the `add()` command.

identify (*x*, *y*)

Returns the name of the tab element at position *x*, *y*, or the empty string if none.

index (*tab_id*)

Returns the numeric index of the tab specified by *tab_id*, or the total number of tabs if *tab_id* is the string "end".

insert (*pos*, *child*, ****kw**)

Inserts a pane at the specified position.

pos is either the string "end", an integer index, or the name of a managed child. If *child* is already managed by the notebook, moves it to the specified position.

可用的選項清單請見 [Tab Options](#)。

select (*tab_id*=None)

Selects the specified *tab_id*.

The associated child window will be displayed, and the previously selected window (if different) is unmapped. If *tab_id* is omitted, returns the widget name of the currently selected pane.

tab (*tab_id*, *option*=None, ****kw**)

Query or modify the options of the specific *tab_id*.

If *kw* is not given, returns a dictionary of the tab option values. If *option* is specified, returns the value of that *option*. Otherwise, sets the options to the corresponding values.

tabs ()

Returns a list of windows managed by the notebook.

enable_traversal ()

Enable keyboard traversal for a toplevel window containing this notebook.

This will extend the bindings for the toplevel window containing the notebook as follows:

- **Control-Tab**: selects the tab following the currently selected one.
- **Shift-Control-Tab**: selects the tab preceding the currently selected one.
- **Alt-K**: where *K* is the mnemonic (underlined) character of any tab, will select that tab.

Multiple notebooks in a single toplevel may be enabled for traversal, including nested notebooks. However, notebook traversal only works properly if all panes have the notebook they are in as master.

25.8.7 Progressbar

The `ttk.Progressbar` widget shows the status of a long-running operation. It can operate in two modes: 1) the determinate mode which shows the amount completed relative to the total amount of work to be done and 2) the indeterminate mode which provides an animated display to let the user know that work is progressing.

Options

This widget accepts the following specific options:

Option	描述
orient	One of "horizontal" or "vertical". Specifies the orientation of the progress bar.
length	Specifies the length of the long axis of the progress bar (width if horizontal, height if vertical).
mode	One of "determinate" or "indeterminate".
maximum	A number specifying the maximum value. Defaults to 100.
value	The current value of the progress bar. In "determinate" mode, this represents the amount of work completed. In "indeterminate" mode, it is interpreted as modulo <i>maximum</i> ; that is, the progress bar completes one "cycle" when its value increases by <i>maximum</i> .
variable	A name which is linked to the option value. If specified, the value of the progress bar is automatically set to the value of this name whenever the latter is modified.
phase	Read-only option. The widget periodically increments the value of this option whenever its value is greater than 0 and, in determinate mode, less than maximum. This option may be used by the current theme to provide additional animation effects.

ttk.Progressbar

class tkinter.ttk.Progressbar

- start** (*interval=None*)
Begin autoincrement mode: schedules a recurring timer event that calls *Progressbar.step()* every *interval* milliseconds. If omitted, *interval* defaults to 50 milliseconds.
- step** (*amount=None*)
Increments the progress bar's value by *amount*.
amount defaults to 1.0 if omitted.
- stop** ()
Stop autoincrement mode: cancels any recurring timer event initiated by *Progressbar.start()* for this progress bar.

25.8.8 Separator

The `ttk.Separator` widget displays a horizontal or vertical separator bar.
It has no other methods besides the ones inherited from `ttk.Widget`.

Options

This widget accepts the following specific option:

Option	描述
orient	One of "horizontal" or "vertical". Specifies the orientation of the separator.

25.8.9 Sizegrip

The `ttk.Sizegrip` widget (also known as a grow box) allows the user to resize the containing toplevel window by pressing and dragging the grip.

This widget has neither specific options nor specific methods, besides the ones inherited from `ttk.Widget`.

Platform-specific notes

- On macOS, toplevel windows automatically include a built-in size grip by default. Adding a `Sizegrip` is harmless, since the built-in grip will just mask the widget.

Bugs

- If the containing toplevel's position was specified relative to the right or bottom of the screen (e.g. `...()`), the `Sizegrip` widget will not resize the window.
- This widget supports only "southeast" resizing.

25.8.10 Treeview

The `ttk.Treeview` widget displays a hierarchical collection of items. Each item has a textual label, an optional image, and an optional list of data values. The data values are displayed in successive columns after the tree label.

The order in which data values are displayed may be controlled by setting the widget option `displaycolumns`. The tree widget can also display column headings. Columns may be accessed by number or symbolic names listed in the widget option `columns`. See *Column Identifiers*.

Each item is identified by a unique name. The widget will generate item IDs if they are not supplied by the caller. There is a distinguished root item, named `{ }`. The root item itself is not displayed; its children appear at the top level of the hierarchy.

Each item also has a list of tags, which can be used to associate event bindings with individual items and control the appearance of the item.

The `Treeview` widget supports horizontal and vertical scrolling, according to the options described in *Scrollable Widget Options* and the methods `Treeview.xview()` and `Treeview.yview()`.

Options

This widget accepts the following specific options:

Option	描述
columns	A list of column identifiers, specifying the number of columns and their names.
displaycolumns	A list of column identifiers (either symbolic or integer indices) specifying which data columns are displayed and the order in which they appear, or the string "#all".
height	Specifies the number of rows which should be visible. Note: the requested width is determined from the sum of the column widths.
padding	Specifies the internal padding for the widget. The padding is a list of up to four length specifications.
selectmode	Controls how the built-in class bindings manage the selection. One of "extended", "browse" or "none". If set to "extended" (the default), multiple items may be selected. If "browse", only a single item will be selected at a time. If "none", the selection will not be changed. Note that the application code and tag bindings can set the selection however they wish, regardless of the value of this option.
show	A list containing zero or more of the following values, specifying which elements of the tree to display. <ul style="list-style-type: none"> tree: display tree labels in column #0. headings: display the heading row. The default is "tree headings", i.e., show all elements. Note: Column #0 always refers to the tree column, even if show="tree" is not specified.

Item Options

The following item options may be specified for items in the insert and item widget commands.

Option	描述
text	The textual label to display for the item.
image	A Tk Image, displayed to the left of the label.
values	The list of values associated with the item. Each item should have the same number of values as the widget option columns. If there are fewer values than columns, the remaining values are assumed empty. If there are more values than columns, the extra values are ignored.
open	True/False value indicating whether the item's children should be displayed or hidden.
tags	A list of tags associated with this item.

Tag Options

The following options may be specified on tags:

Option	描述
foreground	Specifies the text foreground color.
background	Specifies the cell or item background color.
font	Specifies the font to use when drawing text.
image	Specifies the item image, in case the item's image option is empty.

Column Identifiers

Column identifiers take any of the following forms:

- A symbolic name from the list of columns option.
- An integer *n*, specifying the *n*th data column.
- A string of the form *#n*, where *n* is an integer, specifying the *n*th display column.

解:

- Item's option values may be displayed in a different order than the order in which they are stored.
- Column #0 always refers to the tree column, even if `show="tree"` is not specified.

A data column number is an index into an item's option values list; a display column number is the column number in the tree where the values are displayed. Tree labels are displayed in column #0. If option `displaycolumns` is not set, then data column *n* is displayed in column *#n+1*. Again, **column #0 always refers to the tree column.**

Virtual Events

The Treeview widget generates the following virtual events.

Event	描述
«TreeviewSelect»	Generated whenever the selection changes.
«TreeviewOpen»	Generated just before settings the focus item to <code>open=True</code> .
«TreeviewClose»	Generated just after setting the focus item to <code>open=False</code> .

The `Treeview.focus()` and `Treeview.selection()` methods can be used to determine the affected item or items.

ttk.Treeview

`class tkinter.ttk.Treeview`

bbox (*item*, *column=None*)

Returns the bounding box (relative to the treeview widget's window) of the specified *item* in the form (*x*, *y*, *width*, *height*).

If *column* is specified, returns the bounding box of that cell. If the *item* is not visible (i.e., if it is a descendant of a closed item or is scrolled offscreen), returns an empty string.

get_children (*item=None*)

Returns the list of children belonging to *item*.

If *item* is not specified, returns root children.

set_children (*item*, **newchildren*)

Replaces *item*'s child with *newchildren*.

Children present in *item* that are not present in *newchildren* are detached from the tree. No items in *newchildren* may be an ancestor of *item*. Note that not specifying *newchildren* results in detaching *item*'s children.

column (*column*, *option=None*, ***kw*)

Query or modify the options for the specified *column*.

If *kw* is not given, returns a dict of the column option values. If *option* is specified then the value for that *option* is returned. Otherwise, sets the options to the corresponding values.

The valid options/values are:

id

Returns the column name. This is a read-only option.

anchor: One of the standard Tk anchor values.

Specifies how the text in this column should be aligned with respect to the cell.

minwidth: width

The minimum width of the column in pixels. The treeview widget will not make the column any smaller than specified by this option when the widget is resized or the user drags a column.

stretch: True/False

Specifies whether the column's width should be adjusted when the widget is resized.

width: width

The width of the column in pixels.

To configure the tree column, call this with `column = "#0"`

delete (*items)

Delete all specified *items* and all their descendants.

The root item may not be deleted.

detach (*items)

Unlinks all of the specified *items* from the tree.

The items and all of their descendants are still present, and may be reinserted at another point in the tree, but will not be displayed.

The root item may not be detached.

exists (item)

Returns `True` if the specified *item* is present in the tree.

focus (item=None)

If *item* is specified, sets the focus item to *item*. Otherwise, returns the current focus item, or `"` if there is none.

heading (column, option=None, **kw)

Query or modify the heading options for the specified *column*.

If *kw* is not given, returns a dict of the heading option values. If *option* is specified then the value for that *option* is returned. Otherwise, sets the options to the corresponding values.

The valid options/values are:

text: text

The text to display in the column heading.

image: imageName

Specifies an image to display to the right of the column heading.

anchor: anchor

Specifies how the heading text should be aligned. One of the standard Tk anchor values.

command: callback

A callback to be invoked when the heading label is pressed.

To configure the tree column heading, call this with `column = "#0"`.

identify (component, x, y)

Returns a description of the specified *component* under the point given by *x* and *y*, or the empty string if no such *component* is present at that position.

identify_row (y)

Returns the item ID of the item at position *y*.

identify_column (*x*)Returns the data column identifier of the cell at position *x*.

The tree column has ID #0.

identify_region (*x*, *y*)

Returns one of:

region	meaning
heading	Tree heading area.
separator	Space between two columns headings.
tree	The tree area.
cell	A data cell.

Availability: Tk 8.6.

identify_element (*x*, *y*)Returns the element at position *x*, *y*.

Availability: Tk 8.6.

index (*item*)Returns the integer index of *item* within its parent's list of children.**insert** (*parent*, *index*, *iid=None*, ***kw*)

Creates a new item and returns the item identifier of the newly created item.

parent is the item ID of the parent item, or the empty string to create a new top-level item. *index* is an integer, or the value "end", specifying where in the list of parent's children to insert the new item. If *index* is less than or equal to zero, the new node is inserted at the beginning; if *index* is greater than or equal to the current number of children, it is inserted at the end. If *iid* is specified, it is used as the item identifier; *iid* must not already exist in the tree. Otherwise, a new unique identifier is generated.

See [Item Options](#) for the list of available options.**item** (*item*, *option=None*, ***kw*)Query or modify the options for the specified *item*.

If no options are given, a dict with options/values for the item is returned. If *option* is specified then the value for that option is returned. Otherwise, sets the options to the corresponding values as given by *kw*.

move (*item*, *parent*, *index*)Moves *item* to position *index* in *parent*'s list of children.

It is illegal to move an item under one of its descendants. If *index* is less than or equal to zero, *item* is moved to the beginning; if greater than or equal to the number of children, it is moved to the end. If *item* was detached it is reattached.

next (*item*)Returns the identifier of *item*'s next sibling, or "" if *item* is the last child of its parent.**parent** (*item*)Returns the ID of the parent of *item*, or "" if *item* is at the top level of the hierarchy.**prev** (*item*)Returns the identifier of *item*'s previous sibling, or "" if *item* is the first child of its parent.**reattach** (*item*, *parent*, *index*)An alias for [Treeview.move\(\)](#).

see (*item*)

Ensure that *item* is visible.

Sets all of *item*'s ancestors open option to `True`, and scrolls the widget if necessary so that *item* is within the visible portion of the tree.

selection ()

Returns a tuple of selected items.

在 3.8 版的變更: `selection()` no longer takes arguments. For changing the selection state use the following selection methods.

selection_set (**items*)

items becomes the new selection.

在 3.6 版的變更: *items* can be passed as separate arguments, not just as a single tuple.

selection_add (**items*)

Add *items* to the selection.

在 3.6 版的變更: *items* can be passed as separate arguments, not just as a single tuple.

selection_remove (**items*)

Remove *items* from the selection.

在 3.6 版的變更: *items* can be passed as separate arguments, not just as a single tuple.

selection_toggle (**items*)

Toggle the selection state of each item in *items*.

在 3.6 版的變更: *items* can be passed as separate arguments, not just as a single tuple.

set (*item*, *column=None*, *value=None*)

With one argument, returns a dictionary of column/value pairs for the specified *item*. With two arguments, returns the current value of the specified *column*. With three arguments, sets the value of given *column* in given *item* to the specified *value*.

tag_bind (*tagname*, *sequence=None*, *callback=None*)

Bind a callback for the given event *sequence* to the tag *tagname*. When an event is delivered to an item, the callbacks for each of the item's tags option are called.

tag_configure (*tagname*, *option=None*, ***kw*)

Query or modify the options for the specified *tagname*.

If *kw* is not given, returns a dict of the option settings for *tagname*. If *option* is specified, returns the value for that *option* for the specified *tagname*. Otherwise, sets the options to the corresponding values for the given *tagname*.

tag_has (*tagname*, *item=None*)

If *item* is specified, returns 1 or 0 depending on whether the specified *item* has the given *tagname*. Otherwise, returns a list of all items that have the specified tag.

Availability: Tk 8.6

xview (**args*)

Query or modify horizontal position of the treeview.

yview (**args*)

Query or modify vertical position of the treeview.

25.8.11 Ttk Styling

Each widget in `ttk` is assigned a style, which specifies the set of elements making up the widget and how they are arranged, along with dynamic and default settings for element options. By default the style name is the same as the widget's class name, but it may be overridden by the widget's style option. If you don't know the class name of a widget, use the method `Misc.winfo_class()` (`somewidget.winfo_class()`).

也參考:

Tcl'2004 conference presentation

This document explains how the theme engine works

class `tkinter.ttk.Style`

This class is used to manipulate the style database.

configure (*style*, *query_opt=None*, ***kw*)

Query or set the default value of the specified option(s) in *style*.

Each key in *kw* is an option and each value is a string identifying the value for that option.

For example, to change every default button to be a flat button with some padding and a different background color:

```
from tkinter import ttk
import tkinter

root = tkinter.Tk()

ttk.Style().configure("TButton", padding=6, relief="flat",
                     background="#ccc")

btn = ttk.Button(text="Sample")
btn.pack()

root.mainloop()
```

map (*style*, *query_opt=None*, ***kw*)

Query or sets dynamic values of the specified option(s) in *style*.

Each key in *kw* is an option and each value should be a list or a tuple (usually) containing statespecs grouped in tuples, lists, or some other preference. A statespec is a compound of one or more states and then a value.

An example may make it more understandable:

```
import tkinter
from tkinter import ttk

root = tkinter.Tk()

style = ttk.Style()
style.map("C.TButton",
        foreground=[('pressed', 'red'), ('active', 'blue')],
        background=[('pressed', '!disabled', 'black'), ('active', 'white')]
)

colored_btn = ttk.Button(text="Test", style="C.TButton").pack()

root.mainloop()
```

Note that the order of the (states, value) sequences for an option does matter, if the order is changed to `[('active', 'blue'), ('pressed', 'red')]` in the foreground option, for example, the result would be a blue foreground when the widget were in active or pressed states.

lookup (*style, option, state=None, default=None*)

Returns the value specified for *option* in *style*.

If *state* is specified, it is expected to be a sequence of one or more states. If the *default* argument is set, it is used as a fallback value in case no specification for *option* is found.

To check what font a Button uses by default:

```
from tkinter import ttk

print(ttk.Style().lookup("TButton", "font"))
```

layout (*style, layoutspec=None*)

Define the widget layout for given *style*. If *layoutspec* is omitted, return the layout specification for given *style*.

layoutspec, if specified, is expected to be a list or some other sequence type (excluding strings), where each item should be a tuple and the first item is the layout name and the second item should have the format described in [Layouts](#).

To understand the format, see the following example (it is not intended to do anything useful):

```
from tkinter import ttk
import tkinter

root = tkinter.Tk()

style = ttk.Style()
style.layout("TMenubutton", [
    ("Menubutton.background", None),
    ("Menubutton.button", {"children":
        [ ("Menubutton.focus", {"children":
            [ ("Menubutton.padding", {"children":
                [ ("Menubutton.label", {"side": "left", "expand": 1})]
            })]
        })]
    })],
])

mbtn = ttk.Menubutton(text='Text')
mbtn.pack()
root.mainloop()
```

element_create (*elementname, etype, *args, **kw*)

Create a new element in the current theme, of the given *etype* which is expected to be either "image" or "from".

If "image" is used, *args* should contain the default image name followed by statespec/value pairs (this is the *imagespec*), and *kw* may have the following options:

border=padding

padding is a list of up to four integers, specifying the left, top, right, and bottom borders, respectively.

height=height

Specifies a minimum height for the element. If less than zero, the base image's height is used as a default.

padding=padding

Specifies the element's interior padding. Defaults to border's value if not specified.

sticky=spec

Specifies how the image is placed within the final parcel. *spec* contains zero or more characters "n", "s", "w", or "e".

width=width

Specifies a minimum width for the element. If less than zero, the base image's width is used as a default.

Example:

```
img1 = tkinter.PhotoImage(master=root, file='button.png')
img1 = tkinter.PhotoImage(master=root, file='button-pressed.png')
img1 = tkinter.PhotoImage(master=root, file='button-active.png')
style = ttk.Style(root)
style.element_create('Button.button', 'image',
                    img1, ('pressed', img2), ('active', img3),
                    border=(2, 4), sticky='we')
```

If "from" is used as the value of *etype*, `element_create()` will clone an existing element. *args* is expected to contain a themename, from which the element will be cloned, and optionally an element to clone from. If this element to clone from is not specified, an empty element will be used. *kw* is discarded.

Example:

```
style = ttk.Style(root)
style.element_create('plain.background', 'from', 'default')
```

element_names()

Returns the list of elements defined in the current theme.

element_options(elementname)

Returns the list of *elementname*'s options.

theme_create(themename, parent=None, settings=None)

Create a new theme.

It is an error if *themename* already exists. If *parent* is specified, the new theme will inherit styles, elements and layouts from the parent theme. If *settings* are present they are expected to have the same syntax used for `theme_settings()`.

theme_settings(themename, settings)

Temporarily sets the current theme to *themename*, apply specified *settings* and then restore the previous theme.

Each key in *settings* is a style and each value may contain the keys 'configure', 'map', 'layout' and 'element create' and they are expected to have the same format as specified by the methods `Style.configure()`, `Style.map()`, `Style.layout()` and `Style.element_create()` respectively.

As an example, let's change the Combobox for the default theme a bit:

```
from tkinter import ttk
import tkinter

root = tkinter.Tk()

style = ttk.Style()
style.theme_settings("default", {
    "TCombobox": {
        "configure": {"padding": 5},
        "map": {
            "background": [("active", "green2"),
                          ("!disabled", "green4")],
            "fieldbackground": [("!disabled", "green3")],
            "foreground": [("focus", "OliveDrab1"),
                          ("!disabled", "OliveDrab2")]
        }
    }
})
```

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```
    }
  })

  combo = ttk.Combobox().pack()

  root.mainloop()
```

theme_names()

Returns a list of all known themes.

theme_use (*themename=None*)If *themename* is not given, returns the theme in use. Otherwise, sets the current theme to *themename*, refreshes all widgets and emits a «ThemeChanged» event.

Layouts

A layout can be just `None`, if it takes no options, or a dict of options specifying how to arrange the element. The layout mechanism uses a simplified version of the pack geometry manager: given an initial cavity, each element is allocated a parcel.

The valid options/values are:

side: whichside

Specifies which side of the cavity to place the element; one of top, right, bottom or left. If omitted, the element occupies the entire cavity.

sticky: nswe

Specifies where the element is placed inside its allocated parcel.

unit: 0 or 1If set to 1, causes the element and all of its descendants to be treated as a single element for the purposes of `Widget.identify()` et al. It's used for things like scrollbar thumbs with grips.**children: [sublayout...]**Specifies a list of elements to place inside the element. Each element is a tuple (or other sequence type) where the first item is the layout name, and the other is a *Layout*.

25.9 tkinter.tix --- Tk 擴充小工具

原始碼: [Lib/tkinter/tix.py](#)

在 3.6 版之後被~~棄用~~: This Tk extension is unmaintained and should not be used in new code. Use `tkinter.ttk` instead.

The `tkinter.tix` (Tk Interface Extension) module provides an additional rich set of widgets. Although the standard Tk library has many useful widgets, they are far from complete. The `tkinter.tix` library provides most of the commonly needed widgets that are missing from standard Tk: *HList*, *ComboBox*, *Control* (a.k.a. *SpinBox*) and an assortment of scrollable widgets. `tkinter.tix` also includes many more widgets that are generally useful in a wide range of applications: *NoteBook*, *FileEntry*, *PanedWindow*, etc; there are more than 40 of them.

With all these new widgets, you can introduce new interaction techniques into applications, creating more useful and more intuitive user interfaces. You can design your application by choosing the most appropriate widgets to match the special needs of your application and users.

也參考:**Tix 首頁**

The home page for Tix. This includes links to additional documentation and downloads.

Tix 首頁

On-line version of the man pages and reference material.

Tix 程式指南

On-line version of the programmer's reference material.

Tix 開發應用程式

Tix applications for development of Tix and Tkinter programs. Tide applications work under Tk or Tkinter, and include **TixInspect**, an inspector to remotely modify and debug Tix/Tk/Tkinter applications.

25.9.1 Using Tix

class `tkinter.tix.Tk` (*screenName=None, baseName=None, className='Tix'*)

Toplevel widget of Tix which represents mostly the main window of an application. It has an associated Tcl interpreter.

Classes in the `tkinter.tix` module subclasses the classes in the `tkinter`. The former imports the latter, so to use `tkinter.tix` with Tkinter, all you need to do is to import one module. In general, you can just import `tkinter.tix`, and replace the toplevel call to `tkinter.Tk` with `tix.Tk`:

```
from tkinter import tix
from tkinter.constants import *
root = tix.Tk()
```

To use `tkinter.tix`, you must have the Tix widgets installed, usually alongside your installation of the Tk widgets. To test your installation, try the following:

```
from tkinter import tix
root = tix.Tk()
root.tk.eval('package require Tix')
```

25.9.2 Tix Widgets

Tix introduces over 40 widget classes to the `tkinter` repertoire.

Basic Widgets

class `tkinter.tix.Balloon`

A **Balloon** that pops up over a widget to provide help. When the user moves the cursor inside a widget to which a Balloon widget has been bound, a small pop-up window with a descriptive message will be shown on the screen.

class `tkinter.tix.ButtonBox`

The **ButtonBox** widget creates a box of buttons, such as is commonly used for Ok Cancel.

class `tkinter.tix.ComboBox`

The **ComboBox** widget is similar to the combo box control in MS Windows. The user can select a choice by either typing in the entry subwidget or selecting from the listbox subwidget.

class `tkinter.tix.Control`

The **Control** widget is also known as the **SpinBox** widget. The user can adjust the value by pressing the two arrow buttons or by entering the value directly into the entry. The new value will be checked against the user-defined upper and lower limits.

class `tkinter.tix.LabelEntry`

The **LabelEntry** widget packages an entry widget and a label into one mega widget. It can be used to simplify the creation of "entry-form" type of interface.

class `tkinter.tix.LabelFrame`

The `LabelFrame` widget packages a frame widget and a label into one mega widget. To create widgets inside a `LabelFrame` widget, one creates the new widgets relative to the `frame` subwidget and manage them inside the `frame` subwidget.

class `tkinter.tix.Meter`

The `Meter` widget can be used to show the progress of a background job which may take a long time to execute.

class `tkinter.tix.OptionMenu`

The `OptionMenu` creates a menu button of options.

class `tkinter.tix.PopupMenu`

The `PopupMenu` widget can be used as a replacement of the `tk_popup` command. The advantage of the `Tix.PopupMenu` widget is it requires less application code to manipulate.

class `tkinter.tix.Select`

The `Select` widget is a container of button subwidgets. It can be used to provide radio-box or check-box style of selection options for the user.

class `tkinter.tix.StdButtonBox`

The `StdButtonBox` widget is a group of standard buttons for Motif-like dialog boxes.

File Selectors

class `tkinter.tix.DirList`

The `DirList` widget displays a list view of a directory, its previous directories and its sub-directories. The user can choose one of the directories displayed in the list or change to another directory.

class `tkinter.tix.DirTree`

The `DirTree` widget displays a tree view of a directory, its previous directories and its sub-directories. The user can choose one of the directories displayed in the list or change to another directory.

class `tkinter.tix.DirSelectDialog`

The `DirSelectDialog` widget presents the directories in the file system in a dialog window. The user can use this dialog window to navigate through the file system to select the desired directory.

class `tkinter.tix.DirSelectBox`

The `DirSelectBox` is similar to the standard Motif(TM) directory-selection box. It is generally used for the user to choose a directory. `DirSelectBox` stores the directories mostly recently selected into a `ComboBox` widget so that they can be quickly selected again.

class `tkinter.tix.ExFileSelectBox`

The `ExFileSelectBox` widget is usually embedded in a `tixExFileSelectDialog` widget. It provides a convenient method for the user to select files. The style of the `ExFileSelectBox` widget is very similar to the standard file dialog on MS Windows 3.1.

class `tkinter.tix.FileSelectBox`

The `FileSelectBox` is similar to the standard Motif(TM) file-selection box. It is generally used for the user to choose a file. `FileSelectBox` stores the files mostly recently selected into a `ComboBox` widget so that they can be quickly selected again.

class `tkinter.tix.FileEntry`

The `FileEntry` widget can be used to input a filename. The user can type in the filename manually. Alternatively, the user can press the button widget that sits next to the entry, which will bring up a file selection dialog.

Hierarchical ListBox

class `tkinter.tix.HList`

The `HList` widget can be used to display any data that have a hierarchical structure, for example, file system directory trees. The list entries are indented and connected by branch lines according to their places in the hierarchy.

class `tkinter.tix.CheckList`

The `CheckList` widget displays a list of items to be selected by the user. `CheckList` acts similarly to the `Tk` `checkbutton` or `radiobutton` widgets, except it is capable of handling many more items than `checkbuttons` or `radiobuttons`.

class `tkinter.tix.Tree`

The `Tree` widget can be used to display hierarchical data in a tree form. The user can adjust the view of the tree by opening or closing parts of the tree.

Tabular ListBox

class `tkinter.tix.TList`

The `TList` widget can be used to display data in a tabular format. The list entries of a `TList` widget are similar to the entries in the `Tk` listbox widget. The main differences are (1) the `TList` widget can display the list entries in a two dimensional format and (2) you can use graphical images as well as multiple colors and fonts for the list entries.

Manager Widgets

class `tkinter.tix.PanedWindow`

The `PanedWindow` widget allows the user to interactively manipulate the sizes of several panes. The panes can be arranged either vertically or horizontally. The user changes the sizes of the panes by dragging the resize handle between two panes.

class `tkinter.tix.ListNoteBook`

The `ListNoteBook` widget is very similar to the `TixNoteBook` widget: it can be used to display many windows in a limited space using a notebook metaphor. The notebook is divided into a stack of pages (windows). At one time only one of these pages can be shown. The user can navigate through these pages by choosing the name of the desired page in the `hlist` subwidget.

class `tkinter.tix.NoteBook`

The `NoteBook` widget can be used to display many windows in a limited space using a notebook metaphor. The notebook is divided into a stack of pages. At one time only one of these pages can be shown. The user can navigate through these pages by choosing the visual "tabs" at the top of the `NoteBook` widget.

Image Types

The `tkinter.tix` module adds:

- `pixmap` capabilities to all `tkinter.tix` and `tkinter` widgets to create color images from XPM files.
- `Compound` image types can be used to create images that consists of multiple horizontal lines; each line is composed of a series of items (texts, bitmaps, images or spaces) arranged from left to right. For example, a compound image can be used to display a bitmap and a text string simultaneously in a `Tk Button` widget.

Miscellaneous Widgets

`class tkinter.tix.InputOnly`

The `InputOnly` widgets are to accept inputs from the user, which can be done with the `bind` command (Unix only).

Form Geometry Manager

In addition, `tkinter.tix` augments `tkinter` by providing:

`class tkinter.tix.Form`

The `Form` geometry manager based on attachment rules for all Tk widgets.

25.9.3 Tix 指令

`class tkinter.tix.tixCommand`

The `tix` commands provide access to miscellaneous elements of Tix's internal state and the Tix application context. Most of the information manipulated by these methods pertains to the application as a whole, or to a screen or display, rather than to a particular window.

To view the current settings, the common usage is:

```
from tkinter import tix
root = tix.Tk()
print(root.tix_configure())
```

`tixCommand.tix_configure` (*cnf=None, **kw*)

Query or modify the configuration options of the Tix application context. If no option is specified, returns a dictionary all of the available options. If option is specified with no value, then the method returns a list describing the one named option (this list will be identical to the corresponding sublist of the value returned if no option is specified). If one or more option-value pairs are specified, then the method modifies the given option(s) to have the given value(s); in this case the method returns an empty string. Option may be any of the configuration options.

`tixCommand.tix_cget` (*option*)

Returns the current value of the configuration option given by *option*. Option may be any of the configuration options.

`tixCommand.tix_getbitmap` (*name*)

Locates a bitmap file of the name *name*.xpm or *name* in one of the bitmap directories (see the `tix_addbitmapdir()` method). By using `tix_getbitmap()`, you can avoid hard coding the pathnames of the bitmap files in your application. When successful, it returns the complete pathname of the bitmap file, prefixed with the character @. The returned value can be used to configure the `bitmap` option of the Tk and Tix widgets.

`tixCommand.tix_addbitmapdir` (*directory*)

Tix maintains a list of directories under which the `tix_getimage()` and `tix_getbitmap()` methods will search for image files. The standard bitmap directory is `$TIX_LIBRARY/bitmaps`. The `tix_addbitmapdir()` method adds *directory* into this list. By using this method, the image files of an applications can also be located using the `tix_getimage()` or `tix_getbitmap()` method.

`tixCommand.tix_filedialog` (*[dlgclass]*)

Returns the file selection dialog that may be shared among different calls from this application. This method will create a file selection dialog widget when it is called the first time. This dialog will be returned by all subsequent calls to `tix_filedialog()`. An optional *dlgclass* parameter can be passed as a string to specified what type of file selection dialog widget is desired. Possible options are `tix`, `FileSelectDialog` or `tixExFileSelectDialog`.

`tixCommand.tix_getimage (self, name)`

Locates an image file of the name `name.xpm`, `name.xbm` or `name.ppm` in one of the bitmap directories (see the `tix_addbitmapdir()` method above). If more than one file with the same name (but different extensions) exist, then the image type is chosen according to the depth of the X display: xbm images are chosen on monochrome displays and color images are chosen on color displays. By using `tix_getimage()`, you can avoid hard coding the pathnames of the image files in your application. When successful, this method returns the name of the newly created image, which can be used to configure the `image` option of the Tk and Tix widgets.

`tixCommand.tix_option_get (name)`

Gets the options maintained by the Tix scheme mechanism.

`tixCommand.tix_resetoptions (newScheme, newFontSet[, newScmPrio])`

Resets the scheme and fontset of the Tix application to `newScheme` and `newFontSet`, respectively. This affects only those widgets created after this call. Therefore, it is best to call the `resetoptions` method before the creation of any widgets in a Tix application.

The optional parameter `newScmPrio` can be given to reset the priority level of the Tk options set by the Tix schemes.

Because of the way Tk handles the X option database, after Tix has been imported and init'd, it is not possible to reset the color schemes and font sets using the `tix_config()` method. Instead, the `tix_resetoptions()` method must be used.

25.10 IDLE

原始碼: [Lib/idlelib/](#)

IDLE is Python's Integrated Development and Learning Environment.

IDLE has the following features:

- cross-platform: works mostly the same on Windows, Unix, and macOS
- Python shell window (interactive interpreter) with colorizing of code input, output, and error messages
- multi-window text editor with multiple undo, Python colorizing, smart indent, call tips, auto completion, and other features
- search within any window, replace within editor windows, and search through multiple files (grep)
- debugger with persistent breakpoints, stepping, and viewing of global and local namespaces
- configuration, browsers, and other dialogs

25.10.1 目F

IDLE has two main window types, the Shell window and the Editor window. It is possible to have multiple editor windows simultaneously. On Windows and Linux, each has its own top menu. Each menu documented below indicates which window type it is associated with.

Output windows, such as used for Edit => Find in Files, are a subtype of editor window. They currently have the same top menu but a different default title and context menu.

On macOS, there is one application menu. It dynamically changes according to the window currently selected. It has an IDLE menu, and some entries described below are moved around to conform to Apple guidelines.

File menu (Shell and Editor)

新增檔案

Create a new file editing window.

Open...

Open an existing file with an Open dialog.

Open Module...

Open an existing module (searches sys.path).

Recent Files

Open a list of recent files. Click one to open it.

Module Browser

Show functions, classes, and methods in the current Editor file in a tree structure. In the shell, open a module first.

Path Browser

Show sys.path directories, modules, functions, classes and methods in a tree structure.

Save

Save the current window to the associated file, if there is one. Windows that have been changed since being opened or last saved have a * before and after the window title. If there is no associated file, do Save As instead.

Save As...

Save the current window with a Save As dialog. The file saved becomes the new associated file for the window. (If your file namager is set to hide extensions, the current extension will be omitted in the file name box. If the new filename has no '.', '.py' and '.txt' will be added for Python and text files, except that on macOS Aqua, '.py' is added for all files.)

Save Copy As...

Save the current window to different file without changing the associated file. (See Save As note above about filename extensions.)

Print Window

Print the current window to the default printer.

Close Window

Close the current window (if an unsaved editor, ask to save; if an unsaved Shell, ask to quit execution). Calling `exit()` or `close()` in the Shell window also closes Shell. If this is the only window, also exit IDLE.

離開 IDLE

Close all windows and quit IDLE (ask to save unsaved edit windows).

Edit menu (Shell and Editor)

Undo

Undo the last change to the current window. A maximum of 1000 changes may be undone.

Redo

Redo the last undone change to the current window.

Select All (選擇全部)

Select the entire contents of the current window.

Cut (剪下)

Copy selection into the system-wide clipboard; then delete the selection.

Copy (F F)

Copy selection into the system-wide clipboard.

Paste (貼上)

Insert contents of the system-wide clipboard into the current window.

The clipboard functions are also available in context menus.

Find...

Open a search dialog with many options

Find Again

Repeat the last search, if there is one.

Find Selection

Search for the currently selected string, if there is one.

Find in Files...

Open a file search dialog. Put results in a new output window.

Replace...

Open a search-and-replace dialog.

Go to Line

Move the cursor to the beginning of the line requested and make that line visible. A request past the end of the file goes to the end. Clear any selection and update the line and column status.

Show Completions

Open a scrollable list allowing selection of existing names. See [Completions](#) in the Editing and navigation section below.

Expand Word

Expand a prefix you have typed to match a full word in the same window; repeat to get a different expansion.

Show Call Tip

After an unclosed parenthesis for a function, open a small window with function parameter hints. See [Calltips](#) in the Editing and navigation section below.

Show Surrounding Parens

Highlight the surrounding parenthesis.

Format menu (Editor window only)**Format Paragraph**

Reformat the current blank-line-delimited paragraph in comment block or multiline string or selected line in a string. All lines in the paragraph will be formatted to less than N columns, where N defaults to 72.

Indent Region

Shift selected lines right by the indent width (default 4 spaces).

Dedent Region

Shift selected lines left by the indent width (default 4 spaces).

Comment Out Region

Insert `##` in front of selected lines.

Uncomment Region

Remove leading `#` or `##` from selected lines.

Tabify Region

Turn *leading* stretches of spaces into tabs. (Note: We recommend using 4 space blocks to indent Python code.)

Untabify Region

Turn *all* tabs into the correct number of spaces.

Toggle Tabs

Open a dialog to switch between indenting with spaces and tabs.

New Indent Width

Open a dialog to change indent width. The accepted default by the Python community is 4 spaces.

Strip Trailing Chitespace

Remove trailing space and other whitespace characters after the last non-whitespace character of a line by

applying `str.rstrip` to each line, including lines within multiline strings. Except for Shell windows, remove extra newlines at the end of the file.

Run menu (Editor window only)

Run Module

Do *Check Module*. If no error, restart the shell to clean the environment, then execute the module. Output is displayed in the Shell window. Note that output requires use of `print` or `write`. When execution is complete, the Shell retains focus and displays a prompt. At this point, one may interactively explore the result of execution. This is similar to executing a file with `python -i file` at a command line.

Run... Customized

Same as *Run Module*, but run the module with customized settings. *Command Line Arguments* extend `sys.argv` as if passed on a command line. The module can be run in the Shell without restarting.

Check Module

Check the syntax of the module currently open in the Editor window. If the module has not been saved IDLE will either prompt the user to save or autosave, as selected in the General tab of the Idle Settings dialog. If there is a syntax error, the approximate location is indicated in the Editor window.

Python Shell

Open or wake up the Python Shell window.

Shell menu (Shell window only)

View Last Restart

Scroll the shell window to the last Shell restart.

Restart Shell

Restart the shell to clean the environment and reset display and exception handling.

Previous History

Cycle through earlier commands in history which match the current entry.

Next History

Cycle through later commands in history which match the current entry.

Interrupt Execution

Stop a running program.

Debug menu (Shell window only)

Go to File/Line

Look on the current line, with the cursor, and the line above for a filename and line number. If found, open the file if not already open, and show the line. Use this to view source lines referenced in an exception traceback and lines found by Find in Files. Also available in the context menu of the Shell window and Output windows.

Debugger (toggle)

When activated, code entered in the Shell or run from an Editor will run under the debugger. In the Editor, breakpoints can be set with the context menu. This feature is still incomplete and somewhat experimental.

Stack Viewer

Show the stack traceback of the last exception in a tree widget, with access to locals and globals.

Auto-open Stack Viewer

Toggle automatically opening the stack viewer on an unhandled exception.

Options menu (Shell and Editor)

Configure IDLE

Open a configuration dialog and change preferences for the following: fonts, indentation, keybindings, text color themes, startup windows and size, additional help sources, and extensions. On macOS, open the configuration dialog by selecting Preferences in the application menu. For more details, see [Setting preferences](#) under Help and preferences.

Most configuration options apply to all windows or all future windows. The option items below only apply to the active window.

Show/Hide Code Context (Editor Window only)

Open a pane at the top of the edit window which shows the block context of the code which has scrolled above the top of the window. See [Code Context](#) in the Editing and Navigation section below.

Show/Hide Line Numbers (Editor Window only)

Open a column to the left of the edit window which shows the number of each line of text. The default is off, which may be changed in the preferences (see [Setting preferences](#)).

Zoom/Restore Height

Toggles the window between normal size and maximum height. The initial size defaults to 40 lines by 80 chars unless changed on the General tab of the Configure IDLE dialog. The maximum height for a screen is determined by momentarily maximizing a window the first time one is zoomed on the screen. Changing screen settings may invalidate the saved height. This toggle has no effect when a window is maximized.

Window menu (Shell and Editor)

Lists the names of all open windows; select one to bring it to the foreground (deiconifying it if necessary).

Help menu (Shell and Editor)

About IDLE

Display version, copyright, license, credits, and more.

IDLE Help

Display this IDLE document, detailing the menu options, basic editing and navigation, and other tips.

Python Docs

Access local Python documentation, if installed, or start a web browser and open docs.python.org showing the latest Python documentation.

Turtle Demo

Run the `turtledemo` module with example Python code and turtle drawings.

Additional help sources may be added here with the Configure IDLE dialog under the General tab. See the [Help sources](#) subsection below for more on Help menu choices.

Context menus

Open a context menu by right-clicking in a window (Control-click on macOS). Context menus have the standard clipboard functions also on the Edit menu.

Cut (剪下)

Copy selection into the system-wide clipboard; then delete the selection.

Copy (F F)

Copy selection into the system-wide clipboard.

Paste (貼上)

Insert contents of the system-wide clipboard into the current window.

Editor windows also have breakpoint functions. Lines with a breakpoint set are specially marked. Breakpoints only have an effect when running under the debugger. Breakpoints for a file are saved in the user's `.idlerc` directory.

Set Breakpoint

Set a breakpoint on the current line.

Clear Breakpoint

Clear the breakpoint on that line.

Shell and Output windows also have the following.

Go to file/line

Same as in Debug menu.

The Shell window also has an output squeezing facility explained in the *Python Shell window* subsection below.

Squeeze

If the cursor is over an output line, squeeze all the output between the code above and the prompt below down to a 'Squeezed text' label.

25.10.2 Editing and Navigation

Editor windows

IDLE may open editor windows when it starts, depending on settings and how you start IDLE. Thereafter, use the File menu. There can be only one open editor window for a given file.

The title bar contains the name of the file, the full path, and the version of Python and IDLE running the window. The status bar contains the line number ('Ln') and column number ('Col'). Line numbers start with 1; column numbers with 0.

IDLE assumes that files with a known `.py*` extension contain Python code and that other files do not. Run Python code with the Run menu.

Key bindings

The IDLE insertion cursor is a thin vertical bar between character positions. When characters are entered, the insertion cursor and everything to its right moves right one character and the new character is entered in the new space.

Several non-character keys move the cursor and possibly delete characters. Deletion does not put text on the clipboard, but IDLE has an undo list. Wherever this doc discusses keys, 'C' refers to the `Control` key on Windows and Unix and the `Command` key on macOS. (And all such discussions assume that the keys have not been re-bound to something else.)

- Arrow keys move the cursor one character or line.
- `C-LeftArrow` and `C-RightArrow` moves left or right one word.
- `Home` and `End` go to the beginning or end of the line.
- `Page Up` and `Page Down` go up or down one screen.
- `C-Home` and `C-End` go to beginning or end of the file.
- `Backspace` and `Del` (or `C-d`) delete the previous or next character.
- `C-Backspace` and `C-Del` delete one word left or right.
- `C-k` deletes ('kills') everything to the right.

Standard keybindings (like `C-c` to copy and `C-v` to paste) may work. Keybindings are selected in the Configure IDLE dialog.

Automatic indentation

After a block-opening statement, the next line is indented by 4 spaces (in the Python Shell window by one tab). After certain keywords (break, return etc.) the next line is dedented. In leading indentation, `Backspace` deletes up to 4 spaces if they are there. `Tab` inserts spaces (in the Python Shell window one tab), number depends on Indent width. Currently, tabs are restricted to four spaces due to Tcl/Tk limitations.

See also the indent/dedent region commands on the *Format menu*.

Search and Replace

Any selection becomes a search target. However, only selections within a line work because searches are only performed within lines with the terminal newline removed. If `[x] Regular expression` is checked, the target is interpreted according to the Python `re` module.

Completions

Completions are supplied, when requested and available, for module names, attributes of classes or functions, or filenames. Each request method displays a completion box with existing names. (See tab completions below for an exception.) For any box, change the name being completed and the item highlighted in the box by typing and deleting characters; by hitting Up, Down, PageUp, PageDown, Home, and End keys; and by a single click within the box. Close the box with `Escape`, `Enter`, and double `Tab` keys or clicks outside the box. A double click within the box selects and closes.

One way to open a box is to type a key character and wait for a predefined interval. This defaults to 2 seconds; customize it in the settings dialog. (To prevent auto popups, set the delay to a large number of milliseconds, such as 100000000.) For imported module names or class or function attributes, type `'.'`. For filenames in the root directory, type `os.sep` or `os.altsep` immediately after an opening quote. (On Windows, one can specify a drive first.) Move into subdirectories by typing a directory name and a separator.

Instead of waiting, or after a box is closed, open a completion box immediately with Show Completions on the Edit menu. The default hot key is `C-space`. If one types a prefix for the desired name before opening the box, the first match or near miss is made visible. The result is the same as if one enters a prefix after the box is displayed. Show Completions after a quote completes filenames in the current directory instead of a root directory.

Hitting `Tab` after a prefix usually has the same effect as Show Completions. (With no prefix, it indents.) However, if there is only one match to the prefix, that match is immediately added to the editor text without opening a box.

Invoking 'Show Completions', or hitting `Tab` after a prefix, outside of a string and without a preceding `'.'` opens a box with keywords, builtin names, and available module-level names.

When editing code in an editor (as oppose to Shell), increase the available module-level names by running your code and not restarting the Shell thereafter. This is especially useful after adding imports at the top of a file. This also increases possible attribute completions.

Completion boxes initially exclude names beginning with `'_'` or, for modules, not included in `'__all__'`. The hidden names can be accessed by typing `'_'` after `'.'`, either before or after the box is opened.

Calltips

A calltip is shown automatically when one types `(` after the name of an *accessible* function. A function name expression may include dots and subscripts. A calltip remains until it is clicked, the cursor is moved out of the argument area, or `)` is typed. Whenever the cursor is in the argument part of a definition, select Edit and "Show Call Tip" on the menu or enter its shortcut to display a calltip.

The calltip consists of the function's signature and docstring up to the latter's first blank line or the fifth non-blank line. (Some builtin functions lack an accessible signature.) A `'/'` or `'**'` in the signature indicates that the preceding or following arguments are passed by position or name (keyword) only. Details are subject to change.

In Shell, the accessible functions depends on what modules have been imported into the user process, including those imported by Idle itself, and which definitions have been run, all since the last restart.

For example, restart the Shell and enter `itertools.count()`. A calltip appears because Idle imports `itertools` into the user process for its own use. (This could change.) Enter `turtle.write()` and nothing appears. Idle does not itself import `turtle`. The menu entry and shortcut also do nothing. Enter `import turtle`. Thereafter, `turtle.write()` will display a calltip.

In an editor, import statements have no effect until one runs the file. One might want to run a file after writing import statements, after adding function definitions, or after opening an existing file.

Code Context

Within an editor window containing Python code, code context can be toggled in order to show or hide a pane at the top of the window. When shown, this pane freezes the opening lines for block code, such as those beginning with `class`, `def`, or `if` keywords, that would have otherwise scrolled out of view. The size of the pane will be expanded and contracted as needed to show the all current levels of context, up to the maximum number of lines defined in the Configure IDLE dialog (which defaults to 15). If there are no current context lines and the feature is toggled on, a single blank line will display. Clicking on a line in the context pane will move that line to the top of the editor.

The text and background colors for the context pane can be configured under the Highlights tab in the Configure IDLE dialog.

Shell window

In IDLE's Shell, enter, edit, and recall complete statements. (Most consoles and terminals only work with a single physical line at a time).

Submit a single-line statement for execution by hitting `Return` with the cursor anywhere on the line. If a line is extended with Backslash (`\`), the cursor must be on the last physical line. Submit a multi-line compound statement by entering a blank line after the statement.

When one pastes code into Shell, it is not compiled and possibly executed until one hits `Return`, as specified above. One may edit pasted code first. If one pastes more than one statement into Shell, the result will be a `SyntaxError` when multiple statements are compiled as if they were one.

Lines containing `RESTART` mean that the user execution process has been re-started. This occurs when the user execution process has crashed, when one requests a restart on the Shell menu, or when one runs code in an editor window.

The editing features described in previous subsections work when entering code interactively. IDLE's Shell window also responds to the following:

- `C-c` attempts to interrupt statement execution (but may fail).
- `C-d` closes Shell if typed at a `>>>` prompt.
- `Alt-p` and `Alt-n` (`C-p` and `C-n` on macOS) retrieve to the current prompt the previous or next previously entered statement that matches anything already typed.
- `Return` while the cursor is on any previous statement appends the latter to anything already typed at the prompt.

Text colors

Idle defaults to black on white text, but colors text with special meanings. For the shell, these are shell output, shell error, user output, and user error. For Python code, at the shell prompt or in an editor, these are keywords, builtin class and function names, names following `class` and `def`, strings, and comments. For any text window, these are the cursor (when present), found text (when possible), and selected text.

Idle also highlights the soft keywords `match`, `case`, and `_` in pattern-matching statements. However, this highlighting is not perfect and will be incorrect in some rare cases, including some `_s` in `case` patterns.

Text coloring is done in the background, so uncolorized text is occasionally visible. To change the color scheme, use the Configure IDLE dialog Highlighting tab. The marking of debugger breakpoint lines in the editor and text in popups and dialogs is not user-configurable.

25.10.3 Startup and Code Execution

Upon startup with the `-s` option, IDLE will execute the file referenced by the environment variables `IDLESTARTUP` or `PYTHONSTARTUP`. IDLE first checks for `IDLESTARTUP`; if `IDLESTARTUP` is present the file referenced is run. If `IDLESTARTUP` is not present, IDLE checks for `PYTHONSTARTUP`. Files referenced by these environment variables are convenient places to store functions that are used frequently from the IDLE shell, or for executing import statements to import common modules.

In addition, Tk also loads a startup file if it is present. Note that the Tk file is loaded unconditionally. This additional file is `.Idle.py` and is looked for in the user's home directory. Statements in this file will be executed in the Tk namespace, so this file is not useful for importing functions to be used from IDLE's Python shell.

Command line usage

```
idle.py [-c command] [-d] [-e] [-h] [-i] [-r file] [-s] [-t title] [-] [arg] ...

-c command    run command in the shell window
-d            enable debugger and open shell window
-e            open editor window
-h            print help message with legal combinations and exit
-i            open shell window
-r file       run file in shell window
-s            run $IDLESTARTUP or $PYTHONSTARTUP first, in shell window
-t title      set title of shell window
-            run stdin in shell (- must be last option before args)
```

If there are arguments:

- If `-`, `-c`, or `r` is used, all arguments are placed in `sys.argv[1:...]` and `sys.argv[0]` is set to `'-'`, `'-c'`, or `'-r'`. No editor window is opened, even if that is the default set in the Options dialog.
- Otherwise, arguments are files opened for editing and `sys.argv` reflects the arguments passed to IDLE itself.

Startup failure

Idle uses a socket to communicate between the IDLE GUI process and the user code execution process. A connection must be established whenever the Shell starts or restarts. (The latter is indicated by a divider line that says 'RESTART'). If the user process fails to connect to the GUI process, it usually displays a Tk error box with a 'cannot connect' message that directs the user here. It then exits.

One specific connection failure on Unix systems results from misconfigured masquerading rules somewhere in a system's network setup. When IDLE is started from a terminal, one will see a message starting with `** Invalid host:.` The valid value is `127.0.0.1 (idlelib.rpc.LOCALHOST)`. One can diagnose with `tcpconnect -irv 127.0.0.1 6543` in one terminal window and `tcplisten <same args>` in another.

A common cause of failure is a user-written file with the same name as a standard library module, such as *random.py* and *tkinter.py*. When such a file is located in the same directory as a file that is about to be run, IDLE cannot import the stdlib file. The current fix is to rename the user file.

Though less common than in the past, an antivirus or firewall program may stop the connection. If the program cannot be taught to allow the connection, then it must be turned off for IDLE to work. It is safe to allow this internal connection because no data is visible on external ports. A similar problem is a network mis-configuration that blocks connections.

Python installation issues occasionally stop IDLE: multiple versions can clash, or a single installation might need admin access. If one undo the clash, or cannot or does not want to run as admin, it might be easiest to completely remove Python and start over.

A zombie pythonw.exe process could be a problem. On Windows, use Task Manager to check for one and stop it if there is. Sometimes a restart initiated by a program crash or Keyboard Interrupt (control-C) may fail to connect. Dismissing the error box or using Restart Shell on the Shell menu may fix a temporary problem.

When IDLE first starts, it attempts to read user configuration files in `~/.idlerc/` (~ is one's home directory). If there is a problem, an error message should be displayed. Leaving aside random disk glitches, this can be prevented by never editing the files by hand. Instead, use the configuration dialog, under Options. Once there is an error in a user configuration file, the best solution may be to delete it and start over with the settings dialog.

If IDLE quits with no message, and it was not started from a console, try starting it from a console or terminal (`python -m idlelib`) and see if this results in an error message.

On Unix-based systems with tcl/tk older than 8.6.11 (see About IDLE) certain characters of certain fonts can cause a tk failure with a message to the terminal. This can happen either if one starts IDLE to edit a file with such a character or later when entering such a character. If one cannot upgrade tcl/tk, then re-configure IDLE to use a font that works better.

Running user code

With rare exceptions, the result of executing Python code with IDLE is intended to be the same as executing the same code by the default method, directly with Python in a text-mode system console or terminal window. However, the different interface and operation occasionally affect visible results. For instance, `sys.modules` starts with more entries, and `threading.active_count()` returns 2 instead of 1.

By default, IDLE runs user code in a separate OS process rather than in the user interface process that runs the shell and editor. In the execution process, it replaces `sys.stdin`, `sys.stdout`, and `sys.stderr` with objects that get input from and send output to the Shell window. The original values stored in `sys.__stdin__`, `sys.__stdout__`, and `sys.__stderr__` are not touched, but may be `None`.

Sending print output from one process to a text widget in another is slower than printing to a system terminal in the same process. This has the most effect when printing multiple arguments, as the string for each argument, each separator, the newline are sent separately. For development, this is usually not a problem, but if one wants to print faster in IDLE, format and join together everything one wants displayed together and then print a single string. Both format strings and `str.join()` can help combine fields and lines.

IDLE's standard stream replacements are not inherited by subprocesses created in the execution process, whether directly by user code or by modules such as multiprocessing. If such subprocess use `input` from `sys.stdin` or `print` or `write` to `sys.stdout` or `sys.stderr`, IDLE should be started in a command line window. (On Windows, use `python` or `py` rather than `pythonw` or `pyw`.) The secondary subprocess will then be attached to that window for input and output.

If `sys` is reset by user code, such as with `importlib.reload(sys)`, IDLE's changes are lost and input from the keyboard and output to the screen will not work correctly.

When Shell has the focus, it controls the keyboard and screen. This is normally transparent, but functions that directly access the keyboard and screen will not work. These include system-specific functions that determine whether a key has been pressed and if so, which.

The IDLE code running in the execution process adds frames to the call stack that would not be there otherwise. IDLE wraps `sys.getrecursionlimit` and `sys.setrecursionlimit` to reduce the effect of the additional

stack frames.

When user code raises `SystemExit` either directly or by calling `sys.exit`, IDLE returns to a Shell prompt instead of exiting.

User output in Shell

When a program outputs text, the result is determined by the corresponding output device. When IDLE executes user code, `sys.stdout` and `sys.stderr` are connected to the display area of IDLE's Shell. Some of its features are inherited from the underlying Tk Text widget. Others are programmed additions. Where it matters, Shell is designed for development rather than production runs.

For instance, Shell never throws away output. A program that sends unlimited output to Shell will eventually fill memory, resulting in a memory error. In contrast, some system text windows only keep the last *n* lines of output. A Windows console, for instance, keeps a user-settable 1 to 9999 lines, with 300 the default.

A Tk Text widget, and hence IDLE's Shell, displays characters (codepoints) in the BMP (Basic Multilingual Plane) subset of Unicode. Which characters are displayed with a proper glyph and which with a replacement box depends on the operating system and installed fonts. Tab characters cause the following text to begin after the next tab stop. (They occur every 8 'characters'). Newline characters cause following text to appear on a new line. Other control characters are ignored or displayed as a space, box, or something else, depending on the operating system and font. (Moving the text cursor through such output with arrow keys may exhibit some surprising spacing behavior.)

```
>>> s = 'a\tb\a<\x02><\r>\bc\nd' # Enter 22 chars.
>>> len(s)
14
>>> s # Display repr(s)
'a\tb\x07<\x02><\r>\x08c\nd'
>>> print(s, end='') # Display s as is.
# Result varies by OS and font. Try it.
```

The `repr` function is used for interactive echo of expression values. It returns an altered version of the input string in which control codes, some BMP codepoints, and all non-BMP codepoints are replaced with escape codes. As demonstrated above, it allows one to identify the characters in a string, regardless of how they are displayed.

Normal and error output are generally kept separate (on separate lines) from code input and each other. They each get different highlight colors.

For `SyntaxError` tracebacks, the normal '^' marking where the error was detected is replaced by coloring the text with an error highlight. When code run from a file causes other exceptions, one may right click on a traceback line to jump to the corresponding line in an IDLE editor. The file will be opened if necessary.

Shell has a special facility for squeezing output lines down to a 'Squeezed text' label. This is done automatically for output over *N* lines (*N* = 50 by default). *N* can be changed in the PyShell section of the General page of the Settings dialog. Output with fewer lines can be squeezed by right clicking on the output. This can be useful lines long enough to slow down scrolling.

Squeezed output is expanded in place by double-clicking the label. It can also be sent to the clipboard or a separate view window by right-clicking the label.

Developing tkinter applications

IDLE is intentionally different from standard Python in order to facilitate development of tkinter programs. Enter `import tkinter as tk; root = tk.Tk()` in standard Python and nothing appears. Enter the same in IDLE and a tk window appears. In standard Python, one must also enter `root.update()` to see the window. IDLE does the equivalent in the background, about 20 times a second, which is about every 50 milliseconds. Next enter `b = tk.Button(root, text='button');` `b.pack()`. Again, nothing visibly changes in standard Python until one enters `root.update()`.

Most tkinter programs run `root.mainloop()`, which usually does not return until the tk app is destroyed. If the program is run with `python -i` or from an IDLE editor, a `>>>` shell prompt does not appear until `mainloop()` returns, at which time there is nothing left to interact with.

When running a tkinter program from an IDLE editor, one can comment out the `mainloop` call. One then gets a shell prompt immediately and can interact with the live application. One just has to remember to re-enable the `mainloop` call when running in standard Python.

Running without a subprocess

By default, IDLE executes user code in a separate subprocess via a socket, which uses the internal loopback interface. This connection is not externally visible and no data is sent to or received from the internet. If firewall software complains anyway, you can ignore it.

If the attempt to make the socket connection fails, Idle will notify you. Such failures are sometimes transient, but if persistent, the problem may be either a firewall blocking the connection or misconfiguration of a particular system. Until the problem is fixed, one can run Idle with the `-n` command line switch.

If IDLE is started with the `-n` command line switch it will run in a single process and will not create the subprocess which runs the RPC Python execution server. This can be useful if Python cannot create the subprocess or the RPC socket interface on your platform. However, in this mode user code is not isolated from IDLE itself. Also, the environment is not restarted when Run/Run Module (F5) is selected. If your code has been modified, you must `reload()` the affected modules and re-import any specific items (e.g. `from foo import baz`) if the changes are to take effect. For these reasons, it is preferable to run IDLE with the default subprocess if at all possible.

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25.10.4 Help and Preferences

Help sources

Help menu entry "IDLE Help" displays a formatted html version of the IDLE chapter of the Library Reference. The result, in a read-only tkinter text window, is close to what one sees in a web browser. Navigate through the text with a mousewheel, the scrollbar, or up and down arrow keys held down. Or click the TOC (Table of Contents) button and select a section header in the opened box.

Help menu entry "Python Docs" opens the extensive sources of help, including tutorials, available at `docs.python.org/x.y`, where 'x.y' is the currently running Python version. If your system has an off-line copy of the docs (this may be an installation option), that will be opened instead.

Selected URLs can be added or removed from the help menu at any time using the General tab of the Configure IDLE dialog.

Setting preferences

The font preferences, highlighting, keys, and general preferences can be changed via Configure IDLE on the Option menu. Non-default user settings are saved in a `.idlerc` directory in the user's home directory. Problems caused by bad user configuration files are solved by editing or deleting one or more of the files in `.idlerc`.

On the Font tab, see the text sample for the effect of font face and size on multiple characters in multiple languages. Edit the sample to add other characters of personal interest. Use the sample to select monospaced fonts. If particular characters have problems in Shell or an editor, add them to the top of the sample and try changing first size and then font.

On the Highlights and Keys tab, select a built-in or custom color theme and key set. To use a newer built-in color theme or key set with older IDLEs, save it as a new custom theme or key set and it will be accessible to older IDLEs.

IDLE on macOS

Under System Preferences: Dock, one can set "Prefer tabs when opening documents" to "Always". This setting is not compatible with the tk/tkinter GUI framework used by IDLE, and it breaks a few IDLE features.

Extensions

IDLE contains an extension facility. Preferences for extensions can be changed with the Extensions tab of the preferences dialog. See the beginning of `config-extensions.def` in the `idlelib` directory for further information. The only current default extension is `zzdummy`, an example also used for testing.

25.10.5 idlelib

原始碼: [Lib/idlelib/](#)

The `Lib/idlelib` package implements the IDLE application. See the rest of this page for how to use IDLE.

The files in `idlelib` are described in `idlelib/README.txt`. Access it either in `idlelib` or click Help => About IDLE on the IDLE menu. This file also maps IDLE menu items to the code that implements the item. Except for files listed under 'Startup', the `idlelib` code is 'private' in sense that feature changes can be backported (see [PEP 434](#)).

The modules described in this chapter help you write software. For example, the `pydoc` module takes a module and generates documentation based on the module's contents. The `doctest` and `unittest` modules contains frameworks for writing unit tests that automatically exercise code and verify that the expected output is produced. `2to3` can translate Python 2.x source code into valid Python 3.x code.

The list of modules described in this chapter is:

26.1 typing --- Support for type hints

在 3.5 版新加入.

原始碼: [Lib/typing.py](#)

備註: The Python runtime does not enforce function and variable type annotations. They can be used by third party tools such as *type checkers*, IDEs, linters, etc.

This module provides runtime support for type hints. For the original specification of the typing system, see [PEP 484](#). For a simplified introduction to type hints, see [PEP 483](#).

The function below takes and returns a string and is annotated as follows:

```
def greeting(name: str) -> str:
    return 'Hello ' + name
```

In the function `greeting`, the argument `name` is expected to be of type `str` and the return type `str`. Subtypes are accepted as arguments.

New features are frequently added to the `typing` module. The `typing_extensions` package provides backports of these new features to older versions of Python.

For a summary of deprecated features and a deprecation timeline, please see [Deprecation Timeline of Major Features](#).

也參考:

”[Typing cheat sheet](#)”

A quick overview of type hints (hosted at the mypy docs)

”Type System Reference” section of the mypy docs

The Python typing system is standardised via PEPs, so this reference should broadly apply to most Python type checkers. (Some parts may still be specific to mypy.)

”Static Typing with Python”

Type-checker-agnostic documentation written by the community detailing type system features, useful typing related tools and typing best practices.

26.1.1 Relevant PEPs

Since the initial introduction of type hints in **PEP 484** and **PEP 483**, a number of PEPs have modified and enhanced Python’s framework for type annotations:

- **PEP 526: Syntax for Variable Annotations**
Introducing syntax for annotating variables outside of function definitions, and `ClassVar`
- **PEP 544: Protocols: Structural subtyping (static duck typing)**
Introducing `Protocol` and the `@runtime_checkable` decorator
- **PEP 585: Type Hinting Generics In Standard Collections**
*Introducing `types.GenericAlias` and the ability to use standard library classes as *generic types**
- **PEP 586: Literal Types**
Introducing `Literal`
- **PEP 589: TypedDict: Type Hints for Dictionaries with a Fixed Set of Keys**
Introducing `TypedDict`
- **PEP 591: Adding a final qualifier to typing**
Introducing `Final` and the `@final` decorator
- **PEP 593: Flexible function and variable annotations**
Introducing `Annotated`
- **PEP 604: Allow writing union types as `X | Y`**
*Introducing `types.UnionType` and the ability to use the binary-or operator `|` to signify a *union of types**
- **PEP 612: Parameter Specification Variables**
Introducing `ParamSpec` and `Concatenate`
- **PEP 613: Explicit Type Aliases**
↗ `↗` `TypeAlias`
- **PEP 646: Variadic Generics**
↗ `↗` `TypeVarTuple`
- **PEP 647: User-Defined Type Guards**
↗ `↗` `TypeGuard`
- **PEP 655: Marking individual TypedDict items as required or potentially missing**
↗ `↗` `Required` 和 `NotRequired`
- **PEP 673: Self type**
↗ `↗` `Self`
- **PEP 675: Arbitrary Literal String Type**
↗ `↗` `LiteralString`
- **PEP 681: Data Class Transforms**
↗ `↗` `@dataclass_transform` 裝飾器

26.1.2 Type aliases

A type alias is defined by assigning the type to the alias. In this example, `Vector` and `list[float]` will be treated as interchangeable synonyms:

```
Vector = list[float]

def scale(scalar: float, vector: Vector) -> Vector:
    return [scalar * num for num in vector]

# passes type checking; a list of floats qualifies as a Vector.
new_vector = scale(2.0, [1.0, -4.2, 5.4])
```

Type aliases are useful for simplifying complex type signatures. For example:

```
from collections.abc import Sequence

ConnectionOptions = dict[str, str]
Address = tuple[str, int]
Server = tuple[Address, ConnectionOptions]

def broadcast_message(message: str, servers: Sequence[Server]) -> None:
    ...

# The static type checker will treat the previous type signature as
# being exactly equivalent to this one.
def broadcast_message(
    message: str,
    servers: Sequence[tuple[tuple[str, int], dict[str, str]]] -> None:
    ...
```

Type aliases may be marked with `TypeAlias` to make it explicit that the statement is a type alias declaration, not a normal variable assignment:

```
from typing import TypeAlias

Vector: TypeAlias = list[float]
```

26.1.3 NewType

Use the `NewType` helper to create distinct types:

```
from typing import NewType

UserId = NewType('UserId', int)
some_id = UserId(524313)
```

The static type checker will treat the new type as if it were a subclass of the original type. This is useful in helping catch logical errors:

```
def get_user_name(user_id: UserId) -> str:
    ...

# passes type checking
user_a = get_user_name(UserId(42351))

# fails type checking; an int is not a UserId
user_b = get_user_name(-1)
```

You may still perform all `int` operations on a variable of type `UserId`, but the result will always be of type `int`. This lets you pass in a `UserId` wherever an `int` might be expected, but will prevent you from accidentally creating

a `UserId` in an invalid way:

```
# 'output' is of type 'int', not 'UserId'
output = UserId(23413) + UserId(54341)
```

Note that these checks are enforced only by the static type checker. At runtime, the statement `Derived = NewType('Derived', Base)` will make `Derived` a callable that immediately returns whatever parameter you pass it. That means the expression `Derived(some_value)` does not create a new class or introduce much overhead beyond that of a regular function call.

More precisely, the expression `some_value is Derived(some_value)` is always true at runtime.

It is invalid to create a subtype of `Derived`:

```
from typing import NewType

UserId = NewType('UserId', int)

# Fails at runtime and does not pass type checking
class AdminUserId(UserId): pass
```

However, it is possible to create a *NewType* based on a 'derived' *NewType*:

```
from typing import NewType

UserId = NewType('UserId', int)

ProUserId = NewType('ProUserId', UserId)
```

and typechecking for `ProUserId` will work as expected.

更多細節請見 [PEP 484](#)。

備 F: Recall that the use of a type alias declares two types to be *equivalent* to one another. Doing `Alias = Original` will make the static type checker treat `Alias` as being *exactly equivalent* to `Original` in all cases. This is useful when you want to simplify complex type signatures.

In contrast, `NewType` declares one type to be a *subtype* of another. Doing `Derived = NewType('Derived', Original)` will make the static type checker treat `Derived` as a *subclass* of `Original`, which means a value of type `Original` cannot be used in places where a value of type `Derived` is expected. This is useful when you want to prevent logic errors with minimal runtime cost.

在 3.5.2 版新加入。

在 3.10 版的變更: `NewType` is now a class rather than a function. As a result, there is some additional runtime cost when calling `NewType` over a regular function.

在 3.11 版的變更: The performance of calling `NewType` has been restored to its level in Python 3.9.

26.1.4 Annotating callable objects

Functions -- or other *callable* objects -- can be annotated using `collections.abc.Callable` or `typing.Callable`. `Callable[[int], str]` signifies a function that takes a single parameter of type `int` and returns a `str`.

舉例來 F

```
from collections.abc import Callable, Awaitable

def feeder(get_next_item: Callable[[], str]) -> None:
    ... # Body
```

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```
def async_query(on_success: Callable[[int], None],
                on_error: Callable[[int, Exception], None]) -> None:
    ... # Body

async def on_update(value: str) -> None:
    ... # Body

callback: Callable[[str], Awaitable[None]] = on_update
```

The subscription syntax must always be used with exactly two values: the argument list and the return type. The argument list must be a list of types, a *ParamSpec*, *Concatenate*, or an ellipsis. The return type must be a single type.

If a literal ellipsis `...` is given as the argument list, it indicates that a callable with any arbitrary parameter list would be acceptable:

```
def concat(x: str, y: str) -> str:
    return x + y

x: Callable[..., str]
x = str # OK
x = concat # Also OK
```

Callable cannot express complex signatures such as functions that take a variadic number of arguments, *overloaded functions*, or functions that have keyword-only parameters. However, these signatures can be expressed by defining a *Protocol* class with a `__call__()` method:

```
from collections.abc import Iterable
from typing import Protocol

class Combiner(Protocol):
    def __call__(self, *vals: bytes, maxlen: int | None = None) -> list[bytes]: ...

def batch_proc(data: Iterable[bytes], cb_results: Combiner) -> bytes:
    for item in data:
        ...

def good_cb(*vals: bytes, maxlen: int | None = None) -> list[bytes]:
    ...
def bad_cb(*vals: bytes, maxitems: int | None) -> list[bytes]:
    ...

batch_proc([], good_cb) # OK
batch_proc([], bad_cb) # Error! Argument 2 has incompatible type because of
                        # different name and kind in the callback
```

Callables which take other callables as arguments may indicate that their parameter types are dependent on each other using *ParamSpec*. Additionally, if that callable adds or removes arguments from other callables, the *Concatenate* operator may be used. They take the form `Callable[ParamSpecVariable, ReturnType]` and `Callable[Concatenate[Arg1Type, Arg2Type, ..., ParamSpecVariable], ReturnType]` respectively.

在 3.10 版的變更: Callable now supports *ParamSpec* and *Concatenate*. See [PEP 612](#) for more details.

也參考:

The documentation for *ParamSpec* and *Concatenate* provides examples of usage in Callable.

26.1.5 Generics

Since type information about objects kept in containers cannot be statically inferred in a generic way, many container classes in the standard library support subscription to denote the expected types of container elements.

```
from collections.abc import Mapping, Sequence

class Employee: ...

# Sequence[Employee] indicates that all elements in the sequence
# must be instances of "Employee".
# Mapping[str, str] indicates that all keys and all values in the mapping
# must be strings.
def notify_by_email(employees: Sequence[Employee],
                   overrides: Mapping[str, str]) -> None: ...
```

Generics can be parameterized by using a factory available in typing called *TypeVar*.

```
from collections.abc import Sequence
from typing import TypeVar

T = TypeVar('T')                                # Declare type variable "T"

def first(l: Sequence[T]) -> T:                 # Function is generic over the TypeVar "T"
    return l[0]
```

26.1.6 Annotating tuples

For most containers in Python, the typing system assumes that all elements in the container will be of the same type. For example:

```
from collections.abc import Mapping

# Type checker will infer that all elements in ``x`` are meant to be ints
x: list[int] = []

# Type checker error: ``list`` only accepts a single type argument:
y: list[int, str] = [1, 'foo']

# Type checker will infer that all keys in ``z`` are meant to be strings,
# and that all values in ``z`` are meant to be either strings or ints
z: Mapping[str, str | int] = {}
```

list only accepts one type argument, so a type checker would emit an error on the *y* assignment above. Similarly, *Mapping* only accepts two type arguments: the first indicates the type of the keys, and the second indicates the type of the values.

Unlike most other Python containers, however, it is common in idiomatic Python code for tuples to have elements which are not all of the same type. For this reason, tuples are special-cased in Python's typing system. *tuple* accepts *any number* of type arguments:

```
# OK: ``x`` is assigned to a tuple of length 1 where the sole element is an int
x: tuple[int] = (5,)

# OK: ``y`` is assigned to a tuple of length 2;
# element 1 is an int, element 2 is a str
y: tuple[int, str] = (5, "foo")

# Error: the type annotation indicates a tuple of length 1,
# but ``z`` has been assigned to a tuple of length 3
z: tuple[int] = (1, 2, 3)
```

To denote a tuple which could be of *any* length, and in which all elements are of the same type *T*, use `tuple[T, ...]`. To denote an empty tuple, use `tuple[()]`. Using plain `tuple` as an annotation is equivalent to using `tuple[Any, ...]`:

```
x: tuple[int, ...] = (1, 2)
# These reassignments are OK: ``tuple[int, ...]`` indicates x can be of any length
x = (1, 2, 3)
x = ()
# This reassignment is an error: all elements in ``x`` must be ints
x = ("foo", "bar")

# ``y`` can only ever be assigned to an empty tuple
y: tuple[()] = ()

z: tuple = ("foo", "bar")
# These reassignments are OK: plain ``tuple`` is equivalent to ``tuple[Any, ...]``
z = (1, 2, 3)
z = ()
```

26.1.7 The type of class objects

A variable annotated with *C* may accept a value of type *C*. In contrast, a variable annotated with `type[C]` (or `typing.Type[C]`) may accept values that are classes themselves -- specifically, it will accept the *class object* of *C*. For example:

```
a = 3          # Has type ``int``
b = int        # Has type ``type[int]``
c = type(a)    # Also has type ``type[int]``
```

Note that `type[C]` is covariant:

```
class User: ...
class ProUser(User): ...
class TeamUser(User): ...

def make_new_user(user_class: type[User]) -> User:
    # ...
    return user_class()

make_new_user(User)      # OK
make_new_user(ProUser)   # Also OK: ``type[ProUser]`` is a subtype of
→ ``type[User]``
make_new_user(TeamUser)  # Still fine
make_new_user(User())    # Error: expected ``type[User]`` but got ``User``
make_new_user(int)       # Error: ``type[int]`` is not a subtype of ``type[User]``
```

The only legal parameters for `type` are classes, *Any*, *type variables*, and unions of any of these types. For example:

```
def new_non_team_user(user_class: type[BasicUser | ProUser]): ...

new_non_team_user(BasicUser) # OK
new_non_team_user(ProUser)   # OK
new_non_team_user(TeamUser)  # Error: ``type[TeamUser]`` is not a subtype
                             # of ``type[BasicUser | ProUser]``
new_non_team_user(User)      # Also an error
```

`type[Any]` is equivalent to `type`, which is the root of Python's metaclass hierarchy.

26.1.8 User-defined generic types

A user-defined class can be defined as a generic class.

```
from typing import TypedVar, Generic
from logging import Logger

T = TypedVar('T')

class LoggedVar(Generic[T]):
    def __init__(self, value: T, name: str, logger: Logger) -> None:
        self.name = name
        self.logger = logger
        self.value = value

    def set(self, new: T) -> None:
        self.log('Set ' + repr(self.value))
        self.value = new

    def get(self) -> T:
        self.log('Get ' + repr(self.value))
        return self.value

    def log(self, message: str) -> None:
        self.logger.info('%s: %s', self.name, message)
```

`Generic[T]` as a base class defines that the class `LoggedVar` takes a single type parameter `T`. This also makes `T` valid as a type within the class body.

The `Generic` base class defines `__class_getitem__()` so that `LoggedVar[T]` is valid as a type:

```
from collections.abc import Iterable

def zero_all_vars(vars: Iterable[LoggedVar[int]]) -> None:
    for var in vars:
        var.set(0)
```

A generic type can have any number of type variables. All varieties of `TypedVar` are permissible as parameters for a generic type:

```
from typing import TypedVar, Generic, Sequence

T = TypedVar('T', contravariant=True)
B = TypedVar('B', bound=Sequence[bytes], covariant=True)
S = TypedVar('S', int, str)

class WeirdTrio(Generic[T, B, S]):
    ...
```

Each type variable argument to `Generic` must be distinct. This is thus invalid:

```
from typing import TypedVar, Generic
...

T = TypedVar('T')

class Pair(Generic[T, T]):    # INVALID
    ...
```

You can use multiple inheritance with `Generic`:

```

from collections.abc import Sized
from typing import TypeVar, Generic

T = TypeVar('T')

class LinkedList(Sized, Generic[T]):
    ...

```

When inheriting from generic classes, some type parameters could be fixed:

```

from collections.abc import Mapping
from typing import TypeVar

T = TypeVar('T')

class MyDict(Mapping[str, T]):
    ...

```

In this case `MyDict` has a single parameter, `T`.

Using a generic class without specifying type parameters assumes `Any` for each position. In the following example, `MyIterable` is not generic but implicitly inherits from `Iterable[Any]`:

```

from collections.abc import Iterable

class MyIterable(Iterable): # Same as Iterable[Any]
    ...

```

User-defined generic type aliases are also supported. Examples:

```

from collections.abc import Iterable
from typing import TypeVar

S = TypeVar('S')
Response = Iterable[S] | int

# Return type here is same as Iterable[str] | int
def response(query: str) -> Response[str]:
    ...

T = TypeVar('T', int, float, complex)
Vec = Iterable[tuple[T, T]]

def inproduct(v: Vec[T]) -> T: # Same as Iterable[tuple[T, T]]
    return sum(x*y for x, y in v)

```

在 3.7 版的變更: `Generic` no longer has a custom metaclass.

User-defined generics for parameter expressions are also supported via parameter specification variables in the form `Generic[P]`. The behavior is consistent with type variables' described above as parameter specification variables are treated by the typing module as a specialized type variable. The one exception to this is that a list of types can be used to substitute a `ParamSpec`:

```

>>> from typing import Generic, ParamSpec, TypeVar

>>> T = TypeVar('T')
>>> P = ParamSpec('P')

>>> class Z(Generic[T, P]): ...
...
>>> Z[int, [dict, float]]
__main__.Z[int, (<class 'dict'>, <class 'float'>)]

```

Furthermore, a generic with only one parameter specification variable will accept parameter lists in the forms `X[[Type1, Type2, ...]]` and also `X[Type1, Type2, ...]` for aesthetic reasons. Internally, the latter is converted to the former, so the following are equivalent:

```
>>> class X(Generic[P]): ...
...
>>> X[int, str]
__main__.X[(

```

Note that generics with *ParamSpec* may not have correct `__parameters__` after substitution in some cases because they are intended primarily for static type checking.

在 3.10 版的變更: *Generic* can now be parameterized over parameter expressions. See *ParamSpec* and **PEP 612** for more details.

A user-defined generic class can have ABCs as base classes without a metaclass conflict. Generic metaclasses are not supported. The outcome of parameterizing generics is cached, and most types in the typing module are *hashable* and comparable for equality.

26.1.9 Any 型 F

A special kind of type is *Any*. A static type checker will treat every type as being compatible with *Any* and *Any* as being compatible with every type.

This means that it is possible to perform any operation or method call on a value of type *Any* and assign it to any variable:

```
from typing import Any

a: Any = None
a = []          # OK
a = 2           # OK

s: str = ''
s = a           # OK

def foo(item: Any) -> int:
    # Passes type checking; 'item' could be any type,
    # and that type might have a 'bar' method
    item.bar()
    ...
```

Notice that no type checking is performed when assigning a value of type *Any* to a more precise type. For example, the static type checker did not report an error when assigning `a` to `s` even though `s` was declared to be of type *str* and receives an *int* value at runtime!

Furthermore, all functions without a return type or parameter types will implicitly default to using *Any*:

```
def legacy_parser(text):
    ...
    return data

# A static type checker will treat the above
# as having the same signature as:
def legacy_parser(text: Any) -> Any:
    ...
    return data
```

This behavior allows *Any* to be used as an *escape hatch* when you need to mix dynamically and statically typed code.

Contrast the behavior of `Any` with the behavior of `object`. Similar to `Any`, every type is a subtype of `object`. However, unlike `Any`, the reverse is not true: `object` is *not* a subtype of every other type.

That means when the type of a value is `object`, a type checker will reject almost all operations on it, and assigning it to a variable (or using it as a return value) of a more specialized type is a type error. For example:

```
def hash_a(item: object) -> int:
    # Fails type checking; an object does not have a 'magic' method.
    item.magic()
    ...

def hash_b(item: Any) -> int:
    # Passes type checking
    item.magic()
    ...

# Passes type checking, since ints and strs are subclasses of object
hash_a(42)
hash_a("foo")

# Passes type checking, since Any is compatible with all types
hash_b(42)
hash_b("foo")
```

Use `object` to indicate that a value could be any type in a typesafe manner. Use `Any` to indicate that a value is dynamically typed.

26.1.10 Nominal vs structural subtyping

Initially [PEP 484](#) defined the Python static type system as using *nominal subtyping*. This means that a class `A` is allowed where a class `B` is expected if and only if `A` is a subclass of `B`.

This requirement previously also applied to abstract base classes, such as `Iterable`. The problem with this approach is that a class had to be explicitly marked to support them, which is unpythonic and unlike what one would normally do in idiomatic dynamically typed Python code. For example, this conforms to [PEP 484](#):

```
from collections.abc import Sized, Iterable, Iterator

class Bucket(Sized, Iterable[int]):
    ...
    def __len__(self) -> int: ...
    def __iter__(self) -> Iterator[int]: ...
```

[PEP 544](#) allows to solve this problem by allowing users to write the above code without explicit base classes in the class definition, allowing `Bucket` to be implicitly considered a subtype of both `Sized` and `Iterable[int]` by static type checkers. This is known as *structural subtyping* (or static duck-typing):

```
from collections.abc import Iterator, Iterable

class Bucket: # Note: no base classes
    ...
    def __len__(self) -> int: ...
    def __iter__(self) -> Iterator[int]: ...

def collect(items: Iterable[int]) -> int: ...
result = collect(Bucket()) # Passes type check
```

Moreover, by subclassing a special class `Protocol`, a user can define new custom protocols to fully enjoy structural subtyping (see examples below).

26.1.11 模組 `typing` 內容

The `typing` module defines the following classes, functions and decorators.

Special typing primitives

Special types

These can be used as types in annotations. They do not support subscription using `[]`.

`typing.Any`

Special type indicating an unconstrained type.

- Every type is compatible with `Any`.
- `Any` is compatible with every type.

在 3.11 版的變更: `Any` can now be used as a base class. This can be useful for avoiding type checker errors with classes that can duck type anywhere or are highly dynamic.

`typing.AnyStr`

A *constrained type variable*.

Definition:

```
AnyStr = TypeVar('AnyStr', str, bytes)
```

`AnyStr` is meant to be used for functions that may accept `str` or `bytes` arguments but cannot allow the two to mix.

舉例來:

```
def concat(a: AnyStr, b: AnyStr) -> AnyStr:
    return a + b

concat("foo", "bar")      # OK, output has type 'str'
concat(b"foo", b"bar")    # OK, output has type 'bytes'
concat("foo", b"bar")     # Error, cannot mix str and bytes
```

Note that, despite its name, `AnyStr` has nothing to do with the `Any` type, nor does it mean "any string". In particular, `AnyStr` and `str | bytes` are different from each other and have different use cases:

```
# Invalid use of AnyStr:
# The type variable is used only once in the function signature,
# so cannot be "solved" by the type checker
def greet_bad(cond: bool) -> AnyStr:
    return "hi there!" if cond else b"greetings!"

# The better way of annotating this function:
def greet_proper(cond: bool) -> str | bytes:
    return "hi there!" if cond else b"greetings!"
```

`typing.LiteralString`

Special type that includes only literal strings.

Any string literal is compatible with `LiteralString`, as is another `LiteralString`. However, an object typed as just `str` is not. A string created by composing `LiteralString`-typed objects is also acceptable as a `LiteralString`.

舉例來:


```
def run_query(sql: LiteralString) -> None:
    ...

def caller(arbitrary_string: str, literal_string: LiteralString) -> None:
    run_query("SELECT * FROM students") # OK
    run_query(literal_string) # OK
    run_query("SELECT * FROM " + literal_string) # OK
    run_query(arbitrary_string) # type checker error
    run_query( # type checker error
        f"SELECT * FROM students WHERE name = {arbitrary_string}"
    )
```

`LiteralString` is useful for sensitive APIs where arbitrary user-generated strings could generate problems. For example, the two cases above that generate type checker errors could be vulnerable to an SQL injection attack.

更多細節請見 [PEP 675](#)。

在 3.11 版新加入。

`typing.Never`

The `bottom` type, a type that has no members.

This can be used to define a function that should never be called, or a function that never returns:

```
from typing import Never

def never_call_me(arg: Never) -> None:
    pass

def int_or_str(arg: int | str) -> None:
    never_call_me(arg) # type checker error
    match arg:
        case int():
            print("It's an int")
        case str():
            print("It's a str")
        case _:
            never_call_me(arg) # OK, arg is of type Never
```

在 3.11 版新加入: On older Python versions, `NoReturn` may be used to express the same concept. `Never` was added to make the intended meaning more explicit.

`typing.NoReturn`

Special type indicating that a function never returns.

舉例來:

```
from typing import NoReturn

def stop() -> NoReturn:
    raise RuntimeError('no way')
```

`NoReturn` can also be used as a `bottom` type, a type that has no values. Starting in Python 3.11, the `Never` type should be used for this concept instead. Type checkers should treat the two equivalently.

在 3.6.2 版新加入。

`typing.Self`

Special type to represent the current enclosed class.

舉例來:

```

from typing import Self, reveal_type

class Foo:
    def return_self(self) -> Self:
        ...
        return self

class SubclassOfFoo(Foo): pass

reveal_type(Foo().return_self()) # Revealed type is "Foo"
reveal_type(SubclassOfFoo().return_self()) # Revealed type is "SubclassOfFoo"

```

This annotation is semantically equivalent to the following, albeit in a more succinct fashion:

```

from typing import TypeVar

Self = TypeVar("Self", bound="Foo")

class Foo:
    def return_self(self: Self) -> Self:
        ...
        return self

```

In general, if something returns `self`, as in the above examples, you should use `Self` as the return annotation. If `Foo.return_self` was annotated as returning `"Foo"`, then the type checker would infer the object returned from `SubclassOfFoo.return_self` as being of type `Foo` rather than `SubclassOfFoo`.

Other common use cases include:

- *classmethods* that are used as alternative constructors and return instances of the `cls` parameter.
- Annotating an `__enter__()` method which returns `self`.

You should not use `Self` as the return annotation if the method is not guaranteed to return an instance of a subclass when the class is subclassed:

```

class Eggs:
    # Self would be an incorrect return annotation here,
    # as the object returned is always an instance of Eggs,
    # even in subclasses
    def returns_eggs(self) -> "Eggs":
        return Eggs()

```

更多細節請見 [PEP 673](#)。

在 3.11 版新加入。

`typing.TypeAlias`

Special annotation for explicitly declaring a *type alias*.

舉例來 F:

```

from typing import TypeAlias

Factors: TypeAlias = list[int]

```

`TypeAlias` is particularly useful for annotating aliases that make use of forward references, as it can be hard for type checkers to distinguish these from normal variable assignments:

```

from typing import Generic, TypeAlias, TypeVar

T = TypeVar("T")

# "Box" does not exist yet,

```

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```
# so we have to use quotes for the forward reference.
# Using ``TypeAlias`` tells the type checker that this is a type alias_
→ declaration,
# not a variable assignment to a string.
BoxOfStrings: TypeAlias = "Box[str]"

class Box(Generic[T]):
    @classmethod
    def make_box_of_strings(cls) -> BoxOfStrings: ...
```

更多細節請見 [PEP 613](#)。

在 3.10 版新加入。

Special forms

These can be used as types in annotations. They all support subscription using `[]`, but each has a unique syntax.

`typing.Union`

Union type; `Union[X, Y]` is equivalent to `X | Y` and means either X or Y.

To define a union, use e.g. `Union[int, str]` or the shorthand `int | str`. Using that shorthand is recommended. Details:

- The arguments must be types and there must be at least one.
- Unions of unions are flattened, e.g.:

```
Union[Union[int, str], float] == Union[int, str, float]
```

- Unions of a single argument vanish, e.g.:

```
Union[int] == int # The constructor actually returns int
```

- Redundant arguments are skipped, e.g.:

```
Union[int, str, int] == Union[int, str] == int | str
```

- When comparing unions, the argument order is ignored, e.g.:

```
Union[int, str] == Union[str, int]
```

- You cannot subclass or instantiate a Union.
- 你不能寫成 `Union[X][Y]`。

在 3.7 版的變更: Don't remove explicit subclasses from unions at runtime.

在 3.10 版的變更: Unions can now be written as `X | Y`. See [union type expressions](#).

`typing.Optional`

`Optional[X]` is equivalent to `X | None` (or `Union[X, None]`).

Note that this is not the same concept as an optional argument, which is one that has a default. An optional argument with a default does not require the `Optional` qualifier on its type annotation just because it is optional. For example:

```
def foo(arg: int = 0) -> None:
    ...
```

On the other hand, if an explicit value of `None` is allowed, the use of `Optional` is appropriate, whether the argument is optional or not. For example:

```
def foo(arg: Optional[int] = None) -> None:
    ...
```

在 3.10 版的變更: `Optional` can now be written as `X | None`. See *union type expressions*.

typing.Concatenate

Special form for annotating higher-order functions.

`Concatenate` can be used in conjunction with *Callable* and *ParamSpec* to annotate a higher-order callable which adds, removes, or transforms parameters of another callable. Usage is in the form `Concatenate[Arg1Type, Arg2Type, ..., ParamSpecVariable]`. `Concatenate` is currently only valid when used as the first argument to a *Callable*. The last parameter to `Concatenate` must be a *ParamSpec* or ellipsis (`...`).

For example, to annotate a decorator `with_lock` which provides a *threading.Lock* to the decorated function, `Concatenate` can be used to indicate that `with_lock` expects a callable which takes in a *Lock* as the first argument, and returns a callable with a different type signature. In this case, the *ParamSpec* indicates that the returned callable's parameter types are dependent on the parameter types of the callable being passed in:

```
from collections.abc import Callable
from threading import Lock
from typing import Concatenate, ParamSpec, TypeVar

P = ParamSpec('P')
R = TypeVar('R')

# Use this lock to ensure that only one thread is executing a function
# at any time.
my_lock = Lock()

def with_lock(f: Callable[Concatenate[Lock, P], R]) -> Callable[P, R]:
    '''A type-safe decorator which provides a lock.'''
    def inner(*args: P.args, **kwargs: P.kwargs) -> R:
        # Provide the lock as the first argument.
        return f(my_lock, *args, **kwargs)
    return inner

@with_lock
def sum_threadsafe(lock: Lock, numbers: list[float]) -> float:
    '''Add a list of numbers together in a thread-safe manner.'''
    with lock:
        return sum(numbers)

# We don't need to pass in the lock ourselves thanks to the decorator.
sum_threadsafe([1.1, 2.2, 3.3])
```

在 3.10 版新加入.

也參考:

- **PEP 612** -- Parameter Specification Variables (the PEP which introduced *ParamSpec* and *Concatenate*)
- *ParamSpec*
- *Annotating callable objects*

typing.Literal

Special typing form to define "literal types".

`Literal` can be used to indicate to type checkers that the annotated object has a value equivalent to one of the provided literals.

舉例來：

```
def validate_simple(data: Any) -> Literal[True]: # always returns True
    ...

Mode: TypeAlias = Literal['r', 'rb', 'w', 'wb']
def open_helper(file: str, mode: Mode) -> str:
    ...

open_helper('/some/path', 'r') # Passes type check
open_helper('/other/path', 'typo') # Error in type checker
```

`Literal[...] cannot be subclassed`. At runtime, an arbitrary value is allowed as type argument to `Literal[...]`, but type checkers may impose restrictions. See [PEP 586](#) for more details about literal types.

在 3.8 版新加入.

在 3.9.1 版的變更: `Literal` now de-duplicates parameters. Equality comparisons of `Literal` objects are no longer order dependent. `Literal` objects will now raise a `TypeError` exception during equality comparisons if one of their parameters are not *hashable*.

`typing.ClassVar`

Special type construct to mark class variables.

As introduced in [PEP 526](#), a variable annotation wrapped in `ClassVar` indicates that a given attribute is intended to be used as a class variable and should not be set on instances of that class. Usage:

```
class Starship:
    stats: ClassVar[dict[str, int]] = {} # class variable
    damage: int = 10 # instance variable
```

`ClassVar` accepts only types and cannot be further subscribed.

`ClassVar` is not a class itself, and should not be used with `isinstance()` or `issubclass()`. `ClassVar` does not change Python runtime behavior, but it can be used by third-party type checkers. For example, a type checker might flag the following code as an error:

```
enterprise_d = Starship(3000)
enterprise_d.stats = {} # Error, setting class variable on instance
Starship.stats = {} # This is OK
```

在 3.5.3 版新加入.

`typing.Final`

Special typing construct to indicate final names to type checkers.

Final names cannot be reassigned in any scope. Final names declared in class scopes cannot be overridden in subclasses.

舉例來：

```
MAX_SIZE: Final = 9000
MAX_SIZE += 1 # Error reported by type checker

class Connection:
    TIMEOUT: Final[int] = 10

class FastConnector(Connection):
    TIMEOUT = 1 # Error reported by type checker
```

There is no runtime checking of these properties. See [PEP 591](#) for more details.

在 3.8 版新加入.

typing.Required

Special typing construct to mark a *TypedDict* key as required.

主要用於 `total=False` 的 *TypedDict*。更多細節請見 *TypedDict* 與 [PEP 655](#)。

在 3.11 版新加入。

typing.NotRequired

Special typing construct to mark a *TypedDict* key as potentially missing.

更多細節請見 *TypedDict* 與 [PEP 655](#)。

在 3.11 版新加入。

typing.Annotated

Special typing form to add context-specific metadata to an annotation.

Add metadata `x` to a given type `T` by using the annotation `Annotated[T, x]`. Metadata added using `Annotated` can be used by static analysis tools or at runtime. At runtime, the metadata is stored in a `__metadata__` attribute.

If a library or tool encounters an annotation `Annotated[T, x]` and has no special logic for the metadata, it should ignore the metadata and simply treat the annotation as `T`. As such, `Annotated` can be useful for code that wants to use annotations for purposes outside Python's static typing system.

Using `Annotated[T, x]` as an annotation still allows for static typechecking of `T`, as type checkers will simply ignore the metadata `x`. In this way, `Annotated` differs from the `@no_type_check` decorator, which can also be used for adding annotations outside the scope of the typing system, but completely disables typechecking for a function or class.

The responsibility of how to interpret the metadata lies with the tool or library encountering an `Annotated` annotation. A tool or library encountering an `Annotated` type can scan through the metadata elements to determine if they are of interest (e.g., using `isinstance()`).

Annotated[<type>, <metadata>]

Here is an example of how you might use `Annotated` to add metadata to type annotations if you were doing range analysis:

```
@dataclass
class ValueRange:
    lo: int
    hi: int

T1 = Annotated[int, ValueRange(-10, 5)]
T2 = Annotated[T1, ValueRange(-20, 3)]
```

Details of the syntax:

- The first argument to `Annotated` must be a valid type
- Multiple metadata elements can be supplied (`Annotated` supports variadic arguments):

```
@dataclass
class ctype:
    kind: str

Annotated[int, ValueRange(3, 10), ctype("char")]
```

It is up to the tool consuming the annotations to decide whether the client is allowed to add multiple metadata elements to one annotation and how to merge those annotations.

- `Annotated` must be subscripted with at least two arguments (`Annotated[int]` is not valid)
- The order of the metadata elements is preserved and matters for equality checks:

```
assert Annotated[int, ValueRange(3, 10), ctype("char")] != Annotated[
    int, ctype("char"), ValueRange(3, 10)
]
```

- Nested Annotated types are flattened. The order of the metadata elements starts with the innermost annotation:

```
assert Annotated[Annotated[int, ValueRange(3, 10)], ctype("char")] ==
↳ Annotated[
    int, ValueRange(3, 10), ctype("char")
]
```

- Duplicated metadata elements are not removed:

```
assert Annotated[int, ValueRange(3, 10)] != Annotated[
    int, ValueRange(3, 10), ValueRange(3, 10)
]
```

- Annotated can be used with nested and generic aliases:

```
@dataclass
class MaxLen:
    value: int

T = TypeVar("T")
Vec: TypeAlias = Annotated[list[tuple[T, T]], MaxLen(10)]

assert Vec[int] == Annotated[list[tuple[int, int]], MaxLen(10)]
```

- Annotated cannot be used with an unpacked *TypeVarTuple*:

```
Variadic: TypeAlias = Annotated[*Ts, Ann1]  # NOT valid
```

這會等價於：

```
Annotated[T1, T2, T3, ..., Ann1]
```

where T1, T2, etc. are *TypeVars*. This would be invalid: only one type should be passed to Annotated.

- By default, `get_type_hints()` strips the metadata from annotations. Pass `include_extras=True` to have the metadata preserved:

```
>>> from typing import Annotated, get_type_hints
>>> def func(x: Annotated[int, "metadata"]) -> None: pass
...
>>> get_type_hints(func)
{'x': <class 'int'>, 'return': <class 'NoneType'>}
>>> get_type_hints(func, include_extras=True)
{'x': typing.Annotated[int, 'metadata'], 'return': <class 'NoneType'>}
```

- At runtime, the metadata associated with an Annotated type can be retrieved via the `__metadata__` attribute:

```
>>> from typing import Annotated
>>> X = Annotated[int, "very", "important", "metadata"]
>>> X
typing.Annotated[int, 'very', 'important', 'metadata']
>>> X.__metadata__
('very', 'important', 'metadata')
```

也參考：

PEP 593 - Flexible function and variable annotations

The PEP introducing Annotated to the standard library.

在 3.9 版新加入.

typing.TypeGuard

Special typing construct for marking user-defined type guard functions.

TypeGuard can be used to annotate the return type of a user-defined type guard function. TypeGuard only accepts a single type argument. At runtime, functions marked this way should return a boolean.

TypeGuard aims to benefit *type narrowing* -- a technique used by static type checkers to determine a more precise type of an expression within a program's code flow. Usually type narrowing is done by analyzing conditional code flow and applying the narrowing to a block of code. The conditional expression here is sometimes referred to as a "type guard":

```
def is_str(val: str | float):
    # "isinstance" type guard
    if isinstance(val, str):
        # Type of `val` is narrowed to `str`
        ...
    else:
        # Else, type of `val` is narrowed to `float`.
        ...
```

Sometimes it would be convenient to use a user-defined boolean function as a type guard. Such a function should use TypeGuard[...] as its return type to alert static type checkers to this intention.

Using -> TypeGuard tells the static type checker that for a given function:

1. The return value is a boolean.
2. If the return value is True, the type of its argument is the type inside TypeGuard.

舉例來 F:

```
def is_str_list(val: list[object]) -> TypeGuard[list[str]]:
    '''Determines whether all objects in the list are strings'''
    return all(isinstance(x, str) for x in val)

def func1(val: list[object]):
    if is_str_list(val):
        # Type of `val` is narrowed to `list[str]`.
        print(" ".join(val))
    else:
        # Type of `val` remains as `list[object]`.
        print("Not a list of strings!")
```

If is_str_list is a class or instance method, then the type in TypeGuard maps to the type of the second parameter after cls or self.

In short, the form def foo(arg: TypeA) -> TypeGuard[TypeB]: ..., means that if foo(arg) returns True, then arg narrows from TypeA to TypeB.

備 F: TypeB need not be a narrower form of TypeA -- it can even be a wider form. The main reason is to allow for things like narrowing list[object] to list[str] even though the latter is not a subtype of the former, since list is invariant. The responsibility of writing type-safe type guards is left to the user.

TypeGuard also works with type variables. See PEP 647 for more details.

在 3.10 版新加入.

typing.Unpack

Typing operator to conceptually mark an object as having been unpacked.

For example, using the unpack operator `*` on a *type variable tuple* is equivalent to using `Unpack` to mark the type variable tuple as having been unpacked:

```
Ts = TypeVarTuple('Ts')
tup: tuple[*Ts]
# Effectively does:
tup: tuple[Unpack[Ts]]
```

In fact, `Unpack` can be used interchangeably with `*` in the context of `typing.TypeVarTuple` and `builtins.tuple` types. You might see `Unpack` being used explicitly in older versions of Python, where `*` couldn't be used in certain places:

```
# In older versions of Python, TypeVarTuple and Unpack
# are located in the `typing_extensions` backports package.
from typing_extensions import TypeVarTuple, Unpack

Ts = TypeVarTuple('Ts')
tup: tuple[*Ts]           # Syntax error on Python <= 3.10!
tup: tuple[Unpack[Ts]]    # Semantically equivalent, and backwards-compatible
```

在 3.11 版新加入。

Building generic types

The following classes should not be used directly as annotations. Their intended purpose is to be building blocks for creating generic types.

class typing.Generic

Abstract base class for generic types.

A generic type is typically declared by inheriting from an instantiation of this class with one or more type variables. For example, a generic mapping type might be defined as:

```
class Mapping(Generic[KT, VT]):
    def __getitem__(self, key: KT) -> VT:
        ...
    # Etc.
```

This class can then be used as follows:

```
X = TypeVar('X')
Y = TypeVar('Y')

def lookup_name(mapping: Mapping[X, Y], key: X, default: Y) -> Y:
    try:
        return mapping[key]
    except KeyError:
        return default
```

class typing.TypeVar (name, *constraints, bound=None, covariant=False, contravariant=False)

Type variable.

用法:

```
T = TypeVar('T')    # Can be anything
S = TypeVar('S', bound=str) # Can be any subtype of str
A = TypeVar('A', str, bytes) # Must be exactly str or bytes
```

Type variables exist primarily for the benefit of static type checkers. They serve as the parameters for generic types as well as for generic function and type alias definitions. See *Generic* for more information on generic types. Generic functions work as follows:

```
def repeat(x: T, n: int) -> Sequence[T]:
    """Return a list containing n references to x."""
    return [x]*n

def print_capitalized(x: S) -> S:
    """Print x capitalized, and return x."""
    print(x.capitalize())
    return x

def concatenate(x: A, y: A) -> A:
    """Add two strings or bytes objects together."""
    return x + y
```

Note that type variables can be *bound*, *constrained*, or neither, but cannot be both bound *and* constrained.

Type variables may be marked covariant or contravariant by passing `covariant=True` or `contravariant=True`. See [PEP 484](#) for more details. By default, type variables are invariant.

Bound type variables and constrained type variables have different semantics in several important ways. Using a *bound* type variable means that the `TypeVar` will be solved using the most specific type possible:

```
x = print_capitalized('a string')
reveal_type(x) # revealed type is str

class StringSubclass(str):
    pass

y = print_capitalized(StringSubclass('another string'))
reveal_type(y) # revealed type is StringSubclass

z = print_capitalized(45) # error: int is not a subtype of str
```

Type variables can be bound to concrete types, abstract types (ABCs or protocols), and even unions of types:

```
U = TypeVar('U', bound=str|bytes) # Can be any subtype of the union str/bytes
V = TypeVar('V', bound=SupportsAbs) # Can be anything with an __abs__ method
```

Using a *constrained* type variable, however, means that the `TypeVar` can only ever be solved as being exactly one of the constraints given:

```
a = concatenate('one', 'two')
reveal_type(a) # revealed type is str

b = concatenate(StringSubclass('one'), StringSubclass('two'))
reveal_type(b) # revealed type is str, despite StringSubclass being passed in

c = concatenate('one', b'two') # error: type variable 'A' can be either str_
→ or bytes in a function call, but not both
```

At runtime, `isinstance(x, T)` will raise `TypeError`.

`__name__`

The name of the type variable.

`__covariant__`

Whether the type var has been marked as covariant.

__contravariant__

Whether the type var has been marked as contravariant.

__bound__

The bound of the type variable, if any.

__constraints__

A tuple containing the constraints of the type variable, if any.

class `typing.TypeVarTuple(name)`

Type variable tuple. A specialized form of *type variable* that enables *variadic* generics.

用法:

```
T = TypeVar("T")
Ts = TypeVarTuple("Ts")

def move_first_element_to_last(tup: tuple[T, *Ts]) -> tuple[*Ts, T]:
    return (*tup[1:], tup[0])
```

A normal type variable enables parameterization with a single type. A type variable tuple, in contrast, allows parameterization with an *arbitrary* number of types by acting like an *arbitrary* number of type variables wrapped in a tuple. For example:

```
# T is bound to int, Ts is bound to ()
# Return value is (1,), which has type tuple[int]
move_first_element_to_last(tup=(1,))

# T is bound to int, Ts is bound to (str,)
# Return value is ('spam', 1), which has type tuple[str, int]
move_first_element_to_last(tup=(1, 'spam'))

# T is bound to int, Ts is bound to (str, float)
# Return value is ('spam', 3.0, 1), which has type tuple[str, float, int]
move_first_element_to_last(tup=(1, 'spam', 3.0))

# This fails to type check (and fails at runtime)
# because tuple[()] is not compatible with tuple[T, *Ts]
# (at least one element is required)
move_first_element_to_last(tup=())
```

Note the use of the unpacking operator `*` in `tuple[T, *Ts]`. Conceptually, you can think of `Ts` as a tuple of type variables (`T1, T2, ...`). `tuple[T, *Ts]` would then become `tuple[T, *(T1, T2, ...)]`, which is equivalent to `tuple[T, T1, T2, ...]`. (Note that in older versions of Python, you might see this written using *Unpack* instead, as `Unpack[Ts]`.)

Type variable tuples must *always* be unpacked. This helps distinguish type variable tuples from normal type variables:

```
x: Ts          # Not valid
x: tuple[Ts]   # Not valid
x: tuple[*Ts]  # The correct way to do it
```

Type variable tuples can be used in the same contexts as normal type variables. For example, in class definitions, arguments, and return types:

```
Shape = TypeVarTuple("Shape")
class Array(Generic[*Shape]):
    def __getitem__(self, key: tuple[*Shape]) -> float: ...
    def __abs__(self) -> "Array[*Shape]": ...
    def get_shape(self) -> tuple[*Shape]: ...
```

Type variable tuples can be happily combined with normal type variables:

```
DType = TypeVar('DType')
Shape = TypeVarTuple('Shape')

class Array(Generic[DType, *Shape]): # This is fine
    pass

class Array2(Generic[*Shape, DType]): # This would also be fine
    pass

class Height: ...
class Width: ...

float_array_1d: Array[float, Height] = Array() # Totally fine
int_array_2d: Array[int, Height, Width] = Array() # Yup, fine too
```

However, note that at most one type variable tuple may appear in a single list of type arguments or type parameters:

```
x: tuple[*Ts, *Ts] # Not valid
class Array(Generic[*Shape, *Shape]): # Not valid
    pass
```

Finally, an unpacked type variable tuple can be used as the type annotation of `*args`:

```
def call_soon(
    callback: Callable[[*Ts], None],
    *args: *Ts
) -> None:
    ...
    callback(*args)
```

In contrast to non-unpacked annotations of `*args` - e.g. `*args: int`, which would specify that *all* arguments are `int` - `*args: *Ts` enables reference to the types of the *individual* arguments in `*args`. Here, this allows us to ensure the types of the `*args` passed to `call_soon` match the types of the (positional) arguments of `callback`.

See [PEP 646](#) for more details on type variable tuples.

`__name__`

The name of the type variable tuple.

在 3.11 版新加入。

class `typing.ParamSpec` (`name`, *, `bound=None`, `covariant=False`, `contravariant=False`)

Parameter specification variable. A specialized version of [type variables](#).

用法：

```
P = ParamSpec('P')
```

Parameter specification variables exist primarily for the benefit of static type checkers. They are used to forward the parameter types of one callable to another callable -- a pattern commonly found in higher order functions and decorators. They are only valid when used in `Concatenate`, or as the first argument to `Callable`, or as parameters for user-defined Generics. See [Generic](#) for more information on generic types.

For example, to add basic logging to a function, one can create a decorator `add_logging` to log function calls. The parameter specification variable tells the type checker that the callable passed into the decorator and the new callable returned by it have inter-dependent type parameters:

```
from collections.abc import Callable
from typing import TypeVar, ParamSpec
import logging
```

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```

T = TypeVar('T')
P = ParamSpec('P')

def add_logging(f: Callable[P, T]) -> Callable[P, T]:
    '''A type-safe decorator to add logging to a function.'''
    def inner(*args: P.args, **kwargs: P.kwargs) -> T:
        logging.info(f'{f.__name__} was called')
        return f(*args, **kwargs)
    return inner

@add_logging
def add_two(x: float, y: float) -> float:
    '''Add two numbers together.'''
    return x + y

```

Without `ParamSpec`, the simplest way to annotate this previously was to use a `TypeVar` with bound `Callable[..., Any]`. However this causes two problems:

1. The type checker can't type check the inner function because `*args` and `**kwargs` have to be typed `Any`.
2. `cast()` may be required in the body of the `add_logging` decorator when returning the inner function, or the static type checker must be told to ignore the `return inner`.

args

kwargs

Since `ParamSpec` captures both positional and keyword parameters, `P.args` and `P.kwargs` can be used to split a `ParamSpec` into its components. `P.args` represents the tuple of positional parameters in a given call and should only be used to annotate `*args`. `P.kwargs` represents the mapping of keyword parameters to their values in a given call, and should be only be used to annotate `**kwargs`. Both attributes require the annotated parameter to be in scope. At runtime, `P.args` and `P.kwargs` are instances respectively of `ParamSpecArgs` and `ParamSpecKwargs`.

__name__

The name of the parameter specification.

Parameter specification variables created with `covariant=True` or `contravariant=True` can be used to declare covariant or contravariant generic types. The bound argument is also accepted, similar to `TypeVar`. However the actual semantics of these keywords are yet to be decided.

在 3.10 版新加入.

備 註: Only parameter specification variables defined in global scope can be pickled.

也参考:

- **PEP 612** -- Parameter Specification Variables (the PEP which introduced `ParamSpec` and `Concatenate`)
- `Concatenate`
- *Annotating callable objects*

`typing.ParamSpecArgs`

`typing.ParamSpecKwargs`

Arguments and keyword arguments attributes of a `ParamSpec`. The `P.args` attribute of a `ParamSpec` is an instance of `ParamSpecArgs`, and `P.kwargs` is an instance of `ParamSpecKwargs`. They are intended for runtime introspection and have no special meaning to static type checkers.

Calling `get_origin()` on either of these objects will return the original `ParamSpec`:

```
>>> from typing import ParamSpec, get_origin
>>> P = ParamSpec("P")
>>> get_origin(P.args) is P
True
>>> get_origin(P.kwargs) is P
True
```

在 3.10 版新加入。

Other special directives

These functions and classes should not be used directly as annotations. Their intended purpose is to be building blocks for creating and declaring types.

`class typing.NamedTuple`

Typed version of `collections.namedtuple()`.

用法：

```
class Employee(NamedTuple):
    name: str
    id: int
```

這等價於：

```
Employee = collections.namedtuple('Employee', ['name', 'id'])
```

To give a field a default value, you can assign to it in the class body:

```
class Employee(NamedTuple):
    name: str
    id: int = 3

employee = Employee('Guido')
assert employee.id == 3
```

Fields with a default value must come after any fields without a default.

The resulting class has an extra attribute `__annotations__` giving a dict that maps the field names to the field types. (The field names are in the `_fields` attribute and the default values are in the `_field_defaults` attribute, both of which are part of the `namedtuple()` API.)

`NamedTuple` subclasses can also have docstrings and methods:

```
class Employee(NamedTuple):
    """Represents an employee."""
    name: str
    id: int = 3

    def __repr__(self) -> str:
        return f'<Employee {self.name}, id={self.id}>'
```

`NamedTuple` subclasses can be generic:

```
class Group(NamedTuple, Generic[T]):
    key: T
    group: list[T]
```

Backward-compatible usage:

```
Employee = namedtuple('Employee', [('name', str), ('id', int)])
```

在 3.6 版的變更: Added support for [PEP 526](#) variable annotation syntax.

在 3.6.1 版的變更: Added support for default values, methods, and docstrings.

在 3.8 版的變更: The `_field_types` and `__annotations__` attributes are now regular dictionaries instead of instances of `OrderedDict`.

在 3.9 版的變更: Removed the `_field_types` attribute in favor of the more standard `__annotations__` attribute which has the same information.

在 3.11 版的變更: Added support for generic namedtuples.

class `typing.NewType` (*name, tp*)

Helper class to create low-overhead *distinct types*.

A `NewType` is considered a distinct type by a typechecker. At runtime, however, calling a `NewType` returns its argument unchanged.

用法:

```
UserId = NewType('UserId', int) # Declare the NewType "UserId"
first_user = UserId(1) # "UserId" returns the argument unchanged at runtime
```

__module__

The module in which the new type is defined.

__name__

The name of the new type.

__supertype__

The type that the new type is based on.

在 3.5.2 版新加入.

在 3.10 版的變更: `NewType` is now a class rather than a function.

class `typing.Protocol` (*Generic*)

Base class for protocol classes.

Protocol classes are defined like this:

```
class Proto(Protocol):
    def meth(self) -> int:
        ...
```

Such classes are primarily used with static type checkers that recognize structural subtyping (static duck-typing), for example:

```
class C:
    def meth(self) -> int:
        return 0

def func(x: Proto) -> int:
    return x.meth()

func(C()) # Passes static type check
```

See [PEP 544](#) for more details. Protocol classes decorated with `runtime_checkable()` (described later) act as simple-minded runtime protocols that check only the presence of given attributes, ignoring their type signatures.

Protocol classes can be generic, for example:

```
T = TypeVar("T")

class GenProto(Protocol[T]):
    def meth(self) -> T:
        ...
```

在 3.8 版新加入。

`@typing.runtime_checkable`

Mark a protocol class as a runtime protocol.

Such a protocol can be used with `isinstance()` and `issubclass()`. This raises `TypeError` when applied to a non-protocol class. This allows a simple-minded structural check, very similar to “one trick ponies” in `collections.abc` such as `Iterable`. For example:

```
@runtime_checkable
class Closable(Protocol):
    def close(self): ...

assert isinstance(open('/some/file'), Closable)

@runtime_checkable
class Named(Protocol):
    name: str

import threading
assert isinstance(threading.Thread(name='Bob'), Named)
```

備 F: `runtime_checkable()` will check only the presence of the required methods or attributes, not their type signatures or types. For example, `ssl.SSLObject` is a class, therefore it passes an `issubclass()` check against `Callable`. However, the `ssl.SSLObject.__init__` method exists only to raise a `TypeError` with a more informative message, therefore making it impossible to call (instantiate) `ssl.SSLObject`.

備 F: An `isinstance()` check against a runtime-checkable protocol can be surprisingly slow compared to an `isinstance()` check against a non-protocol class. Consider using alternative idioms such as `hasattr()` calls for structural checks in performance-sensitive code.

在 3.8 版新加入。

`class typing.TypedDict(dict)`

Special construct to add type hints to a dictionary. At runtime it is a plain `dict`.

`TypedDict` declares a dictionary type that expects all of its instances to have a certain set of keys, where each key is associated with a value of a consistent type. This expectation is not checked at runtime but is only enforced by type checkers. Usage:

```
class Point2D(TypedDict):
    x: int
    y: int
    label: str

a: Point2D = {'x': 1, 'y': 2, 'label': 'good'} # OK
b: Point2D = {'z': 3, 'label': 'bad'}          # Fails type check

assert Point2D(x=1, y=2, label='first') == dict(x=1, y=2, label='first')
```

To allow using this feature with older versions of Python that do not support **PEP 526**, `TypedDict` supports two additional equivalent syntactic forms:

- Using a literal `dict` as the second argument:

```
Point2D = TypedDict('Point2D', {'x': int, 'y': int, 'label': str})
```

- Using keyword arguments:

```
Point2D = TypedDict('Point2D', x=int, y=int, label=str)
```

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: The keyword-argument syntax is deprecated in 3.11 and will be removed in 3.13. It may also be unsupported by static type checkers.

The functional syntax should also be used when any of the keys are not valid identifiers, for example because they are keywords or contain hyphens. Example:

```
# raises SyntaxError
class Point2D(TypedDict):
    in: int # 'in' is a keyword
    x-y: int # name with hyphens

# OK, functional syntax
Point2D = TypedDict('Point2D', {'in': int, 'x-y': int})
```

By default, all keys must be present in a TypedDict. It is possible to mark individual keys as non-required using `NotRequired`:

```
class Point2D(TypedDict):
    x: int
    y: int
    label: NotRequired[str]

# Alternative syntax
Point2D = TypedDict('Point2D', {'x': int, 'y': int, 'label': NotRequired[str]})
```

This means that a `Point2D` TypedDict can have the `label` key omitted.

It is also possible to mark all keys as non-required by default by specifying a totality of `False`:

```
class Point2D(TypedDict, total=False):
    x: int
    y: int

# Alternative syntax
Point2D = TypedDict('Point2D', {'x': int, 'y': int}, total=False)
```

This means that a `Point2D` TypedDict can have any of the keys omitted. A type checker is only expected to support a literal `False` or `True` as the value of the `total` argument. `True` is the default, and makes all items defined in the class body required.

Individual keys of a `total=False` TypedDict can be marked as required using `Required`:

```
class Point2D(TypedDict, total=False):
    x: Required[int]
    y: Required[int]
    label: str

# Alternative syntax
Point2D = TypedDict('Point2D', {
    'x': Required[int],
    'y': Required[int],
    'label': str
}, total=False)
```

It is possible for a TypedDict type to inherit from one or more other TypedDict types using the class-based syntax. Usage:

```
class Point3D(Point2D):
    z: int
```

Point3D has three items: x, y and z. It is equivalent to this definition:

```
class Point3D(TypedDict):
    x: int
    y: int
    z: int
```

A TypedDict cannot inherit from a non-TypedDict class, except for *Generic*. For example:

```
class X(TypedDict):
    x: int

class Y(TypedDict):
    y: int

class Z(object): pass # A non-TypedDict class

class XY(X, Y): pass # OK

class XZ(X, Z): pass # raises TypeError
```

A TypedDict can be generic:

```
T = TypeVar("T")

class Group(TypedDict, Generic[T]):
    key: T
    group: list[T]
```

A TypedDict can be introspected via annotations dicts (see annotations-howto for more information on annotations best practices), `__total__`, `__required_keys__`, and `__optional_keys__`.

`__total__`

Point2D.`__total__` gives the value of the total argument. Example:

```
>>> from typing import TypedDict
>>> class Point2D(TypedDict): pass
>>> Point2D.__total__
True
>>> class Point2D(TypedDict, total=False): pass
>>> Point2D.__total__
False
>>> class Point3D(Point2D): pass
>>> Point3D.__total__
True
```

This attribute reflects *only* the value of the total argument to the current TypedDict class, not whether the class is semantically total. For example, a TypedDict with `__total__` set to True may have keys marked with *NotRequired*, or it may inherit from another TypedDict with total=False. Therefore, it is generally better to use `__required_keys__` and `__optional_keys__` for introspection.

`__required_keys__`

在 3.9 版新加入.

`__optional_keys__`

Point2D.`__required_keys__` and Point2D.`__optional_keys__` return *frozenset* objects containing required and non-required keys, respectively.

Keys marked with *Required* will always appear in `__required_keys__` and keys marked with *NotRequired* will always appear in `__optional_keys__`.

For backwards compatibility with Python 3.10 and below, it is also possible to use inheritance to declare both required and non-required keys in the same `TypedDict`. This is done by declaring a `TypedDict` with one value for the `total` argument and then inheriting from it in another `TypedDict` with a different value for `total`:

```
>>> class Point2D(TypedDict, total=False):
...     x: int
...     y: int
...
>>> class Point3D(Point2D):
...     z: int
...
>>> Point3D.__required_keys__ == frozenset({'z'})
True
>>> Point3D.__optional_keys__ == frozenset({'x', 'y'})
True
```

在 3.9 版新加入。

備註： If `from __future__ import annotations` is used or if annotations are given as strings, annotations are not evaluated when the `TypedDict` is defined. Therefore, the runtime introspection that `__required_keys__` and `__optional_keys__` rely on may not work properly, and the values of the attributes may be incorrect.

See [PEP 589](#) for more examples and detailed rules of using `TypedDict`.

在 3.8 版新加入。

在 3.11 版的變更: Added support for marking individual keys as *Required* or *NotRequired*. See [PEP 655](#).

在 3.11 版的變更: Added support for generic `TypedDict`s.

協定

The following protocols are provided by the `typing` module. All are decorated with `@runtime_checkable`.

class `typing.SupportsAbs`

An ABC with one abstract method `__abs__` that is covariant in its return type.

class `typing.SupportsBytes`

一個有抽象方法 `__bytes__` 的 ABC。

class `typing.SupportsComplex`

一個有抽象方法 `__complex__` 的 ABC。

class `typing.SupportsFloat`

一個有抽象方法 `__float__` 的 ABC。

class `typing.SupportsIndex`

一個有抽象方法 `__index__` 的 ABC。

在 3.8 版新加入。

class `typing.SupportsInt`

一個有抽象方法 `__int__` 的 ABC。

class `typing.SupportsRound`

An ABC with one abstract method `__round__` that is covariant in its return type.

ABCs for working with IO

```
class typing.IO
```

```
class typing.TextIO
```

```
class typing.BinaryIO
```

Generic type `IO[AnyStr]` and its subclasses `TextIO(IO[str])` and `BinaryIO(IO[bytes])` represent the types of I/O streams such as returned by `open()`.

函式與裝飾器

```
typing.cast(typ, val)
```

Cast a value to a type.

This returns the value unchanged. To the type checker this signals that the return value has the designated type, but at runtime we intentionally don't check anything (we want this to be as fast as possible).

```
typing.assert_type(val, typ, /)
```

Ask a static type checker to confirm that `val` has an inferred type of `typ`.

At runtime this does nothing: it returns the first argument unchanged with no checks or side effects, no matter the actual type of the argument.

When a static type checker encounters a call to `assert_type()`, it emits an error if the value is not of the specified type:

```
def greet(name: str) -> None:
    assert_type(name, str)  # OK, inferred type of `name` is `str`
    assert_type(name, int)  # type checker error
```

This function is useful for ensuring the type checker's understanding of a script is in line with the developer's intentions:

```
def complex_function(arg: object):
    # Do some complex type-narrowing logic,
    # after which we hope the inferred type will be `int`
    ...
    # Test whether the type checker correctly understands our function
    assert_type(arg, int)
```

在 3.11 版新加入.

```
typing.assert_never(arg, /)
```

Ask a static type checker to confirm that a line of code is unreachable.

舉例來:

```
def int_or_str(arg: int | str) -> None:
    match arg:
        case int():
            print("It's an int")
        case str():
            print("It's a str")
        case _ as unreachable:
            assert_never(unreachable)
```

Here, the annotations allow the type checker to infer that the last case can never execute, because `arg` is either an `int` or a `str`, and both options are covered by earlier cases.

If a type checker finds that a call to `assert_never()` is reachable, it will emit an error. For example, if the type annotation for `arg` was instead `int | str | float`, the type checker would emit an error pointing out that `unreachable` is of type `float`. For a call to `assert_never` to pass type checking, the inferred type of the argument passed in must be the bottom type, `Never`, and nothing else.

At runtime, this throws an exception when called.

也参考:

[Unreachable Code and Exhaustiveness Checking](#) has more information about exhaustiveness checking with static typing.

在 3.11 版新加入.

`typing.reveal_type(obj, /)`

Ask a static type checker to reveal the inferred type of an expression.

When a static type checker encounters a call to this function, it emits a diagnostic with the inferred type of the argument. For example:

```
x: int = 1
reveal_type(x)  # Revealed type is "builtins.int"
```

This can be useful when you want to debug how your type checker handles a particular piece of code.

At runtime, this function prints the runtime type of its argument to `sys.stderr` and returns the argument unchanged (allowing the call to be used within an expression):

```
x = reveal_type(1)  # prints "Runtime type is int"
print(x)  # prints "1"
```

Note that the runtime type may be different from (more or less specific than) the type statically inferred by a type checker.

Most type checkers support `reveal_type()` anywhere, even if the name is not imported from `typing`. Importing the name from `typing`, however, allows your code to run without runtime errors and communicates intent more clearly.

在 3.11 版新加入.

`@typing.dataclass_transform(*, eq_default=True, order_default=False, kw_only_default=False, field_specifiers=(), **kwargs)`

Decorator to mark an object as providing `dataclass`-like behavior.

`dataclass_transform` may be used to decorate a class, metaclass, or a function that is itself a decorator. The presence of `@dataclass_transform()` tells a static type checker that the decorated object performs runtime “magic” that transforms a class in a similar way to `@dataclasses.dataclass`.

Example usage with a decorator function:

```
T = TypeVar("T")

@dataclass_transform()
def create_model(cls: type[T]) -> type[T]:
    ...
    return cls

@create_model
class CustomerModel:
    id: int
    name: str
```

On a base class:

```
@dataclass_transform()
class ModelBase: ...

class CustomerModel(ModelBase):
    id: int
    name: str
```

On a metaclass:

```
@dataclass_transform()
class ModelMeta(type): ...

class ModelBase(metaclass=ModelMeta): ...

class CustomerModel(ModelBase):
    id: int
    name: str
```

The `CustomerModel` classes defined above will be treated by type checkers similarly to classes created with `@dataclasses.dataclass`. For example, type checkers will assume these classes have `__init__` methods that accept `id` and `name`.

The decorated class, metaclass, or function may accept the following bool arguments which type checkers will assume have the same effect as they would have on the `@dataclasses.dataclass` decorator: `init`, `eq`, `order`, `unsafe_hash`, `frozen`, `match_args`, `kw_only`, and `slots`. It must be possible for the value of these arguments (`True` or `False`) to be statically evaluated.

The arguments to the `dataclass_transform` decorator can be used to customize the default behaviors of the decorated class, metaclass, or function:

參數

- **eq_default** (*bool*) -- Indicates whether the `eq` parameter is assumed to be `True` or `False` if it is omitted by the caller. Defaults to `True`.
- **order_default** (*bool*) -- Indicates whether the `order` parameter is assumed to be `True` or `False` if it is omitted by the caller. Defaults to `False`.
- **kw_only_default** (*bool*) -- Indicates whether the `kw_only` parameter is assumed to be `True` or `False` if it is omitted by the caller. Defaults to `False`.
- **field_specifiers** (*tuple* [*Callable* [..., *Any*], ...]) -- Specifies a static list of supported classes or functions that describe fields, similar to `dataclasses.field()`. Defaults to `()`.
- ****kwargs** (*Any*) -- Arbitrary other keyword arguments are accepted in order to allow for possible future extensions.

Type checkers recognize the following optional parameters on field specifiers:

表格 1: Recognised parameters for field specifiers

Parameter name	Description
<code>init</code>	Indicates whether the field should be included in the synthesized <code>__init__</code> method. If unspecified, <code>init</code> defaults to <code>True</code> .
<code>default</code>	Provides the default value for the field.
<code>default_factory</code>	Provides a runtime callback that returns the default value for the field. If neither <code>default</code> nor <code>default_factory</code> are specified, the field is assumed to have no default value and must be provided a value when the class is instantiated.
<code>factory</code>	An alias for the <code>default_factory</code> parameter on field specifiers.
<code>kw_only</code>	Indicates whether the field should be marked as keyword-only. If <code>True</code> , the field will be keyword-only. If <code>False</code> , it will not be keyword-only. If unspecified, the value of the <code>kw_only</code> parameter on the object decorated with <code>dataclass_transform</code> will be used, or if that is unspecified, the value of <code>kw_only_default</code> on <code>dataclass_transform</code> will be used.
<code>alias</code>	Provides an alternative name for the field. This alternative name is used in the synthesized <code>__init__</code> method.

At runtime, this decorator records its arguments in the `__dataclass_transform__` attribute on the decorated object. It has no other runtime effect.

更多細節請見 [PEP 681](#)。

在 3.11 版新加入。

`@typing.overload`

Decorator for creating overloaded functions and methods.

The `@overload` decorator allows describing functions and methods that support multiple different combinations of argument types. A series of `@overload`-decorated definitions must be followed by exactly one non-`@overload`-decorated definition (for the same function/method).

`@overload`-decorated definitions are for the benefit of the type checker only, since they will be overwritten by the non-`@overload`-decorated definition. The non-`@overload`-decorated definition, meanwhile, will be used at runtime but should be ignored by a type checker. At runtime, calling an `@overload`-decorated function directly will raise `NotImplementedError`.

An example of overload that gives a more precise type than can be expressed using a union or a type variable:

```
@overload
def process(response: None) -> None:
    ...
@overload
def process(response: int) -> tuple[int, str]:
    ...
@overload
def process(response: bytes) -> str:
    ...
def process(response):
    ... # actual implementation goes here
```

See [PEP 484](#) for more details and comparison with other typing semantics.

在 3.11 版的變更: Overloaded functions can now be introspected at runtime using `get_overloads()`.

`typing.get_overloads(func)`

Return a sequence of `@overload`-decorated definitions for *func*.

func is the function object for the implementation of the overloaded function. For example, given the definition of `process` in the documentation for `@overload`, `get_overloads(process)` will return a sequence of three function objects for the three defined overloads. If called on a function with no overloads, `get_overloads()` returns an empty sequence.

`get_overloads()` can be used for introspecting an overloaded function at runtime.

在 3.11 版新加入。

`typing.clear_overloads()`

Clear all registered overloads in the internal registry.

This can be used to reclaim the memory used by the registry.

在 3.11 版新加入。

`@typing.final`

Decorator to indicate final methods and final classes.

Decorating a method with `@final` indicates to a type checker that the method cannot be overridden in a subclass. Decorating a class with `@final` indicates that it cannot be subclassed.

舉例來 F:

```
class Base:
    @final
    def done(self) -> None:
        ...
class Sub(Base):
```

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```

def done(self) -> None: # Error reported by type checker
    ...

@final
class Leaf:
    ...
class Other(Leaf): # Error reported by type checker
    ...

```

There is no runtime checking of these properties. See [PEP 591](#) for more details.

在 3.8 版新加入。

在 3.11 版的變更: The decorator will now attempt to set a `__final__` attribute to `True` on the decorated object. Thus, a check like `if getattr(obj, "__final__", False)` can be used at runtime to determine whether an object `obj` has been marked as final. If the decorated object does not support setting attributes, the decorator returns the object unchanged without raising an exception.

`@typing.no_type_check`

Decorator to indicate that annotations are not type hints.

This works as a class or function *decorator*. With a class, it applies recursively to all methods and classes defined in that class (but not to methods defined in its superclasses or subclasses). Type checkers will ignore all annotations in a function or class with this decorator.

`@no_type_check` mutates the decorated object in place.

`@typing.no_type_check_decorator`

Decorator to give another decorator the `no_type_check()` effect.

This wraps the decorator with something that wraps the decorated function in `no_type_check()`.

`@typing.type_check_only`

Decorator to mark a class or function as unavailable at runtime.

This decorator is itself not available at runtime. It is mainly intended to mark classes that are defined in type stub files if an implementation returns an instance of a private class:

```

@type_check_only
class Response: # private or not available at runtime
    code: int
    def get_header(self, name: str) -> str: ...

def fetch_response() -> Response: ...

```

Note that returning instances of private classes is not recommended. It is usually preferable to make such classes public.

Introspection helpers

`typing.get_type_hints(obj, globals=None, locals=None, include_extras=False)`

Return a dictionary containing type hints for a function, method, module or class object.

This is often the same as `obj.__annotations__`. In addition, forward references encoded as string literals are handled by evaluating them in `globals` and `locals` namespaces. For a class `C`, return a dictionary constructed by merging all the `__annotations__` along `C.__mro__` in reverse order.

The function recursively replaces all `Annotated[T, ...]` with `T`, unless `include_extras` is set to `True` (see *Annotated* for more information). For example:


```

class Student(NamedTuple):
    name: Annotated[str, 'some marker']

assert get_type_hints(Student) == {'name': str}
assert get_type_hints(Student, include_extras=False) == {'name': str}
assert get_type_hints(Student, include_extras=True) == {
    'name': Annotated[str, 'some marker']
}

```

備 F: `get_type_hints()` does not work with imported *type aliases* that include forward references. Enabling postponed evaluation of annotations (**PEP 563**) may remove the need for most forward references.

在 3.9 版的變更: 新增 `include_extras` 參數 (如 **PEP 593** 中所述)。更多資訊請見 *Annotated* 的文件。

在 3.11 版的變更: Previously, `Optional[t]` was added for function and method annotations if a default value equal to `None` was set. Now the annotation is returned unchanged.

`typing.get_origin(tp)`

Get the unsubscripted version of a type: for a typing object of the form `X[Y, Z, ...]` return `X`.

If `X` is a typing-module alias for a builtin or *collections* class, it will be normalized to the original class. If `X` is an instance of *ParamSpecArgs* or *ParamSpecKwargs*, return the underlying *ParamSpec*. Return `None` for unsupported objects.

舉例:

```

assert get_origin(str) is None
assert get_origin(Dict[str, int]) is dict
assert get_origin(Union[int, str]) is Union
P = ParamSpec('P')
assert get_origin(P.args) is P
assert get_origin(P.kwargs) is P

```

在 3.8 版新加入.

`typing.get_args(tp)`

Get type arguments with all substitutions performed: for a typing object of the form `X[Y, Z, ...]` return `(Y, Z, ...)`.

If `X` is a union or *Literal* contained in another generic type, the order of `(Y, Z, ...)` may be different from the order of the original arguments `[Y, Z, ...]` due to type caching. Return `()` for unsupported objects.

舉例:

```

assert get_args(int) == ()
assert get_args(Dict[int, str]) == (int, str)
assert get_args(Union[int, str]) == (int, str)

```

在 3.8 版新加入.

`typing.is_typeddict(tp)`

Check if a type is a *TypedDict*.

舉例來 F

```

class Film(TypedDict):
    title: str
    year: int

```

(繼續下一頁)

(繼續上一頁)

```

assert is_typeddict(Film)
assert not is_typeddict(list | str)

# TypedDict is a factory for creating typed dicts,
# not a typed dict itself
assert not is_typeddict(TypedDict)

```

在 3.10 版新加入。

class typing.**ForwardRef**

Class used for internal typing representation of string forward references.

For example, `List["SomeClass"]` is implicitly transformed into `List[ForwardRef("SomeClass")]`. `ForwardRef` should not be instantiated by a user, but may be used by introspection tools.

備 F: **PEP 585** generic types such as `list["SomeClass"]` will not be implicitly transformed into `list[ForwardRef("SomeClass")]` and thus will not automatically resolve to `list[SomeClass]`.

在 3.7.4 版新加入。

常數

typing.**TYPE_CHECKING**

A special constant that is assumed to be `True` by 3rd party static type checkers. It is `False` at runtime.

用法：

```

if TYPE_CHECKING:
    import expensive_mod

def fun(arg: 'expensive_mod.SomeType') -> None:
    local_var: expensive_mod.AnotherType = other_fun()

```

The first type annotation must be enclosed in quotes, making it a "forward reference", to hide the `expensive_mod` reference from the interpreter runtime. Type annotations for local variables are not evaluated, so the second annotation does not need to be enclosed in quotes.

備 F: If `from __future__ import annotations` is used, annotations are not evaluated at function definition time. Instead, they are stored as strings in `__annotations__`. This makes it unnecessary to use quotes around the annotation (see **PEP 563**).

在 3.5.2 版新加入。

F 用的 F 名

This module defines several deprecated aliases to pre-existing standard library classes. These were originally included in the typing module in order to support parameterizing these generic classes using `[]`. However, the aliases became redundant in Python 3.9 when the corresponding pre-existing classes were enhanced to support `[]` (see **PEP 585**).

The redundant types are deprecated as of Python 3.9. However, while the aliases may be removed at some point, removal of these aliases is not currently planned. As such, no deprecation warnings are currently issued by the interpreter for these aliases.

If at some point it is decided to remove these deprecated aliases, a deprecation warning will be issued by the interpreter for at least two releases prior to removal. The aliases are guaranteed to remain in the typing module without deprecation warnings until at least Python 3.14.

Type checkers are encouraged to flag uses of the deprecated types if the program they are checking targets a minimum Python version of 3.9 or newer.

Aliases to built-in types

class `typing.Dict` (*dict*, *MutableMapping*[*KT*, *VT*])

Deprecated alias to `dict`.

Note that to annotate arguments, it is preferred to use an abstract collection type such as `Mapping` rather than to use `dict` or `typing.Dict`.

This type can be used as follows:

```
def count_words(text: str) -> Dict[str, int]:
    ...
```

在 3.9 版之後被用: `builtins.dict` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.List` (*list*, *MutableSequence*[*T*])

Deprecated alias to `list`.

Note that to annotate arguments, it is preferred to use an abstract collection type such as `Sequence` or `Iterable` rather than to use `list` or `typing.List`.

This type may be used as follows:

```
T = TypeVar('T', int, float)

def vec2(x: T, y: T) -> List[T]:
    return [x, y]

def keep_positives(vector: Sequence[T]) -> List[T]:
    return [item for item in vector if item > 0]
```

在 3.9 版之後被用: `builtins.list` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.Set` (*set*, *MutableSet*[*T*])

Deprecated alias to `builtins.set`.

Note that to annotate arguments, it is preferred to use an abstract collection type such as `AbstractSet` rather than to use `set` or `typing.Set`.

在 3.9 版之後被用: `builtins.set` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.FrozenSet` (*frozenset*, *AbstractSet*[*T_co*])

Deprecated alias to `builtins.frozenset`.

在 3.9 版之後被用: `builtins.frozenset` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

typing.Tuple

Deprecated alias for `tuple`.

`tuple` and `Tuple` are special-cased in the type system; see *Annotating tuples* for more details.

在 3.9 版之後被用: `builtins.tuple` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.Type` (*Generic*[*CT_co*])

Deprecated alias to `type`.

See *The type of class objects* for details on using `type` or `typing.Type` in type annotations.

在 3.5.2 版新加入。

在 3.9 版之後被 用: `builtins.type` now supports subscripting (`[]`). See **PEP 585** and *Generic Alias Type*.

Aliases to types in collections

class `typing.DefaultDict` (*collections.defaultdict*, *MutableMapping*[*KT*, *VT*])

Deprecated alias to `collections.defaultdict`.

在 3.5.2 版新加入。

在 3.9 版之後被 用: `collections.defaultdict` now supports subscripting (`[]`). See **PEP 585** and *Generic Alias Type*.

class `typing.OrderedDict` (*collections.OrderedDict*, *MutableMapping*[*KT*, *VT*])

Deprecated alias to `collections.OrderedDict`.

在 3.7.2 版新加入。

在 3.9 版之後被 用: `collections.OrderedDict` now supports subscripting (`[]`). See **PEP 585** and *Generic Alias Type*.

class `typing.ChainMap` (*collections.ChainMap*, *MutableMapping*[*KT*, *VT*])

Deprecated alias to `collections.ChainMap`.

在 3.6.1 版新加入。

在 3.9 版之後被 用: `collections.ChainMap` now supports subscripting (`[]`). See **PEP 585** and *Generic Alias Type*.

class `typing.Counter` (*collections.Counter*, *Dict*[*T*, *int*])

Deprecated alias to `collections.Counter`.

在 3.6.1 版新加入。

在 3.9 版之後被 用: `collections.Counter` now supports subscripting (`[]`). See **PEP 585** and *Generic Alias Type*.

class `typing.Deque` (*deque*, *MutableSequence*[*T*])

Deprecated alias to `collections.deque`.

在 3.6.1 版新加入。

在 3.9 版之後被 用: `collections.deque` now supports subscripting (`[]`). See **PEP 585** and *Generic Alias Type*.

Aliases to other concrete types

class `typing.Pattern`

class `typing.Match`

Deprecated aliases corresponding to the return types from `re.compile()` and `re.match()`.

These types (and the corresponding functions) are generic over *AnyStr*. `Pattern` can be specialised as `Pattern[str]` or `Pattern[bytes]`; `Match` can be specialised as `Match[str]` or `Match[bytes]`.

自從版本 3.8 後不推薦使用，將會自版本 3.13 中移除。: The `typing.re` namespace is deprecated and will be removed. These types should be directly imported from `typing` instead.

在 3.9 版之後被☑用: `Classes Pattern` and `Match` from `re` now support []. See [PEP 585](#) and *Generic Alias Type*.

class `typing.Text`

Deprecated alias for `str`.

`Text` is provided to supply a forward compatible path for Python 2 code: in Python 2, `Text` is an alias for `unicode`.

Use `Text` to indicate that a value must contain a unicode string in a manner that is compatible with both Python 2 and Python 3:

```
def add_unicode_checkmark(text: Text) -> Text:
    return text + u' \u2713'
```

在 3.5.2 版新加入.

在 3.11 版之後被☑用: Python 2 is no longer supported, and most type checkers also no longer support type checking Python 2 code. Removal of the alias is not currently planned, but users are encouraged to use `str` instead of `Text`.

Aliases to container ABCs in `collections.abc`

class `typing.AbstractSet` (`Collection[T_co]`)

Deprecated alias to `collections.abc.Set`.

在 3.9 版之後被☑用: `collections.abc.Set` now supports subscripting ([]). See [PEP 585](#) and *Generic Alias Type*.

class `typing.ByteString` (`Sequence[int]`)

This type represents the types `bytes`, `bytearray`, and `memoryview` of byte sequences.

自從版本 3.9 後不推薦使用，將會自版本 3.14 中移除。: Prefer `typing_extensions.Buffer`, or a union like `bytes | bytearray | memoryview`.

class `typing.Collection` (`Sized`, `Iterable[T_co]`, `Container[T_co]`)

Deprecated alias to `collections.abc.Collection`.

在 3.6 版新加入.

在 3.9 版之後被☑用: `collections.abc.Collection` now supports subscripting ([]). See [PEP 585](#) and *Generic Alias Type*.

class `typing.Container` (`Generic[T_co]`)

Deprecated alias to `collections.abc.Container`.

在 3.9 版之後被☑用: `collections.abc.Container` now supports subscripting ([]). See [PEP 585](#) and *Generic Alias Type*.

class `typing.ItemsView` (`MappingView`, `AbstractSet[tuple[KT_co, VT_co]]`)

Deprecated alias to `collections.abc.ItemsView`.

在 3.9 版之後被☑用: `collections.abc.ItemsView` now supports subscripting ([]). See [PEP 585](#) and *Generic Alias Type*.

class `typing.KeysView` (`MappingView`, `AbstractSet[KT_co]`)

Deprecated alias to `collections.abc.KeysView`.

在 3.9 版之後被☑用: `collections.abc.KeysView` now supports subscripting ([]). See [PEP 585](#) and *Generic Alias Type*.

class `typing.Mapping` (*Collection[KT], Generic[KT, VT_co]*)

Deprecated alias to `collections.abc.Mapping`.

This type can be used as follows:

```
def get_position_in_index(word_list: Mapping[str, int], word: str) -> int:
    return word_list[word]
```

在 3.9 版之後被 用: `collections.abc.Mapping` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.MappingView` (*Sized*)

Deprecated alias to `collections.abc.MappingView`.

在 3.9 版之後被 用: `collections.abc.MappingView` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.MutableMapping` (*Mapping[KT, VT]*)

Deprecated alias to `collections.abc.MutableMapping`.

在 3.9 版之後被 用: `collections.abc.MutableMapping` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.MutableSequence` (*Sequence[T]*)

Deprecated alias to `collections.abc.MutableSequence`.

在 3.9 版之後被 用: `collections.abc.MutableSequence` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.MutableSet` (*AbstractSet[T]*)

Deprecated alias to `collections.abc.MutableSet`.

在 3.9 版之後被 用: `collections.abc.MutableSet` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.Sequence` (*Reversible[T_co], Collection[T_co]*)

Deprecated alias to `collections.abc.Sequence`.

在 3.9 版之後被 用: `collections.abc.Sequence` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.ValuesView` (*MappingView, Collection[_VT_co]*)

Deprecated alias to `collections.abc.ValuesView`.

在 3.9 版之後被 用: `collections.abc.ValuesView` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

Aliases to asynchronous ABCs in `collections.abc`

class `typing.Coroutine` (*Awaitable[ReturnType], Generic[YieldType, SendType, ReturnType]*)

Deprecated alias to `collections.abc.Coroutine`.

The variance and order of type variables correspond to those of *Generator*, for example:

```
from collections.abc import Coroutine
c: Coroutine[list[str], str, int] # Some coroutine defined elsewhere
x = c.send('hi')                  # Inferred type of 'x' is list[str]
async def bar() -> None:
    y = await c                    # Inferred type of 'y' is int
```

在 3.5.3 版新加入。

在 3.9 版之後被 用: `collections.abc.Coroutine` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

class `typing.AsyncGenerator` (`AsyncIterator[YieldType]`, `Generic[YieldType, SendType]`)

Deprecated alias to `collections.abc.AsyncGenerator`.

An async generator can be annotated by the generic type `AsyncGenerator[YieldType, SendType]`. For example:

```
async def echo_round() -> AsyncGenerator[int, float]:
    sent = yield 0
    while sent >= 0.0:
        rounded = await round(sent)
        sent = yield rounded
```

Unlike normal generators, async generators cannot return a value, so there is no `ReturnType` type parameter. As with `Generator`, the `SendType` behaves contravariantly.

If your generator will only yield values, set the `SendType` to `None`:

```
async def infinite_stream(start: int) -> AsyncGenerator[int, None]:
    while True:
        yield start
        start = await increment(start)
```

Alternatively, annotate your generator as having a return type of either `AsyncIterable[YieldType]` or `AsyncIterator[YieldType]`:

```
async def infinite_stream(start: int) -> AsyncIterator[int]:
    while True:
        yield start
        start = await increment(start)
```

在 3.6.1 版新加入。

在 3.9 版之後被採用: `collections.abc.AsyncGenerator` now supports subscripting (`[]`). See [PEP 585](#) and [Generic Alias Type](#).

class `typing.AsyncIterable` (`Generic[T_co]`)

Deprecated alias to `collections.abc.AsyncIterable`.

在 3.5.2 版新加入。

在 3.9 版之後被採用: `collections.abc.AsyncIterable` now supports subscripting (`[]`). See [PEP 585](#) and [Generic Alias Type](#).

class `typing.AsyncIterator` (`AsyncIterable[T_co]`)

Deprecated alias to `collections.abc.AsyncIterator`.

在 3.5.2 版新加入。

在 3.9 版之後被採用: `collections.abc.AsyncIterator` now supports subscripting (`[]`). See [PEP 585](#) and [Generic Alias Type](#).

class `typing.Awaitable` (`Generic[T_co]`)

Deprecated alias to `collections.abc.Awaitable`.

在 3.5.2 版新加入。

在 3.9 版之後被採用: `collections.abc.Awaitable` now supports subscripting (`[]`). See [PEP 585](#) and [Generic Alias Type](#).

Aliases to other ABCs in `collections.abc`**class** `typing.Iterable` (*Generic*[*T_co*])Deprecated alias to `collections.abc.Iterable`.在 3.9 版之後被 用: `collections.abc.Iterable` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.**class** `typing.Iterator` (*Iterable*[*T_co*])Deprecated alias to `collections.abc.Iterator`.在 3.9 版之後被 用: `collections.abc.Iterator` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.**typing.Callable**Deprecated alias to `collections.abc.Callable`.See *Annotating callable objects* for details on how to use `collections.abc.Callable` and `typing.Callable` in type annotations.在 3.9 版之後被 用: `collections.abc.Callable` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.在 3.10 版的變更: `Callable` now supports *ParamSpec* and *Concatenate*. See [PEP 612](#) for more details.**class** `typing.Generator` (*Iterator*[*YieldType*], *Generic*[*YieldType*, *SendType*, *ReturnType*])Deprecated alias to `collections.abc.Generator`.A generator can be annotated by the generic type `Generator[YieldType, SendType, ReturnType]`. For example:

```
def echo_round() -> Generator[int, float, str]:
    sent = yield 0
    while sent >= 0:
        sent = yield round(sent)
    return 'Done'
```

Note that unlike many other generics in the typing module, the `SendType` of `Generator` behaves contravariantly, not covariantly or invariantly.If your generator will only yield values, set the `SendType` and `ReturnType` to `None`:

```
def infinite_stream(start: int) -> Generator[int, None, None]:
    while True:
        yield start
        start += 1
```

Alternatively, annotate your generator as having a return type of either `Iterable[YieldType]` or `Iterator[YieldType]`:

```
def infinite_stream(start: int) -> Iterator[int]:
    while True:
        yield start
        start += 1
```

在 3.9 版之後被 用: `collections.abc.Generator` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.**class** `typing.Hashable`Alias to `collections.abc.Hashable`.

`class typing.Reversible (Iterable[T_co])`
Deprecated alias to `collections.abc.Reversible`.
在 3.9 版之後被 用: `collections.abc.Reversible` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.
`class typing.Sized`
Alias to `collections.abc.Sized`.

Aliases to contextlib ABCs

`class typing.ContextManager (Generic[T_co])`
Deprecated alias to `contextlib.AbstractContextManager`.
在 3.5.4 版新加入.
在 3.9 版之後被 用: `contextlib.AbstractContextManager` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.
`class typing.AsyncContextManager (Generic[T_co])`
Deprecated alias to `contextlib.AbstractAsyncContextManager`.
在 3.6.2 版新加入.
在 3.9 版之後被 用: `contextlib.AbstractAsyncContextManager` now supports subscripting (`[]`). See [PEP 585](#) and *Generic Alias Type*.

26.1.12 Deprecation Timeline of Major Features

Certain features in `typing` are deprecated and may be removed in a future version of Python. The following table summarizes major deprecations for your convenience. This is subject to change, and not all deprecations are listed.

Feature	用 於	Projected removal	PEP/issue
<code>typing.io</code> and <code>typing.re</code> sub-modules	3.8	3.13	bpo-38291
<code>typing</code> versions of standard collections	3.9	Undecided (see 用的 名 for more information)	PEP 585
<code>typing.ByteString</code>	3.9	3.14	gh-91896
<code>typing.Text</code>	3.11	Undecided	gh-92332

26.2 pydoc --- Documentation generator and online help system

原始碼: [Lib/pydoc.py](#)

The `pydoc` module automatically generates documentation from Python modules. The documentation can be presented as pages of text on the console, served to a web browser, or saved to HTML files.
For modules, classes, functions and methods, the displayed documentation is derived from the docstring (i.e. the `__doc__` attribute) of the object, and recursively of its documentable members. If there is no docstring, `pydoc` tries to obtain a description from the block of comment lines just above the definition of the class, function or method in the source file, or at the top of the module (see `inspect.getcomments()`).
The built-in function `help()` invokes the online help system in the interactive interpreter, which uses `pydoc` to generate its documentation as text on the console. The same text documentation can also be viewed from outside the Python interpreter by running `pydoc` as a script at the operating system's command prompt. For example, running

```
python -m pydoc sys
```

at a shell prompt will display documentation on the `sys` module, in a style similar to the manual pages shown by the Unix `man` command. The argument to `pydoc` can be the name of a function, module, or package, or a dotted reference to a class, method, or function within a module or module in a package. If the argument to `pydoc` looks like a path (that is, it contains the path separator for your operating system, such as a slash in Unix), and refers to an existing Python source file, then documentation is produced for that file.

備 F: In order to find objects and their documentation, `pydoc` imports the module(s) to be documented. Therefore, any code on module level will be executed on that occasion. Use an `if __name__ == '__main__':` guard to only execute code when a file is invoked as a script and not just imported.

When printing output to the console, `pydoc` attempts to paginate the output for easier reading. If the `PAGER` environment variable is set, `pydoc` will use its value as a pagination program.

Specifying a `-w` flag before the argument will cause HTML documentation to be written out to a file in the current directory, instead of displaying text on the console.

Specifying a `-k` flag before the argument will search the synopsis lines of all available modules for the keyword given as the argument, again in a manner similar to the Unix `man` command. The synopsis line of a module is the first line of its documentation string.

You can also use `pydoc` to start an HTTP server on the local machine that will serve documentation to visiting web browsers. `python -m pydoc -p 1234` will start a HTTP server on port 1234, allowing you to browse the documentation at `http://localhost:1234/` in your preferred web browser. Specifying 0 as the port number will select an arbitrary unused port.

`python -m pydoc -n <hostname>` will start the server listening at the given hostname. By default the hostname is 'localhost' but if you want the server to be reached from other machines, you may want to change the host name that the server responds to. During development this is especially useful if you want to run `pydoc` from within a container.

`python -m pydoc -b` will start the server and additionally open a web browser to a module index page. Each served page has a navigation bar at the top where you can *Get* help on an individual item, *Search* all modules with a keyword in their synopsis line, and go to the *Module index*, *Topics* and *Keywords* pages.

When `pydoc` generates documentation, it uses the current environment and path to locate modules. Thus, invoking `pydoc spam` documents precisely the version of the module you would get if you started the Python interpreter and typed `import spam`.

Module docs for core modules are assumed to reside in `https://docs.python.org/X.Y/library/` where X and Y are the major and minor version numbers of the Python interpreter. This can be overridden by setting the `PYTHONDOCS` environment variable to a different URL or to a local directory containing the Library Reference Manual pages.

在 3.2 版的變更: 新增 `-b` 選項。

在 3.3 版的變更: The `-g` command line option was removed.

在 3.4 版的變更: `pydoc` now uses `inspect.signature()` rather than `inspect.getfullargspec()` to extract signature information from callables.

在 3.7 版的變更: 新增 `-n` 選項。

26.3 Python Development Mode

在 3.7 版新加入.

The Python Development Mode introduces additional runtime checks that are too expensive to be enabled by default. It should not be more verbose than the default if the code is correct; new warnings are only emitted when an issue is detected.

It can be enabled using the `-X dev` command line option or by setting the `PYTHONDEVMODE` environment variable to 1.

See also Python debug build.

26.3.1 Effects of the Python Development Mode

Enabling the Python Development Mode is similar to the following command, but with additional effects described below:

```
PYTHONMALLOC=debug PYTHONASYNCIODEBUG=1 python3 -W default -X faulthandler
```

Effects of the Python Development Mode:

- Add default *warning filter*. The following warnings are shown:

- *DeprecationWarning*
- *ImportWarning*
- *PendingDeprecationWarning*
- *ResourceWarning*

Normally, the above warnings are filtered by the default *warning filters*.

It behaves as if the `-W default` command line option is used.

Use the `-W error` command line option or set the `PYTHONWARNINGS` environment variable to `error` to treat warnings as errors.

- Install debug hooks on memory allocators to check for:
 - Buffer underflow
 - Buffer overflow
 - Memory allocator API violation
 - Unsafe usage of the GIL

See the `PyMem_SetupDebugHooks()` C function.

It behaves as if the `PYTHONMALLOC` environment variable is set to `debug`.

To enable the Python Development Mode without installing debug hooks on memory allocators, set the `PYTHONMALLOC` environment variable to `default`.

- Call `faulthandler.enable()` at Python startup to install handlers for the *SIGSEGV*, *SIGFPE*, *SIGABRT*, *SIGBUS* and *SIGILL* signals to dump the Python traceback on a crash.

It behaves as if the `-X faulthandler` command line option is used or if the `PYTHONFAULTHANDLER` environment variable is set to 1.

- Enable *asyncio debug mode*. For example, *asyncio* checks for coroutines that were not awaited and logs them.

It behaves as if the `PYTHONASYNCIODEBUG` environment variable is set to 1.

- Check the *encoding* and *errors* arguments for string encoding and decoding operations. Examples: `open()`, `str.encode()` and `bytes.decode()`.

By default, for best performance, the *errors* argument is only checked at the first encoding/decoding error and the *encoding* argument is sometimes ignored for empty strings.

- The `io.IOBase` destructor logs `close()` exceptions.
- Set the `dev_mode` attribute of `sys.flags` to `True`.

The Python Development Mode does not enable the `tracemalloc` module by default, because the overhead cost (to performance and memory) would be too large. Enabling the `tracemalloc` module provides additional information on the origin of some errors. For example, `ResourceWarning` logs the traceback where the resource was allocated, and a buffer overflow error logs the traceback where the memory block was allocated.

The Python Development Mode does not prevent the `-O` command line option from removing `assert` statements nor from setting `__debug__` to `False`.

The Python Development Mode can only be enabled at the Python startup. Its value can be read from `sys.flags.dev_mode`.

在 3.8 版的變更: The `io.IOBase` destructor now logs `close()` exceptions.

在 3.9 版的變更: The *encoding* and *errors* arguments are now checked for string encoding and decoding operations.

26.3.2 ResourceWarning 范例

Example of a script counting the number of lines of the text file specified in the command line:

```
import sys

def main():
    fp = open(sys.argv[1])
    nlines = len(fp.readlines())
    print(nlines)
    # The file is closed implicitly

if __name__ == "__main__":
    main()
```

The script does not close the file explicitly. By default, Python does not emit any warning. Example using `README.txt`, which has 269 lines:

```
$ python3 script.py README.txt
269
```

Enabling the Python Development Mode displays a `ResourceWarning` warning:

```
$ python3 -X dev script.py README.txt
269
script.py:10: ResourceWarning: unclosed file <_io.TextIOWrapper name='README.rst'
mode='r' encoding='UTF-8'>
  main()
ResourceWarning: Enable tracemalloc to get the object allocation traceback
```

In addition, enabling `tracemalloc` shows the line where the file was opened:

```
$ python3 -X dev -X tracemalloc=5 script.py README.rst
269
script.py:10: ResourceWarning: unclosed file <_io.TextIOWrapper name='README.rst'
mode='r' encoding='UTF-8'>
  main()
Object allocated at (most recent call last):
```

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```
File "script.py", lineno 10
    main()
File "script.py", lineno 4
    fp = open(sys.argv[1])
```

The fix is to close explicitly the file. Example using a context manager:

```
def main():
    # Close the file explicitly when exiting the with block
    with open(sys.argv[1]) as fp:
        nlines = len(fp.readlines())
    print(nlines)
```

Not closing a resource explicitly can leave a resource open for way longer than expected; it can cause severe issues upon exiting Python. It is bad in CPython, but it is even worse in PyPy. Closing resources explicitly makes an application more deterministic and more reliable.

26.3.3 Bad file descriptor error example

Script displaying the first line of itself:

```
import os

def main():
    fp = open(__file__)
    firstline = fp.readline()
    print(firstline.rstrip())
    os.close(fp.fileno())
    # The file is closed implicitly

main()
```

By default, Python does not emit any warning:

```
$ python3 script.py
import os
```

The Python Development Mode shows a *ResourceWarning* and logs a “Bad file descriptor” error when finalizing the file object:

```
$ python3 -X dev script.py
import os
script.py:10: ResourceWarning: unclosed file <_io.TextIOWrapper name='script.py'
↪mode='r' encoding='UTF-8'>
    main()
ResourceWarning: Enable tracemalloc to get the object allocation traceback
Exception ignored in: <_io.TextIOWrapper name='script.py' mode='r' encoding='UTF-8'
↪'>
Traceback (most recent call last):
  File "script.py", line 10, in <module>
    main()
OSError: [Errno 9] Bad file descriptor
```

`os.close(fp.fileno())` closes the file descriptor. When the file object finalizer tries to close the file descriptor again, it fails with the *Bad file descriptor* error. A file descriptor must be closed only once. In the worst case scenario, closing it twice can lead to a crash (see [bpo-18748](#) for an example).

The fix is to remove the `os.close(fp.fileno())` line, or open the file with `closefd=False`.

26.4 doctest --- Test interactive Python examples

原始碼: Lib/doctest.py

The `doctest` module searches for pieces of text that look like interactive Python sessions, and then executes those sessions to verify that they work exactly as shown. There are several common ways to use doctest:

- To check that a module's docstrings are up-to-date by verifying that all interactive examples still work as documented.
- To perform regression testing by verifying that interactive examples from a test file or a test object work as expected.
- To write tutorial documentation for a package, liberally illustrated with input-output examples. Depending on whether the examples or the expository text are emphasized, this has the flavor of "literate testing" or "executable documentation".

Here's a complete but small example module:

```
"""
This is the "example" module.

The example module supplies one function, factorial(). For example,

>>> factorial(5)
120
"""

def factorial(n):
    """Return the factorial of n, an exact integer >= 0.

    >>> [factorial(n) for n in range(6)]
    [1, 1, 2, 6, 24, 120]
    >>> factorial(30)
    265252859812191058636308480000000
    >>> factorial(-1)
    Traceback (most recent call last):
        ...
    ValueError: n must be >= 0

    Factorials of floats are OK, but the float must be an exact integer:
    >>> factorial(30.1)
    Traceback (most recent call last):
        ...
    ValueError: n must be exact integer
    >>> factorial(30.0)
    26525285981219105863630848000000

    It must also not be ridiculously large:
    >>> factorial(1e100)
    Traceback (most recent call last):
        ...
    OverflowError: n too large
    """

    import math
    if not n >= 0:
        raise ValueError("n must be >= 0")
    if math.floor(n) != n:
        raise ValueError("n must be exact integer")
    if n+1 == n: # catch a value like 1e300
```

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```

        raise OverflowError("n too large")
    result = 1
    factor = 2
    while factor <= n:
        result *= factor
        factor += 1
    return result

if __name__ == "__main__":
    import doctest
    doctest.testmod()

```

If you run `example.py` directly from the command line, `doctest` works its magic:

```

$ python example.py
$

```

There's no output! That's normal, and it means all the examples worked. Pass `-v` to the script, and `doctest` prints a detailed log of what it's trying, and prints a summary at the end:

```

$ python example.py -v
Trying:
    factorial(5)
Expecting:
    120
ok
Trying:
    [factorial(n) for n in range(6)]
Expecting:
    [1, 1, 2, 6, 24, 120]
ok

```

And so on, eventually ending with:

```

Trying:
    factorial(1e100)
Expecting:
    Traceback (most recent call last):
      ...
    OverflowError: n too large
ok
2 items passed all tests:
  1 tests in __main__
  8 tests in __main__.factorial
9 tests in 2 items.
9 passed and 0 failed.
Test passed.
$

```

That's all you need to know to start making productive use of `doctest`! Jump in. The following sections provide full details. Note that there are many examples of doctests in the standard Python test suite and libraries. Especially useful examples can be found in the standard test file `Lib/test/test_doctest/test_doctest.py`.

26.4.1 Simple Usage: Checking Examples in Docstrings

The simplest way to start using doctest (but not necessarily the way you'll continue to do it) is to end each module `M` with:

```
if __name__ == "__main__":
    import doctest
    doctest.testmod()
```

`doctest` then examines docstrings in module `M`.

Running the module as a script causes the examples in the docstrings to get executed and verified:

```
python M.py
```

This won't display anything unless an example fails, in which case the failing example(s) and the cause(s) of the failure(s) are printed to stdout, and the final line of output is `***Test Failed*** N failures.`, where `N` is the number of examples that failed.

Run it with the `-v` switch instead:

```
python M.py -v
```

and a detailed report of all examples tried is printed to standard output, along with assorted summaries at the end.

You can force verbose mode by passing `verbose=True` to `testmod()`, or prohibit it by passing `verbose=False`. In either of those cases, `sys.argv` is not examined by `testmod()` (so passing `-v` or not has no effect).

There is also a command line shortcut for running `testmod()`. You can instruct the Python interpreter to run the doctest module directly from the standard library and pass the module name(s) on the command line:

```
python -m doctest -v example.py
```

This will import `example.py` as a standalone module and run `testmod()` on it. Note that this may not work correctly if the file is part of a package and imports other submodules from that package.

For more information on `testmod()`, see section [Basic API](#).

26.4.2 Simple Usage: Checking Examples in a Text File

Another simple application of doctest is testing interactive examples in a text file. This can be done with the `testfile()` function:

```
import doctest
doctest.testfile("example.txt")
```

That short script executes and verifies any interactive Python examples contained in the file `example.txt`. The file content is treated as if it were a single giant docstring; the file doesn't need to contain a Python program! For example, perhaps `example.txt` contains this:

```
The ``example`` module
=====

Using ``factorial``
-----

This is an example text file in reStructuredText format. First import
``factorial`` from the ``example`` module:

    >>> from example import factorial
```

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Now use it:

```
>>> factorial(6)
120
```

Running `doctest.testfile("example.txt")` then finds the error in this documentation:

```
File "./example.txt", line 14, in example.txt
Failed example:
    factorial(6)
Expected:
    120
Got:
    720
```

As with `testmod()`, `testfile()` won't display anything unless an example fails. If an example does fail, then the failing example(s) and the cause(s) of the failure(s) are printed to stdout, using the same format as `testmod()`.

By default, `testfile()` looks for files in the calling module's directory. See section [Basic API](#) for a description of the optional arguments that can be used to tell it to look for files in other locations.

Like `testmod()`, `testfile()`'s verbosity can be set with the `-v` command-line switch or with the optional keyword argument `verbose`.

There is also a command line shortcut for running `testfile()`. You can instruct the Python interpreter to run the doctest module directly from the standard library and pass the file name(s) on the command line:

```
python -m doctest -v example.txt
```

Because the file name does not end with `.py`, `doctest` infers that it must be run with `testfile()`, not `testmod()`.

For more information on `testfile()`, see section [Basic API](#).

26.4.3 How It Works

This section examines in detail how doctest works: which docstrings it looks at, how it finds interactive examples, what execution context it uses, how it handles exceptions, and how option flags can be used to control its behavior. This is the information that you need to know to write doctest examples; for information about actually running doctest on these examples, see the following sections.

Which Docstrings Are Examined?

The module docstring, and all function, class and method docstrings are searched. Objects imported into the module are not searched.

In addition, there are cases when you want tests to be part of a module but not part of the help text, which requires that the tests not be included in the docstring. Doctest looks for a module-level variable called `__test__` and uses it to locate other tests. If `M.__test__` exists, it must be a dict, and each entry maps a (string) name to a function object, class object, or string. Function and class object docstrings found from `M.__test__` are searched, and strings are treated as if they were docstrings. In output, a key `K` in `M.__test__` appears with name `M.__test__.K`.

For example, place this block of code at the top of `example.py`:

```
__test__ = {
    'numbers': """
>>> factorial(6)
720
```

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```
>>> [factorial(n) for n in range(6)]
[1, 1, 2, 6, 24, 120]
"""
}
```

The value of `example.__test__["numbers"]` will be treated as a docstring and all the tests inside it will be run. It is important to note that the value can be mapped to a function, class object, or module; if so, `doctest` searches them recursively for docstrings, which are then scanned for tests.

Any classes found are recursively searched similarly, to test docstrings in their contained methods and nested classes.

How are Docstring Examples Recognized?

In most cases a copy-and-paste of an interactive console session works fine, but `doctest` isn't trying to do an exact emulation of any specific Python shell.

```
>>> # comments are ignored
>>> x = 12
>>> x
12
>>> if x == 13:
...     print("yes")
... else:
...     print("no")
...     print("NO")
...     print("NO!!!")
...
no
NO
NO!!!
>>>
```

Any expected output must immediately follow the final `'>>> '` or `'... '` line containing the code, and the expected output (if any) extends to the next `'>>> '` or all-whitespace line.

The fine print:

- Expected output cannot contain an all-whitespace line, since such a line is taken to signal the end of expected output. If expected output does contain a blank line, put `<BLANKLINE>` in your doctest example each place a blank line is expected.
- All hard tab characters are expanded to spaces, using 8-column tab stops. Tabs in output generated by the tested code are not modified. Because any hard tabs in the sample output *are* expanded, this means that if the code output includes hard tabs, the only way the doctest can pass is if the `NORMALIZE_WHITESPACE` option or *directive* is in effect. Alternatively, the test can be rewritten to capture the output and compare it to an expected value as part of the test. This handling of tabs in the source was arrived at through trial and error, and has proven to be the least error prone way of handling them. It is possible to use a different algorithm for handling tabs by writing a custom `DocTestParser` class.
- Output to stdout is captured, but not output to stderr (exception tracebacks are captured via a different means).
- If you continue a line via backslashing in an interactive session, or for any other reason use a backslash, you should use a raw docstring, which will preserve your backslashes exactly as you type them:

```
>>> def f(x):
...     r'''Backslashes in a raw docstring: m\n'''
>>> print(f.__doc__)
Backslashes in a raw docstring: m\n
```

Otherwise, the backslash will be interpreted as part of the string. For example, the `\n` above would be interpreted as a newline character. Alternatively, you can double each backslash in the doctest version (and not use a raw string):

```
>>> def f(x):
...     '''Backslashes in a raw docstring: m\\n'''
>>> print(f.__doc__)
Backslashes in a raw docstring: m\\n
```

- The starting column doesn't matter:

```
>>> assert "Easy!"
>>> import math
>>> math.floor(1.9)
1
```

and as many leading whitespace characters are stripped from the expected output as appeared in the initial '>>> ' line that started the example.

What's the Execution Context?

By default, each time `doctest` finds a docstring to test, it uses a *shallow copy* of `M`'s globals, so that running tests doesn't change the module's real globals, and so that one test in `M` can't leave behind crumbs that accidentally allow another test to work. This means examples can freely use any names defined at top-level in `M`, and names defined earlier in the docstring being run. Examples cannot see names defined in other docstrings.

You can force use of your own dict as the execution context by passing `globals=your_dict` to `testmod()` or `testfile()` instead.

What About Exceptions?

No problem, provided that the traceback is the only output produced by the example: just paste in the traceback.¹ Since tracebacks contain details that are likely to change rapidly (for example, exact file paths and line numbers), this is one case where `doctest` works hard to be flexible in what it accepts.

簡單範例：

```
>>> [1, 2, 3].remove(42)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: list.remove(x): x not in list
```

That `doctest` succeeds if `ValueError` is raised, with the `list.remove(x): x not in list` detail as shown.

The expected output for an exception must start with a traceback header, which may be either of the following two lines, indented the same as the first line of the example:

```
Traceback (most recent call last):
Traceback (innermost last):
```

The traceback header is followed by an optional traceback stack, whose contents are ignored by `doctest`. The traceback stack is typically omitted, or copied verbatim from an interactive session.

The traceback stack is followed by the most interesting part: the line(s) containing the exception type and detail. This is usually the last line of a traceback, but can extend across multiple lines if the exception has a multi-line detail:

```
>>> raise ValueError('multi\n    line\ndetail')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: multi
```

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¹ Examples containing both expected output and an exception are not supported. Trying to guess where one ends and the other begins is too error-prone, and that also makes for a confusing test.

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```

line
detail

```

The last three lines (starting with `ValueError`) are compared against the exception's type and detail, and the rest are ignored.

Best practice is to omit the traceback stack, unless it adds significant documentation value to the example. So the last example is probably better as:

```

>>> raise ValueError('multi\n    line\ndetail')
Traceback (most recent call last):
...
ValueError: multi
    line
detail

```

Note that tracebacks are treated very specially. In particular, in the rewritten example, the use of `...` is independent of doctest's `ELLIPSIS` option. The ellipsis in that example could be left out, or could just as well be three (or three hundred) commas or digits, or an indented transcript of a Monty Python skit.

Some details you should read once, but won't need to remember:

- Doctest can't guess whether your expected output came from an exception traceback or from ordinary printing. So, e.g., an example that expects `ValueError: 42 is prime` will pass whether `ValueError` is actually raised or if the example merely prints that traceback text. In practice, ordinary output rarely begins with a traceback header line, so this doesn't create real problems.
- Each line of the traceback stack (if present) must be indented further than the first line of the example, *or* start with a non-alphanumeric character. The first line following the traceback header indented the same and starting with an alphanumeric is taken to be the start of the exception detail. Of course this does the right thing for genuine tracebacks.
- When the `IGNORE_EXCEPTION_DETAIL` doctest option is specified, everything following the leftmost colon and any module information in the exception name is ignored.
- The interactive shell omits the traceback header line for some `SyntaxErrors`. But doctest uses the traceback header line to distinguish exceptions from non-exceptions. So in the rare case where you need to test a `SyntaxError` that omits the traceback header, you will need to manually add the traceback header line to your test example.
- For some exceptions, Python displays the position of the error using `^` markers and tildes:

```

>>> 1 + None
File "<stdin>", line 1
    1 + None
    ~^~~~~~
TypeError: unsupported operand type(s) for +: 'int' and 'NoneType'

```

Since the lines showing the position of the error come before the exception type and detail, they are not checked by doctest. For example, the following test would pass, even though it puts the `^` marker in the wrong location:

```

>>> 1 + None
File "<stdin>", line 1
    1 + None
    ^~~~~~
TypeError: unsupported operand type(s) for +: 'int' and 'NoneType'

```

Option Flags

A number of option flags control various aspects of doctest's behavior. Symbolic names for the flags are supplied as module constants, which can be bitwise ORed together and passed to various functions. The names can also be used in *doctest directives*, and may be passed to the doctest command line interface via the `-o` option.

在 3.4 版新加入: The `-o` command line option.

The first group of options define test semantics, controlling aspects of how doctest decides whether actual output matches an example's expected output:

`doctest.DONT_ACCEPT_TRUE_FOR_1`

By default, if an expected output block contains just 1, an actual output block containing just 1 or just True is considered to be a match, and similarly for 0 versus False. When `DONT_ACCEPT_TRUE_FOR_1` is specified, neither substitution is allowed. The default behavior caters to that Python changed the return type of many functions from integer to boolean; doctests expecting "little integer" output still work in these cases. This option will probably go away, but not for several years.

`doctest.DONT_ACCEPT_BLANKLINE`

By default, if an expected output block contains a line containing only the string `<BLANKLINE>`, then that line will match a blank line in the actual output. Because a genuinely blank line delimits the expected output, this is the only way to communicate that a blank line is expected. When `DONT_ACCEPT_BLANKLINE` is specified, this substitution is not allowed.

`doctest.NORMALIZE_WHITESPACE`

When specified, all sequences of whitespace (blanks and newlines) are treated as equal. Any sequence of whitespace within the expected output will match any sequence of whitespace within the actual output. By default, whitespace must match exactly. `NORMALIZE_WHITESPACE` is especially useful when a line of expected output is very long, and you want to wrap it across multiple lines in your source.

`doctest.ELLIPSIS`

When specified, an ellipsis marker (`. . .`) in the expected output can match any substring in the actual output. This includes substrings that span line boundaries, and empty substrings, so it's best to keep usage of this simple. Complicated uses can lead to the same kinds of "oops, it matched too much!" surprises that `. *` is prone to in regular expressions.

`doctest.IGNORE_EXCEPTION_DETAIL`

When specified, doctests expecting exceptions pass so long as an exception of the expected type is raised, even if the details (message and fully qualified exception name) don't match.

For example, an example expecting `ValueError: 42` will pass if the actual exception raised is `ValueError: 3*14`, but will fail if, say, a `TypeError` is raised instead. It will also ignore any fully qualified name included before the exception class, which can vary between implementations and versions of Python and the code/libraries in use. Hence, all three of these variations will work with the flag specified:

```
>>> raise Exception('message')
Traceback (most recent call last):
Exception: message

>>> raise Exception('message')
Traceback (most recent call last):
builtins.Exception: message

>>> raise Exception('message')
Traceback (most recent call last):
__main__.Exception: message
```

Note that `ELLIPSIS` can also be used to ignore the details of the exception message, but such a test may still fail based on whether the module name is present or matches exactly.

在 3.2 版的變更: `IGNORE_EXCEPTION_DETAIL` now also ignores any information relating to the module containing the exception under test.

doctest.SKIP

When specified, do not run the example at all. This can be useful in contexts where doctest examples serve as both documentation and test cases, and an example should be included for documentation purposes, but should not be checked. E.g., the example's output might be random; or the example might depend on resources which would be unavailable to the test driver.

The SKIP flag can also be used for temporarily "commenting out" examples.

doctest.COMPARISON_FLAGS

A bitmask or'ing together all the comparison flags above.

The second group of options controls how test failures are reported:

doctest.REPORT_UDIFF

When specified, failures that involve multi-line expected and actual outputs are displayed using a unified diff.

doctest.REPORT_CDIFF

When specified, failures that involve multi-line expected and actual outputs will be displayed using a context diff.

doctest.REPORT_NDIFF

When specified, differences are computed by `diff.lib.Differ`, using the same algorithm as the popular `ndiff.py` utility. This is the only method that marks differences within lines as well as across lines. For example, if a line of expected output contains digit 1 where actual output contains letter l, a line is inserted with a caret marking the mismatching column positions.

doctest.REPORT_ONLY_FIRST_FAILURE

When specified, display the first failing example in each doctest, but suppress output for all remaining examples. This will prevent doctest from reporting correct examples that break because of earlier failures; but it might also hide incorrect examples that fail independently of the first failure. When `REPORT_ONLY_FIRST_FAILURE` is specified, the remaining examples are still run, and still count towards the total number of failures reported; only the output is suppressed.

doctest.FAIL_FAST

When specified, exit after the first failing example and don't attempt to run the remaining examples. Thus, the number of failures reported will be at most 1. This flag may be useful during debugging, since examples after the first failure won't even produce debugging output.

The doctest command line accepts the option `-f` as a shorthand for `-o FAIL_FAST`.

在 3.4 版新加入.

doctest.REPORTING_FLAGS

A bitmask or'ing together all the reporting flags above.

There is also a way to register new option flag names, though this isn't useful unless you intend to extend *doctest* internals via subclassing:

doctest.register_optionflag(name)

Create a new option flag with a given name, and return the new flag's integer value. `register_optionflag()` can be used when subclassing *OutputChecker* or *DocTestRunner* to create new options that are supported by your subclasses. `register_optionflag()` should always be called using the following idiom:

```
MY_FLAG = register_optionflag('MY_FLAG')
```

Directives

Doctest directives may be used to modify the *option flags* for an individual example. Doctest directives are special Python comments following an example's source code:

```
directive          ::=  "#" "doctest:" directive_options
directive_options  ::=  directive_option ("," directive_option)*
directive_option   ::=  on_or_off directive_option_name
on_or_off          ::=  "+" | "-"
directive_option_name ::=  "DONT_ACCEPT_BLANKLINE" | "NORMALIZE_WHITESPACE" | ...
```

Whitespace is not allowed between the + or – and the directive option name. The directive option name can be any of the option flag names explained above.

An example's doctest directives modify doctest's behavior for that single example. Use + to enable the named behavior, or – to disable it.

For example, this test passes:

```
>>> print(list(range(20))) # doctest: +NORMALIZE_WHITESPACE
[0,  1,  2,  3,  4,  5,  6,  7,  8,  9,
10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
```

Without the directive it would fail, both because the actual output doesn't have two blanks before the single-digit list elements, and because the actual output is on a single line. This test also passes, and also requires a directive to do so:

```
>>> print(list(range(20))) # doctest: +ELLIPSIS
[0, 1, ..., 18, 19]
```

Multiple directives can be used on a single physical line, separated by commas:

```
>>> print(list(range(20))) # doctest: +ELLIPSIS, +NORMALIZE_WHITESPACE
[0,  1, ...,  18,  19]
```

If multiple directive comments are used for a single example, then they are combined:

```
>>> print(list(range(20))) # doctest: +ELLIPSIS
... # doctest: +NORMALIZE_WHITESPACE
[0,  1, ...,  18,  19]
```

As the previous example shows, you can add . . . lines to your example containing only directives. This can be useful when an example is too long for a directive to comfortably fit on the same line:

```
>>> print(list(range(5)) + list(range(10, 20)) + list(range(30, 40)))
... # doctest: +ELLIPSIS
[0, ..., 4, 10, ..., 19, 30, ..., 39]
```

Note that since all options are disabled by default, and directives apply only to the example they appear in, enabling options (via + in a directive) is usually the only meaningful choice. However, option flags can also be passed to functions that run doctests, establishing different defaults. In such cases, disabling an option via – in a directive can be useful.

Warnings

`doctest` is serious about requiring exact matches in expected output. If even a single character doesn't match, the test fails. This will probably surprise you a few times, as you learn exactly what Python does and doesn't guarantee about output. For example, when printing a set, Python doesn't guarantee that the element is printed in any particular order, so a test like

```
>>> foo()
{"Hermione", "Harry"}
```

is vulnerable! One workaround is to do

```
>>> foo() == {"Hermione", "Harry"}
True
```

instead. Another is to do

```
>>> d = sorted(foo())
>>> d
['Harry', 'Hermione']
```

There are others, but you get the idea.

Another bad idea is to print things that embed an object address, like

```
>>> id(1.0)  # certain to fail some of the time
7948648
>>> class C: pass
>>> C()  # the default repr() for instances embeds an address
<C object at 0x00AC18F0>
```

The `ELLIPSIS` directive gives a nice approach for the last example:

```
>>> C()  # doctest: +ELLIPSIS
<C object at 0x...>
```

Floating-point numbers are also subject to small output variations across platforms, because Python defers to the platform C library for float formatting, and C libraries vary widely in quality here.

```
>>> 1./7  # risky
0.14285714285714285
>>> print(1./7)  # safer
0.142857142857
>>> print(round(1./7, 6))  # much safer
0.142857
```

Numbers of the form $I/2.^{*}J$ are safe across all platforms, and I often contrive doctest examples to produce numbers of that form:

```
>>> 3./4  # utterly safe
0.75
```

Simple fractions are also easier for people to understand, and that makes for better documentation.

26.4.4 Basic API

The functions `testmod()` and `testfile()` provide a simple interface to doctest that should be sufficient for most basic uses. For a less formal introduction to these two functions, see sections *Simple Usage: Checking Examples in Docstrings* and *Simple Usage: Checking Examples in a Text File*.

```
doctest.testfile(filename, module_relative=True, name=None, package=None, globs=None,
                 verbose=None, report=True, optionflags=0, extraglobs=None, raise_on_error=False,
                 parser=DocTestParser(), encoding=None)
```

All arguments except `filename` are optional, and should be specified in keyword form.

Test examples in the file named `filename`. Return `(failure_count, test_count)`.

Optional argument `module_relative` specifies how the filename should be interpreted:

- If `module_relative` is `True` (the default), then `filename` specifies an OS-independent module-relative path. By default, this path is relative to the calling module's directory; but if the `package` argument is specified, then it is relative to that package. To ensure OS-independence, `filename` should use `/` characters to separate path segments, and may not be an absolute path (i.e., it may not begin with `/`).
- If `module_relative` is `False`, then `filename` specifies an OS-specific path. The path may be absolute or relative; relative paths are resolved with respect to the current working directory.

Optional argument `name` gives the name of the test; by default, or if `None`, `os.path.basename(filename)` is used.

Optional argument `package` is a Python package or the name of a Python package whose directory should be used as the base directory for a module-relative filename. If no package is specified, then the calling module's directory is used as the base directory for module-relative filenames. It is an error to specify `package` if `module_relative` is `False`.

Optional argument `globs` gives a dict to be used as the globals when executing examples. A new shallow copy of this dict is created for the doctest, so its examples start with a clean slate. By default, or if `None`, a new empty dict is used.

Optional argument `extraglobs` gives a dict merged into the globals used to execute examples. This works like `dict.update()`: if `globs` and `extraglobs` have a common key, the associated value in `extraglobs` appears in the combined dict. By default, or if `None`, no extra globals are used. This is an advanced feature that allows parameterization of doctests. For example, a doctest can be written for a base class, using a generic name for the class, then reused to test any number of subclasses by passing an `extraglobs` dict mapping the generic name to the subclass to be tested.

Optional argument `verbose` prints lots of stuff if true, and prints only failures if false; by default, or if `None`, it's true if and only if `'-v'` is in `sys.argv`.

Optional argument `report` prints a summary at the end when true, else prints nothing at the end. In verbose mode, the summary is detailed, else the summary is very brief (in fact, empty if all tests passed).

Optional argument `optionflags` (default value 0) takes the bitwise OR of option flags. See section *Option Flags*.

Optional argument `raise_on_error` defaults to false. If true, an exception is raised upon the first failure or unexpected exception in an example. This allows failures to be post-mortem debugged. Default behavior is to continue running examples.

Optional argument `parser` specifies a `DocTestParser` (or subclass) that should be used to extract tests from the files. It defaults to a normal parser (i.e., `DocTestParser()`).

Optional argument `encoding` specifies an encoding that should be used to convert the file to unicode.

```
doctest.testmod(m=None, name=None, globs=None, verbose=None, report=True, optionflags=0,
               extraglobs=None, raise_on_error=False, exclude_empty=False)
```

All arguments are optional, and all except for `m` should be specified in keyword form.

Test examples in docstrings in functions and classes reachable from module `m` (or module `__main__` if `m` is not supplied or is `None`), starting with `m.__doc__`.

Also test examples reachable from dict `m.__test__`, if it exists. `m.__test__` maps names (strings) to functions, classes and strings; function and class docstrings are searched for examples; strings are searched directly, as if they were docstrings.

Only docstrings attached to objects belonging to module *m* are searched.

Return (failure_count, test_count).

Optional argument *name* gives the name of the module; by default, or if None, `m.__name__` is used.

Optional argument *exclude_empty* defaults to false. If true, objects for which no doctests are found are excluded from consideration. The default is a backward compatibility hack, so that code still using `doctest.master.summarize` in conjunction with `testmod()` continues to get output for objects with no tests. The *exclude_empty* argument to the newer `DocTestFinder` constructor defaults to true.

Optional arguments *extraglobs*, *verbose*, *report*, *optionflags*, *raise_on_error*, and *globs* are the same as for function `testfile()` above, except that *globs* defaults to `m.__dict__`.

```
doctest.run_docstring_examples(f, globs, verbose=False, name='NoName', compileflags=None,
                               optionflags=0)
```

Test examples associated with object *f*; for example, *f* may be a string, a module, a function, or a class object.

A shallow copy of dictionary argument *globs* is used for the execution context.

Optional argument *name* is used in failure messages, and defaults to "NoName".

If optional argument *verbose* is true, output is generated even if there are no failures. By default, output is generated only in case of an example failure.

Optional argument *compileflags* gives the set of flags that should be used by the Python compiler when running the examples. By default, or if None, flags are deduced corresponding to the set of future features found in *globs*.

Optional argument *optionflags* works as for function `testfile()` above.

26.4.5 unittest API

As your collection of doctest'ed modules grows, you'll want a way to run all their doctests systematically. `doctest` provides two functions that can be used to create `unittest` test suites from modules and text files containing doctests. To integrate with `unittest` test discovery, include a `load_tests` function in your test module:

```
import unittest
import doctest
import my_module_with_doctests

def load_tests(loader, tests, ignore):
    tests.addTests(doctest.DocTestSuite(my_module_with_doctests))
    return tests
```

There are two main functions for creating `unittest.TestSuite` instances from text files and modules with doctests:

```
doctest.DocFileSuite(*paths, module_relative=True, package=None, setUp=None, tearDown=None,
                     globs=None, optionflags=0, parser=DocTestParser(), encoding=None)
```

Convert doctest tests from one or more text files to a `unittest.TestSuite`.

The returned `unittest.TestSuite` is to be run by the unittest framework and runs the interactive examples in each file. If an example in any file fails, then the synthesized unit test fails, and a `failureException` exception is raised showing the name of the file containing the test and a (sometimes approximate) line number.

Pass one or more paths (as strings) to text files to be examined.

Options may be provided as keyword arguments:

Optional argument *module_relative* specifies how the filenames in *paths* should be interpreted:

- If *module_relative* is `True` (the default), then each filename in *paths* specifies an OS-independent module-relative path. By default, this path is relative to the calling module's directory; but if the *package* argument is specified, then it is relative to that package. To ensure OS-independence, each filename should use `/` characters to separate path segments, and may not be an absolute path (i.e., it may not begin with `/`).
- If *module_relative* is `False`, then each filename in *paths* specifies an OS-specific path. The path may be absolute or relative; relative paths are resolved with respect to the current working directory.

Optional argument *package* is a Python package or the name of a Python package whose directory should be used as the base directory for module-relative filenames in *paths*. If no package is specified, then the calling module's directory is used as the base directory for module-relative filenames. It is an error to specify *package* if *module_relative* is `False`.

Optional argument *setUp* specifies a set-up function for the test suite. This is called before running the tests in each file. The *setUp* function will be passed a *DocTest* object. The *setUp* function can access the test globals as the *globs* attribute of the test passed.

Optional argument *tearDown* specifies a tear-down function for the test suite. This is called after running the tests in each file. The *tearDown* function will be passed a *DocTest* object. The *setUp* function can access the test globals as the *globs* attribute of the test passed.

Optional argument *globs* is a dictionary containing the initial global variables for the tests. A new copy of this dictionary is created for each test. By default, *globs* is a new empty dictionary.

Optional argument *optionflags* specifies the default doctest options for the tests, created by or-ing together individual option flags. See section *Option Flags*. See function *set_unittest_reportflags()* below for a better way to set reporting options.

Optional argument *parser* specifies a *DocTestParser* (or subclass) that should be used to extract tests from the files. It defaults to a normal parser (i.e., *DocTestParser()*).

Optional argument *encoding* specifies an encoding that should be used to convert the file to unicode.

The global `__file__` is added to the globals provided to doctests loaded from a text file using *DocFileSuite()*.

```
doctest.DocTestSuite (module=None, globs=None, extraglobs=None, test_finder=None, setUp=None,
                      tearDown=None, checker=None)
```

Convert doctest tests for a module to a *unittest.TestSuite*.

The returned *unittest.TestSuite* is to be run by the unittest framework and runs each doctest in the module. If any of the doctests fail, then the synthesized unit test fails, and a *failureException* exception is raised showing the name of the file containing the test and a (sometimes approximate) line number.

Optional argument *module* provides the module to be tested. It can be a module object or a (possibly dotted) module name. If not specified, the module calling this function is used.

Optional argument *globs* is a dictionary containing the initial global variables for the tests. A new copy of this dictionary is created for each test. By default, *globs* is a new empty dictionary.

Optional argument *extraglobs* specifies an extra set of global variables, which is merged into *globs*. By default, no extra globals are used.

Optional argument *test_finder* is the *DocTestFinder* object (or a drop-in replacement) that is used to extract doctests from the module.

Optional arguments *setUp*, *tearDown*, and *optionflags* are the same as for function *DocFileSuite()* above.

This function uses the same search technique as *testmod()*.

在 3.5 版的變更: *DocTestSuite()* returns an empty *unittest.TestSuite* if *module* contains no docstrings instead of raising *ValueError*.

exception *doctest.failureException*

When doctests which have been converted to unit tests by *DocFileSuite()* or *DocTestSuite()* fail, this exception is raised showing the name of the file containing the test and a (sometimes approximate) line number.

Under the covers, `DocTestSuite()` creates a `unittest.TestSuite` out of `doctest.DocTestCase` instances, and `DocTestCase` is a subclass of `unittest.TestCase`. `DocTestCase` isn't documented here (it's an internal detail), but studying its code can answer questions about the exact details of `unittest` integration.

Similarly, `DocFileSuite()` creates a `unittest.TestSuite` out of `doctest.DocFileCase` instances, and `DocFileCase` is a subclass of `DocTestCase`.

So both ways of creating a `unittest.TestSuite` run instances of `DocTestCase`. This is important for a subtle reason: when you run `doctest` functions yourself, you can control the `doctest` options in use directly, by passing option flags to `doctest` functions. However, if you're writing a `unittest` framework, `unittest` ultimately controls when and how tests get run. The framework author typically wants to control `doctest` reporting options (perhaps, e.g., specified by command line options), but there's no way to pass options through `unittest` to `doctest` test runners.

For this reason, `doctest` also supports a notion of `doctest` reporting flags specific to `unittest` support, via this function:

`doctest.set_unittest_reportflags(flags)`

Set the `doctest` reporting flags to use.

Argument `flags` takes the bitwise OR of option flags. See section [Option Flags](#). Only "reporting flags" can be used.

This is a module-global setting, and affects all future doctests run by module `unittest`: the `runTest()` method of `DocTestCase` looks at the option flags specified for the test case when the `DocTestCase` instance was constructed. If no reporting flags were specified (which is the typical and expected case), `doctest`'s `unittest` reporting flags are bitwise ORED into the option flags, and the option flags so augmented are passed to the `DocTestRunner` instance created to run the doctest. If any reporting flags were specified when the `DocTestCase` instance was constructed, `doctest`'s `unittest` reporting flags are ignored.

The value of the `unittest` reporting flags in effect before the function was called is returned by the function.

26.4.6 Advanced API

The basic API is a simple wrapper that's intended to make `doctest` easy to use. It is fairly flexible, and should meet most users' needs; however, if you require more fine-grained control over testing, or wish to extend `doctest`'s capabilities, then you should use the advanced API.

The advanced API revolves around two container classes, which are used to store the interactive examples extracted from `doctest` cases:

- *Example*: A single Python *statement*, paired with its expected output.
- *DocTest*: A collection of *Examples*, typically extracted from a single docstring or text file.

Additional processing classes are defined to find, parse, and run, and check `doctest` examples:

- *DocTestFinder*: Finds all docstrings in a given module, and uses a *DocTestParser* to create a *DocTest* from every docstring that contains interactive examples.
- *DocTestParser*: Creates a *DocTest* object from a string (such as an object's docstring).
- *DocTestRunner*: Executes the examples in a *DocTest*, and uses an *OutputChecker* to verify their output.
- *OutputChecker*: Compares the actual output from a `doctest` example with the expected output, and decides whether they match.

The relationships among these processing classes are summarized in the following diagram:



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		Example		
v		...	v	
DocTestParser		Example	OutputChecker	
+-----+				

DocTest 物件

class doctest.**DocTest** (*examples, globs, name, filename, lineno, docstring*)

A collection of doctest examples that should be run in a single namespace. The constructor arguments are used to initialize the attributes of the same names.

DocTest defines the following attributes. They are initialized by the constructor, and should not be modified directly.

examples

A list of *Example* objects encoding the individual interactive Python examples that should be run by this test.

globs

The namespace (aka globals) that the examples should be run in. This is a dictionary mapping names to values. Any changes to the namespace made by the examples (such as binding new variables) will be reflected in *globs* after the test is run.

name

A string name identifying the *DocTest*. Typically, this is the name of the object or file that the test was extracted from.

filename

The name of the file that this *DocTest* was extracted from; or *None* if the filename is unknown, or if the *DocTest* was not extracted from a file.

lineno

The line number within *filename* where this *DocTest* begins, or *None* if the line number is unavailable. This line number is zero-based with respect to the beginning of the file.

docstring

The string that the test was extracted from, or *None* if the string is unavailable, or if the test was not extracted from a string.

Example 物件

class doctest.**Example** (*source, want, exc_msg=None, lineno=0, indent=0, options=None*)

A single interactive example, consisting of a Python statement and its expected output. The constructor arguments are used to initialize the attributes of the same names.

Example defines the following attributes. They are initialized by the constructor, and should not be modified directly.

source

A string containing the example’s source code. This source code consists of a single Python statement, and always ends with a newline; the constructor adds a newline when necessary.

want

The expected output from running the example’s source code (either from stdout, or a traceback in case of exception). *want* ends with a newline unless no output is expected, in which case it’s an empty string. The constructor adds a newline when necessary.

exc_msg

The exception message generated by the example, if the example is expected to generate an exception; or None if it is not expected to generate an exception. This exception message is compared against the return value of `traceback.format_exception_only()`. `exc_msg` ends with a newline unless it's None. The constructor adds a newline if needed.

lineno

The line number within the string containing this example where the example begins. This line number is zero-based with respect to the beginning of the containing string.

indent

The example's indentation in the containing string, i.e., the number of space characters that precede the example's first prompt.

options

A dictionary mapping from option flags to True or False, which is used to override default options for this example. Any option flags not contained in this dictionary are left at their default value (as specified by the `DocTestRunner`'s `optionflags`). By default, no options are set.

DocTestFinder 物件

```
class doctest.DocTestFinder (verbose=False, parser=DocTestParser(), recurse=True,  
                             exclude_empty=True)
```

A processing class used to extract the `DocTests` that are relevant to a given object, from its docstring and the docstrings of its contained objects. `DocTests` can be extracted from modules, classes, functions, methods, staticmethods, classmethods, and properties.

The optional argument `verbose` can be used to display the objects searched by the finder. It defaults to `False` (no output).

The optional argument `parser` specifies the `DocTestParser` object (or a drop-in replacement) that is used to extract doctests from docstrings.

If the optional argument `recurse` is false, then `DocTestFinder.find()` will only examine the given object, and not any contained objects.

If the optional argument `exclude_empty` is false, then `DocTestFinder.find()` will include tests for objects with empty docstrings.

`DocTestFinder` defines the following method:

```
find (obj[, name][, module][, globs][, extraglobs])
```

Return a list of the `DocTests` that are defined by `obj`'s docstring, or by any of its contained objects' docstrings.

The optional argument `name` specifies the object's name; this name will be used to construct names for the returned `DocTests`. If `name` is not specified, then `obj.__name__` is used.

The optional parameter `module` is the module that contains the given object. If the module is not specified or is `None`, then the test finder will attempt to automatically determine the correct module. The object's module is used:

- As a default namespace, if `globs` is not specified.
- To prevent the `DocTestFinder` from extracting `DocTests` from objects that are imported from other modules. (Contained objects with modules other than `module` are ignored.)
- To find the name of the file containing the object.
- To help find the line number of the object within its file.

If `module` is `False`, no attempt to find the module will be made. This is obscure, of use mostly in testing doctest itself: if `module` is `False`, or is `None` but cannot be found automatically, then all objects are

considered to belong to the (non-existent) module, so all contained objects will (recursively) be searched for doctests.

The globals for each *DocTest* is formed by combining *globs* and *extraglobs* (bindings in *extraglobs* override bindings in *globs*). A new shallow copy of the globals dictionary is created for each *DocTest*. If *globs* is not specified, then it defaults to the module's `__dict__`, if specified, or `{ }` otherwise. If *extraglobs* is not specified, then it defaults to `{ }`.

DocTestParser 物件

class `doctest.DocTestParser`

A processing class used to extract interactive examples from a string, and use them to create a *DocTest* object.

DocTestParser defines the following methods:

get_doctest (*string*, *globs*, *name*, *filename*, *lineno*)

Extract all doctest examples from the given string, and collect them into a *DocTest* object.

globs, *name*, *filename*, and *lineno* are attributes for the new *DocTest* object. See the documentation for *DocTest* for more information.

get_examples (*string*, *name*=<string>')

Extract all doctest examples from the given string, and return them as a list of *Example* objects. Line numbers are 0-based. The optional argument *name* is a name identifying this string, and is only used for error messages.

parse (*string*, *name*=<string>')

Divide the given string into examples and intervening text, and return them as a list of alternating *Examples* and strings. Line numbers for the *Examples* are 0-based. The optional argument *name* is a name identifying this string, and is only used for error messages.

DocTestRunner 物件

class `doctest.DocTestRunner` (*checker*=None, *verbose*=None, *optionflags*=0)

A processing class used to execute and verify the interactive examples in a *DocTest*.

The comparison between expected outputs and actual outputs is done by an *OutputChecker*. This comparison may be customized with a number of option flags; see section *Option Flags* for more information. If the option flags are insufficient, then the comparison may also be customized by passing a subclass of *OutputChecker* to the constructor.

The test runner's display output can be controlled in two ways. First, an output function can be passed to `TestRunner.run()`; this function will be called with strings that should be displayed. It defaults to `sys.stdout.write`. If capturing the output is not sufficient, then the display output can be also customized by subclassing *DocTestRunner*, and overriding the methods *report_start()*, *report_success()*, *report_unexpected_exception()*, and *report_failure()*.

The optional keyword argument *checker* specifies the *OutputChecker* object (or drop-in replacement) that should be used to compare the expected outputs to the actual outputs of doctest examples.

The optional keyword argument *verbose* controls the *DocTestRunner*'s verbosity. If *verbose* is `True`, then information is printed about each example, as it is run. If *verbose* is `False`, then only failures are printed. If *verbose* is unspecified, or `None`, then verbose output is used iff the command-line switch `-v` is used.

The optional keyword argument *optionflags* can be used to control how the test runner compares expected output to actual output, and how it displays failures. For more information, see section *Option Flags*.

DocTestRunner defines the following methods:

report_start (*out, test, example*)

Report that the test runner is about to process the given example. This method is provided to allow subclasses of *DocTestRunner* to customize their output; it should not be called directly.

example is the example about to be processed. *test* is the test containing *example*. *out* is the output function that was passed to *DocTestRunner.run()*.

report_success (*out, test, example, got*)

Report that the given example ran successfully. This method is provided to allow subclasses of *DocTestRunner* to customize their output; it should not be called directly.

example is the example about to be processed. *got* is the actual output from the example. *test* is the test containing *example*. *out* is the output function that was passed to *DocTestRunner.run()*.

report_failure (*out, test, example, got*)

Report that the given example failed. This method is provided to allow subclasses of *DocTestRunner* to customize their output; it should not be called directly.

example is the example about to be processed. *got* is the actual output from the example. *test* is the test containing *example*. *out* is the output function that was passed to *DocTestRunner.run()*.

report_unexpected_exception (*out, test, example, exc_info*)

Report that the given example raised an unexpected exception. This method is provided to allow subclasses of *DocTestRunner* to customize their output; it should not be called directly.

example is the example about to be processed. *exc_info* is a tuple containing information about the unexpected exception (as returned by *sys.exc_info()*). *test* is the test containing *example*. *out* is the output function that was passed to *DocTestRunner.run()*.

run (*test, compileflags=None, out=None, clear_globs=True*)

Run the examples in *test* (a *DocTest* object), and display the results using the writer function *out*.

The examples are run in the namespace *test.globs*. If *clear_globs* is true (the default), then this namespace will be cleared after the test runs, to help with garbage collection. If you would like to examine the namespace after the test completes, then use *clear_globs=False*.

compileflags gives the set of flags that should be used by the Python compiler when running the examples. If not specified, then it will default to the set of future-import flags that apply to *globs*.

The output of each example is checked using the *DocTestRunner*'s output checker, and the results are formatted by the *DocTestRunner.report_*()* methods.

summarize (*verbose=None*)

Print a summary of all the test cases that have been run by this *DocTestRunner*, and return a *named tuple* *TestResults(failed, attempted)*.

The optional *verbose* argument controls how detailed the summary is. If the verbosity is not specified, then the *DocTestRunner*'s verbosity is used.

OutputChecker 物件

class *doctest.OutputChecker*

A class used to check the whether the actual output from a doctest example matches the expected output. *OutputChecker* defines two methods: *check_output()*, which compares a given pair of outputs, and returns True if they match; and *output_difference()*, which returns a string describing the differences between two outputs.

OutputChecker defines the following methods:

check_output (*want, got, optionflags*)

Return True iff the actual output from an example (*got*) matches the expected output (*want*). These strings are always considered to match if they are identical; but depending on what option flags the test

runner is using, several non-exact match types are also possible. See section *Option Flags* for more information about option flags.

output_difference (*example*, *got*, *optionflags*)

Return a string describing the differences between the expected output for a given example (*example*) and the actual output (*got*). *optionflags* is the set of option flags used to compare *want* and *got*.

26.4.7 Debugging

Doctest provides several mechanisms for debugging doctest examples:

- Several functions convert doctests to executable Python programs, which can be run under the Python debugger, *pdb*.
- The *DebugRunner* class is a subclass of *DocTestRunner* that raises an exception for the first failing example, containing information about that example. This information can be used to perform post-mortem debugging on the example.
- The *unittest* cases generated by *DocTestSuite()* support the *debug()* method defined by *unittest.TestCase*.
- You can add a call to *pdb.set_trace()* in a doctest example, and you'll drop into the Python debugger when that line is executed. Then you can inspect current values of variables, and so on. For example, suppose *a.py* contains just this module docstring:

```
"""
>>> def f(x):
...     g(x*2)
>>> def g(x):
...     print(x+3)
...     import pdb; pdb.set_trace()
>>> f(3)
9
"""
```

Then an interactive Python session may look like this:

```
>>> import a, doctest
>>> doctest.testmod(a)
--Return--
> <doctest a[1]>(3)g()->None
-> import pdb; pdb.set_trace()
(Pdb) list
1      def g(x):
2          print(x+3)
3  ->      import pdb; pdb.set_trace()
[EOF]
(Pdb) p x
6
(Pdb) step
--Return--
> <doctest a[0]>(2)f()->None
-> g(x*2)
(Pdb) list
1      def f(x):
2  ->      g(x*2)
[EOF]
(Pdb) p x
3
(Pdb) step
--Return--
> <doctest a[2]>(1)?()->None
```

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```
-> f(3)
(Pdb) cont
(0, 3)
>>>
```

Functions that convert doctests to Python code, and possibly run the synthesized code under the debugger:

`doctest.script_from_examples(s)`

Convert text with examples to a script.

Argument *s* is a string containing doctest examples. The string is converted to a Python script, where doctest examples in *s* are converted to regular code, and everything else is converted to Python comments. The generated script is returned as a string. For example,

```
import doctest
print(doctest.script_from_examples(r"""
    Set x and y to 1 and 2.
    >>> x, y = 1, 2

    Print their sum:
    >>> print(x+y)
    3
    """))
```

displays:

```
# Set x and y to 1 and 2.
x, y = 1, 2
#
# Print their sum:
print(x+y)
# Expected:
## 3
```

This function is used internally by other functions (see below), but can also be useful when you want to transform an interactive Python session into a Python script.

`doctest.testsource(module, name)`

Convert the doctest for an object to a script.

Argument *module* is a module object, or dotted name of a module, containing the object whose doctests are of interest. Argument *name* is the name (within the module) of the object with the doctests of interest. The result is a string, containing the object's docstring converted to a Python script, as described for `script_from_examples()` above. For example, if module `a.py` contains a top-level function `f()`, then

```
import a, doctest
print(doctest.testsource(a, "a.f"))
```

prints a script version of function `f()`'s docstring, with doctests converted to code, and the rest placed in comments.

`doctest.debug(module, name, pm=False)`

Debug the doctests for an object.

The *module* and *name* arguments are the same as for function `testsource()` above. The synthesized Python script for the named object's docstring is written to a temporary file, and then that file is run under the control of the Python debugger, `pdb`.

A shallow copy of `module.__dict__` is used for both local and global execution context.

Optional argument *pm* controls whether post-mortem debugging is used. If *pm* has a true value, the script file is run directly, and the debugger gets involved only if the script terminates via raising an unhandled exception.

If it does, then post-mortem debugging is invoked, via `pdb.post_mortem()`, passing the traceback object from the unhandled exception. If `pm` is not specified, or is false, the script is run under the debugger from the start, via passing an appropriate `exec()` call to `pdb.run()`.

`doctest.debug_src(src, pm=False, globs=None)`

Debug the doctests in a string.

This is like function `debug()` above, except that a string containing doctest examples is specified directly, via the `src` argument.

Optional argument `pm` has the same meaning as in function `debug()` above.

Optional argument `globs` gives a dictionary to use as both local and global execution context. If not specified, or None, an empty dictionary is used. If specified, a shallow copy of the dictionary is used.

The `DebugRunner` class, and the special exceptions it may raise, are of most interest to testing framework authors, and will only be sketched here. See the source code, and especially `DebugRunner`'s docstring (which is a doctest!) for more details:

class `doctest.DebugRunner` (*checker=None, verbose=None, optionflags=0*)

A subclass of `DocTestRunner` that raises an exception as soon as a failure is encountered. If an unexpected exception occurs, an `UnexpectedException` exception is raised, containing the test, the example, and the original exception. If the output doesn't match, then a `DocTestFailure` exception is raised, containing the test, the example, and the actual output.

For information about the constructor parameters and methods, see the documentation for `DocTestRunner` in section *Advanced API*.

There are two exceptions that may be raised by `DebugRunner` instances:

exception `doctest.DocTestFailure` (*test, example, got*)

An exception raised by `DocTestRunner` to signal that a doctest example's actual output did not match its expected output. The constructor arguments are used to initialize the attributes of the same names.

`DocTestFailure` defines the following attributes:

`DocTestFailure.test`

The `DocTest` object that was being run when the example failed.

`DocTestFailure.example`

The `Example` that failed.

`DocTestFailure.got`

The example's actual output.

exception `doctest.UnexpectedException` (*test, example, exc_info*)

An exception raised by `DocTestRunner` to signal that a doctest example raised an unexpected exception. The constructor arguments are used to initialize the attributes of the same names.

`UnexpectedException` defines the following attributes:

`UnexpectedException.test`

The `DocTest` object that was being run when the example failed.

`UnexpectedException.example`

The `Example` that failed.

`UnexpectedException.exc_info`

A tuple containing information about the unexpected exception, as returned by `sys.exc_info()`.

26.4.8 Soapbox

As mentioned in the introduction, *doctest* has grown to have three primary uses:

1. Checking examples in docstrings.
2. Regression testing.
3. Executable documentation / literate testing.

These uses have different requirements, and it is important to distinguish them. In particular, filling your docstrings with obscure test cases makes for bad documentation.

When writing a docstring, choose docstring examples with care. There's an art to this that needs to be learned---it may not be natural at first. Examples should add genuine value to the documentation. A good example can often be worth many words. If done with care, the examples will be invaluable for your users, and will pay back the time it takes to collect them many times over as the years go by and things change. I'm still amazed at how often one of my *doctest* examples stops working after a "harmless" change.

Doctest also makes an excellent tool for regression testing, especially if you don't skimp on explanatory text. By interleaving prose and examples, it becomes much easier to keep track of what's actually being tested, and why. When a test fails, good prose can make it much easier to figure out what the problem is, and how it should be fixed. It's true that you could write extensive comments in code-based testing, but few programmers do. Many have found that using doctest approaches instead leads to much clearer tests. Perhaps this is simply because doctest makes writing prose a little easier than writing code, while writing comments in code is a little harder. I think it goes deeper than just that: the natural attitude when writing a doctest-based test is that you want to explain the fine points of your software, and illustrate them with examples. This in turn naturally leads to test files that start with the simplest features, and logically progress to complications and edge cases. A coherent narrative is the result, instead of a collection of isolated functions that test isolated bits of functionality seemingly at random. It's a different attitude, and produces different results, blurring the distinction between testing and explaining.

Regression testing is best confined to dedicated objects or files. There are several options for organizing tests:

- Write text files containing test cases as interactive examples, and test the files using *testfile()* or *DocFileSuite()*. This is recommended, although is easiest to do for new projects, designed from the start to use doctest.
- Define functions named *_regtest_topic* that consist of single docstrings, containing test cases for the named topics. These functions can be included in the same file as the module, or separated out into a separate test file.
- Define a *__test__* dictionary mapping from regression test topics to docstrings containing test cases.

When you have placed your tests in a module, the module can itself be the test runner. When a test fails, you can arrange for your test runner to re-run only the failing doctest while you debug the problem. Here is a minimal example of such a test runner:

```
if __name__ == '__main__':
    import doctest
    flags = doctest.REPORT_NDIFF|doctest.FAIL_FAST
    if len(sys.argv) > 1:
        name = sys.argv[1]
        if name in globals():
            obj = globals()[name]
        else:
            obj = __test__[name]
        doctest.run_docstring_examples(obj, globals(), name=name,
                                      optionflags=flags)
    else:
        fail, total = doctest.testmod(optionflags=flags)
        print("{} failures out of {} tests".format(fail, total))
```

解

26.5 unittest --- 單元測試框架

原始碼: `Lib/unittest/__init__.py`

(假如你已經熟悉相關基礎的測試概念，你可能會希望跳過以下段落，直接參考[assert 方法清單](#)。)

`unittest` 原生的單元測試框架最初由 JUnit 開發，和其他程式語言相似有主要的單元測試框架。支援自動化測試，對測試分享安裝與關閉程式碼，集合所有匯總的測試，且獨立各個測試報告框架。

`unittest` 用來作實現支援一些重要的物件導向方法的概念：

test fixture

一個 *test fixture* 代表執行一個或多個測試所需要的準備，以及其他相關清理操作，例如可以是建立臨時性的或是代理用 (proxy) 資料庫、目錄、或是啟動一個伺服器程序。

test case (測試用例)

一個 *test case* 是一個獨立的單元測試。這是用來確認一個特定設定的輸入的特殊回饋。`unittest` 提供一個基礎類，類 `TestCase`，可以用來建立一個新的測試條例。

test suite (測試套件)

test suite 是一個搜集測試條例，測試套件，或是兩者皆有。它需要一起被執行用來匯總測試。

test runner (測試執行器)

test runner 是一個編排測試執行與提供結果給使用者的一個元件。執行器可以使用圖形化介面，文字介面或是回傳一個特值用來標示出執行測試的結果。

也參考：

doctest 模組

另一個執行測試的模組，但使用不一樣的測試方法與規範。

Simple Smalltalk Testing: With Patterns

Kent Beck 的原始論文討論使用 `unittest` 這樣模式的測試框架。

pytest

第三方的單元測試框架，但在撰寫測試時使用更輕量的語法。例如：`assert func(10) == 42`。

The Python Testing Tools Taxonomy

一份詳細的 Python 測試工具列表，包含 functional testing 框架和 mock object 函式庫。

Testing in Python Mailing List

一個專門興趣的群組用來討論 Python 中的測試方式與測試工具。

The script `Tools/unittestgui/unittestgui.py` in the Python source distribution is a GUI tool for test discovery and execution. This is intended largely for ease of use for those new to unit testing. For production environments it is recommended that tests be driven by a continuous integration system such as [Buildbot](#), [Jenkins](#), [GitHub Actions](#), or [AppVeyor](#).

26.5.1 簡單范例

`unittest` 模組提供一系列豐富的工具用來建構與執行測試。本節將展示這一系列工具中一部份，它們已能滿足大部份使用者需求。

這是一段簡短的代碼用來測試 3 個字串方法：

```
import unittest

class TestStringMethods(unittest.TestCase):
```

(繼續下一頁)

(繼續上一頁)

```

def test_upper(self):
    self.assertEqual('foo'.upper(), 'FOO')

def test_isupper(self):
    self.assertTrue('FOO'.isupper())
    self.assertFalse('Foo'.isupper())

def test_split(self):
    s = 'hello world'
    self.assertEqual(s.split(), ['hello', 'world'])
    # check that s.split fails when the separator is not a string
    with self.assertRaises(TypeError):
        s.split(2)

if __name__ == '__main__':
    unittest.main()

```

測試用例 (testcase) 可以透過繼承 `unittest.TestCase` 類來建立。這定義了三個獨立的物件方法，名稱皆以 `test` 開頭。這樣的命名方式能告知 `test runner` 哪些物件方法定義的測試。

每個測試的關鍵呼叫 `assertEqual()` 來確認是否期望的結果；`assertTrue()` 或是 `assertFalse()` 用來驗證一個條件式；`assertRaises()` 用來驗證是否觸發一個特定的 `exception`。使用這些物件方法來取代 `assert` 陳述句，將能使 `test runner` 收集所有的測試結果並生成一個報表。

The `setUp()` and `tearDown()` methods allow you to define instructions that will be executed before and after each test method. They are covered in more detail in the section [Organizing test code](#).

最後將顯示一個簡單的方法去執行測試 `unittest.main()` 提供一個命令執行列介面測試本。當透過命令執行列執行，輸出結果將會像是：

```

...
-----
Ran 3 tests in 0.000s

OK

```

在測試時加入 `-v` 選項將指示 `unittest.main()` 提高 `verbosity` 層級，生成以下的輸出：

```

test_isupper (__main__.TestStringMethods.test_isupper) ... ok
test_split (__main__.TestStringMethods.test_split) ... ok
test_upper (__main__.TestStringMethods.test_upper) ... ok

-----
Ran 3 tests in 0.001s

OK

```

以上的例子顯示大多數使用 `unittest` 特徵足以滿足大多數日常測試的需求。接下來第一部分文件的剩余部分將繼續探索完整特徵設定。

在 3.11 版的變更: The behavior of returning a value from a test method (other than the default `None` value), is now deprecated.

26.5.2 命令執行列介面 (Command-Line Interface)

單元測試模組可以透過命令執行列執行測試模組，物件甚至個的測試方法：

```
python -m unittest test_module1 test_module2
python -m unittest test_module.TestClass
python -m unittest test_module.TestClass.test_method
```

你可以通過一個串列與任何模組名稱的組合，完全符合類與方法的名稱。

測試模組可以根據檔案路徑指定：

```
python -m unittest tests/test_something.py
```

這允許你使用 shell 檔案名稱補完功能 (filename completion) 來指定測試模組。給定的檔案路徑必須亦能被當作模組 `import`。此路徑轉成模組名稱的方式移除 `.py` 並將路徑分隔符 (path separator) 轉成 `.`。假如你的測試檔案無法被 `import` 成模組，你應該直接執行該測試檔案。

通過增加 `-v` 的旗標數，可以在你執行測試時得到更多細節 (更高的 verbosity)：

```
python -m unittest -v test_module
```

若執行時不代任何引數，將執行 *Test Discovery* (測試探索)：

```
python -m unittest
```

列出所有命令列選項：

```
python -m unittest -h
```

在 3.2 版的變更：在早期的版本可以個執行測試方法和不需要模組或是類。

命令列模式選項

unittest 支援以下命令列選項：

-b, --buffer

Standard output 與 standard error stream 將在測試執行被緩衝 (buffer)。這些輸出在測試通過時被。若是測試錯誤或失敗，這些輸出將會正常地被印出，且被加入至錯誤訊息中。

-c, --catch

Control-C 測試執行過程中等待正確的測試結果回報目前止所有的測試結果。第二個 Control-C 出一般例外 *KeyboardInterrupt*。

參照 *Signal Handling* 針對函式提供的功能。

-f, --failfast

在第一次錯誤或是失敗停止執行測試。

-k

Only run test methods and classes that match the pattern or substring. This option may be used multiple times, in which case all test cases that match any of the given patterns are included.

Patterns that contain a wildcard character (*) are matched against the test name using *fnmatch.fnmatchcase()*; otherwise simple case-sensitive substring matching is used.

Patterns are matched against the fully qualified test method name as imported by the test loader.

For example, `-k foo` matches `foo_tests.SomeTest.test_something`, `bar_tests.SomeTest.test_foo`, but not `bar_tests.FooTest.test_something`.

--locals

透過 `traceback` 顯示本地變數。

在 3.2 版新加入: 增加命令列模式選項 `-b`、`-c` 與 `-f`。

在 3.5 版新加入: 命令列選項 `--locals`。

在 3.7 版新加入: 命令列選項 `-k`。

對執行所有的專案或是一個子集合測試, 命令列模式可以可以被用來做測試探索。

26.5.3 Test Discovery (測試探索)

在 3.2 版新加入。

單元測試支援簡單的 `test discovery` (測試探索)。為了相容於測試探索, 所有的測試檔案都要是模組或是套件, 能從專案的最上層目錄中 `import` (代表它們的檔案名稱必須是有效的 `identifiers`)。

`Test discovery` (測試探索) 實作在 `TestLoader.discover()`, 但也可以被用於命令列模式。基本的命令列模式用法如下:

```
cd project_directory
python -m unittest discover
```

備註: `python -m unittest` 作快捷徑, 其功能相當於 `python -m unittest discover`。假如你想傳遞引數至探索測試的話, 一定要明確地加入 `discover` 子指令。

`discover` 子指令有以下幾個選項:

-v, --verbose

詳細 (verbose) 輸出

-s, --start-directory directory

開始尋找的資料夾 (預設 `.`)

-p, --pattern pattern

匹配測試檔案的模式 (預設 `test*.py`)

-t, --top-level-directory directory

專案的最高階層目錄 (defaults to start directory)

`-s`, `-p`, 和 `-t` 選項依照傳遞位置作引數排序順序。以下兩個命令列被視為等價:

```
python -m unittest discover -s project_directory -p "*_test.py"
python -m unittest discover project_directory "*_test.py"
```

As well as being a path it is possible to pass a package name, for example `myproject.subpackage.test`, as the start directory. The package name you supply will then be imported and its location on the filesystem will be used as the start directory.

警示: `Test discovery` loads tests by importing them. Once test discovery has found all the test files from the start directory you specify it turns the paths into package names to import. For example `foo/bar/baz.py` will be imported as `foo.bar.baz`.

If you have a package installed globally and attempt test discovery on a different copy of the package then the import *could* happen from the wrong place. If this happens test discovery will warn you and exit.

If you supply the start directory as a package name rather than a path to a directory then discover assumes that whichever location it imports from is the location you intended, so you will not get the warning.

Test modules and packages can customize test loading and discovery by through the *load_tests protocol*.

在 3.4 版的變更: Test discovery supports *namespace packages* for the start directory. Note that you need to specify the top level directory too (e.g. `python -m unittest discover -s root/namespace -t root`).

在 3.11 版的變更: *unittest* dropped the *namespace packages* support in Python 3.11. It has been broken since Python 3.7. Start directory and subdirectories containing tests must be regular package that have `__init__.py` file.

Directories containing start directory still can be a namespace package. In this case, you need to specify start directory as dotted package name, and target directory explicitly. For example:

```
# proj/ <-- current directory
#   namespace/
#     mypkg/
#       __init__.py
#       test_mypkg.py

python -m unittest discover -s namespace.mypkg -t .
```

26.5.4 Organizing test code

The basic building blocks of unit testing are *test cases* --- single scenarios that must be set up and checked for correctness. In *unittest*, test cases are represented by *unittest.TestCase* instances. To make your own test cases you must write subclasses of *TestCase* or use *FunctionTestCase*.

The testing code of a *TestCase* instance should be entirely self contained, such that it can be run either in isolation or in arbitrary combination with any number of other test cases.

The simplest *TestCase* subclass will simply implement a test method (i.e. a method whose name starts with `test`) in order to perform specific testing code:

```
import unittest

class DefaultWidgetSizeTestCase(unittest.TestCase):
    def test_default_widget_size(self):
        widget = Widget('The widget')
        self.assertEqual(widget.size(), (50, 50))
```

Note that in order to test something, we use one of the *assert* methods* provided by the *TestCase* base class. If the test fails, an exception will be raised with an explanatory message, and *unittest* will identify the test case as a *failure*. Any other exceptions will be treated as *errors*.

Tests can be numerous, and their set-up can be repetitive. Luckily, we can factor out set-up code by implementing a method called *setUp()*, which the testing framework will automatically call for every single test we run:

```
import unittest

class WidgetTestCase(unittest.TestCase):
    def setUp(self):
        self.widget = Widget('The widget')

    def test_default_widget_size(self):
        self.assertEqual(self.widget.size(), (50,50),
                         'incorrect default size')

    def test_widget_resize(self):
        self.widget.resize(100,150)
        self.assertEqual(self.widget.size(), (100,150),
                         'wrong size after resize')
```

備 F: The order in which the various tests will be run is determined by sorting the test method names with respect to the built-in ordering for strings.

If the `setUp()` method raises an exception while the test is running, the framework will consider the test to have suffered an error, and the test method will not be executed.

Similarly, we can provide a `tearDown()` method that tidies up after the test method has been run:

```
import unittest

class WidgetTestCase(unittest.TestCase):
    def setUp(self):
        self.widget = Widget('The widget')

    def tearDown(self):
        self.widget.dispose()
```

If `setUp()` succeeded, `tearDown()` will be run whether the test method succeeded or not.

Such a working environment for the testing code is called a *test fixture*. A new `TestCase` instance is created as a unique test fixture used to execute each individual test method. Thus `setUp()`, `tearDown()`, and `__init__()` will be called once per test.

It is recommended that you use `TestCase` implementations to group tests together according to the features they test. `unittest` provides a mechanism for this: the *test suite*, represented by `unittest`'s `TestSuite` class. In most cases, calling `unittest.main()` will do the right thing and collect all the module's test cases for you and execute them.

However, should you want to customize the building of your test suite, you can do it yourself:

```
def suite():
    suite = unittest.TestSuite()
    suite.addTest(WidgetTestCase('test_default_widget_size'))
    suite.addTest(WidgetTestCase('test_widget_resize'))
    return suite

if __name__ == '__main__':
    runner = unittest.TextTestRunner()
    runner.run(suite())
```

You can place the definitions of test cases and test suites in the same modules as the code they are to test (such as `widget.py`), but there are several advantages to placing the test code in a separate module, such as `test_widget.py`:

- The test module can be run standalone from the command line.
- The test code can more easily be separated from shipped code.
- There is less temptation to change test code to fit the code it tests without a good reason.
- Test code should be modified much less frequently than the code it tests.
- Tested code can be refactored more easily.
- Tests for modules written in C must be in separate modules anyway, so why not be consistent?
- If the testing strategy changes, there is no need to change the source code.

26.5.5 Re-using old test code

Some users will find that they have existing test code that they would like to run from `unittest`, without converting every old test function to a `TestCase` subclass.

For this reason, `unittest` provides a `FunctionTestCase` class. This subclass of `TestCase` can be used to wrap an existing test function. Set-up and tear-down functions can also be provided.

Given the following test function:

```
def testSomething():
    something = makeSomething()
    assert something.name is not None
    # ...
```

one can create an equivalent test case instance as follows, with optional set-up and tear-down methods:

```
testcase = unittest.FunctionTestCase(testSomething,
                                     setUp=makeSomethingDB,
                                     tearDown=deleteSomethingDB)
```

備 F: Even though `FunctionTestCase` can be used to quickly convert an existing test base over to a `unittest`-based system, this approach is not recommended. Taking the time to set up proper `TestCase` subclasses will make future test refactorings infinitely easier.

In some cases, the existing tests may have been written using the `doctest` module. If so, `doctest` provides a `DocTestSuite` class that can automatically build `unittest.TestSuite` instances from the existing `doctest`-based tests.

26.5.6 Skipping tests and expected failures

在 3.1 版新加入。

Unittest supports skipping individual test methods and even whole classes of tests. In addition, it supports marking a test as an "expected failure," a test that is broken and will fail, but shouldn't be counted as a failure on a `TestResult`.

Skipping a test is simply a matter of using the `skip() decorator` or one of its conditional variants, calling `TestCase.skipTest()` within a `setUp()` or test method, or raising `SkipTest` directly.

Basic skipping looks like this:

```
class MyTestCase(unittest.TestCase):

    @unittest.skip("demonstrating skipping")
    def test_nothing(self):
        self.fail("shouldn't happen")

    @unittest.skipIf(mylib.__version__ < (1, 3),
                    "not supported in this library version")
    def test_format(self):
        # Tests that work for only a certain version of the library.
        pass

    @unittest.skipUnless(sys.platform.startswith("win"), "requires Windows")
    def test_windows_support(self):
        # windows specific testing code
        pass

    def test_maybe_skipped(self):
        if not external_resource_available():
```

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```

self.skipTest("external resource not available")
# test code that depends on the external resource
pass

```

This is the output of running the example above in verbose mode:

```

test_format (__main__.MyTestCase.test_format) ... skipped 'not supported in this
↳ library version'
test_nothing (__main__.MyTestCase.test_nothing) ... skipped 'demonstrating skipping
↳ '
test_maybe_skipped (__main__.MyTestCase.test_maybe_skipped) ... skipped 'external
↳ resource not available'
test_windows_support (__main__.MyTestCase.test_windows_support) ... skipped
↳ 'requires Windows'

-----
Ran 4 tests in 0.005s

OK (skipped=4)

```

Classes can be skipped just like methods:

```

@unittest.skip("showing class skipping")
class MySkippedTestCase(unittest.TestCase):
    def test_not_run(self):
        pass

```

`TestCase.setUp()` can also skip the test. This is useful when a resource that needs to be set up is not available.

Expected failures use the `expectedFailure()` decorator.

```

class ExpectedFailureTestCase(unittest.TestCase):
    @unittest.expectedFailure
    def test_fail(self):
        self.assertEqual(1, 0, "broken")

```

It's easy to roll your own skipping decorators by making a decorator that calls `skip()` on the test when it wants it to be skipped. This decorator skips the test unless the passed object has a certain attribute:

```

def skipUnlessHasattr(obj, attr):
    if hasattr(obj, attr):
        return lambda func: func
    return unittest.skip("{} doesn't have {}".format(obj, attr))

```

The following decorators and exception implement test skipping and expected failures:

`@unittest.skip(reason)`

Unconditionally skip the decorated test. *reason* should describe why the test is being skipped.

`@unittest.skipIf(condition, reason)`

Skip the decorated test if *condition* is true.

`@unittest.skipUnless(condition, reason)`

Skip the decorated test unless *condition* is true.

`@unittest.expectedFailure`

Mark the test as an expected failure or error. If the test fails or errors in the test function itself (rather than in one of the *test fixture* methods) then it will be considered a success. If the test passes, it will be considered a failure.

exception `unittest.SkipTest(reason)`

This exception is raised to skip a test.

Usually you can use `TestCase.skipTest()` or one of the skipping decorators instead of raising this directly.

Skipped tests will not have `setUp()` or `tearDown()` run around them. Skipped classes will not have `setUpClass()` or `tearDownClass()` run. Skipped modules will not have `setUpModule()` or `tearDownModule()` run.

26.5.7 Distinguishing test iterations using subtests

在 3.4 版新加入。

When there are very small differences among your tests, for instance some parameters, unittest allows you to distinguish them inside the body of a test method using the `subTest()` context manager.

舉例來 F，以下測試：

```
class NumbersTest(unittest.TestCase):

    def test_even(self):
        """
        Test that numbers between 0 and 5 are all even.
        """
        for i in range(0, 6):
            with self.subTest(i=i):
                self.assertEqual(i % 2, 0)
```

會有以下輸出：

```
=====
FAIL: test_even (__main__.NumbersTest.test_even) (i=1)
Test that numbers between 0 and 5 are all even.
-----
Traceback (most recent call last):
  File "subtests.py", line 11, in test_even
    self.assertEqual(i % 2, 0)
    ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
AssertionError: 1 != 0

=====
FAIL: test_even (__main__.NumbersTest.test_even) (i=3)
Test that numbers between 0 and 5 are all even.
-----
Traceback (most recent call last):
  File "subtests.py", line 11, in test_even
    self.assertEqual(i % 2, 0)
    ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
AssertionError: 1 != 0

=====
FAIL: test_even (__main__.NumbersTest.test_even) (i=5)
Test that numbers between 0 and 5 are all even.
-----
Traceback (most recent call last):
  File "subtests.py", line 11, in test_even
    self.assertEqual(i % 2, 0)
    ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
AssertionError: 1 != 0
```

Without using a subtest, execution would stop after the first failure, and the error would be less easy to diagnose because the value of `i` wouldn't be displayed:

```
=====
FAIL: test_even (__main__.NumbersTest.test_even)
-----
Traceback (most recent call last):
  File "subtests.py", line 32, in test_even
    self.assertEqual(i % 2, 0)
AssertionError: 1 != 0
```

26.5.8 Classes and functions

This section describes in depth the API of `unittest`.

Test cases

class `unittest.TestCase` (*methodName*='runTest')

Instances of the `TestCase` class represent the logical test units in the `unittest` universe. This class is intended to be used as a base class, with specific tests being implemented by concrete subclasses. This class implements the interface needed by the test runner to allow it to drive the tests, and methods that the test code can use to check for and report various kinds of failure.

Each instance of `TestCase` will run a single base method: the method named *methodName*. In most uses of `TestCase`, you will neither change the *methodName* nor reimplement the default `runTest()` method.

在 3.2 版的變更: `TestCase` can be instantiated successfully without providing a *methodName*. This makes it easier to experiment with `TestCase` from the interactive interpreter.

`TestCase` instances provide three groups of methods: one group used to run the test, another used by the test implementation to check conditions and report failures, and some inquiry methods allowing information about the test itself to be gathered.

Methods in the first group (running the test) are:

setUp()

Method called to prepare the test fixture. This is called immediately before calling the test method; other than `AssertionError` or `SkipTest`, any exception raised by this method will be considered an error rather than a test failure. The default implementation does nothing.

tearDown()

Method called immediately after the test method has been called and the result recorded. This is called even if the test method raised an exception, so the implementation in subclasses may need to be particularly careful about checking internal state. Any exception, other than `AssertionError` or `SkipTest`, raised by this method will be considered an additional error rather than a test failure (thus increasing the total number of reported errors). This method will only be called if the `setUp()` succeeds, regardless of the outcome of the test method. The default implementation does nothing.

setUpClass()

A class method called before tests in an individual class are run. `setUpClass` is called with the class as the only argument and must be decorated as a `classmethod()`:

```
@classmethod
def setUpClass(cls):
    ...
```

更多細節請見 *Class and Module Fixtures*。

在 3.2 版新加入。

tearDownClass()

A class method called after tests in an individual class have run. `tearDownClass` is called with the class as the only argument and must be decorated as a `classmethod()`:

```
@classmethod
def tearDownClass(cls):
    ...
```

更多細節請見 *Class and Module Fixtures*。

在 3.2 版新加入。

run (*result=None*)

Run the test, collecting the result into the `TestResult` object passed as *result*. If *result* is omitted or `None`, a temporary result object is created (by calling the `defaultTestResult()` method) and used. The result object is returned to `run()`'s caller.

The same effect may be had by simply calling the `TestCase` instance.

在 3.3 版的變更: Previous versions of `run` did not return the result. Neither did calling an instance.

skipTest (*reason*)

Calling this during a test method or `setUp()` skips the current test. See *Skipping tests and expected failures* for more information.

在 3.1 版新加入。

subTest (*msg=None, **params*)

Return a context manager which executes the enclosed code block as a subtest. *msg* and *params* are optional, arbitrary values which are displayed whenever a subtest fails, allowing you to identify them clearly.

A test case can contain any number of subtest declarations, and they can be arbitrarily nested.

更多資訊請見 *Distinguishing test iterations using subtests*。

在 3.4 版新加入。

debug ()

Run the test without collecting the result. This allows exceptions raised by the test to be propagated to the caller, and can be used to support running tests under a debugger.

The `TestCase` class provides several assert methods to check for and report failures. The following table lists the most commonly used methods (see the tables below for more assert methods):

Method	Checks that	New in
<code>assertEqual(a, b)</code>	<code>a == b</code>	
<code>assertNotEqual(a, b)</code>	<code>a != b</code>	
<code>assertTrue(x)</code>	<code>bool(x)</code> is True	
<code>assertFalse(x)</code>	<code>bool(x)</code> is False	
<code>assertIs(a, b)</code>	<code>a is b</code>	3.1
<code>assertIsNot(a, b)</code>	<code>a is not b</code>	3.1
<code>assertIsNone(x)</code>	<code>x is None</code>	3.1
<code>assertIsNotNone(x)</code>	<code>x is not None</code>	3.1
<code>assertIn(a, b)</code>	<code>a in b</code>	3.1
<code>assertNotIn(a, b)</code>	<code>a not in b</code>	3.1
<code>assertIsInstance(a, b)</code>	<code>isinstance(a, b)</code>	3.2
<code>assertNotIsInstance(a, b)</code>	<code>not isinstance(a, b)</code>	3.2

All the assert methods accept a *msg* argument that, if specified, is used as the error message on failure (see also `longMessage`). Note that the *msg* keyword argument can be passed to `assertRaises()`, `assertRaisesRegex()`, `assertWarns()`, `assertWarnsRegex()` only when they are used as a context manager.

assertEqual (*first, second, msg=None*)

Test that *first* and *second* are equal. If the values do not compare equal, the test will fail.

In addition, if *first* and *second* are the exact same type and one of list, tuple, dict, set, frozenset or str or any type that a subclass registers with `addTypeEqualityFunc()` the type-specific equality function will be called in order to generate a more useful default error message (see also the *list of type-specific methods*).

在 3.1 版的變更: Added the automatic calling of type-specific equality function.

在 3.2 版的變更: `assertMultiLineEqual()` added as the default type equality function for comparing strings.

assertNotEqual (*first, second, msg=None*)

Test that *first* and *second* are not equal. If the values do compare equal, the test will fail.

assertTrue (*expr, msg=None*)

assertFalse (*expr, msg=None*)

Test that *expr* is true (or false).

Note that this is equivalent to `bool(expr) is True` and not to `expr is True` (use `assertIs(expr, True)` for the latter). This method should also be avoided when more specific methods are available (e.g. `assertEqual(a, b)` instead of `assertTrue(a == b)`), because they provide a better error message in case of failure.

assertIs (*first, second, msg=None*)

assertIsNot (*first, second, msg=None*)

Test that *first* and *second* are (or are not) the same object.

在 3.1 版新加入.

assertIsNone (*expr, msg=None*)

assertIsNotNone (*expr, msg=None*)

Test that *expr* is (or is not) None.

在 3.1 版新加入.

assertIn (*member, container, msg=None*)

assertNotIn (*member, container, msg=None*)

Test that *member* is (or is not) in *container*.

在 3.1 版新加入.

assertIsInstance (*obj, cls, msg=None*)

assertNotIsInstance (*obj, cls, msg=None*)

Test that *obj* is (or is not) an instance of *cls* (which can be a class or a tuple of classes, as supported by `isinstance()`). To check for the exact type, use `assertIs(type(obj), cls)`.

在 3.2 版新加入.

It is also possible to check the production of exceptions, warnings, and log messages using the following methods:

Method	Checks that	New in
<code>assertRaises(exc, fun, *args, **kwargs)</code>	<code>fun(*args, **kwargs)</code> raises <code>exc</code>	
<code>assertRaisesRegex(exc, r, fun, *args, **kwargs)</code>	<code>fun(*args, **kwargs)</code> raises <code>exc</code> and the message matches regex <code>r</code>	3.1
<code>assertWarns(warn, fun, *args, **kwargs)</code>	<code>fun(*args, **kwargs)</code> raises <code>warn</code>	3.2
<code>assertWarnsRegex(warn, r, fun, *args, **kwargs)</code>	<code>fun(*args, **kwargs)</code> raises <code>warn</code> and the message matches regex <code>r</code>	3.2
<code>assertLogs(logger, level)</code>	The <code>with</code> block logs on <code>logger</code> with minimum <code>level</code>	3.4
<code>assertNoLogs(logger, level)</code>	The <code>with</code> block does not log on <code>logger</code> with minimum <code>level</code>	3.10

assertRaises (*exception*, *callable*, **args*, ***kwargs*)

assertRaises (*exception*, *, *msg*=None)

Test that an exception is raised when *callable* is called with any positional or keyword arguments that are also passed to `assertRaises()`. The test passes if *exception* is raised, is an error if another exception is raised, or fails if no exception is raised. To catch any of a group of exceptions, a tuple containing the exception classes may be passed as *exception*.

If only the *exception* and possibly the *msg* arguments are given, return a context manager so that the code under test can be written inline rather than as a function:

```
with self.assertRaises(SomeException):
    do_something()
```

When used as a context manager, `assertRaises()` accepts the additional keyword argument *msg*.

The context manager will store the caught exception object in its `exception` attribute. This can be useful if the intention is to perform additional checks on the exception raised:

```
with self.assertRaises(SomeException) as cm:
    do_something()

the_exception = cm.exception
self.assertEqual(the_exception.error_code, 3)
```

在 3.1 版的變更: Added the ability to use `assertRaises()` as a context manager.

在 3.2 版的變更: 新增 `exception` 屬性。

在 3.3 版的變更: Added the *msg* keyword argument when used as a context manager.

assertRaisesRegex (*exception*, *regex*, *callable*, **args*, ***kwargs*)

assertRaisesRegex (*exception*, *regex*, *, *msg*=None)

Like `assertRaises()` but also tests that *regex* matches on the string representation of the raised exception. *regex* may be a regular expression object or a string containing a regular expression suitable for use by `re.search()`. Examples:

```
self.assertRaisesRegex(ValueError, "invalid literal for.*XYZ'",
                        int, 'XYZ')
```

或是:

```
with self.assertRaisesRegex(ValueError, 'literal'):
    int('XYZ')
```

在 3.1 版新加入: Added under the name `assertRaisesRegexp`.

在 3.2 版的變更: 重新命名 `assertRaisesRegexp()`。

在 3.3 版的變更: Added the `msg` keyword argument when used as a context manager.

assertWarns (*warning, callable, *args, **kws*)

assertWarns (*warning, *, msg=None*)

Test that a warning is triggered when *callable* is called with any positional or keyword arguments that are also passed to `assertWarns()`. The test passes if *warning* is triggered and fails if it isn't. Any exception is an error. To catch any of a group of warnings, a tuple containing the warning classes may be passed as *warnings*.

If only the *warning* and possibly the *msg* arguments are given, return a context manager so that the code under test can be written inline rather than as a function:

```
with self.assertWarns(SomeWarning):
    do_something()
```

When used as a context manager, `assertWarns()` accepts the additional keyword argument *msg*.

The context manager will store the caught warning object in its *warning* attribute, and the source line which triggered the warnings in the *filename* and *lineno* attributes. This can be useful if the intention is to perform additional checks on the warning caught:

```
with self.assertWarns(SomeWarning) as cm:
    do_something()

self.assertIn('myfile.py', cm.filename)
self.assertEqual(320, cm.lineno)
```

This method works regardless of the warning filters in place when it is called.

在 3.2 版新加入.

在 3.3 版的變更: Added the *msg* keyword argument when used as a context manager.

assertWarnsRegex (*warning, regex, callable, *args, **kws*)

assertWarnsRegex (*warning, regex, *, msg=None*)

Like `assertWarns()` but also tests that *regex* matches on the message of the triggered warning. *regex* may be a regular expression object or a string containing a regular expression suitable for use by `re.search()`. Example:

```
self.assertWarnsRegex(DeprecationWarning,
    r'legacy_function\(\) is deprecated',
    legacy_function, 'XYZ')
```

或是:

```
with self.assertWarnsRegex(RuntimeWarning, 'unsafe frobnicating'):
    frobnicate('/etc/passwd')
```

在 3.2 版新加入.

在 3.3 版的變更: Added the *msg* keyword argument when used as a context manager.

assertLogs (*logger=None, level=None*)

A context manager to test that at least one message is logged on the *logger* or one of its children, with at least the given *level*.

If given, *logger* should be a `logging.Logger` object or a `str` giving the name of a logger. The default is the root logger, which will catch all messages that were not blocked by a non-propagating descendent logger.

If given, *level* should be either a numeric logging level or its string equivalent (for example either "ERROR" or `logging.ERROR`). The default is `logging.INFO`.

The test passes if at least one message emitted inside the `with` block matches the *logger* and *level* conditions, otherwise it fails.

The object returned by the context manager is a recording helper which keeps tracks of the matching log messages. It has two attributes:

records

A list of `logging.LogRecord` objects of the matching log messages.

output

A list of `str` objects with the formatted output of matching messages.

範例:

```
with self.assertLogs('foo', level='INFO') as cm:
    logging.getLogger('foo').info('first message')
    logging.getLogger('foo.bar').error('second message')
self.assertEqual(cm.output, ['INFO:foo:first message',
                             'ERROR:foo.bar:second message'])
```

在 3.4 版新加入。

assertNoLogs (*logger=None, level=None*)

A context manager to test that no messages are logged on the *logger* or one of its children, with at least the given *level*.

If given, *logger* should be a `logging.Logger` object or a `str` giving the name of a logger. The default is the root logger, which will catch all messages.

If given, *level* should be either a numeric logging level or its string equivalent (for example either "ERROR" or `logging.ERROR`). The default is `logging.INFO`.

Unlike `assertLogs()`, nothing will be returned by the context manager.

在 3.10 版新加入。

There are also other methods used to perform more specific checks, such as:

Method	Checks that	New in
<code>assertAlmostEqual(a, b)</code>	<code>round(a-b, 7) == 0</code>	
<code>assertNotAlmostEqual(a, b)</code>	<code>round(a-b, 7) != 0</code>	
<code>assertGreater(a, b)</code>	<code>a > b</code>	3.1
<code>assertGreaterEqual(a, b)</code>	<code>a >= b</code>	3.1
<code>assertLess(a, b)</code>	<code>a < b</code>	3.1
<code>assertLessEqual(a, b)</code>	<code>a <= b</code>	3.1
<code>assertRegex(s, r)</code>	<code>r.search(s)</code>	3.1
<code>assertNotRegex(s, r)</code>	<code>not r.search(s)</code>	3.2
<code>assertCountEqual(a, b)</code>	<i>a</i> and <i>b</i> have the same elements in the same number, regardless of their order.	3.2

assertAlmostEqual (*first, second, places=7, msg=None, delta=None*)

assertNotAlmostEqual (*first, second, places=7, msg=None, delta=None*)

Test that *first* and *second* are approximately (or not approximately) equal by computing the difference, rounding to the given number of decimal *places* (default 7), and comparing to zero. Note that these methods round the values to the given number of *decimal places* (i.e. like the `round()` function) and not *significant digits*.

If *delta* is supplied instead of *places* then the difference between *first* and *second* must be less or equal to (or greater than) *delta*.

Supplying both *delta* and *places* raises a `TypeError`.

在 3.2 版的變更: `assertAlmostEqual()` automatically considers almost equal objects that compare equal. `assertNotAlmostEqual()` automatically fails if the objects compare equal. Added the *delta* keyword argument.

assertGreater (*first, second, msg=None*)

assertGreaterEqual (*first, second, msg=None*)

assertLess (*first, second, msg=None*)

assertLessEqual (*first, second, msg=None*)

Test that *first* is respectively `>`, `>=`, `<` or `<=` than *second* depending on the method name. If not, the test will fail:

```
>>> self.assertGreaterEqual(3, 4)
AssertionError: "3" unexpectedly not greater than or equal to "4"
```

在 3.1 版新加入。

assertRegex (*text, regex, msg=None*)

assertNotRegex (*text, regex, msg=None*)

Test that a *regex* search matches (or does not match) *text*. In case of failure, the error message will include the pattern and the *text* (or the pattern and the part of *text* that unexpectedly matched). *regex* may be a regular expression object or a string containing a regular expression suitable for use by `re.search()`.

在 3.1 版新加入: Added under the name `assertRegexpMatches`.

在 3.2 版的變更: The method `assertRegexpMatches()` has been renamed to `assertRegex()`.

在 3.2 版新加入: `assertNotRegex()`。

在 3.5 版新加入: The name `assertNotRegexpMatches` is a deprecated alias for `assertNotRegex()`.

assertCountEqual (*first, second, msg=None*)

Test that sequence *first* contains the same elements as *second*, regardless of their order. When they don't, an error message listing the differences between the sequences will be generated.

Duplicate elements are *not* ignored when comparing *first* and *second*. It verifies whether each element has the same count in both sequences. Equivalent to: `assertEqual(Counter(list(first)), Counter(list(second)))` but works with sequences of unhashable objects as well.

在 3.2 版新加入。

The `assertEqual()` method dispatches the equality check for objects of the same type to different type-specific methods. These methods are already implemented for most of the built-in types, but it's also possible to register new methods using `addTypeEqualityFunc()`:

addTypeEqualityFunc (*typeobj, function*)

Registers a type-specific method called by `assertEqual()` to check if two objects of exactly the same *typeobj* (not subclasses) compare equal. *function* must take two positional arguments and a third `msg=None` keyword argument just as `assertEqual()` does. It must raise `self.failureException(msg)` when inequality between the first two parameters is detected -- possibly providing useful information and explaining the inequalities in details in the error message.

在 3.1 版新加入。

The list of type-specific methods automatically used by `assertEqual()` are summarized in the following table. Note that it's usually not necessary to invoke these methods directly.

Method	Used to compare	New in
<code>assertMultiLineEqual(a, b)</code>	strings	3.1
<code>assertSequenceEqual(a, b)</code>	sequences	3.1
<code>assertListEqual(a, b)</code>	lists	3.1
<code>assertTupleEqual(a, b)</code>	tuples	3.1
<code>assertSetEqual(a, b)</code>	sets or frozensets	3.1
<code>assertDictEqual(a, b)</code>	dicts	3.1

assertMultiLineEqual (*first, second, msg=None*)

Test that the multiline string *first* is equal to the string *second*. When not equal a diff of the two strings highlighting the differences will be included in the error message. This method is used by default when comparing strings with `assertEqual()`.

在 3.1 版新加入。

assertSequenceEqual (*first, second, msg=None, seq_type=None*)

Tests that two sequences are equal. If a *seq_type* is supplied, both *first* and *second* must be instances of *seq_type* or a failure will be raised. If the sequences are different an error message is constructed that shows the difference between the two.

This method is not called directly by `assertEqual()`, but it's used to implement `assertListEqual()` and `assertTupleEqual()`.

在 3.1 版新加入。

assertListEqual (*first, second, msg=None*)

assertTupleEqual (*first, second, msg=None*)

Tests that two lists or tuples are equal. If not, an error message is constructed that shows only the differences between the two. An error is also raised if either of the parameters are of the wrong type. These methods are used by default when comparing lists or tuples with `assertEqual()`.

在 3.1 版新加入。

assertSetEqual (*first, second, msg=None*)

Tests that two sets are equal. If not, an error message is constructed that lists the differences between the sets. This method is used by default when comparing sets or frozensets with `assertEqual()`.

Fails if either of *first* or *second* does not have a `set.difference()` method.

在 3.1 版新加入。

assertDictEqual (*first, second, msg=None*)

Test that two dictionaries are equal. If not, an error message is constructed that shows the differences in the dictionaries. This method will be used by default to compare dictionaries in calls to `assertEqual()`.

在 3.1 版新加入。

Finally the `TestCase` provides the following methods and attributes:

fail (*msg=None*)

Signals a test failure unconditionally, with *msg* or `None` for the error message.

failureException

This class attribute gives the exception raised by the test method. If a test framework needs to use a specialized exception, possibly to carry additional information, it must subclass this exception in order to "play fair" with the framework. The initial value of this attribute is `AssertionError`.

longMessage

This class attribute determines what happens when a custom failure message is passed as the `msg` argument to an `assertXXX` call that fails. `True` is the default value. In this case, the custom message is appended to the end of the standard failure message. When set to `False`, the custom message replaces the standard message.

The class setting can be overridden in individual test methods by assigning an instance attribute, `self.longMessage`, to `True` or `False` before calling the assert methods.

The class setting gets reset before each test call.

在 3.1 版新加入。

maxDiff

This attribute controls the maximum length of diffs output by assert methods that report diffs on failure. It defaults to 80*8 characters. Assert methods affected by this attribute are `assertSequenceEqual()` (including all the sequence comparison methods that delegate to it), `assertDictEqual()` and `assertMultiLineEqual()`.

Setting `maxDiff` to `None` means that there is no maximum length of diffs.

在 3.2 版新加入。

Testing frameworks can use the following methods to collect information on the test:

countTestCases()

Return the number of tests represented by this test object. For `TestCase` instances, this will always be 1.

defaultTestResult()

Return an instance of the test result class that should be used for this test case class (if no other result instance is provided to the `run()` method).

For `TestCase` instances, this will always be an instance of `TestResult`; subclasses of `TestCase` should override this as necessary.

id()

Return a string identifying the specific test case. This is usually the full name of the test method, including the module and class name.

shortDescription()

Returns a description of the test, or `None` if no description has been provided. The default implementation of this method returns the first line of the test method's docstring, if available, or `None`.

在 3.1 版的變更: In 3.1 this was changed to add the test name to the short description even in the presence of a docstring. This caused compatibility issues with unittest extensions and adding the test name was moved to the `TextTestResult` in Python 3.2.

addCleanup(function, /, *args, **kwargs)

Add a function to be called after `tearDown()` to cleanup resources used during the test. Functions will be called in reverse order to the order they are added (LIFO). They are called with any arguments and keyword arguments passed into `addCleanup()` when they are added.

If `setUp()` fails, meaning that `tearDown()` is not called, then any cleanup functions added will still be called.

在 3.1 版新加入。

enterContext(cm)

Enter the supplied *context manager*. If successful, also add its `__exit__()` method as a cleanup function by `addCleanup()` and return the result of the `__enter__()` method.

在 3.11 版新加入。

doCleanups()

This method is called unconditionally after `tearDown()`, or after `setUp()` if `setUp()` raises an exception.

It is responsible for calling all the cleanup functions added by `addCleanup()`. If you need cleanup functions to be called *prior* to `tearDown()` then you can call `doCleanups()` yourself.

`doCleanups()` pops methods off the stack of cleanup functions one at a time, so it can be called at any time.

在 3.1 版新加入。

classmethod addClassCleanup(function, /, *args, **kwargs)

Add a function to be called after `tearDownClass()` to cleanup resources used during the test class. Functions will be called in reverse order to the order they are added (LIFO). They are called with any arguments and keyword arguments passed into `addClassCleanup()` when they are added.

If `setUpClass()` fails, meaning that `tearDownClass()` is not called, then any cleanup functions added will still be called.

在 3.8 版新加入。

classmethod enterClassContext(cm)

Enter the supplied *context manager*. If successful, also add its `__exit__()` method as a cleanup function by `addClassCleanup()` and return the result of the `__enter__()` method.

在 3.11 版新加入。

classmethod doClassCleanups()

This method is called unconditionally after `tearDownClass()`, or after `setUpClass()` if `setUpClass()` raises an exception.

It is responsible for calling all the cleanup functions added by `addClassCleanup()`. If you need cleanup functions to be called *prior* to `tearDownClass()` then you can call `doClassCleanups()` yourself.

`doClassCleanups()` pops methods off the stack of cleanup functions one at a time, so it can be called at any time.

在 3.8 版新加入。

class unittest.IsolatedAsyncioTestCase(methodName='runTest')

This class provides an API similar to `TestCase` and also accepts coroutines as test functions.

在 3.8 版新加入。

coroutine asyncSetUp()

Method called to prepare the test fixture. This is called after `setUp()`. This is called immediately before calling the test method; other than `AssertionError` or `SkipTest`, any exception raised by this method will be considered an error rather than a test failure. The default implementation does nothing.

coroutine asyncTearDown()

Method called immediately after the test method has been called and the result recorded. This is called before `tearDown()`. This is called even if the test method raised an exception, so the implementation in subclasses may need to be particularly careful about checking internal state. Any exception, other than `AssertionError` or `SkipTest`, raised by this method will be considered an additional error rather than a test failure (thus increasing the total number of reported errors). This method will only be called if the `asyncSetUp()` succeeds, regardless of the outcome of the test method. The default implementation does nothing.

addAsyncCleanup(function, /, *args, **kwargs)

This method accepts a coroutine that can be used as a cleanup function.

coroutine `enterAsyncContext(cm)`

Enter the supplied *asynchronous context manager*. If successful, also add its `__aexit__()` method as a cleanup function by `addAsyncCleanup()` and return the result of the `__aenter__()` method.

在 3.11 版新加入。

run (`result=None`)

Sets up a new event loop to run the test, collecting the result into the *TestResult* object passed as *result*. If *result* is omitted or `None`, a temporary result object is created (by calling the `defaultTestResult()` method) and used. The result object is returned to `run()`'s caller. At the end of the test all the tasks in the event loop are cancelled.

An example illustrating the order:

```
from unittest import IsolatedAsyncioTestCase

events = []

class Test(IsolatedAsyncioTestCase):

    def setUp(self):
        events.append("setUp")

    async def asyncSetUp(self):
        self._async_connection = await AsyncConnection()
        events.append("asyncSetUp")

    async def test_response(self):
        events.append("test_response")
        response = await self._async_connection.get("https://example.com")
        self.assertEqual(response.status_code, 200)
        self.addAsyncCleanup(self.on_cleanup)

    def tearDown(self):
        events.append("tearDown")

    async def asyncTearDown(self):
        await self._async_connection.close()
        events.append("asyncTearDown")

    async def on_cleanup(self):
        events.append("cleanup")

if __name__ == "__main__":
    unittest.main()
```

After running the test, `events` would contain `["setUp", "asyncSetUp", "test_response", "asyncTearDown", "tearDown", "cleanup"]`.

class `unittest.FunctionTestCase` (*testFunc*, *setUp=None*, *tearDown=None*, *description=None*)

This class implements the portion of the *TestCase* interface which allows the test runner to drive the test, but does not provide the methods which test code can use to check and report errors. This is used to create test cases using legacy test code, allowing it to be integrated into a *unittest*-based test framework.

Deprecated aliases

For historical reasons, some of the `TestCase` methods had one or more aliases that are now deprecated. The following table lists the correct names along with their deprecated aliases:

Method Name	Deprecated alias	Deprecated alias
<code>assertEqual()</code>	<code>failUnlessEqual</code>	<code>assertEquals</code>
<code>assertNotEqual()</code>	<code>failIfEqual</code>	<code>assertNotEquals</code>
<code>assertTrue()</code>	<code>failUnless</code>	<code>assert_</code>
<code>assertFalse()</code>	<code>failIf</code>	
<code>assertRaises()</code>	<code>failUnlessRaises</code>	
<code>assertAlmostEqual()</code>	<code>failUnlessAlmostEqual</code>	<code>assertAlmostEquals</code>
<code>assertNotAlmostEqual()</code>	<code>failIfAlmostEqual</code>	<code>assertNotAlmostEquals</code>
<code>assertRegex()</code>		<code>assertRegexpMatches</code>
<code>assertNotRegex()</code>		<code>assertNotRegexpMatches</code>
<code>assertRaisesRegex()</code>		<code>assertRaisesRegexp</code>

在 3.1 版之後被 用: The `fail*` aliases listed in the second column have been deprecated.

在 3.2 版之後被 用: The `assert*` aliases listed in the third column have been deprecated.

在 3.2 版之後被 用: `assertRegexpMatches` and `assertRaisesRegexp` have been renamed to `assertRegex()` and `assertRaisesRegex()`.

在 3.5 版之後被 用: The `assertNotRegexpMatches` name is deprecated in favor of `assertNotRegex()`.

Grouping tests

class `unittest.TestSuite (tests=())`

This class represents an aggregation of individual test cases and test suites. The class presents the interface needed by the test runner to allow it to be run as any other test case. Running a `TestSuite` instance is the same as iterating over the suite, running each test individually.

If `tests` is given, it must be an iterable of individual test cases or other test suites that will be used to build the suite initially. Additional methods are provided to add test cases and suites to the collection later on.

`TestSuite` objects behave much like `TestCase` objects, except they do not actually implement a test. Instead, they are used to aggregate tests into groups of tests that should be run together. Some additional methods are available to add tests to `TestSuite` instances:

addTest (`test`)

Add a `TestCase` or `TestSuite` to the suite.

addTests (`tests`)

Add all the tests from an iterable of `TestCase` and `TestSuite` instances to this test suite.

This is equivalent to iterating over `tests`, calling `addTest()` for each element.

`TestSuite` shares the following methods with `TestCase`:

run (`result`)

Run the tests associated with this suite, collecting the result into the test result object passed as `result`. Note that unlike `TestCase.run()`, `TestSuite.run()` requires the result object to be passed in.

debug ()

Run the tests associated with this suite without collecting the result. This allows exceptions raised by the test to be propagated to the caller and can be used to support running tests under a debugger.

countTestCases()

Return the number of tests represented by this test object, including all individual tests and sub-suites.

__iter__()

Tests grouped by a *TestSuite* are always accessed by iteration. Subclasses can lazily provide tests by overriding `__iter__()`. Note that this method may be called several times on a single suite (for example when counting tests or comparing for equality) so the tests returned by repeated iterations before *TestSuite.run()* must be the same for each call iteration. After *TestSuite.run()*, callers should not rely on the tests returned by this method unless the caller uses a subclass that overrides *TestSuite._removeTestAtIndex()* to preserve test references.

在 3.2 版的變更: In earlier versions the *TestSuite* accessed tests directly rather than through iteration, so overriding `__iter__()` wasn't sufficient for providing tests.

在 3.4 版的變更: In earlier versions the *TestSuite* held references to each *TestCase* after *TestSuite.run()*. Subclasses can restore that behavior by overriding *TestSuite._removeTestAtIndex()*.

In the typical usage of a *TestSuite* object, the *run()* method is invoked by a *TestRunner* rather than by the end-user test harness.

Loading and running tests

class unittest.TestLoader

The *TestLoader* class is used to create test suites from classes and modules. Normally, there is no need to create an instance of this class; the *unittest* module provides an instance that can be shared as *unittest.defaultTestLoader*. Using a subclass or instance, however, allows customization of some configurable properties.

TestLoader objects have the following attributes:

errors

A list of the non-fatal errors encountered while loading tests. Not reset by the loader at any point. Fatal errors are signalled by the relevant method raising an exception to the caller. Non-fatal errors are also indicated by a synthetic test that will raise the original error when run.

在 3.5 版新加入.

TestLoader objects have the following methods:

loadTestsFromTestCase(testCaseClass)

Return a suite of all test cases contained in the *TestCase*-derived *testCaseClass*.

A test case instance is created for each method named by *getTestCaseNames()*. By default these are the method names beginning with *test*. If *getTestCaseNames()* returns no methods, but the *runTest()* method is implemented, a single test case is created for that method instead.

loadTestsFromModule(module, pattern=None)

Return a suite of all test cases contained in the given module. This method searches *module* for classes derived from *TestCase* and creates an instance of the class for each test method defined for the class.

備[Ⓕ]: While using a hierarchy of *TestCase*-derived classes can be convenient in sharing fixtures and helper functions, defining test methods on base classes that are not intended to be instantiated directly does not play well with this method. Doing so, however, can be useful when the fixtures are different and defined in subclasses.

If a module provides a *load_tests* function it will be called to load the tests. This allows modules to customize test loading. This is the *load_tests protocol*. The *pattern* argument is passed as the third argument to *load_tests*.

在 3.2 版的變更: Support for *load_tests* added.

在 3.5 版的變更: The undocumented and unofficial `use_load_tests` default argument is deprecated and ignored, although it is still accepted for backward compatibility. The method also now accepts a keyword-only argument `pattern` which is passed to `load_tests` as the third argument.

loadTestsFromName (*name*, *module=None*)

Return a suite of all test cases given a string specifier.

The specifier *name* is a "dotted name" that may resolve either to a module, a test case class, a test method within a test case class, a `TestSuite` instance, or a callable object which returns a `TestCase` or `TestSuite` instance. These checks are applied in the order listed here; that is, a method on a possible test case class will be picked up as "a test method within a test case class", rather than "a callable object".

For example, if you have a module `SampleTests` containing a `TestCase`-derived class `SampleTestCase` with three test methods (`test_one()`, `test_two()`, and `test_three()`), the specifier `'SampleTests.SampleTestCase'` would cause this method to return a suite which will run all three test methods. Using the specifier `'SampleTests.SampleTestCase.test_two'` would cause it to return a test suite which will run only the `test_two()` test method. The specifier can refer to modules and packages which have not been imported; they will be imported as a side-effect.

The method optionally resolves *name* relative to the given *module*.

在 3.5 版的變更: If an `ImportError` or `AttributeError` occurs while traversing *name* then a synthetic test that raises that error when run will be returned. These errors are included in the errors accumulated by `self.errors`.

loadTestsFromNames (*names*, *module=None*)

Similar to `loadTestsFromName()`, but takes a sequence of names rather than a single name. The return value is a test suite which supports all the tests defined for each name.

getTestCaseNames (*testCaseClass*)

Return a sorted sequence of method names found within *testCaseClass*; this should be a subclass of `TestCase`.

discover (*start_dir*, *pattern='test*.py'*, *top_level_dir=None*)

Find all the test modules by recursing into subdirectories from the specified start directory, and return a `TestSuite` object containing them. Only test files that match *pattern* will be loaded. (Using shell style pattern matching.) Only module names that are importable (i.e. are valid Python identifiers) will be loaded.

All test modules must be importable from the top level of the project. If the start directory is not the top level directory then the top level directory must be specified separately.

If importing a module fails, for example due to a syntax error, then this will be recorded as a single error and discovery will continue. If the import failure is due to `SkipTest` being raised, it will be recorded as a skip instead of an error.

If a package (a directory containing a file named `__init__.py`) is found, the package will be checked for a `load_tests` function. If this exists then it will be called `package.load_tests(loader, tests, pattern)`. Test discovery takes care to ensure that a package is only checked for tests once during an invocation, even if the `load_tests` function itself calls `loader.discover`.

If `load_tests` exists then discovery does *not* recurse into the package, `load_tests` is responsible for loading all tests in the package.

The pattern is deliberately not stored as a loader attribute so that packages can continue discovery themselves. *top_level_dir* is stored so `load_tests` does not need to pass this argument in to `loader.discover()`.

start_dir can be a dotted module name as well as a directory.

在 3.2 版新加入.

在 3.4 版的變更: Modules that raise `SkipTest` on import are recorded as skips, not errors.

在 3.4 版的變更: *start_dir* can be a *namespace packages*.

在 3.4 版的變更: Paths are sorted before being imported so that execution order is the same even if the underlying file system's ordering is not dependent on file name.

在 3.5 版的變更: Found packages are now checked for `load_tests` regardless of whether their path matches *pattern*, because it is impossible for a package name to match the default pattern.

在 3.11 版的變更: *start_dir* can not be a *namespace packages*. It has been broken since Python 3.7 and Python 3.11 officially remove it.

The following attributes of a *TestLoader* can be configured either by subclassing or assignment on an instance:

testMethodPrefix

String giving the prefix of method names which will be interpreted as test methods. The default value is 'test'.

This affects *getTestCaseNames()* and all the `loadTestsFrom*` methods.

sortTestMethodsUsing

Function to be used to compare method names when sorting them in *getTestCaseNames()* and all the `loadTestsFrom*` methods.

suiteClass

Callable object that constructs a test suite from a list of tests. No methods on the resulting object are needed. The default value is the *TestSuite* class.

This affects all the `loadTestsFrom*` methods.

testNamePatterns

List of Unix shell-style wildcard test name patterns that test methods have to match to be included in test suites (see `-k` option).

If this attribute is not `None` (the default), all test methods to be included in test suites must match one of the patterns in this list. Note that matches are always performed using *fnmatch.fnmatchcase()*, so unlike patterns passed to the `-k` option, simple substring patterns will have to be converted using `*` wildcards.

This affects all the `loadTestsFrom*` methods.

在 3.7 版新加入.

class unittest.TestResult

This class is used to compile information about which tests have succeeded and which have failed.

A *TestResult* object stores the results of a set of tests. The *TestCase* and *TestSuite* classes ensure that results are properly recorded; test authors do not need to worry about recording the outcome of tests.

Testing frameworks built on top of *unittest* may want access to the *TestResult* object generated by running a set of tests for reporting purposes; a *TestResult* instance is returned by the `TestRunner.run()` method for this purpose.

TestResult instances have the following attributes that will be of interest when inspecting the results of running a set of tests:

errors

A list containing 2-tuples of *TestCase* instances and strings holding formatted tracebacks. Each tuple represents a test which raised an unexpected exception.

failures

A list containing 2-tuples of *TestCase* instances and strings holding formatted tracebacks. Each tuple represents a test where a failure was explicitly signalled using the *assert* methods*.

skipped

A list containing 2-tuples of *TestCase* instances and strings holding the reason for skipping the test.

在 3.1 版新加入.

expectedFailures

A list containing 2-tuples of *TestCase* instances and strings holding formatted tracebacks. Each tuple represents an expected failure or error of the test case.

unexpectedSuccesses

A list containing *TestCase* instances that were marked as expected failures, but succeeded.

shouldStop

Set to `True` when the execution of tests should stop by *stop()*.

testsRun

The total number of tests run so far.

buffer

If set to `true`, `sys.stdout` and `sys.stderr` will be buffered in between *startTest()* and *stopTest()* being called. Collected output will only be echoed onto the real `sys.stdout` and `sys.stderr` if the test fails or errors. Any output is also attached to the failure / error message.

在 3.2 版新加入。

failfast

If set to `true` *stop()* will be called on the first failure or error, halting the test run.

在 3.2 版新加入。

tb_locals

If set to `true` then local variables will be shown in tracebacks.

在 3.5 版新加入。

wasSuccessful()

Return `True` if all tests run so far have passed, otherwise returns `False`.

在 3.4 版的變更: Returns `False` if there were any *unexpectedSuccesses* from tests marked with the *expectedFailure()* decorator.

stop()

This method can be called to signal that the set of tests being run should be aborted by setting the *shouldStop* attribute to `True`. *TestRunner* objects should respect this flag and return without running any additional tests.

For example, this feature is used by the *TextTestRunner* class to stop the test framework when the user signals an interrupt from the keyboard. Interactive tools which provide *TestRunner* implementations can use this in a similar manner.

The following methods of the *TestResult* class are used to maintain the internal data structures, and may be extended in subclasses to support additional reporting requirements. This is particularly useful in building tools which support interactive reporting while tests are being run.

startTest(test)

Called when the test case *test* is about to be run.

stopTest(test)

Called after the test case *test* has been executed, regardless of the outcome.

startTestRun()

Called once before any tests are executed.

在 3.1 版新加入。

stopTestRun()

Called once after all tests are executed.

在 3.1 版新加入。

addError (*test*, *err*)

Called when the test case *test* raises an unexpected exception. *err* is a tuple of the form returned by `sys.exc_info()`: (type, value, traceback).

The default implementation appends a tuple (*test*, *formatted_err*) to the instance's *errors* attribute, where *formatted_err* is a formatted traceback derived from *err*.

addFailure (*test*, *err*)

Called when the test case *test* signals a failure. *err* is a tuple of the form returned by `sys.exc_info()`: (type, value, traceback).

The default implementation appends a tuple (*test*, *formatted_err*) to the instance's *failures* attribute, where *formatted_err* is a formatted traceback derived from *err*.

addSuccess (*test*)

Called when the test case *test* succeeds.

The default implementation does nothing.

addSkip (*test*, *reason*)

Called when the test case *test* is skipped. *reason* is the reason the test gave for skipping.

The default implementation appends a tuple (*test*, *reason*) to the instance's *skipped* attribute.

addExpectedFailure (*test*, *err*)

Called when the test case *test* fails or errors, but was marked with the `expectedFailure()` decorator.

The default implementation appends a tuple (*test*, *formatted_err*) to the instance's *expectedFailures* attribute, where *formatted_err* is a formatted traceback derived from *err*.

addUnexpectedSuccess (*test*)

Called when the test case *test* was marked with the `expectedFailure()` decorator, but succeeded.

The default implementation appends the test to the instance's *unexpectedSuccesses* attribute.

addSubTest (*test*, *subtest*, *outcome*)

Called when a subtest finishes. *test* is the test case corresponding to the test method. *subtest* is a custom *TestCase* instance describing the subtest.

If *outcome* is *None*, the subtest succeeded. Otherwise, it failed with an exception where *outcome* is a tuple of the form returned by `sys.exc_info()`: (type, value, traceback).

The default implementation does nothing when the outcome is a success, and records subtest failures as normal failures.

在 3.4 版新加入。

class unittest.**TextTestResult** (*stream*, *descriptions*, *verbosity*)

A concrete implementation of *TestResult* used by the *TextTestRunner*.

在 3.2 版新加入: This class was previously named `_TextTestResult`. The old name still exists as an alias but is deprecated.

unittest.defaultTestLoader

Instance of the *TestLoader* class intended to be shared. If no customization of the *TestLoader* is needed, this instance can be used instead of repeatedly creating new instances.

class unittest.**TextTestRunner** (*stream=None*, *descriptions=True*, *verbosity=1*, *failfast=False*,
buffer=False, *resultclass=None*, *warnings=None*, *, *tb_locals=False*)

A basic test runner implementation that outputs results to a stream. If *stream* is *None*, the default, `sys.stderr` is used as the output stream. This class has a few configurable parameters, but is essentially very simple. Graphical applications which run test suites should provide alternate implementations. Such implementations should accept `**kwargs` as the interface to construct runners changes when features are added to unittest.

By default this runner shows *DeprecationWarning*, *PendingDeprecationWarning*, *ResourceWarning* and *ImportWarning* even if they are *ignored by default*. Deprecation warnings caused by *deprecated unittest methods* are also special-cased and, when the warning filters are 'default' or 'always', they will appear only once per-module, in order to avoid too many warning messages. This behavior can be overridden using Python's `-Wd` or `-Wa` options (see Warning control) and leaving *warnings* to `None`.

在 3.2 版的變更: 新增 `warnings` 引數。

在 3.2 版的變更: The default stream is set to `sys.stderr` at instantiation time rather than import time.

在 3.5 版的變更: 新增 `tb_locals` 參數。

`_makeResult()`

This method returns the instance of *TestResult* used by `run()`. It is not intended to be called directly, but can be overridden in subclasses to provide a custom *TestResult*.

`_makeResult()` instantiates the class or callable passed in the *TextTestRunner* constructor as the *resultclass* argument. It defaults to *TextTestResult* if no *resultclass* is provided. The result class is instantiated with the following arguments:

```
stream, descriptions, verbosity
```

`run(test)`

This method is the main public interface to the *TextTestRunner*. This method takes a *TestSuite* or *TestCase* instance. A *TestResult* is created by calling `_makeResult()` and the test(s) are run and the results printed to stdout.

```
unittest.main(module='__main__', defaultTest=None, argv=None, testRunner=None,
               testLoader=unittest.defaultTestLoader, exit=True, verbosity=1, failfast=None,
               catchbreak=None, buffer=None, warnings=None)
```

A command-line program that loads a set of tests from *module* and runs them; this is primarily for making test modules conveniently executable. The simplest use for this function is to include the following line at the end of a test script:

```
if __name__ == '__main__':
    unittest.main()
```

You can run tests with more detailed information by passing in the *verbosity* argument:

```
if __name__ == '__main__':
    unittest.main(verbosity=2)
```

The *defaultTest* argument is either the name of a single test or an iterable of test names to run if no test names are specified via *argv*. If not specified or `None` and no test names are provided via *argv*, all tests found in *module* are run.

The *argv* argument can be a list of options passed to the program, with the first element being the program name. If not specified or `None`, the values of `sys.argv` are used.

The *testRunner* argument can either be a test runner class or an already created instance of it. By default `main` calls `sys.exit()` with an exit code indicating success or failure of the tests run.

The *testLoader* argument has to be a *TestLoader* instance, and defaults to *defaultTestLoader*.

`main` supports being used from the interactive interpreter by passing in the argument `exit=False`. This displays the result on standard output without calling `sys.exit()`:

```
>>> from unittest import main
>>> main(module='test_module', exit=False)
```

The *failfast*, *catchbreak* and *buffer* parameters have the same effect as the same-name *command-line options*.

The *warnings* argument specifies the *warning filter* that should be used while running the tests. If it's not specified, it will remain `None` if a `-W` option is passed to **python** (see Warning control), otherwise it will be set to `'default'`.

Calling `main` actually returns an instance of the `TestProgram` class. This stores the result of the tests run as the `result` attribute.

在 3.1 版的變更: 新增 *exit* 參數。

在 3.2 版的變更: The *verbosity*, *failfast*, *catchbreak*, *buffer* and *warnings* parameters were added.

在 3.4 版的變更: The *defaultTest* parameter was changed to also accept an iterable of test names.

load_tests Protocol

在 3.2 版新加入。

Modules or packages can customize how tests are loaded from them during normal test runs or test discovery by implementing a function called `load_tests`.

If a test module defines `load_tests` it will be called by `TestLoader.loadTestsFromModule()` with the following arguments:

```
load_tests(loader, standard_tests, pattern)
```

where *pattern* is passed straight through from `loadTestsFromModule`. It defaults to `None`.

It should return a `TestSuite`.

loader is the instance of `TestLoader` doing the loading. *standard_tests* are the tests that would be loaded by default from the module. It is common for test modules to only want to add or remove tests from the standard set of tests. The third argument is used when loading packages as part of test discovery.

A typical `load_tests` function that loads tests from a specific set of `TestCase` classes may look like:

```
test_cases = (TestCase1, TestCase2, TestCase3)

def load_tests(loader, tests, pattern):
    suite = TestSuite()
    for test_class in test_cases:
        tests = loader.loadTestsFromTestCase(test_class)
        suite.addTests(tests)
    return suite
```

If discovery is started in a directory containing a package, either from the command line or by calling `TestLoader.discover()`, then the package `__init__.py` will be checked for `load_tests`. If that function does not exist, discovery will recurse into the package as though it were just another directory. Otherwise, discovery of the package's tests will be left up to `load_tests` which is called with the following arguments:

```
load_tests(loader, standard_tests, pattern)
```

This should return a `TestSuite` representing all the tests from the package. (`standard_tests` will only contain tests collected from `__init__.py`.)

Because the *pattern* is passed into `load_tests` the package is free to continue (and potentially modify) test discovery. A 'do nothing' `load_tests` function for a test package would look like:

```
def load_tests(loader, standard_tests, pattern):
    # top level directory cached on loader instance
    this_dir = os.path.dirname(__file__)
    package_tests = loader.discover(start_dir=this_dir, pattern=pattern)
    standard_tests.addTests(package_tests)
    return standard_tests
```


在 3.5 版的變更: Discovery no longer checks package names for matching *pattern* due to the impossibility of package names matching the default pattern.

26.5.9 Class and Module Fixtures

Class and module level fixtures are implemented in *TestSuite*. When the test suite encounters a test from a new class then `tearDownClass()` from the previous class (if there is one) is called, followed by `setUpClass()` from the new class.

Similarly if a test is from a different module from the previous test then `tearDownModule` from the previous module is run, followed by `setUpModule` from the new module.

After all the tests have run the final `tearDownClass` and `tearDownModule` are run.

Note that shared fixtures do not play well with [potential] features like test parallelization and they break test isolation. They should be used with care.

The default ordering of tests created by the unittest test loaders is to group all tests from the same modules and classes together. This will lead to `setUpClass` / `setUpModule` (etc) being called exactly once per class and module. If you randomize the order, so that tests from different modules and classes are adjacent to each other, then these shared fixture functions may be called multiple times in a single test run.

Shared fixtures are not intended to work with suites with non-standard ordering. A *BaseTestSuite* still exists for frameworks that don't want to support shared fixtures.

If there are any exceptions raised during one of the shared fixture functions the test is reported as an error. Because there is no corresponding test instance an `_ErrorHandler` object (that has the same interface as a *TestCase*) is created to represent the error. If you are just using the standard unittest test runner then this detail doesn't matter, but if you are a framework author it may be relevant.

setUpClass and tearDownClass

These must be implemented as class methods:

```
import unittest

class Test(unittest.TestCase):
    @classmethod
    def setUpClass(cls):
        cls._connection = createExpensiveConnectionObject()

    @classmethod
    def tearDownClass(cls):
        cls._connection.destroy()
```

If you want the `setUpClass` and `tearDownClass` on base classes called then you must call up to them yourself. The implementations in *TestCase* are empty.

If an exception is raised during a `setUpClass` then the tests in the class are not run and the `tearDownClass` is not run. Skipped classes will not have `setUpClass` or `tearDownClass` run. If the exception is a *SkipTest* exception then the class will be reported as having been skipped instead of as an error.

setUpModule and tearDownModule

These should be implemented as functions:

```
def setUpModule():
    createConnection()

def tearDownModule():
    closeConnection()
```

If an exception is raised in a `setUpModule` then none of the tests in the module will be run and the `tearDownModule` will not be run. If the exception is a `SkipTest` exception then the module will be reported as having been skipped instead of as an error.

To add cleanup code that must be run even in the case of an exception, use `addModuleCleanup`:

`unittest.addModuleCleanup(function, /, *args, **kwargs)`

Add a function to be called after `tearDownModule()` to cleanup resources used during the test class. Functions will be called in reverse order to the order they are added (LIFO). They are called with any arguments and keyword arguments passed into `addModuleCleanup()` when they are added.

If `setUpModule()` fails, meaning that `tearDownModule()` is not called, then any cleanup functions added will still be called.

在 3.8 版新加入。

`classmethod unittest.enterModuleContext(cm)`

Enter the supplied *context manager*. If successful, also add its `__exit__()` method as a cleanup function by `addModuleCleanup()` and return the result of the `__enter__()` method.

在 3.11 版新加入。

`unittest.doModuleCleanups()`

This function is called unconditionally after `tearDownModule()`, or after `setUpModule()` if `setUpModule()` raises an exception.

It is responsible for calling all the cleanup functions added by `addModuleCleanup()`. If you need cleanup functions to be called *prior* to `tearDownModule()` then you can call `doModuleCleanups()` yourself.

`doModuleCleanups()` pops methods off the stack of cleanup functions one at a time, so it can be called at any time.

在 3.8 版新加入。

26.5.10 Signal Handling

在 3.2 版新加入。

The `-c/--catch` command-line option to `unittest`, along with the `catchbreak` parameter to `unittest.main()`, provide more friendly handling of control-C during a test run. With catch break behavior enabled control-C will allow the currently running test to complete, and the test run will then end and report all the results so far. A second control-c will raise a `KeyboardInterrupt` in the usual way.

The control-c handling signal handler attempts to remain compatible with code or tests that install their own `signal.SIGINT` handler. If the `unittest` handler is called but *isn't* the installed `signal.SIGINT` handler, i.e. it has been replaced by the system under test and delegated to, then it calls the default handler. This will normally be the expected behavior by code that replaces an installed handler and delegates to it. For individual tests that need `unittest` control-c handling disabled the `removeHandler()` decorator can be used.

There are a few utility functions for framework authors to enable control-c handling functionality within test frameworks.

`unittest.installHandler()`

Install the control-c handler. When a `signal.SIGINT` is received (usually in response to the user pressing control-c) all registered results have `stop()` called.

`unittest.registerResult(result)`

Register a `TestResult` object for control-c handling. Registering a result stores a weak reference to it, so it doesn't prevent the result from being garbage collected.

Registering a `TestResult` object has no side-effects if control-c handling is not enabled, so test frameworks can unconditionally register all results they create independently of whether or not handling is enabled.

`unittest.removeResult(result)`

Remove a registered result. Once a result has been removed then `stop()` will no longer be called on that result object in response to a control-c.

`unittest.removeHandler(function=None)`

When called without arguments this function removes the control-c handler if it has been installed. This function can also be used as a test decorator to temporarily remove the handler while the test is being executed:

```
@unittest.removeHandler
def test_signal_handling(self):
    ...
```

26.6 unittest.mock --- mock object library

在 3.3 版新加入.

原始碼: [Lib/unittest/mock.py](#)

`unittest.mock` is a library for testing in Python. It allows you to replace parts of your system under test with mock objects and make assertions about how they have been used.

`unittest.mock` provides a core `Mock` class removing the need to create a host of stubs throughout your test suite. After performing an action, you can make assertions about which methods / attributes were used and arguments they were called with. You can also specify return values and set needed attributes in the normal way.

Additionally, mock provides a `patch()` decorator that handles patching module and class level attributes within the scope of a test, along with `sentinel` for creating unique objects. See the [quick guide](#) for some examples of how to use `Mock`, `MagicMock` and `patch()`.

Mock is designed for use with `unittest` and is based on the 'action -> assertion' pattern instead of 'record -> replay' used by many mocking frameworks.

There is a backport of `unittest.mock` for earlier versions of Python, available as [mock on PyPI](#).

26.6.1 Quick Guide

`Mock` and `MagicMock` objects create all attributes and methods as you access them and store details of how they have been used. You can configure them, to specify return values or limit what attributes are available, and then make assertions about how they have been used:

```
>>> from unittest.mock import MagicMock
>>> thing = ProductionClass()
>>> thing.method = MagicMock(return_value=3)
>>> thing.method(3, 4, 5, key='value')
3
>>> thing.method.assert_called_with(3, 4, 5, key='value')
```

`side_effect` allows you to perform side effects, including raising an exception when a mock is called:

```
>>> mock = Mock(side_effect=KeyError('foo'))
>>> mock()
Traceback (most recent call last):
...
KeyError: 'foo'
```

```
>>> values = {'a': 1, 'b': 2, 'c': 3}
>>> def side_effect(arg):
...     return values[arg]
...
>>> mock.side_effect = side_effect
>>> mock('a'), mock('b'), mock('c')
(1, 2, 3)
>>> mock.side_effect = [5, 4, 3, 2, 1]
>>> mock(), mock(), mock()
(5, 4, 3)
```

Mock has many other ways you can configure it and control its behaviour. For example the *spec* argument configures the mock to take its specification from another object. Attempting to access attributes or methods on the mock that don't exist on the spec will fail with an *AttributeError*.

The *patch()* decorator / context manager makes it easy to mock classes or objects in a module under test. The object you specify will be replaced with a mock (or other object) during the test and restored when the test ends:

```
>>> from unittest.mock import patch
>>> @patch('module.ClassName2')
... @patch('module.ClassName1')
... def test(MockClass1, MockClass2):
...     module.ClassName1()
...     module.ClassName2()
...     assert MockClass1 is module.ClassName1
...     assert MockClass2 is module.ClassName2
...     assert MockClass1.called
...     assert MockClass2.called
...
>>> test()
```

備F: When you nest patch decorators the mocks are passed in to the decorated function in the same order they applied (the normal *Python* order that decorators are applied). This means from the bottom up, so in the example above the mock for `module.ClassName1` is passed in first.

With *patch()* it matters that you patch objects in the namespace where they are looked up. This is normally straightforward, but for a quick guide read *where to patch*.

As well as a decorator *patch()* can be used as a context manager in a with statement:

```
>>> with patch.object(ProductionClass, 'method', return_value=None) as mock_method:
...     thing = ProductionClass()
...     thing.method(1, 2, 3)
...
>>> mock_method.assert_called_once_with(1, 2, 3)
```

There is also *patch.dict()* for setting values in a dictionary just during a scope and restoring the dictionary to its original state when the test ends:

```
>>> foo = {'key': 'value'}
>>> original = foo.copy()
>>> with patch.dict(foo, {'newkey': 'newvalue'}, clear=True):
```

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```
...     assert foo == {'newkey': 'newvalue'}
...
>>> assert foo == original
```

Mock supports the mocking of Python *magic methods*. The easiest way of using magic methods is with the *MagicMock* class. It allows you to do things like:

```
>>> mock = MagicMock()
>>> mock.__str__.return_value = 'foobarbaz'
>>> str(mock)
'foobarbaz'
>>> mock.__str__.assert_called_with()
```

Mock allows you to assign functions (or other Mock instances) to magic methods and they will be called appropriately. The *MagicMock* class is just a Mock variant that has all of the magic methods pre-created for you (well, all the useful ones anyway).

The following is an example of using magic methods with the ordinary Mock class:

```
>>> mock = Mock()
>>> mock.__str__ = Mock(return_value='whewheeee')
>>> str(mock)
'whewheeee'
```

For ensuring that the mock objects in your tests have the same api as the objects they are replacing, you can use *auto-specing*. Auto-specing can be done through the *autospec* argument to patch, or the *create_autospec()* function. Auto-specing creates mock objects that have the same attributes and methods as the objects they are replacing, and any functions and methods (including constructors) have the same call signature as the real object.

This ensures that your mocks will fail in the same way as your production code if they are used incorrectly:

```
>>> from unittest.mock import create_autospec
>>> def function(a, b, c):
...     pass
...
>>> mock_function = create_autospec(function, return_value='fishy')
>>> mock_function(1, 2, 3)
'fishy'
>>> mock_function.assert_called_once_with(1, 2, 3)
>>> mock_function('wrong arguments')
Traceback (most recent call last):
...
TypeError: <lambda>() takes exactly 3 arguments (1 given)
```

create_autospec() can also be used on classes, where it copies the signature of the *__init__* method, and on callable objects where it copies the signature of the *__call__* method.

26.6.2 The Mock Class

Mock is a flexible mock object intended to replace the use of stubs and test doubles throughout your code. Mocks are callable and create attributes as new mocks when you access them¹. Accessing the same attribute will always return the same mock. Mocks record how you use them, allowing you to make assertions about what your code has done to them.

MagicMock is a subclass of *Mock* with all the magic methods pre-created and ready to use. There are also non-callable variants, useful when you are mocking out objects that aren't callable: *NonCallableMock* and *NonCallableMagicMock*

¹ The only exceptions are magic methods and attributes (those that have leading and trailing double underscores). Mock doesn't create these but instead raises an *AttributeError*. This is because the interpreter will often implicitly request these methods, and gets very confused to get a new Mock object when it expects a magic method. If you need magic method support see *magic methods*.

The `patch()` decorators makes it easy to temporarily replace classes in a particular module with a `Mock` object. By default `patch()` will create a `MagicMock` for you. You can specify an alternative class of `Mock` using the `new_callable` argument to `patch()`.

```
class unittest.mock.Mock (spec=None, side_effect=None, return_value=DEFAULT, wraps=None,
                             name=None, spec_set=None, unsafe=False, **kwargs)
```

Create a new `Mock` object. `Mock` takes several optional arguments that specify the behaviour of the `Mock` object:

- `spec`: This can be either a list of strings or an existing object (a class or instance) that acts as the specification for the mock object. If you pass in an object then a list of strings is formed by calling `dir` on the object (excluding unsupported magic attributes and methods). Accessing any attribute not in this list will raise an `AttributeError`.

If `spec` is an object (rather than a list of strings) then `__class__` returns the class of the spec object. This allows mocks to pass `isinstance()` tests.

- `spec_set`: A stricter variant of `spec`. If used, attempting to `set` or `get` an attribute on the mock that isn't on the object passed as `spec_set` will raise an `AttributeError`.
- `side_effect`: A function to be called whenever the `Mock` is called. See the `side_effect` attribute. Useful for raising exceptions or dynamically changing return values. The function is called with the same arguments as the mock, and unless it returns `DEFAULT`, the return value of this function is used as the return value.

Alternatively `side_effect` can be an exception class or instance. In this case the exception will be raised when the mock is called.

If `side_effect` is an iterable then each call to the mock will return the next value from the iterable.

A `side_effect` can be cleared by setting it to `None`.

- `return_value`: The value returned when the mock is called. By default this is a new `Mock` (created on first access). See the `return_value` attribute.
- `unsafe`: By default, accessing any attribute whose name starts with `assert`, `assert`, `assert`, `assert` or `assert` will raise an `AttributeError`. Passing `unsafe=True` will allow access to these attributes.

在 3.5 版新加入.

- `wraps`: Item for the mock object to wrap. If `wraps` is not `None` then calling the `Mock` will pass the call through to the wrapped object (returning the real result). Attribute access on the mock will return a `Mock` object that wraps the corresponding attribute of the wrapped object (so attempting to access an attribute that doesn't exist will raise an `AttributeError`).

If the mock has an explicit `return_value` set then calls are not passed to the wrapped object and the `return_value` is returned instead.

- `name`: If the mock has a name then it will be used in the repr of the mock. This can be useful for debugging. The name is propagated to child mocks.

Mocks can also be called with arbitrary keyword arguments. These will be used to set attributes on the mock after it is created. See the `configure_mock()` method for details.

`assert_called()`

Assert that the mock was called at least once.

```
>>> mock = Mock()
>>> mock.method()
<Mock name='mock.method()' id='...'>
>>> mock.method.assert_called()
```

在 3.6 版新加入.

`assert_called_once()`

Assert that the mock was called exactly once.

```

>>> mock = Mock()
>>> mock.method()
<Mock name='mock.method()' id='...'>
>>> mock.method.assert_called_once()
>>> mock.method()
<Mock name='mock.method()' id='...'>
>>> mock.method.assert_called_once()
Traceback (most recent call last):
...
AssertionError: Expected 'method' to have been called once. Called 2 times.

```

在 3.6 版新加入。

assert_called_with (*args, **kwargs)

This method is a convenient way of asserting that the last call has been made in a particular way:

```

>>> mock = Mock()
>>> mock.method(1, 2, 3, test='wow')
<Mock name='mock.method()' id='...'>
>>> mock.method.assert_called_with(1, 2, 3, test='wow')

```

assert_called_once_with (*args, **kwargs)

Assert that the mock was called exactly once and that call was with the specified arguments.

```

>>> mock = Mock(return_value=None)
>>> mock('foo', bar='baz')
>>> mock.assert_called_once_with('foo', bar='baz')
>>> mock('other', bar='values')
>>> mock.assert_called_once_with('other', bar='values')
Traceback (most recent call last):
...
AssertionError: Expected 'mock' to be called once. Called 2 times.

```

assert_any_call (*args, **kwargs)

assert the mock has been called with the specified arguments.

The assert passes if the mock has *ever* been called, unlike `assert_called_with()` and `assert_called_once_with()` that only pass if the call is the most recent one, and in the case of `assert_called_once_with()` it must also be the only call.

```

>>> mock = Mock(return_value=None)
>>> mock(1, 2, arg='thing')
>>> mock('some', 'thing', 'else')
>>> mock.assert_any_call(1, 2, arg='thing')

```

assert_has_calls (calls, any_order=False)

assert the mock has been called with the specified calls. The `mock_calls` list is checked for the calls.

If `any_order` is false then the calls must be sequential. There can be extra calls before or after the specified calls.

If `any_order` is true then the calls can be in any order, but they must all appear in `mock_calls`.

```

>>> mock = Mock(return_value=None)
>>> mock(1)
>>> mock(2)
>>> mock(3)
>>> mock(4)
>>> calls = [call(2), call(3)]
>>> mock.assert_has_calls(calls)
>>> calls = [call(4), call(2), call(3)]
>>> mock.assert_has_calls(calls, any_order=True)

```

assert_not_called()

Assert the mock was never called.

```
>>> m = Mock()
>>> m.hello.assert_not_called()
>>> obj = m.hello()
>>> m.hello.assert_not_called()
Traceback (most recent call last):
...
AssertionError: Expected 'hello' to not have been called. Called 1 times.
```

在 3.5 版新加入.

reset_mock (*, *return_value=False*, *side_effect=False*)

The `reset_mock` method resets all the call attributes on a mock object:

```
>>> mock = Mock(return_value=None)
>>> mock('hello')
>>> mock.called
True
>>> mock.reset_mock()
>>> mock.called
False
```

在 3.6 版的變更: Added two keyword-only arguments to the `reset_mock` function.

This can be useful where you want to make a series of assertions that reuse the same object. Note that `reset_mock()` *doesn't* clear the return value, *side_effect* or any child attributes you have set using normal assignment by default. In case you want to reset *return_value* or *side_effect*, then pass the corresponding parameter as `True`. Child mocks and the return value mock (if any) are reset as well.

備F: *return_value*, and *side_effect* are keyword-only arguments.

mock_add_spec (*spec*, *spec_set=False*)

Add a spec to a mock. *spec* can either be an object or a list of strings. Only attributes on the *spec* can be fetched as attributes from the mock.

If *spec_set* is true then only attributes on the spec can be set.

attach_mock (*mock*, *attribute*)

Attach a mock as an attribute of this one, replacing its name and parent. Calls to the attached mock will be recorded in the *method_calls* and *mock_calls* attributes of this one.

configure_mock (***kwargs*)

Set attributes on the mock through keyword arguments.

Attributes plus return values and side effects can be set on child mocks using standard dot notation and unpacking a dictionary in the method call:

```
>>> mock = Mock()
>>> attrs = {'method.return_value': 3, 'other.side_effect': KeyError}
>>> mock.configure_mock(**attrs)
>>> mock.method()
3
>>> mock.other()
Traceback (most recent call last):
...
KeyError
```

The same thing can be achieved in the constructor call to mocks:


```
>>> attrs = {'method.return_value': 3, 'other.side_effect': KeyError}
>>> mock = Mock(some_attribute='eggs', **attrs)
>>> mock.some_attribute
'eggs'
>>> mock.method()
3
>>> mock.other()
Traceback (most recent call last):
...
KeyError
```

`configure_mock()` exists to make it easier to do configuration after the mock has been created.

`__dir__()`

`Mock` objects limit the results of `dir(some_mock)` to useful results. For mocks with a *spec* this includes all the permitted attributes for the mock.

See `FILTER_DIR` for what this filtering does, and how to switch it off.

`_get_child_mock(**kw)`

Create the child mocks for attributes and return value. By default child mocks will be the same type as the parent. Subclasses of `Mock` may want to override this to customize the way child mocks are made.

For non-callable mocks the callable variant will be used (rather than any custom subclass).

`called`

A boolean representing whether or not the mock object has been called:

```
>>> mock = Mock(return_value=None)
>>> mock.called
False
>>> mock()
>>> mock.called
True
```

`call_count`

An integer telling you how many times the mock object has been called:

```
>>> mock = Mock(return_value=None)
>>> mock.call_count
0
>>> mock()
>>> mock()
>>> mock.call_count
2
```

`return_value`

Set this to configure the value returned by calling the mock:

```
>>> mock = Mock()
>>> mock.return_value = 'fish'
>>> mock()
'fish'
```

The default return value is a mock object and you can configure it in the normal way:

```
>>> mock = Mock()
>>> mock.return_value.attribute = sentinel.Attribute
>>> mock.return_value()
<Mock name='mock()' id='...'>
>>> mock.return_value.assert_called_with()
```

`return_value` can also be set in the constructor:

```
>>> mock = Mock(return_value=3)
>>> mock.return_value
3
>>> mock()
3
```

side_effect

This can either be a function to be called when the mock is called, an iterable or an exception (class or instance) to be raised.

If you pass in a function it will be called with same arguments as the mock and unless the function returns the `DEFAULT` singleton the call to the mock will then return whatever the function returns. If the function returns `DEFAULT` then the mock will return its normal value (from the `return_value`).

If you pass in an iterable, it is used to retrieve an iterator which must yield a value on every call. This value can either be an exception instance to be raised, or a value to be returned from the call to the mock (`DEFAULT` handling is identical to the function case).

An example of a mock that raises an exception (to test exception handling of an API):

```
>>> mock = Mock()
>>> mock.side_effect = Exception('Boom!')
>>> mock()
Traceback (most recent call last):
...
Exception: Boom!
```

Using `side_effect` to return a sequence of values:

```
>>> mock = Mock()
>>> mock.side_effect = [3, 2, 1]
>>> mock(), mock(), mock()
(3, 2, 1)
```

Using a callable:

```
>>> mock = Mock(return_value=3)
>>> def side_effect(*args, **kwargs):
...     return DEFAULT
...
>>> mock.side_effect = side_effect
>>> mock()
3
```

`side_effect` can be set in the constructor. Here's an example that adds one to the value the mock is called with and returns it:

```
>>> side_effect = lambda value: value + 1
>>> mock = Mock(side_effect=side_effect)
>>> mock(3)
4
>>> mock(-8)
-7
```

Setting `side_effect` to `None` clears it:

```
>>> m = Mock(side_effect=KeyError, return_value=3)
>>> m()
Traceback (most recent call last):
...
KeyError
>>> m.side_effect = None
```

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```
>>> m()
3
```

call_args

This is either `None` (if the mock hasn't been called), or the arguments that the mock was last called with. This will be in the form of a tuple: the first member, which can also be accessed through the `args` property, is any ordered arguments the mock was called with (or an empty tuple) and the second member, which can also be accessed through the `kwargs` property, is any keyword arguments (or an empty dictionary).

```
>>> mock = Mock(return_value=None)
>>> print(mock.call_args)
None
>>> mock()
>>> mock.call_args
call()
>>> mock.call_args == ()
True
>>> mock(3, 4)
>>> mock.call_args
call(3, 4)
>>> mock.call_args == ((3, 4),)
True
>>> mock.call_args.args
(3, 4)
>>> mock.call_args.kwargs
{}
>>> mock(3, 4, 5, key='fish', next='w00t!')
>>> mock.call_args
call(3, 4, 5, key='fish', next='w00t!')
>>> mock.call_args.args
(3, 4, 5)
>>> mock.call_args.kwargs
{'key': 'fish', 'next': 'w00t!'}
```

`call_args`, along with members of the lists `call_args_list`, `method_calls` and `mock_calls` are `call` objects. These are tuples, so they can be unpacked to get at the individual arguments and make more complex assertions. See *[calls as tuples](#)*.

在 3.8 版的變更: 新增 `args` 與 `kwargs` 特性。

call_args_list

This is a list of all the calls made to the mock object in sequence (so the length of the list is the number of times it has been called). Before any calls have been made it is an empty list. The `call` object can be used for conveniently constructing lists of calls to compare with `call_args_list`.

```
>>> mock = Mock(return_value=None)
>>> mock()
>>> mock(3, 4)
>>> mock(key='fish', next='w00t!')
>>> mock.call_args_list
[call(), call(3, 4), call(key='fish', next='w00t!')]
>>> expected = [(), ((3, 4),), ({'key': 'fish', 'next': 'w00t!'},)]
>>> mock.call_args_list == expected
True
```

Members of `call_args_list` are `call` objects. These can be unpacked as tuples to get at the individual arguments. See *[calls as tuples](#)*.

method_calls

As well as tracking calls to themselves, mocks also track calls to methods and attributes, and *their* methods

and attributes:

```
>>> mock = Mock()
>>> mock.method()
<Mock name='mock.method()' id='...'>
>>> mock.property.method.attribute()
<Mock name='mock.property.method.attribute()' id='...'>
>>> mock.method_calls
[call.method(), call.property.method.attribute()]
```

Members of `method_calls` are `call` objects. These can be unpacked as tuples to get at the individual arguments. See *[calls as tuples](#)*.

mock_calls

`mock_calls` records *all* calls to the mock object, its methods, magic methods *and* return value mocks.

```
>>> mock = MagicMock()
>>> result = mock(1, 2, 3)
>>> mock.first(a=3)
<MagicMock name='mock.first()' id='...'>
>>> mock.second()
<MagicMock name='mock.second()' id='...'>
>>> int(mock)
1
>>> result(1)
<MagicMock name='mock()' id='...'>
>>> expected = [call(1, 2, 3), call.first(a=3), call.second(),
... call.__int__(), call()(1)]
>>> mock.mock_calls == expected
True
```

Members of `mock_calls` are `call` objects. These can be unpacked as tuples to get at the individual arguments. See *[calls as tuples](#)*.

備註: The way `mock_calls` are recorded means that where nested calls are made, the parameters of ancestor calls are not recorded and so will always compare equal:

```
>>> mock = MagicMock()
>>> mock.top(a=3).bottom()
<MagicMock name='mock.top().bottom()' id='...'>
>>> mock.mock_calls
[call.top(a=3), call.top().bottom()]
>>> mock.mock_calls[-1] == call.top(a=-1).bottom()
True
```

__class__

Normally the `__class__` attribute of an object will return its type. For a mock object with a spec, `__class__` returns the spec class instead. This allows mock objects to pass *`isinstance()`* tests for the object they are replacing / masquerading as:

```
>>> mock = Mock(spec=3)
>>> isinstance(mock, int)
True
```

`__class__` is assignable to, this allows a mock to pass an *`isinstance()`* check without forcing you to use a spec:

```
>>> mock = Mock()
>>> mock.__class__ = dict
```

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```
>>> isinstance(mock, dict)
True
```

class `unittest.mock.NonCallableMock` (*spec=None, wraps=None, name=None, spec_set=None, **kwargs*)

A non-callable version of `Mock`. The constructor parameters have the same meaning of `Mock`, with the exception of `return_value` and `side_effect` which have no meaning on a non-callable mock.

Mock objects that use a class or an instance as a `spec` or `spec_set` are able to pass `isinstance()` tests:

```
>>> mock = Mock(spec=SomeClass)
>>> isinstance(mock, SomeClass)
True
>>> mock = Mock(spec_set=SomeClass())
>>> isinstance(mock, SomeClass)
True
```

The `Mock` classes have support for mocking magic methods. See [magic methods](#) for the full details.

The mock classes and the `patch()` decorators all take arbitrary keyword arguments for configuration. For the `patch()` decorators the keywords are passed to the constructor of the mock being created. The keyword arguments are for configuring attributes of the mock:

```
>>> m = MagicMock(attribute=3, other='fish')
>>> m.attribute
3
>>> m.other
'fish'
```

The return value and side effect of child mocks can be set in the same way, using dotted notation. As you can't use dotted names directly in a call you have to create a dictionary and unpack it using `**`:

```
>>> attrs = {'method.return_value': 3, 'other.side_effect': KeyError}
>>> mock = Mock(some_attribute='eggs', **attrs)
>>> mock.some_attribute
'eggs'
>>> mock.method()
3
>>> mock.other()
Traceback (most recent call last):
...
KeyError
```

A callable mock which was created with a `spec` (or a `spec_set`) will introspect the specification object's signature when matching calls to the mock. Therefore, it can match the actual call's arguments regardless of whether they were passed positionally or by name:

```
>>> def f(a, b, c): pass
...
>>> mock = Mock(spec=f)
>>> mock(1, 2, c=3)
<Mock name='mock()' id='140161580456576'>
>>> mock.assert_called_with(1, 2, 3)
>>> mock.assert_called_with(a=1, b=2, c=3)
```

This applies to `assert_called_with()`, `assert_called_once_with()`, `assert_has_calls()` and `assert_any_call()`. When *Autospeccing*, it will also apply to method calls on the mock object.

在 3.4 版的變更: Added signature introspection on specced and autospecced mock objects.

class `unittest.mock.PropertyMock` (*args, **kwargs)

A mock intended to be used as a *property*, or other *descriptor*, on a class. *PropertyMock* provides `__get__()` and `__set__()` methods so you can specify a return value when it is fetched.

Fetching a *PropertyMock* instance from an object calls the mock, with no args. Setting it calls the mock with the value being set.

```
>>> class Foo:
...     @property
...     def foo(self):
...         return 'something'
...     @foo.setter
...     def foo(self, value):
...         pass
...
>>> with patch('__main__.Foo.foo', new_callable=PropertyMock) as mock_foo:
...     mock_foo.return_value = 'mockity-mock'
...     this_foo = Foo()
...     print(this_foo.foo)
...     this_foo.foo = 6
...
mockity-mock
>>> mock_foo.mock_calls
[call(), call(6)]
```

Because of the way mock attributes are stored you can't directly attach a *PropertyMock* to a mock object. Instead you can attach it to the mock type object:

```
>>> m = MagicMock()
>>> p = PropertyMock(return_value=3)
>>> type(m).foo = p
>>> m.foo
3
>>> p.assert_called_once_with()
```

class `unittest.mock.AsyncMock` (spec=None, side_effect=None, return_value=DEFAULT, wraps=None, name=None, spec_set=None, unsafe=False, **kwargs)

An asynchronous version of *MagicMock*. The *AsyncMock* object will behave so the object is recognized as an async function, and the result of a call is an awaitable.

```
>>> mock = AsyncMock()
>>> asyncio.iscoroutinefunction(mock)
True
>>> inspect.isawaitable(mock())
True
```

The result of `mock()` is an async function which will have the outcome of `side_effect` or `return_value` after it has been awaited:

- if `side_effect` is a function, the async function will return the result of that function,
- if `side_effect` is an exception, the async function will raise the exception,
- if `side_effect` is an iterable, the async function will return the next value of the iterable, however, if the sequence of result is exhausted, `StopAsyncIteration` is raised immediately,
- if `side_effect` is not defined, the async function will return the value defined by `return_value`, hence, by default, the async function returns a new *AsyncMock* object.

Setting the `spec` of a *Mock* or *MagicMock* to an async function will result in a coroutine object being returned after calling.

```
>>> async def async_func(): pass
...
>>> mock = MagicMock(async_func)
>>> mock
<MagicMock spec='function' id='...'>
>>> mock()
<coroutine object AsyncMockMixin._mock_call at ...>
```

Setting the *spec* of a *Mock*, *MagicMock*, or *AsyncMock* to a class with asynchronous and synchronous functions will automatically detect the synchronous functions and set them as *MagicMock* (if the parent mock is *AsyncMock* or *MagicMock*) or *Mock* (if the parent mock is *Mock*). All asynchronous functions will be *AsyncMock*.

```
>>> class ExampleClass:
...     def sync_foo():
...         pass
...     async def async_foo():
...         pass
...
>>> a_mock = AsyncMock(ExampleClass)
>>> a_mock.sync_foo
<MagicMock name='mock.sync_foo' id='...'>
>>> a_mock.async_foo
<AsyncMock name='mock.async_foo' id='...'>
>>> mock = Mock(ExampleClass)
>>> mock.sync_foo
<Mock name='mock.sync_foo' id='...'>
>>> mock.async_foo
<AsyncMock name='mock.async_foo' id='...'>
```

在 3.8 版新加入。

assert_awaited()

Assert that the mock was awaited at least once. Note that this is separate from the object having been called, the `await` keyword must be used:

```
>>> mock = AsyncMock()
>>> async def main(coroutine_mock):
...     await coroutine_mock
...
>>> coroutine_mock = mock()
>>> mock.called
True
>>> mock.assert_awaited()
Traceback (most recent call last):
...
AssertionError: Expected mock to have been awaited.
>>> asyncio.run(main(coroutine_mock))
>>> mock.assert_awaited()
```

assert_awaited_once()

Assert that the mock was awaited exactly once.

```
>>> mock = AsyncMock()
>>> async def main():
...     await mock()
...
>>> asyncio.run(main())
>>> mock.assert_awaited_once()
>>> asyncio.run(main())
>>> mock.method.assert_awaited_once()
```

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```
Traceback (most recent call last):
...
AssertionError: Expected mock to have been awaited once. Awaited 2 times.
```

assert_awaited_with (*args, **kwargs)

Assert that the last await was with the specified arguments.

```
>>> mock = AsyncMock()
>>> async def main(*args, **kwargs):
...     await mock(*args, **kwargs)
...
>>> asyncio.run(main('foo', bar='bar'))
>>> mock.assert_awaited_with('foo', bar='bar')
>>> mock.assert_awaited_with('other')
Traceback (most recent call last):
...
AssertionError: expected call not found.
Expected: mock('other')
Actual: mock('foo', bar='bar')
```

assert_awaited_once_with (*args, **kwargs)

Assert that the mock was awaited exactly once and with the specified arguments.

```
>>> mock = AsyncMock()
>>> async def main(*args, **kwargs):
...     await mock(*args, **kwargs)
...
>>> asyncio.run(main('foo', bar='bar'))
>>> mock.assert_awaited_once_with('foo', bar='bar')
>>> asyncio.run(main('foo', bar='bar'))
>>> mock.assert_awaited_once_with('foo', bar='bar')
Traceback (most recent call last):
...
AssertionError: Expected mock to have been awaited once. Awaited 2 times.
```

assert_any_await (*args, **kwargs)

Assert the mock has ever been awaited with the specified arguments.

```
>>> mock = AsyncMock()
>>> async def main(*args, **kwargs):
...     await mock(*args, **kwargs)
...
>>> asyncio.run(main('foo', bar='bar'))
>>> asyncio.run(main('hello'))
>>> mock.assert_any_await('foo', bar='bar')
>>> mock.assert_any_await('other')
Traceback (most recent call last):
...
AssertionError: mock('other') await not found
```

assert_has_awaits (calls, any_order=False)

Assert the mock has been awaited with the specified calls. The *await_args_list* list is checked for the awaits.

If *any_order* is false then the awaits must be sequential. There can be extra calls before or after the specified awaits.

If *any_order* is true then the awaits can be in any order, but they must all appear in *await_args_list*.


```

>>> mock = AsyncMock()
>>> async def main(*args, **kwargs):
...     await mock(*args, **kwargs)
...
>>> calls = [call("foo"), call("bar")]
>>> mock.assert_has_awaits(calls)
Traceback (most recent call last):
...
AssertionError: Awaits not found.
Expected: [call('foo'), call('bar')]
Actual: []
>>> asyncio.run(main('foo'))
>>> asyncio.run(main('bar'))
>>> mock.assert_has_awaits(calls)

```

assert_not_awaited()

Assert that the mock was never awaited.

```

>>> mock = AsyncMock()
>>> mock.assert_not_awaited()

```

reset_mock(*args, **kwargs)

See [Mock.reset_mock\(\)](#). Also sets *await_count* to 0, *await_args* to None, and clears the *await_args_list*.

await_count

An integer keeping track of how many times the mock object has been awaited.

```

>>> mock = AsyncMock()
>>> async def main():
...     await mock()
...
>>> asyncio.run(main())
>>> mock.await_count
1
>>> asyncio.run(main())
>>> mock.await_count
2

```

await_args

This is either None (if the mock hasn't been awaited), or the arguments that the mock was last awaited with. Functions the same as [Mock.call_args](#).

```

>>> mock = AsyncMock()
>>> async def main(*args):
...     await mock(*args)
...
>>> mock.await_args
>>> asyncio.run(main('foo'))
>>> mock.await_args
call('foo')
>>> asyncio.run(main('bar'))
>>> mock.await_args
call('bar')

```

await_args_list

This is a list of all the awaits made to the mock object in sequence (so the length of the list is the number of times it has been awaited). Before any awaits have been made it is an empty list.

```

>>> mock = AsyncMock()
>>> async def main(*args):
...     await mock(*args)
...
>>> mock.await_args_list
[]
>>> asyncio.run(main('foo'))
>>> mock.await_args_list
[call('foo')]
>>> asyncio.run(main('bar'))
>>> mock.await_args_list
[call('foo'), call('bar')]

```

Calling

Mock objects are callable. The call will return the value set as the `return_value` attribute. The default return value is a new Mock object; it is created the first time the return value is accessed (either explicitly or by calling the Mock) - but it is stored and the same one returned each time.

Calls made to the object will be recorded in the attributes like `call_args` and `call_args_list`.

If `side_effect` is set then it will be called after the call has been recorded, so if `side_effect` raises an exception the call is still recorded.

The simplest way to make a mock raise an exception when called is to make `side_effect` an exception class or instance:

```

>>> m = MagicMock(side_effect=IndexError)
>>> m(1, 2, 3)
Traceback (most recent call last):
...
IndexError
>>> m.mock_calls
[call(1, 2, 3)]
>>> m.side_effect = KeyError('Bang!')
>>> m('two', 'three', 'four')
Traceback (most recent call last):
...
KeyError: 'Bang!'
>>> m.mock_calls
[call(1, 2, 3), call('two', 'three', 'four')]

```

If `side_effect` is a function then whatever that function returns is what calls to the mock return. The `side_effect` function is called with the same arguments as the mock. This allows you to vary the return value of the call dynamically, based on the input:

```

>>> def side_effect(value):
...     return value + 1
...
>>> m = MagicMock(side_effect=side_effect)
>>> m(1)
2
>>> m(2)
3
>>> m.mock_calls
[call(1), call(2)]

```

If you want the mock to still return the default return value (a new mock), or any set return value, then there are two ways of doing this. Either return `mock.return_value` from inside `side_effect`, or return `DEFAULT`:

```

>>> m = MagicMock()
>>> def side_effect(*args, **kwargs):
...     return m.return_value
...
>>> m.side_effect = side_effect
>>> m.return_value = 3
>>> m()
3
>>> def side_effect(*args, **kwargs):
...     return DEFAULT
...
>>> m.side_effect = side_effect
>>> m()
3

```

To remove a `side_effect`, and return to the default behaviour, set the `side_effect` to `None`:

```

>>> m = MagicMock(return_value=6)
>>> def side_effect(*args, **kwargs):
...     return 3
...
>>> m.side_effect = side_effect
>>> m()
3
>>> m.side_effect = None
>>> m()
6

```

The `side_effect` can also be any iterable object. Repeated calls to the mock will return values from the iterable (until the iterable is exhausted and a `StopIteration` is raised):

```

>>> m = MagicMock(side_effect=[1, 2, 3])
>>> m()
1
>>> m()
2
>>> m()
3
>>> m()
Traceback (most recent call last):
...
StopIteration

```

If any members of the iterable are exceptions they will be raised instead of returned:

```

>>> iterable = (33, ValueError, 66)
>>> m = MagicMock(side_effect=iterable)
>>> m()
33
>>> m()
Traceback (most recent call last):
...
ValueError
>>> m()
66

```

Deleting Attributes

Mock objects create attributes on demand. This allows them to pretend to be objects of any type.

You may want a mock object to return `False` to a `hasattr()` call, or raise an `AttributeError` when an attribute is fetched. You can do this by providing an object as a `spec` for a mock, but that isn't always convenient.

You "block" attributes by deleting them. Once deleted, accessing an attribute will raise an `AttributeError`.

```
>>> mock = MagicMock()
>>> hasattr(mock, 'm')
True
>>> del mock.m
>>> hasattr(mock, 'm')
False
>>> del mock.f
>>> mock.f
Traceback (most recent call last):
...
AttributeError: f
```

Mock names and the name attribute

Since "name" is an argument to the `Mock` constructor, if you want your mock object to have a "name" attribute you can't just pass it in at creation time. There are two alternatives. One option is to use `configure_mock()`:

```
>>> mock = MagicMock()
>>> mock.configure_mock(name='my_name')
>>> mock.name
'my_name'
```

A simpler option is to simply set the "name" attribute after mock creation:

```
>>> mock = MagicMock()
>>> mock.name = "foo"
```

Attaching Mocks as Attributes

When you attach a mock as an attribute of another mock (or as the return value) it becomes a "child" of that mock. Calls to the child are recorded in the `method_calls` and `mock_calls` attributes of the parent. This is useful for configuring child mocks and then attaching them to the parent, or for attaching mocks to a parent that records all calls to the children and allows you to make assertions about the order of calls between mocks:

```
>>> parent = MagicMock()
>>> child1 = MagicMock(return_value=None)
>>> child2 = MagicMock(return_value=None)
>>> parent.child1 = child1
>>> parent.child2 = child2
>>> child1(1)
>>> child2(2)
>>> parent.mock_calls
[call.child1(1), call.child2(2)]
```

The exception to this is if the mock has a name. This allows you to prevent the "parenting" if for some reason you don't want it to happen.

```
>>> mock = MagicMock()
>>> not_a_child = MagicMock(name='not-a-child')
>>> mock.attribute = not_a_child
```

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```
>>> mock.attribute()
<MagicMock name='not-a-child()' id='... '>
>>> mock.mock_calls
[]
```

Mocks created for you by `patch()` are automatically given names. To attach mocks that have names to a parent you use the `attach_mock()` method:

```
>>> thing1 = object()
>>> thing2 = object()
>>> parent = MagicMock()
>>> with patch('__main__.thing1', return_value=None) as child1:
...     with patch('__main__.thing2', return_value=None) as child2:
...         parent.attach_mock(child1, 'child1')
...         parent.attach_mock(child2, 'child2')
...         child1('one')
...         child2('two')
...
>>> parent.mock_calls
[call.child1('one'), call.child2('two')]
```

26.6.3 The patchers

The patch decorators are used for patching objects only within the scope of the function they decorate. They automatically handle the unpatching for you, even if exceptions are raised. All of these functions can also be used in with statements or as class decorators.

patch

備 F: The key is to do the patching in the right namespace. See the section [where to patch](#).

`unittest.mock.patch` (*target*, *new*=`DEFAULT`, *spec*=`None`, *create*=`False`, *spec_set*=`None`, *autospec*=`None`, *new_callable*=`None`, ***kwargs*)

`patch()` acts as a function decorator, class decorator or a context manager. Inside the body of the function or with statement, the *target* is patched with a *new* object. When the function/with statement exits the patch is undone.

If *new* is omitted, then the target is replaced with an `AsyncMock` if the patched object is an async function or a `MagicMock` otherwise. If `patch()` is used as a decorator and *new* is omitted, the created mock is passed in as an extra argument to the decorated function. If `patch()` is used as a context manager the created mock is returned by the context manager.

target should be a string in the form `'package.module.ClassName'`. The *target* is imported and the specified object replaced with the *new* object, so the *target* must be importable from the environment you are calling `patch()` from. The target is imported when the decorated function is executed, not at decoration time.

The *spec* and *spec_set* keyword arguments are passed to the `MagicMock` if patch is creating one for you.

In addition you can pass *spec*=`True` or *spec_set*=`True`, which causes patch to pass in the object being mocked as the *spec*/*spec_set* object.

new_callable allows you to specify a different class, or callable object, that will be called to create the *new* object. By default `AsyncMock` is used for async functions and `MagicMock` for the rest.

A more powerful form of *spec* is *autospec*. If you set *autospec*=`True` then the mock will be created with a *spec* from the object being replaced. All attributes of the mock will also have the *spec* of the corresponding


```
>>> Original = Class
>>> patcher = patch('__main__.Class', spec=True)
>>> MockClass = patcher.start()
>>> instance = MockClass()
>>> assert isinstance(instance, Original)
>>> patcher.stop()
```

The *new_callable* argument is useful where you want to use an alternative class to the default *MagicMock* for the created mock. For example, if you wanted a *NonCallableMock* to be used:

```
>>> thing = object()
>>> with patch('__main__.thing', new_callable=NonCallableMock) as mock_thing:
...     assert thing is mock_thing
...     thing()
...
Traceback (most recent call last):
...
TypeError: 'NonCallableMock' object is not callable
```

Another use case might be to replace an object with an *io.StringIO* instance:

```
>>> from io import StringIO
>>> def foo():
...     print('Something')
...
>>> @patch('sys.stdout', new_callable=StringIO)
... def test(mock_stdout):
...     foo()
...     assert mock_stdout.getvalue() == 'Something\n'
...
>>> test()
```

When *patch()* is creating a mock for you, it is common that the first thing you need to do is to configure the mock. Some of that configuration can be done in the call to *patch*. Any arbitrary keywords you pass into the call will be used to set attributes on the created mock:

```
>>> patcher = patch('__main__.thing', first='one', second='two')
>>> mock_thing = patcher.start()
>>> mock_thing.first
'one'
>>> mock_thing.second
'two'
```

As well as attributes on the created mock attributes, like the *return_value* and *side_effect*, of child mocks can also be configured. These aren't syntactically valid to pass in directly as keyword arguments, but a dictionary with these as keys can still be expanded into a *patch()* call using ****:

```
>>> config = {'method.return_value': 3, 'other.side_effect': KeyError}
>>> patcher = patch('__main__.thing', **config)
>>> mock_thing = patcher.start()
>>> mock_thing.method()
3
>>> mock_thing.other()
Traceback (most recent call last):
...
KeyError
```

By default, attempting to patch a function in a module (or a method or an attribute in a class) that does not exist will fail with *AttributeError*:

```
>>> @patch('sys.non_existing_attribute', 42)
... def test():
...     assert sys.non_existing_attribute == 42
...
>>> test()
Traceback (most recent call last):
...
AttributeError: <module 'sys' (built-in)> does not have the attribute 'non_
↪existing_attribute'
```

but adding `create=True` in the call to `patch()` will make the previous example work as expected:

```
>>> @patch('sys.non_existing_attribute', 42, create=True)
... def test(mock_stdout):
...     assert sys.non_existing_attribute == 42
...
>>> test()
```

在 3.8 版的變更: `patch()` now returns an `AsyncMock` if the target is an async function.

patch.object

`patch.object(target, attribute, new=DEFAULT, spec=None, create=False, spec_set=None, autospec=None, new_callable=None, **kwargs)`

patch the named member (*attribute*) on an object (*target*) with a mock object.

`patch.object()` can be used as a decorator, class decorator or a context manager. Arguments *new*, *spec*, *create*, *spec_set*, *autospec* and *new_callable* have the same meaning as for `patch()`. Like `patch()`, `patch.object()` takes arbitrary keyword arguments for configuring the mock object it creates.

When used as a class decorator `patch.object()` honours `patch.TEST_PREFIX` for choosing which methods to wrap.

You can either call `patch.object()` with three arguments or two arguments. The three argument form takes the object to be patched, the attribute name and the object to replace the attribute with.

When calling with the two argument form you omit the replacement object, and a mock is created for you and passed in as an extra argument to the decorated function:

```
>>> @patch.object(SomeClass, 'class_method')
... def test(mock_method):
...     SomeClass.class_method(3)
...     mock_method.assert_called_with(3)
...
>>> test()
```

spec, *create* and the other arguments to `patch.object()` have the same meaning as they do for `patch()`.

patch.dict

`patch.dict(in_dict, values=(), clear=False, **kwargs)`

Patch a dictionary, or dictionary like object, and restore the dictionary to its original state after the test.

in_dict can be a dictionary or a mapping like container. If it is a mapping then it must at least support getting, setting and deleting items plus iterating over keys.

in_dict can also be a string specifying the name of the dictionary, which will then be fetched by importing it.

values can be a dictionary of values to set in the dictionary. *values* can also be an iterable of (*key*, *value*) pairs.

If *clear* is true then the dictionary will be cleared before the new values are set.

`patch.dict()` can also be called with arbitrary keyword arguments to set values in the dictionary.

在 3.8 版的變更: `patch.dict()` now returns the patched dictionary when used as a context manager.

`patch.dict()` can be used as a context manager, decorator or class decorator:

```
>>> foo = {}
>>> @patch.dict(foo, {'newkey': 'newvalue'})
... def test():
...     assert foo == {'newkey': 'newvalue'}
>>> test()
>>> assert foo == {}
```

When used as a class decorator `patch.dict()` honours `patch.TEST_PREFIX` (default to 'test') for choosing which methods to wrap:

```
>>> import os
>>> import unittest
>>> from unittest.mock import patch
>>> @patch.dict('os.environ', {'newkey': 'newvalue'})
... class TestSample(unittest.TestCase):
...     def test_sample(self):
...         self.assertEqual(os.environ['newkey'], 'newvalue')
```

If you want to use a different prefix for your test, you can inform the patchers of the different prefix by setting `patch.TEST_PREFIX`. For more details about how to change the value of see [TEST_PREFIX](#).

`patch.dict()` can be used to add members to a dictionary, or simply let a test change a dictionary, and ensure the dictionary is restored when the test ends.

```
>>> foo = {}
>>> with patch.dict(foo, {'newkey': 'newvalue'}) as patched_foo:
...     assert foo == {'newkey': 'newvalue'}
...     assert patched_foo == {'newkey': 'newvalue'}
...     # You can add, update or delete keys of foo (or patched_foo, it's the same.
↪dict)
...     patched_foo['spam'] = 'eggs'
...
>>> assert foo == {}
>>> assert patched_foo == {}
```

```
>>> import os
>>> with patch.dict('os.environ', {'newkey': 'newvalue'}):
...     print(os.environ['newkey'])
...
newvalue
>>> assert 'newkey' not in os.environ
```

Keywords can be used in the `patch.dict()` call to set values in the dictionary:

```
>>> mymodule = MagicMock()
>>> mymodule.function.return_value = 'fish'
>>> with patch.dict('sys.modules', mymodule=mymodule):
...     import mymodule
...     mymodule.function('some', 'args')
...
'fish'
```

`patch.dict()` can be used with dictionary like objects that aren't actually dictionaries. At the very minimum they must support item getting, setting, deleting and either iteration or membership test. This corresponds to the magic methods `__getitem__()`, `__setitem__()`, `__delitem__()` and either `__iter__()` or `__contains__()`.

```

>>> class Container:
...     def __init__(self):
...         self.values = {}
...     def __getitem__(self, name):
...         return self.values[name]
...     def __setitem__(self, name, value):
...         self.values[name] = value
...     def __delitem__(self, name):
...         del self.values[name]
...     def __iter__(self):
...         return iter(self.values)
...
>>> thing = Container()
>>> thing['one'] = 1
>>> with patch.dict(thing, one=2, two=3):
...     assert thing['one'] == 2
...     assert thing['two'] == 3
...
>>> assert thing['one'] == 1
>>> assert list(thing) == ['one']

```

patch.multiple

`patch.multiple(target, spec=None, create=False, spec_set=None, autospec=None, new_callable=None, **kwargs)`

Perform multiple patches in a single call. It takes the object to be patched (either as an object or a string to fetch the object by importing) and keyword arguments for the patches:

```

with patch.multiple(settings, FIRST_PATCH='one', SECOND_PATCH='two'):
    ...

```

Use `DEFAULT` as the value if you want `patch.multiple()` to create mocks for you. In this case the created mocks are passed into a decorated function by keyword, and a dictionary is returned when `patch.multiple()` is used as a context manager.

`patch.multiple()` can be used as a decorator, class decorator or a context manager. The arguments `spec`, `spec_set`, `create`, `autospec` and `new_callable` have the same meaning as for `patch()`. These arguments will be applied to *all* patches done by `patch.multiple()`.

When used as a class decorator `patch.multiple()` honours `patch.TEST_PREFIX` for choosing which methods to wrap.

If you want `patch.multiple()` to create mocks for you, then you can use `DEFAULT` as the value. If you use `patch.multiple()` as a decorator then the created mocks are passed into the decorated function by keyword.

```

>>> thing = object()
>>> other = object()

>>> @patch.multiple('__main__', thing=DEFAULT, other=DEFAULT)
... def test_function(thing, other):
...     assert isinstance(thing, MagicMock)
...     assert isinstance(other, MagicMock)
...
>>> test_function()

```

`patch.multiple()` can be nested with other patch decorators, but put arguments passed by keyword *after* any of the standard arguments created by `patch()`:

```

>>> @patch('sys.exit')
... @patch.multiple('__main__', thing=DEFAULT, other=DEFAULT)

```

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```

... def test_function(mock_exit, other, thing):
...     assert 'other' in repr(other)
...     assert 'thing' in repr(thing)
...     assert 'exit' in repr(mock_exit)
...
>>> test_function()

```

If `patch.multiple()` is used as a context manager, the value returned by the context manager is a dictionary where created mocks are keyed by name:

```

>>> with patch.multiple('__main__', thing=DEFAULT, other=DEFAULT) as values:
...     assert 'other' in repr(values['other'])
...     assert 'thing' in repr(values['thing'])
...     assert values['thing'] is thing
...     assert values['other'] is other
...

```

patch methods: start and stop

All the patchers have `start()` and `stop()` methods. These make it simpler to do patching in `setUp` methods or where you want to do multiple patches without nesting decorators or with statements.

To use them call `patch()`, `patch.object()` or `patch.dict()` as normal and keep a reference to the returned patcher object. You can then call `start()` to put the patch in place and `stop()` to undo it.

If you are using `patch()` to create a mock for you then it will be returned by the call to `patcher.start`.

```

>>> patcher = patch('package.module.ClassName')
>>> from package import module
>>> original = module.ClassName
>>> new_mock = patcher.start()
>>> assert module.ClassName is not original
>>> assert module.ClassName is new_mock
>>> patcher.stop()
>>> assert module.ClassName is original
>>> assert module.ClassName is not new_mock

```

A typical use case for this might be for doing multiple patches in the `setUp` method of a `TestCase`:

```

>>> class MyTest(unittest.TestCase):
...     def setUp(self):
...         self.patcher1 = patch('package.module.Class1')
...         self.patcher2 = patch('package.module.Class2')
...         self.MockClass1 = self.patcher1.start()
...         self.MockClass2 = self.patcher2.start()
...
...     def tearDown(self):
...         self.patcher1.stop()
...         self.patcher2.stop()
...
...     def test_something(self):
...         assert package.module.Class1 is self.MockClass1
...         assert package.module.Class2 is self.MockClass2
...
>>> MyTest('test_something').run()

```

警告: If you use this technique you must ensure that the patching is “undone” by calling `stop`. This can be fiddlier than you might think, because if an exception is raised in the `setUp` then `tearDown` is not called. `unittest.TestCase.addCleanup()` makes this easier:

```
>>> class MyTest(unittest.TestCase):
...     def setUp(self):
...         patcher = patch('package.module.Class')
...         self.MockClass = patcher.start()
...         self.addCleanup(patcher.stop)
...
...     def test_something(self):
...         assert package.module.Class is self.MockClass
...
... 
```

As an added bonus you no longer need to keep a reference to the `patcher` object.

It is also possible to stop all patches which have been started by using `patch.stopall()`.

`patch.stopall()`

Stop all active patches. Only stops patches started with `start`.

patch builtins

You can patch any builtins within a module. The following example patches builtin `ord()`:

```
>>> @patch('__main__.ord')
... def test(mock_ord):
...     mock_ord.return_value = 101
...     print(ord('c'))
...
... 
```

```
>>> test()
101
```

TEST_PREFIX

All of the patchers can be used as class decorators. When used in this way they wrap every test method on the class. The patchers recognise methods that start with 'test' as being test methods. This is the same way that the `unittest.TestLoader` finds test methods by default.

It is possible that you want to use a different prefix for your tests. You can inform the patchers of the different prefix by setting `patch.TEST_PREFIX`:

```
>>> patch.TEST_PREFIX = 'foo'
>>> value = 3
>>>
>>> @patch('__main__.value', 'not three')
... class Thing:
...     def foo_one(self):
...         print(value)
...     def foo_two(self):
...         print(value)
...
... 
```

```
>>> Thing().foo_one()
not three
>>> Thing().foo_two()
not three
>>> value
3
```

Nesting Patch Decorators

If you want to perform multiple patches then you can simply stack up the decorators.

You can stack up multiple patch decorators using this pattern:

```
>>> @patch.object(SomeClass, 'class_method')
... @patch.object(SomeClass, 'static_method')
... def test(mock1, mock2):
...     assert SomeClass.static_method is mock1
...     assert SomeClass.class_method is mock2
...     SomeClass.static_method('foo')
...     SomeClass.class_method('bar')
...     return mock1, mock2
...
>>> mock1, mock2 = test()
>>> mock1.assert_called_once_with('foo')
>>> mock2.assert_called_once_with('bar')
```

Note that the decorators are applied from the bottom upwards. This is the standard way that Python applies decorators. The order of the created mocks passed into your test function matches this order.

Where to patch

`patch()` works by (temporarily) changing the object that a *name* points to with another one. There can be many names pointing to any individual object, so for patching to work you must ensure that you patch the name used by the system under test.

The basic principle is that you patch where an object is *looked up*, which is not necessarily the same place as where it is defined. A couple of examples will help to clarify this.

Imagine we have a project that we want to test with the following structure:

```
a.py
-> Defines SomeClass

b.py
-> from a import SomeClass
-> some_function instantiates SomeClass
```

Now we want to test `some_function` but we want to mock out `SomeClass` using `patch()`. The problem is that when we import module `b`, which we will have to do then it imports `SomeClass` from module `a`. If we use `patch()` to mock out `a.SomeClass` then it will have no effect on our test; module `b` already has a reference to the *real* `SomeClass` and it looks like our patching had no effect.

The key is to patch out `SomeClass` where it is used (or where it is looked up). In this case `some_function` will actually look up `SomeClass` in module `b`, where we have imported it. The patching should look like:

```
@patch('b.SomeClass')
```

However, consider the alternative scenario where instead of `from a import SomeClass` module `b` does `import a` and `some_function` uses `a.SomeClass`. Both of these import forms are common. In this case the class we want to patch is being looked up in the module and so we have to patch `a.SomeClass` instead:

```
@patch('a.SomeClass')
```

Patching Descriptors and Proxy Objects

Both `patch` and `patch.object` correctly patch and restore descriptors: class methods, static methods and properties. You should patch these on the *class* rather than an instance. They also work with *some* objects that proxy attribute access, like the `django settings object`.

26.6.4 MagicMock and magic method support

Mocking Magic Methods

`Mock` supports mocking the Python protocol methods, also known as “*magic methods*”. This allows mock objects to replace containers or other objects that implement Python protocols.

Because magic methods are looked up differently from normal methods², this support has been specially implemented. This means that only specific magic methods are supported. The supported list includes *almost* all of them. If there are any missing that you need please let us know.

You mock magic methods by setting the method you are interested in to a function or a mock instance. If you are using a function then it *must* take `self` as the first argument³.

```
>>> def __str__(self):
...     return 'fooble'
...
>>> mock = Mock()
>>> mock.__str__ = __str__
>>> str(mock)
'fooble'
```

```
>>> mock = Mock()
>>> mock.__str__ = Mock()
>>> mock.__str__.return_value = 'fooble'
>>> str(mock)
'fooble'
```

```
>>> mock = Mock()
>>> mock.__iter__ = Mock(return_value=iter([]))
>>> list(mock)
[]
```

One use case for this is for mocking objects used as context managers in a `with` statement:

```
>>> mock = Mock()
>>> mock.__enter__ = Mock(return_value='foo')
>>> mock.__exit__ = Mock(return_value=False)
>>> with mock as m:
...     assert m == 'foo'
...
>>> mock.__enter__.assert_called_with()
>>> mock.__exit__.assert_called_with(None, None, None)
```

Calls to magic methods do not appear in `method_calls`, but they are recorded in `mock_calls`.

備 F: If you use the `spec` keyword argument to create a mock then attempting to set a magic method that isn't in the spec will raise an `AttributeError`.

The full list of supported magic methods is:

² Magic methods *should* be looked up on the class rather than the instance. Different versions of Python are inconsistent about applying this rule. The supported protocol methods should work with all supported versions of Python.

³ The function is basically hooked up to the class, but each `Mock` instance is kept isolated from the others.

- `__hash__`, `__sizeof__`, `__repr__` 和 `__str__`
- `__dir__`, `__format__` 和 `__subclasses__`
- `__round__`, `__floor__`, `__trunc__` 和 `__ceil__`
- Comparisons: `__lt__`, `__gt__`, `__le__`, `__ge__`, `__eq__` and `__ne__`
- Container methods: `__getitem__`, `__setitem__`, `__delitem__`, `__contains__`, `__len__`, `__iter__`, `__reversed__` and `__missing__`
- Context manager: `__enter__`, `__exit__`, `__aenter__` and `__aexit__`
- Unary numeric methods: `__neg__`, `__pos__` and `__invert__`
- The numeric methods (including right hand and in-place variants): `__add__`, `__sub__`, `__mul__`, `__matmul__`, `__truediv__`, `__floordiv__`, `__mod__`, `__divmod__`, `__lshift__`, `__rshift__`, `__and__`, `__xor__`, `__or__`, and `__pow__`
- Numeric conversion methods: `__complex__`, `__int__`, `__float__` and `__index__`
- Descriptor methods: `__get__`, `__set__` and `__delete__`
- Pickling: `__reduce__`, `__reduce_ex__`, `__getinitargs__`, `__getnewargs__`, `__getstate__` and `__setstate__`
- File system path representation: `__fspath__`
- Asynchronous iteration methods: `__aiter__` and `__anext__`

在 3.8 版的變更: Added support for `os.PathLike.__fspath__()`.

在 3.8 版的變更: Added support for `__aenter__`, `__aexit__`, `__aiter__` and `__anext__`.

The following methods exist but are *not* supported as they are either in use by mock, can't be set dynamically, or can cause problems:

- `__getattr__`, `__setattr__`, `__init__` 和 `__new__`
- `__prepare__`, `__instancecheck__`, `__subclasscheck__`, `__del__`

Magic Mock

There are two `MagicMock` variants: `MagicMock` and `NonCallableMagicMock`.

class `unittest.mock.MagicMock(*args, **kw)`

`MagicMock` is a subclass of `Mock` with default implementations of most of the *magic methods*. You can use `MagicMock` without having to configure the magic methods yourself.

The constructor parameters have the same meaning as for `Mock`.

If you use the `spec` or `spec_set` arguments then *only* magic methods that exist in the spec will be created.

class `unittest.mock.NonCallableMagicMock(*args, **kw)`

A non-callable version of `MagicMock`.

The constructor parameters have the same meaning as for `MagicMock`, with the exception of `return_value` and `side_effect` which have no meaning on a non-callable mock.

The magic methods are setup with `MagicMock` objects, so you can configure them and use them in the usual way:

```
>>> mock = MagicMock()
>>> mock[3] = 'fish'
>>> mock.__setitem__.assert_called_with(3, 'fish')
>>> mock.__getitem__.return_value = 'result'
>>> mock[2]
'result'
```

By default many of the protocol methods are required to return objects of a specific type. These methods are preconfigured with a default return value, so that they can be used without you having to do anything if you aren't interested in the return value. You can still *set* the return value manually if you want to change the default.

Methods and their defaults:

- `__lt__`: *NotImplemented*
- `__gt__`: *NotImplemented*
- `__le__`: *NotImplemented*
- `__ge__`: *NotImplemented*
- `__int__`: 1
- `__contains__`: False
- `__len__`: 0
- `__iter__`: `iter([])`
- `__exit__`: False
- `__aexit__`: False
- `__complex__`: `1j`
- `__float__`: `1.0`
- `__bool__`: True
- `__index__`: 1
- `__hash__`: default hash for the mock
- `__str__`: default str for the mock
- `__sizeof__`: default sizeof for the mock

舉例來F:

```
>>> mock = MagicMock()
>>> int(mock)
1
>>> len(mock)
0
>>> list(mock)
[]
>>> object() in mock
False
```

The two equality methods, `__eq__()` and `__ne__()`, are special. They do the default equality comparison on identity, using the *side_effect* attribute, unless you change their return value to return something else:

```
>>> MagicMock() == 3
False
>>> MagicMock() != 3
True
>>> mock = MagicMock()
>>> mock.__eq__.return_value = True
>>> mock == 3
True
```

The return value of `MagicMock.__iter__()` can be any iterable object and isn't required to be an iterator:

```
>>> mock = MagicMock()
>>> mock.__iter__.return_value = ['a', 'b', 'c']
>>> list(mock)
```

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```
[ 'a', 'b', 'c' ]
>>> list(mock)
[ 'a', 'b', 'c' ]
```

If the return value *is* an iterator, then iterating over it once will consume it and subsequent iterations will result in an empty list:

```
>>> mock.__iter__.return_value = iter(['a', 'b', 'c'])
>>> list(mock)
[ 'a', 'b', 'c' ]
>>> list(mock)
[]
```

MagicMock has all of the supported magic methods configured except for some of the obscure and obsolete ones. You can still set these up if you want.

Magic methods that are supported but not setup by default in MagicMock are:

- `__subclasses__`
- `__dir__`
- `__format__`
- `__get__`、`__set__` 和 `__delete__`
- `__reversed__` 和 `__missing__`
- `__reduce__`、`__reduce_ex__`、`__getinitargs__`、`__getnewargs__`、`__getstate__` 和 `__setstate__`
- `__getformat__`

26.6.5 Helpers

sentinel

`unittest.mock.sentinel`

The `sentinel` object provides a convenient way of providing unique objects for your tests.

Attributes are created on demand when you access them by name. Accessing the same attribute will always return the same object. The objects returned have a sensible repr so that test failure messages are readable.

在 3.7 版的變更: The `sentinel` attributes now preserve their identity when they are *copied* or *pickled*.

Sometimes when testing you need to test that a specific object is passed as an argument to another method, or returned. It can be common to create named sentinel objects to test this. `sentinel` provides a convenient way of creating and testing the identity of objects like this.

In this example we monkey patch method to return `sentinel.some_object`:

```
>>> real = ProductionClass()
>>> real.method = Mock(name="method")
>>> real.method.return_value = sentinel.some_object
>>> result = real.method()
>>> assert result is sentinel.some_object
>>> result
sentinel.some_object
```

DEFAULT

unittest.mock.DEFAULT

The `DEFAULT` object is a pre-created sentinel (actually `sentinel.DEFAULT`). It can be used by `side_effect` functions to indicate that the normal return value should be used.

call

unittest.mock.call(*args, **kwargs)

`call()` is a helper object for making simpler assertions, for comparing with `call_args`, `call_args_list`, `mock_calls` and `method_calls`. `call()` can also be used with `assert_has_calls()`.

```
>>> m = MagicMock(return_value=None)
>>> m(1, 2, a='foo', b='bar')
>>> m()
>>> m.call_args_list == [call(1, 2, a='foo', b='bar'), call()]
True
```

call.call_list()

For a call object that represents multiple calls, `call_list()` returns a list of all the intermediate calls as well as the final call.

`call_list` is particularly useful for making assertions on “chained calls”. A chained call is multiple calls on a single line of code. This results in multiple entries in `mock_calls` on a mock. Manually constructing the sequence of calls can be tedious.

`call_list()` can construct the sequence of calls from the same chained call:

```
>>> m = MagicMock()
>>> m(1).method(arg='foo').other('bar')(2.0)
<MagicMock name='mock().method().other()' id='...'>
>>> kall = call(1).method(arg='foo').other('bar')(2.0)
>>> kall.call_list()
[call(1,
  call().method(arg='foo'),
  call().method().other('bar'),
  call().method().other()(2.0)]
>>> m.mock_calls == kall.call_list()
True
```

A call object is either a tuple of (positional args, keyword args) or (name, positional args, keyword args) depending on how it was constructed. When you construct them yourself this isn’t particularly interesting, but the call objects that are in the `Mock.call_args`, `Mock.call_args_list` and `Mock.mock_calls` attributes can be introspected to get at the individual arguments they contain.

The call objects in `Mock.call_args` and `Mock.call_args_list` are two-tuples of (positional args, keyword args) whereas the call objects in `Mock.mock_calls`, along with ones you construct yourself, are three-tuples of (name, positional args, keyword args).

You can use their “tupleness” to pull out the individual arguments for more complex introspection and assertions. The positional arguments are a tuple (an empty tuple if there are no positional arguments) and the keyword arguments are a dictionary:

```
>>> m = MagicMock(return_value=None)
>>> m(1, 2, 3, arg='one', arg2='two')
>>> kall = m.call_args
>>> kall.args
(1, 2, 3)
>>> kall.kwargs
```

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```
{'arg': 'one', 'arg2': 'two'}
>>> kall.args is kall[0]
True
>>> kall.kwargs is kall[1]
True
```

```
>>> m = MagicMock()
>>> m.foo(4, 5, 6, arg='two', arg2='three')
<MagicMock name='mock.foo()' id='...'>
>>> kall = m.mock_calls[0]
>>> name, args, kwargs = kall
>>> name
'foo'
>>> args
(4, 5, 6)
>>> kwargs
{'arg': 'two', 'arg2': 'three'}
>>> name is m.mock_calls[0][0]
True
```

create_autospec

`unittest.mock.create_autospec(spec, spec_set=False, instance=False, **kwargs)`

Create a mock object using another object as a spec. Attributes on the mock will use the corresponding attribute on the *spec* object as their spec.

Functions or methods being mocked will have their arguments checked to ensure that they are called with the correct signature.

If *spec_set* is `True` then attempting to set attributes that don't exist on the spec object will raise an *AttributeError*.

If a class is used as a spec then the return value of the mock (the instance of the class) will have the same spec. You can use a class as the spec for an instance object by passing *instance=True*. The returned mock will only be callable if instances of the mock are callable.

create_autospec() also takes arbitrary keyword arguments that are passed to the constructor of the created mock.

See *Autospeccing* for examples of how to use auto-speccing with *create_autospec()* and the *autospec* argument to *patch()*.

在 3.8 版的變更: *create_autospec()* now returns an *AsyncMock* if the target is an async function.

ANY

`unittest.mock.ANY`

Sometimes you may need to make assertions about *some* of the arguments in a call to mock, but either not care about some of the arguments or want to pull them individually out of *call_args* and make more complex assertions on them.

To ignore certain arguments you can pass in objects that compare equal to *everything*. Calls to *assert_called_with()* and *assert_called_once_with()* will then succeed no matter what was passed in.

```
>>> mock = Mock(return_value=None)
>>> mock('foo', bar=object())
>>> mock.assert_called_once_with('foo', bar=ANY)
```

ANY can also be used in comparisons with call lists like *mock_calls*:

```
>>> m = MagicMock(return_value=None)
>>> m(1)
>>> m(1, 2)
>>> m(object())
>>> m.mock_calls == [call(1), call(1, 2), ANY]
True
```

ANY is not limited to comparisons with call objects and so can also be used in test assertions:

```
class TestStringMethods(unittest.TestCase):

    def test_split(self):
        s = 'hello world'
        self.assertEqual(s.split(), ['hello', ANY])
```

FILTER_DIR

`unittest.mock.FILTER_DIR`

FILTER_DIR is a module level variable that controls the way mock objects respond to *dir()*. The default is `True`, which uses the filtering described below, to only show useful members. If you dislike this filtering, or need to switch it off for diagnostic purposes, then set `mock.FILTER_DIR = False`.

With filtering on, `dir(some_mock)` shows only useful attributes and will include any dynamically created attributes that wouldn't normally be shown. If the mock was created with a *spec* (or *autospec* of course) then all the attributes from the original are shown, even if they haven't been accessed yet:

```
>>> dir(Mock())
['assert_any_call',
 'assert_called',
 'assert_called_once',
 'assert_called_once_with',
 'assert_called_with',
 'assert_has_calls',
 'assert_not_called',
 'attach_mock',
 ...
>>> from urllib import request
>>> dir(Mock(spec=request))
['AbstractBasicAuthHandler',
 'AbstractDigestAuthHandler',
 'AbstractHTTPHandler',
 'BaseHandler',
 ...]
```

Many of the not-very-useful (private to *Mock* rather than the thing being mocked) underscore and double underscore prefixed attributes have been filtered from the result of calling *dir()* on a *Mock*. If you dislike this behaviour you can switch it off by setting the module level switch *FILTER_DIR*:

```
>>> from unittest import mock
>>> mock.FILTER_DIR = False
>>> dir(mock.Mock())
['_NonCallableMock__get_return_value',
 '_NonCallableMock__get_side_effect',
 '_NonCallableMock__return_value_doc',
 '_NonCallableMock__set_return_value',
 '_NonCallableMock__set_side_effect',
 '__call__',
```

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```
'__class__',
...
```

Alternatively you can just use `vars(my_mock)` (instance members) and `dir(type(my_mock))` (type members) to bypass the filtering irrespective of `mock.FILTER_DIR`.

mock_open

`unittest.mock.mock_open(mock=None, read_data=None)`

A helper function to create a mock to replace the use of `open()`. It works for `open()` called directly or used as a context manager.

The `mock` argument is the mock object to configure. If `None` (the default) then a `MagicMock` will be created for you, with the API limited to methods or attributes available on standard file handles.

`read_data` is a string for the `read()`, `readline()`, and `readlines()` methods of the file handle to return. Calls to those methods will take data from `read_data` until it is depleted. The mock of these methods is pretty simplistic: every time the `mock` is called, the `read_data` is rewound to the start. If you need more control over the data that you are feeding to the tested code you will need to customize this mock for yourself. When that is insufficient, one of the in-memory filesystem packages on [PyPI](#) can offer a realistic filesystem for testing.

在 3.4 版的變更: Added `readline()` and `readlines()` support. The mock of `read()` changed to consume `read_data` rather than returning it on each call.

在 3.5 版的變更: `read_data` is now reset on each call to the `mock`.

在 3.8 版的變更: Added `__iter__()` to implementation so that iteration (such as in for loops) correctly consumes `read_data`.

Using `open()` as a context manager is a great way to ensure your file handles are closed properly and is becoming common:

```
with open('/some/path', 'w') as f:
    f.write('something')
```

The issue is that even if you mock out the call to `open()` it is the *returned object* that is used as a context manager (and has `__enter__()` and `__exit__()` called).

Mocking context managers with a `MagicMock` is common enough and fiddly enough that a helper function is useful.

```
>>> m = mock_open()
>>> with patch('__main__.open', m):
...     with open('foo', 'w') as h:
...         h.write('some stuff')
...
>>> m.mock_calls
[call('foo', 'w'),
 call().__enter__(),
 call().write('some stuff'),
 call().__exit__(None, None, None)]
>>> m.assert_called_once_with('foo', 'w')
>>> handle = m()
>>> handle.write.assert_called_once_with('some stuff')
```

And for reading files:

```
>>> with patch('__main__.open', mock_open(read_data='bibble')) as m:
...     with open('foo') as h:
...         result = h.read()
...
>>>
```

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```
>>> m.assert_called_once_with('foo')
>>> assert result == 'bibble'
```

Autospeccing

Autospeccing is based on the existing `spec` feature of `mock`. It limits the api of mocks to the api of an original object (the `spec`), but it is recursive (implemented lazily) so that attributes of mocks only have the same api as the attributes of the `spec`. In addition mocked functions / methods have the same call signature as the original so they raise a `TypeError` if they are called incorrectly.

Before I explain how auto-speccing works, here's why it is needed.

`Mock` is a very powerful and flexible object, but it suffers from two flaws when used to mock out objects from a system under test. One of these flaws is specific to the `Mock` api and the other is a more general problem with using mock objects.

First the problem specific to `Mock`. `Mock` has two assert methods that are extremely handy: `assert_called_with()` and `assert_called_once_with()`.

```
>>> mock = Mock(name='Thing', return_value=None)
>>> mock(1, 2, 3)
>>> mock.assert_called_once_with(1, 2, 3)
>>> mock(1, 2, 3)
>>> mock.assert_called_once_with(1, 2, 3)
Traceback (most recent call last):
...
AssertionError: Expected 'mock' to be called once. Called 2 times.
```

Because mocks auto-create attributes on demand, and allow you to call them with arbitrary arguments, if you misspell one of these assert methods then your assertion is gone:

```
>>> mock = Mock(name='Thing', return_value=None)
>>> mock(1, 2, 3)
>>> mock.assret_called_once_with(4, 5, 6) # Intentional typo!
```

Your tests can pass silently and incorrectly because of the typo.

The second issue is more general to mocking. If you refactor some of your code, rename members and so on, any tests for code that is still using the *old api* but uses mocks instead of the real objects will still pass. This means your tests can all pass even though your code is broken.

Note that this is another reason why you need integration tests as well as unit tests. Testing everything in isolation is all fine and dandy, but if you don't test how your units are "wired together" there is still lots of room for bugs that tests might have caught.

`mock` already provides a feature to help with this, called `spec`ing. If you use a class or instance as the `spec` for a mock then you can only access attributes on the mock that exist on the real class:

```
>>> from urllib import request
>>> mock = Mock(spec=request.Request)
>>> mock.assret_called_with # Intentional typo!
Traceback (most recent call last):
...
AttributeError: Mock object has no attribute 'assret_called_with'
```

The `spec` only applies to the mock itself, so we still have the same issue with any methods on the mock:

```
>>> mock.has_data()
<mock.Mock object at 0x...>
>>> mock.has_data.assret_called_with() # Intentional typo!
```

Auto-spec'ing solves this problem. You can either pass `autospec=True` to `patch()` / `patch.object()` or use the `create_autospec()` function to create a mock with a spec. If you use the `autospec=True` argument to `patch()` then the object that is being replaced will be used as the spec object. Because the spec'ing is done "lazily" (the spec is created as attributes on the mock are accessed) you can use it with very complex or deeply nested objects (like modules that import modules that import modules) without a big performance hit.

Here's an example of it in use:

```
>>> from urllib import request
>>> patcher = patch('__main__.request', autospec=True)
>>> mock_request = patcher.start()
>>> request is mock_request
True
>>> mock_request.Request
<MagicMock name='request.Request' spec='Request' id='...'>
```

You can see that `request.Request` has a spec. `request.Request` takes two arguments in the constructor (one of which is *self*). Here's what happens if we try to call it incorrectly:

```
>>> req = request.Request()
Traceback (most recent call last):
...
TypeError: <lambda>() takes at least 2 arguments (1 given)
```

The spec also applies to instantiated classes (i.e. the return value of spec'ed mocks):

```
>>> req = request.Request('foo')
>>> req
<NonCallableMagicMock name='request.Request()' spec='Request' id='...'>
```

`Request` objects are not callable, so the return value of instantiating our mocked out `request.Request` is a non-callable mock. With the spec in place any typos in our asserts will raise the correct error:

```
>>> req.add_header('spam', 'eggs')
<MagicMock name='request.Request().add_header()' id='...'>
>>> req.add_header.assert_called_with # Intentional typo!
Traceback (most recent call last):
...
AttributeError: Mock object has no attribute 'assert_called_with'
>>> req.add_header.assert_called_with('spam', 'eggs')
```

In many cases you will just be able to add `autospec=True` to your existing `patch()` calls and then be protected against bugs due to typos and api changes.

As well as using *autospec* through `patch()` there is a `create_autospec()` for creating autospecced mocks directly:

```
>>> from urllib import request
>>> mock_request = create_autospec(request)
>>> mock_request.Request('foo', 'bar')
<NonCallableMagicMock name='mock.Request()' spec='Request' id='...'>
```

This isn't without caveats and limitations however, which is why it is not the default behaviour. In order to know what attributes are available on the spec object, *autospec* has to introspect (access attributes) the spec. As you traverse attributes on the mock a corresponding traversal of the original object is happening under the hood. If any of your spec'ed objects have properties or descriptors that can trigger code execution then you may not be able to use *autospec*. On the other hand it is much better to design your objects so that introspection is safe⁴.

A more serious problem is that it is common for instance attributes to be created in the `__init__()` method and not to exist on the class at all. *autospec* can't know about any dynamically created attributes and restricts the api to visible attributes.

⁴ This only applies to classes or already instantiated objects. Calling a mocked class to create a mock instance *does not* create a real instance. It is only attribute lookups - along with calls to `dir()` - that are done.

```
>>> class Something:
...     def __init__(self):
...         self.a = 33
...
>>> with patch('__main__.Something', autospec=True):
...     thing = Something()
...     thing.a
...
Traceback (most recent call last):
...
AttributeError: Mock object has no attribute 'a'
```

There are a few different ways of resolving this problem. The easiest, but not necessarily the least annoying, way is to simply set the required attributes on the mock after creation. Just because *autospec* doesn't allow you to fetch attributes that don't exist on the spec it doesn't prevent you setting them:

```
>>> with patch('__main__.Something', autospec=True):
...     thing = Something()
...     thing.a = 33
...

```

There is a more aggressive version of both *spec* and *autospec* that *does* prevent you setting non-existent attributes. This is useful if you want to ensure your code only *sets* valid attributes too, but obviously it prevents this particular scenario:

```
>>> with patch('__main__.Something', autospec=True, spec_set=True):
...     thing = Something()
...     thing.a = 33
...
Traceback (most recent call last):
...
AttributeError: Mock object has no attribute 'a'
```

Probably the best way of solving the problem is to add class attributes as default values for instance members initialised in `__init__()`. Note that if you are only setting default attributes in `__init__()` then providing them via class attributes (shared between instances of course) is faster too. e.g.

```
class Something:
    a = 33
```

This brings up another issue. It is relatively common to provide a default value of `None` for members that will later be an object of a different type. `None` would be useless as a spec because it wouldn't let you access *any* attributes or methods on it. As `None` is *never* going to be useful as a spec, and probably indicates a member that will normally of some other type, *autospec* doesn't use a spec for members that are set to `None`. These will just be ordinary mocks (well - *MagicMocks*):

```
>>> class Something:
...     member = None
...
>>> mock = create_autospec(Something)
>>> mock.member.foo.bar.baz()
<MagicMock name='mock.member.foo.bar.baz()' id='...'>
```

If modifying your production classes to add defaults isn't to your liking then there are more options. One of these is simply to use an instance as the spec rather than the class. The other is to create a subclass of the production class and add the defaults to the subclass without affecting the production class. Both of these require you to use an alternative object as the spec. Thankfully *patch()* supports this - you can simply pass the alternative object as the *autospec* argument:

```
>>> class Something:
...     def __init__(self):
```

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```

...     self.a = 33
...
>>> class SomethingForTest(Something):
...     a = 33
...
>>> p = patch('__main__.Something', autospec=SomethingForTest)
>>> mock = p.start()
>>> mock.a
<NonCallableMagicMock name='Something.a' spec='int' id='...'>

```

Sealing mocks

`unittest.mock.seal(mock)`

Seal will disable the automatic creation of mocks when accessing an attribute of the mock being sealed or any of its attributes that are already mocks recursively.

If a mock instance with a name or a spec is assigned to an attribute it won't be considered in the sealing chain. This allows one to prevent seal from fixing part of the mock object.

```

>>> mock = Mock()
>>> mock.submock.attribute1 = 2
>>> mock.not_submock = mock.Mock(name="sample_name")
>>> seal(mock)
>>> mock.new_attribute # This will raise AttributeError.
>>> mock.submock.attribute2 # This will raise AttributeError.
>>> mock.not_submock.attribute2 # This won't raise.

```

在 3.7 版新加入。

26.6.6 Order of precedence of `side_effect`, `return_value` and `wraps`

The order of their precedence is:

1. `side_effect`
2. `return_value`
3. `wraps`

If all three are set, mock will return the value from `side_effect`, ignoring `return_value` and the wrapped object altogether. If any two are set, the one with the higher precedence will return the value. Regardless of the order of which was set first, the order of precedence remains unchanged.

```

>>> from unittest.mock import Mock
>>> class Order:
...     @staticmethod
...     def get_value():
...         return "third"
...
>>> order_mock = Mock(spec=Order, wraps=Order)
>>> order_mock.get_value.side_effect = ["first"]
>>> order_mock.get_value.return_value = "second"
>>> order_mock.get_value()
'first'

```

As `None` is the default value of `side_effect`, if you reassign its value back to `None`, the order of precedence will be checked between `return_value` and the wrapped object, ignoring `side_effect`.

```
>>> order_mock.get_value.side_effect = None
>>> order_mock.get_value()
'second'
```

If the value being returned by `side_effect` is `DEFAULT`, it is ignored and the order of precedence moves to the successor to obtain the value to return.

```
>>> from unittest.mock import DEFAULT
>>> order_mock.get_value.side_effect = [DEFAULT]
>>> order_mock.get_value()
'second'
```

When `Mock` wraps an object, the default value of `return_value` will be `DEFAULT`.

```
>>> order_mock = Mock(spec=Order, wraps=Order)
>>> order_mock.return_value
sentinel.DEFAULT
>>> order_mock.get_value.return_value
sentinel.DEFAULT
```

The order of precedence will ignore this value and it will move to the last successor which is the wrapped object.

As the real call is being made to the wrapped object, creating an instance of this mock will return the real instance of the class. The positional arguments, if any, required by the wrapped object must be passed.

```
>>> order_mock_instance = order_mock()
>>> isinstance(order_mock_instance, Order)
True
>>> order_mock_instance.get_value()
'third'
```

```
>>> order_mock.get_value.return_value = DEFAULT
>>> order_mock.get_value()
'third'
```

```
>>> order_mock.get_value.return_value = "second"
>>> order_mock.get_value()
'second'
```

But if you assign `None` to it, this will not be ignored as it is an explicit assignment. So, the order of precedence will not move to the wrapped object.

```
>>> order_mock.get_value.return_value = None
>>> order_mock.get_value() is None
True
```

Even if you set all three at once when initializing the mock, the order of precedence remains the same:

```
>>> order_mock = Mock(spec=Order, wraps=Order,
...                  **{"get_value.side_effect": ["first"],
...                     "get_value.return_value": "second"})
...
>>> order_mock.get_value()
'first'
>>> order_mock.get_value.side_effect = None
>>> order_mock.get_value()
'second'
>>> order_mock.get_value.return_value = DEFAULT
>>> order_mock.get_value()
'third'
```

If *side_effect* is exhausted, the order of precedence will not cause a value to be obtained from the successors. Instead, `StopIteration` exception is raised.

```
>>> order_mock = Mock(spec=Order, wraps=Order)
>>> order_mock.get_value.side_effect = ["first side effect value",
...                                   "another side effect value"]
>>> order_mock.get_value.return_value = "second"
```

```
>>> order_mock.get_value()
'first side effect value'
>>> order_mock.get_value()
'another side effect value'
```

```
>>> order_mock.get_value()
Traceback (most recent call last):
...
StopIteration
```

26.7 unittest.mock --- getting started

在 3.3 版新加入.

26.7.1 Using Mock

Mock Patching Methods

Common uses for *Mock* objects include:

- Patching methods
- Recording method calls on objects

You might want to replace a method on an object to check that it is called with the correct arguments by another part of the system:

```
>>> real = SomeClass()
>>> real.method = MagicMock(name='method')
>>> real.method(3, 4, 5, key='value')
<MagicMock name='method()' id='...'>
```

Once our mock has been used (`real.method` in this example) it has methods and attributes that allow you to make assertions about how it has been used.

備 F: In most of these examples the *Mock* and *MagicMock* classes are interchangeable. As the *MagicMock* is the more capable class it makes a sensible one to use by default.

Once the mock has been called its *called* attribute is set to `True`. More importantly we can use the *assert_called_with()* or *assert_called_once_with()* method to check that it was called with the correct arguments.

This example tests that calling `ProductionClass().method` results in a call to the `something` method:

```
>>> class ProductionClass:
...     def method(self):
...         self.something(1, 2, 3)
...     def something(self, a, b, c):
...         pass
```

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```
...
>>> real = ProductionClass()
>>> real.something = MagicMock()
>>> real.method()
>>> real.something.assert_called_once_with(1, 2, 3)
```

Mock for Method Calls on an Object

In the last example we patched a method directly on an object to check that it was called correctly. Another common use case is to pass an object into a method (or some part of the system under test) and then check that it is used in the correct way.

The simple `ProductionClass` below has a `closer` method. If it is called with an object then it calls `close` on it.

```
>>> class ProductionClass:
...     def closer(self, something):
...         something.close()
... 
```

So to test it we need to pass in an object with a `close` method and check that it was called correctly.

```
>>> real = ProductionClass()
>>> mock = Mock()
>>> real.closer(mock)
>>> mock.close.assert_called_with()
```

We don't have to do any work to provide the 'close' method on our mock. Accessing `close` creates it. So, if 'close' hasn't already been called then accessing it in the test will create it, but `assert_called_with()` will raise a failure exception.

Mocking Classes

A common use case is to mock out classes instantiated by your code under test. When you patch a class, then that class is replaced with a mock. Instances are created by *calling the class*. This means you access the "mock instance" by looking at the return value of the mocked class.

In the example below we have a function `some_function` that instantiates `Foo` and calls a method on it. The call to `patch()` replaces the class `Foo` with a mock. The `Foo` instance is the result of calling the mock, so it is configured by modifying the mock `return_value`.

```
>>> def some_function():
...     instance = module.Foo()
...     return instance.method()
...
>>> with patch('module.Foo') as mock:
...     instance = mock.return_value
...     instance.method.return_value = 'the result'
...     result = some_function()
...     assert result == 'the result'
```

Naming your mocks

It can be useful to give your mocks a name. The name is shown in the repr of the mock and can be helpful when the mock appears in test failure messages. The name is also propagated to attributes or methods of the mock:

```
>>> mock = MagicMock(name='foo')
>>> mock
<MagicMock name='foo' id='...'>
>>> mock.method
<MagicMock name='foo.method' id='...'>
```

Tracking all Calls

Often you want to track more than a single call to a method. The `mock_calls` attribute records all calls to child attributes of the mock - and also to their children.

```
>>> mock = MagicMock()
>>> mock.method()
<MagicMock name='mock.method()' id='...'>
>>> mock.attribute.method(10, x=53)
<MagicMock name='mock.attribute.method()' id='...'>
>>> mock.mock_calls
[call.method(), call.attribute.method(10, x=53)]
```

If you make an assertion about `mock_calls` and any unexpected methods have been called, then the assertion will fail. This is useful because as well as asserting that the calls you expected have been made, you are also checking that they were made in the right order and with no additional calls:

You use the `call` object to construct lists for comparing with `mock_calls`:

```
>>> expected = [call.method(), call.attribute.method(10, x=53)]
>>> mock.mock_calls == expected
True
```

However, parameters to calls that return mocks are not recorded, which means it is not possible to track nested calls where the parameters used to create ancestors are important:

```
>>> m = Mock()
>>> m.factory(important=True).deliver()
<Mock name='mock.factory().deliver()' id='...'>
>>> m.mock_calls[-1] == call.factory(important=False).deliver()
True
```

Setting Return Values and Attributes

Setting the return values on a mock object is trivially easy:

```
>>> mock = Mock()
>>> mock.return_value = 3
>>> mock()
3
```

Of course you can do the same for methods on the mock:

```
>>> mock = Mock()
>>> mock.method.return_value = 3
>>> mock.method()
3
```

The return value can also be set in the constructor:

```
>>> mock = Mock(return_value=3)
>>> mock()
3
```

If you need an attribute setting on your mock, just do it:

```
>>> mock = Mock()
>>> mock.x = 3
>>> mock.x
3
```

Sometimes you want to mock up a more complex situation, like for example `mock.connection.cursor().execute("SELECT 1")`. If we wanted this call to return a list, then we have to configure the result of the nested call.

We can use `call` to construct the set of calls in a “chained call” like this for easy assertion afterwards:

```
>>> mock = Mock()
>>> cursor = mock.connection.cursor.return_value
>>> cursor.execute.return_value = ['foo']
>>> mock.connection.cursor().execute("SELECT 1")
['foo']
>>> expected = call.connection.cursor().execute("SELECT 1").call_list()
>>> mock.mock_calls
[call.connection.cursor(), call.connection.cursor().execute('SELECT 1')]
>>> mock.mock_calls == expected
True
```

It is the call to `.call_list()` that turns our call object into a list of calls representing the chained calls.

Raising exceptions with mocks

A useful attribute is `side_effect`. If you set this to an exception class or instance then the exception will be raised when the mock is called.

```
>>> mock = Mock(side_effect=Exception('Boom!'))
>>> mock()
Traceback (most recent call last):
...
Exception: Boom!
```

Side effect functions and iterables

`side_effect` can also be set to a function or an iterable. The use case for `side_effect` as an iterable is where your mock is going to be called several times, and you want each call to return a different value. When you set `side_effect` to an iterable every call to the mock returns the next value from the iterable:

```
>>> mock = MagicMock(side_effect=[4, 5, 6])
>>> mock()
4
>>> mock()
5
>>> mock()
6
```

For more advanced use cases, like dynamically varying the return values depending on what the mock is called with, `side_effect` can be a function. The function will be called with the same arguments as the mock. Whatever the function returns is what the call returns:

```
>>> vals = {(1, 2): 1, (2, 3): 2}
>>> def side_effect(*args):
...     return vals[args]
...
>>> mock = MagicMock(side_effect=side_effect)
>>> mock(1, 2)
1
>>> mock(2, 3)
2
```

Mocking asynchronous iterators

Since Python 3.8, `AsyncMock` and `MagicMock` have support to mock async-iterators through `__aiter__`. The `return_value` attribute of `__aiter__` can be used to set the return values to be used for iteration.

```
>>> mock = MagicMock() # AsyncMock also works here
>>> mock.__aiter__.return_value = [1, 2, 3]
>>> async def main():
...     return [i async for i in mock]
...
>>> asyncio.run(main())
[1, 2, 3]
```

Mocking asynchronous context manager

Since Python 3.8, `AsyncMock` and `MagicMock` have support to mock async-context-managers through `__aenter__` and `__aexit__`. By default, `__aenter__` and `__aexit__` are `AsyncMock` instances that return an async function.

```
>>> class AsyncContextManager:
...     async def __aenter__(self):
...         return self
...     async def __aexit__(self, exc_type, exc, tb):
...         pass
...
>>> mock_instance = MagicMock(AsyncContextManager()) # AsyncMock also works here
>>> async def main():
...     async with mock_instance as result:
...         pass
...
>>> asyncio.run(main())
>>> mock_instance.__aenter__.assert_awaited_once()
>>> mock_instance.__aexit__.assert_awaited_once()
```

Creating a Mock from an Existing Object

One problem with over use of mocking is that it couples your tests to the implementation of your mocks rather than your real code. Suppose you have a class that implements `some_method`. In a test for another class, you provide a mock of this object that *also* provides `some_method`. If later you refactor the first class, so that it no longer has `some_method` - then your tests will continue to pass even though your code is now broken!

`Mock` allows you to provide an object as a specification for the mock, using the `spec` keyword argument. Accessing methods / attributes on the mock that don't exist on your specification object will immediately raise an attribute error. If you change the implementation of your specification, then tests that use that class will start failing immediately without you having to instantiate the class in those tests.

```
>>> mock = Mock(spec=SomeClass)
>>> mock.old_method()
Traceback (most recent call last):
...
AttributeError: object has no attribute 'old_method'
```

Using a specification also enables a smarter matching of calls made to the mock, regardless of whether some parameters were passed as positional or named arguments:

```
>>> def f(a, b, c): pass
...
>>> mock = Mock(spec=f)
>>> mock(1, 2, 3)
<Mock name='mock()' id='140161580456576'>
>>> mock.assert_called_with(a=1, b=2, c=3)
```

If you want this smarter matching to also work with method calls on the mock, you can use *auto-speccking*.

If you want a stronger form of specification that prevents the setting of arbitrary attributes as well as the getting of them then you can use *spec_set* instead of *spec*.

Using side_effect to return per file content

mock_open() is used to patch *open()* method. *side_effect* can be used to return a new Mock object per call. This can be used to return different contents per file stored in a dictionary:

```
DEFAULT = "default"
data_dict = {"file1": "data1",
            "file2": "data2"}

def open_side_effect(name):
    return mock_open(read_data=data_dict.get(name, DEFAULT))()

with patch("builtins.open", side_effect=open_side_effect):
    with open("file1") as file1:
        assert file1.read() == "data1"

    with open("file2") as file2:
        assert file2.read() == "data2"

    with open("file3") as file2:
        assert file2.read() == "default"
```

26.7.2 Patch Decorators

備F: With *patch()* it matters that you patch objects in the namespace where they are looked up. This is normally straightforward, but for a quick guide read *where to patch*.

A common need in tests is to patch a class attribute or a module attribute, for example patching a builtin or patching a class in a module to test that it is instantiated. Modules and classes are effectively global, so patching on them has to be undone after the test or the patch will persist into other tests and cause hard to diagnose problems.

mock provides three convenient decorators for this: *patch()*, *patch.object()* and *patch.dict()*. *patch* takes a single string, of the form *package.module.Class.attribute* to specify the attribute you are patching. It also optionally takes a value that you want the attribute (or class or whatever) to be replaced with. 'patch.object' takes an object and the name of the attribute you would like patched, plus optionally the value to patch it with.

`patch.object`:

```
>>> original = SomeClass.attribute
>>> @patch.object(SomeClass, 'attribute', sentinel.attribute)
... def test():
...     assert SomeClass.attribute == sentinel.attribute
...
>>> test()
>>> assert SomeClass.attribute == original

>>> @patch('package.module.attribute', sentinel.attribute)
... def test():
...     from package.module import attribute
...     assert attribute is sentinel.attribute
...
>>> test()
```

If you are patching a module (including *builtins*) then use `patch()` instead of `patch.object()`:

```
>>> mock = MagicMock(return_value=sentinel.file_handle)
>>> with patch('builtins.open', mock):
...     handle = open('filename', 'r')
...
>>> mock.assert_called_with('filename', 'r')
>>> assert handle == sentinel.file_handle, "incorrect file handle returned"
```

The module name can be 'dotted', in the form `package.module` if needed:

```
>>> @patch('package.module.ClassName.attribute', sentinel.attribute)
... def test():
...     from package.module import ClassName
...     assert ClassName.attribute == sentinel.attribute
...
>>> test()
```

A nice pattern is to actually decorate test methods themselves:

```
>>> class MyTest(unittest.TestCase):
...     @patch.object(SomeClass, 'attribute', sentinel.attribute)
...     def test_something(self):
...         self.assertEqual(SomeClass.attribute, sentinel.attribute)
...
>>> original = SomeClass.attribute
>>> MyTest('test_something').test_something()
>>> assert SomeClass.attribute == original
```

If you want to patch with a `Mock`, you can use `patch()` with only one argument (or `patch.object()` with two arguments). The mock will be created for you and passed into the test function / method:

```
>>> class MyTest(unittest.TestCase):
...     @patch.object(SomeClass, 'static_method')
...     def test_something(self, mock_method):
...         SomeClass.static_method()
...         mock_method.assert_called_with()
...
>>> MyTest('test_something').test_something()
```

You can stack up multiple patch decorators using this pattern:

```
>>> class MyTest(unittest.TestCase):
...     @patch('package.module.ClassName1')
...     @patch('package.module.ClassName2')
```

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```

...     def test_something(self, MockClass2, MockClass1):
...         self.assertIs(package.module.ClassName1, MockClass1)
...         self.assertIs(package.module.ClassName2, MockClass2)
...
>>> MyTest('test_something').test_something()

```

When you nest patch decorators the mocks are passed in to the decorated function in the same order they applied (the normal *Python* order that decorators are applied). This means from the bottom up, so in the example above the mock for `test_module.ClassName2` is passed in first.

There is also `patch.dict()` for setting values in a dictionary just during a scope and restoring the dictionary to its original state when the test ends:

```

>>> foo = {'key': 'value'}
>>> original = foo.copy()
>>> with patch.dict(foo, {'newkey': 'newvalue'}, clear=True):
...     assert foo == {'newkey': 'newvalue'}
...
>>> assert foo == original

```

`patch`, `patch.object` and `patch.dict` can all be used as context managers.

Where you use `patch()` to create a mock for you, you can get a reference to the mock using the "as" form of the with statement:

```

>>> class ProductionClass:
...     def method(self):
...         pass
...
>>> with patch.object(ProductionClass, 'method') as mock_method:
...     mock_method.return_value = None
...     real = ProductionClass()
...     real.method(1, 2, 3)
...
>>> mock_method.assert_called_with(1, 2, 3)

```

As an alternative `patch`, `patch.object` and `patch.dict` can be used as class decorators. When used in this way it is the same as applying the decorator individually to every method whose name starts with "test".

26.7.3 Further Examples

Here are some more examples for some slightly more advanced scenarios.

Mocking chained calls

Mocking chained calls is actually straightforward with mock once you understand the `return_value` attribute. When a mock is called for the first time, or you fetch its `return_value` before it has been called, a new *Mock* is created.

This means that you can see how the object returned from a call to a mocked object has been used by interrogating the `return_value` mock:

```

>>> mock = Mock()
>>> mock().foo(a=2, b=3)
<Mock name='mock().foo()' id='...'>
>>> mock.return_value.foo.assert_called_with(a=2, b=3)

```

From here it is a simple step to configure and then make assertions about chained calls. Of course another alternative is writing your code in a more testable way in the first place...

So, suppose we have some code that looks a little bit like this:

```
>>> class Something:
...     def __init__(self):
...         self.backend = BackendProvider()
...     def method(self):
...         response = self.backend.get_endpoint('foobar').create_call('spam',
↪ 'eggs').start_call()
...         # more code
```

Assuming that `BackendProvider` is already well tested, how do we test `method()`? Specifically, we want to test that the code section `# more code` uses the response object in the correct way.

As this chain of calls is made from an instance attribute we can monkey patch the `backend` attribute on a `Something` instance. In this particular case we are only interested in the return value from the final call to `start_call` so we don't have much configuration to do. Let's assume the object it returns is 'file-like', so we'll ensure that our response object uses the builtin `open()` as its spec.

To do this we create a mock instance as our mock backend and create a mock response object for it. To set the response as the return value for that final `start_call` we could do this:

```
mock_backend.get_endpoint.return_value.create_call.return_value.start_call.return_
↪ value = mock_response
```

We can do that in a slightly nicer way using the `configure_mock()` method to directly set the return value for us:

```
>>> something = Something()
>>> mock_response = Mock(spec=open)
>>> mock_backend = Mock()
>>> config = {'get_endpoint.return_value.create_call.return_value.start_call.
↪ return_value': mock_response}
>>> mock_backend.configure_mock(**config)
```

With these we monkey patch the "mock backend" in place and can make the real call:

```
>>> something.backend = mock_backend
>>> something.method()
```

Using `mock_calls` we can check the chained call with a single assert. A chained call is several calls in one line of code, so there will be several entries in `mock_calls`. We can use `call.call_list()` to create this list of calls for us:

```
>>> chained = call.get_endpoint('foobar').create_call('spam', 'eggs').start_call()
>>> call_list = chained.call_list()
>>> assert mock_backend.mock_calls == call_list
```

Partial mocking

In some tests I wanted to mock out a call to `datetime.date.today()` to return a known date, but I didn't want to prevent the code under test from creating new date objects. Unfortunately `datetime.date` is written in C, and so I couldn't just monkey-patch out the static `datetime.date.today()` method.

I found a simple way of doing this that involved effectively wrapping the date class with a mock, but passing through calls to the constructor to the real class (and returning real instances).

The `patch decorator` is used here to mock out the `date` class in the module under test. The `side_effect` attribute on the mock date class is then set to a lambda function that returns a real date. When the mock date class is called a real date will be constructed and returned by `side_effect`.

```
>>> from datetime import date
>>> with patch('mymodule.date') as mock_date:
...     mock_date.today.return_value = date(2010, 10, 8)
...     mock_date.side_effect = lambda *args, **kw: date(*args, **kw)
...
...     assert mymodule.date.today() == date(2010, 10, 8)
...     assert mymodule.date(2009, 6, 8) == date(2009, 6, 8)
```

Note that we don't patch `datetime.date` globally, we patch `date` in the module that *uses* it. See [where to patch](#).

When `date.today()` is called a known date is returned, but calls to the `date(...)` constructor still return normal dates. Without this you can find yourself having to calculate an expected result using exactly the same algorithm as the code under test, which is a classic testing anti-pattern.

Calls to the `date` constructor are recorded in the `mock_date` attributes (`call_count` and `friends`) which may also be useful for your tests.

An alternative way of dealing with mocking dates, or other builtin classes, is discussed in [this blog entry](#).

Mocking a Generator Method

A Python generator is a function or method that uses the `yield` statement to return a series of values when iterated over¹.

A generator method / function is called to return the generator object. It is the generator object that is then iterated over. The protocol method for iteration is `__iter__()`, so we can mock this using a [MagicMock](#).

Here's an example class with an "iter" method implemented as a generator:

```
>>> class Foo:
...     def iter(self):
...         for i in [1, 2, 3]:
...             yield i
...
>>> foo = Foo()
>>> list(foo.iter())
[1, 2, 3]
```

How would we mock this class, and in particular its "iter" method?

To configure the values returned from the iteration (implicit in the call to `list`), we need to configure the object returned by the call to `foo.iter()`.

```
>>> mock_foo = MagicMock()
>>> mock_foo.iter.return_value = iter([1, 2, 3])
>>> list(mock_foo.iter())
[1, 2, 3]
```

¹ There are also generator expressions and more advanced uses of generators, but we aren't concerned about them here. A very good introduction to generators and how powerful they are is: [Generator Tricks for Systems Programmers](#).

Applying the same patch to every test method

If you want several patches in place for multiple test methods the obvious way is to apply the patch decorators to every method. This can feel like unnecessary repetition. Instead, you can use `patch()` (in all its various forms) as a class decorator. This applies the patches to all test methods on the class. A test method is identified by methods whose names start with `test`:

```
>>> @patch('mymodule.SomeClass')
... class MyTest(unittest.TestCase):
...
...     def test_one(self, MockSomeClass):
...         self.assertIs(mymodule.SomeClass, MockSomeClass)
...
...     def test_two(self, MockSomeClass):
...         self.assertIs(mymodule.SomeClass, MockSomeClass)
...
...     def not_a_test(self):
...         return 'something'
...
>>> MyTest('test_one').test_one()
>>> MyTest('test_two').test_two()
>>> MyTest('test_two').not_a_test()
'something'
```

An alternative way of managing patches is to use the *patch methods: start and stop*. These allow you to move the patching into your `setUp` and `tearDown` methods.

```
>>> class MyTest(unittest.TestCase):
...     def setUp(self):
...         self.patcher = patch('mymodule.foo')
...         self.mock_foo = self.patcher.start()
...
...     def test_foo(self):
...         self.assertIs(mymodule.foo, self.mock_foo)
...
...     def tearDown(self):
...         self.patcher.stop()
...
>>> MyTest('test_foo').run()
```

If you use this technique you must ensure that the patching is “undone” by calling `stop`. This can be fiddlier than you might think, because if an exception is raised in the `setUp` then `tearDown` is not called. `unittest.TestCase.addCleanup()` makes this easier:

```
>>> class MyTest(unittest.TestCase):
...     def setUp(self):
...         patcher = patch('mymodule.foo')
...         self.addCleanup(patcher.stop)
...         self.mock_foo = patcher.start()
...
...     def test_foo(self):
...         self.assertIs(mymodule.foo, self.mock_foo)
...
>>> MyTest('test_foo').run()
```

Mocking Unbound Methods

Whilst writing tests today I needed to patch an *unbound method* (patching the method on the class rather than on the instance). I needed `self` to be passed in as the first argument because I want to make asserts about which objects were calling this particular method. The issue is that you can't patch with a mock for this, because if you replace an unbound method with a mock it doesn't become a bound method when fetched from the instance, and so it doesn't get `self` passed in. The workaround is to patch the unbound method with a real function instead. The `patch()` decorator makes it so simple to patch out methods with a mock that having to create a real function becomes a nuisance.

If you pass `autospec=True` to patch then it does the patching with a *real* function object. This function object has the same signature as the one it is replacing, but delegates to a mock under the hood. You still get your mock auto-created in exactly the same way as before. What it means though, is that if you use it to patch out an unbound method on a class the mocked function will be turned into a bound method if it is fetched from an instance. It will have `self` passed in as the first argument, which is exactly what I wanted:

```
>>> class Foo:
...     def foo(self):
...         pass
...
>>> with patch.object(Foo, 'foo', autospec=True) as mock_foo:
...     mock_foo.return_value = 'foo'
...     foo = Foo()
...     foo.foo()
...
'foo'
>>> mock_foo.assert_called_once_with(foo)
```

If we don't use `autospec=True` then the unbound method is patched out with a `Mock` instance instead, and isn't called with `self`.

Checking multiple calls with mock

mock has a nice API for making assertions about how your mock objects are used.

```
>>> mock = Mock()
>>> mock.foo_bar.return_value = None
>>> mock.foo_bar('baz', spam='eggs')
>>> mock.foo_bar.assert_called_with('baz', spam='eggs')
```

If your mock is only being called once you can use the `assert_called_once_with()` method that also asserts that the `call_count` is one.

```
>>> mock.foo_bar.assert_called_once_with('baz', spam='eggs')
>>> mock.foo_bar()
>>> mock.foo_bar.assert_called_once_with('baz', spam='eggs')
Traceback (most recent call last):
...
AssertionError: Expected to be called once. Called 2 times.
```

Both `assert_called_with` and `assert_called_once_with` make assertions about the *most recent* call. If your mock is going to be called several times, and you want to make assertions about *all* those calls you can use `call_args_list`:

```
>>> mock = Mock(return_value=None)
>>> mock(1, 2, 3)
>>> mock(4, 5, 6)
>>> mock()
>>> mock.call_args_list
[call(1, 2, 3), call(4, 5, 6), call()]
```

The `call` helper makes it easy to make assertions about these calls. You can build up a list of expected calls and compare it to `call_args_list`. This looks remarkably similar to the repr of the `call_args_list`:

```
>>> expected = [call(1, 2, 3), call(4, 5, 6), call()]
>>> mock.call_args_list == expected
True
```

Coping with mutable arguments

Another situation is rare, but can bite you, is when your mock is called with mutable arguments. `call_args` and `call_args_list` store *references* to the arguments. If the arguments are mutated by the code under test then you can no longer make assertions about what the values were when the mock was called.

Here's some example code that shows the problem. Imagine the following functions defined in 'mymodule':

```
def frob(val):
    pass

def grob(val):
    "First frob and then clear val"
    frob(val)
    val.clear()
```

When we try to test that `grob` calls `frob` with the correct argument look what happens:

```
>>> with patch('mymodule.frob') as mock_frob:
...     val = {6}
...     mymodule.grob(val)
...
>>> val
set()
>>> mock_frob.assert_called_with({6})
Traceback (most recent call last):
...
AssertionError: Expected: (({6},), {})
Called with: ((set(),), {})
```

One possibility would be for mock to copy the arguments you pass in. This could then cause problems if you do assertions that rely on object identity for equality.

Here's one solution that uses the `side_effect` functionality. If you provide a `side_effect` function for a mock then `side_effect` will be called with the same args as the mock. This gives us an opportunity to copy the arguments and store them for later assertions. In this example I'm using *another* mock to store the arguments so that I can use the mock methods for doing the assertion. Again a helper function sets this up for me.

```
>>> from copy import deepcopy
>>> from unittest.mock import Mock, patch, DEFAULT
>>> def copy_call_args(mock):
...     new_mock = Mock()
...     def side_effect(*args, **kwargs):
...         args = deepcopy(args)
...         kwargs = deepcopy(kwargs)
...         new_mock(*args, **kwargs)
...         return DEFAULT
...     mock.side_effect = side_effect
...     return new_mock
...
>>> with patch('mymodule.frob') as mock_frob:
...     new_mock = copy_call_args(mock_frob)
...     val = {6}
...     mymodule.grob(val)
```

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```
...
>>> new_mock.assert_called_with({6})
>>> new_mock.call_args
call({6})
```

`copy_call_args` is called with the mock that will be called. It returns a new mock that we do the assertion on. The `side_effect` function makes a copy of the args and calls our `new_mock` with the copy.

備註: If your mock is only going to be used once there is an easier way of checking arguments at the point they are called. You can simply do the checking inside a `side_effect` function.

```
>>> def side_effect(arg):
...     assert arg == {6}
...
>>> mock = Mock(side_effect=side_effect)
>>> mock({6})
>>> mock(set())
Traceback (most recent call last):
...
AssertionError
```

An alternative approach is to create a subclass of `Mock` or `MagicMock` that copies (using `copy.deepcopy()`) the arguments. Here's an example implementation:

```
>>> from copy import deepcopy
>>> class CopyingMock(MagicMock):
...     def __call__(self, /, *args, **kwargs):
...         args = deepcopy(args)
...         kwargs = deepcopy(kwargs)
...         return super().__call__(*args, **kwargs)
...
>>> c = CopyingMock(return_value=None)
>>> arg = set()
>>> c(arg)
>>> arg.add(1)
>>> c.assert_called_with(set())
>>> c.assert_called_with(arg)
Traceback (most recent call last):
...
AssertionError: Expected call: mock({1})
Actual call: mock(set())
>>> c.foo
<CopyingMock name='mock.foo' id='...'>
```

When you subclass `Mock` or `MagicMock` all dynamically created attributes, and the `return_value` will use your subclass automatically. That means all children of a `CopyingMock` will also have the type `CopyingMock`.

Nesting Patches

Using patch as a context manager is nice, but if you do multiple patches you can end up with nested with statements indenting further and further to the right:

```
>>> class MyTest(unittest.TestCase):
...     def test_foo(self):
...         with patch('mymodule.Foo') as mock_foo:
...             with patch('mymodule.Bar') as mock_bar:
...                 with patch('mymodule.Spam') as mock_spam:
...                     assert mymodule.Foo is mock_foo
...                     assert mymodule.Bar is mock_bar
...                     assert mymodule.Spam is mock_spam
...
>>> original = mymodule.Foo
>>> MyTest('test_foo').test_foo()
>>> assert mymodule.Foo is original
```

With unittest cleanup functions and the *patch methods: start and stop* we can achieve the same effect without the nested indentation. A simple helper method, `create_patch`, puts the patch in place and returns the created mock for us:

```
>>> class MyTest(unittest.TestCase):
...     def create_patch(self, name):
...         patcher = patch(name)
...         thing = patcher.start()
...         self.addCleanup(patcher.stop)
...         return thing
...
...     def test_foo(self):
...         mock_foo = self.create_patch('mymodule.Foo')
...         mock_bar = self.create_patch('mymodule.Bar')
...         mock_spam = self.create_patch('mymodule.Spam')
...
...         assert mymodule.Foo is mock_foo
...         assert mymodule.Bar is mock_bar
...         assert mymodule.Spam is mock_spam
...
>>> original = mymodule.Foo
>>> MyTest('test_foo').run()
>>> assert mymodule.Foo is original
```

Mocking a dictionary with MagicMock

You may want to mock a dictionary, or other container object, recording all access to it whilst having it still behave like a dictionary.

We can do this with *MagicMock*, which will behave like a dictionary, and using *side_effect* to delegate dictionary access to a real underlying dictionary that is under our control.

When the `__getitem__()` and `__setitem__()` methods of our *MagicMock* are called (normal dictionary access) then *side_effect* is called with the key (and in the case of `__setitem__` the value too). We can also control what is returned.

After the *MagicMock* has been used we can use attributes like *call_args_list* to assert about how the dictionary was used:

```
>>> my_dict = {'a': 1, 'b': 2, 'c': 3}
>>> def getitem(name):
```

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```

...     return my_dict[name]
...
>>> def setitem(name, val):
...     my_dict[name] = val
...
>>> mock = MagicMock()
>>> mock.__getitem__.side_effect = getitem
>>> mock.__setitem__.side_effect = setitem

```

備 F: An alternative to using `MagicMock` is to use `Mock` and *only* provide the magic methods you specifically want:

```

>>> mock = Mock()
>>> mock.__getitem__ = Mock(side_effect=getitem)
>>> mock.__setitem__ = Mock(side_effect=setitem)

```

A *third* option is to use `MagicMock` but passing in `dict` as the *spec* (or *spec_set*) argument so that the `MagicMock` created only has dictionary magic methods available:

```

>>> mock = MagicMock(spec_set=dict)
>>> mock.__getitem__.side_effect = getitem
>>> mock.__setitem__.side_effect = setitem

```

With these side effect functions in place, the `mock` will behave like a normal dictionary but recording the access. It even raises a `KeyError` if you try to access a key that doesn't exist.

```

>>> mock['a']
1
>>> mock['c']
3
>>> mock['d']
Traceback (most recent call last):
...
KeyError: 'd'
>>> mock['b'] = 'fish'
>>> mock['d'] = 'eggs'
>>> mock['b']
'fish'
>>> mock['d']
'eggs'

```

After it has been used you can make assertions about the access using the normal mock methods and attributes:

```

>>> mock.__getitem__.call_args_list
[call('a'), call('c'), call('d'), call('b'), call('d')]
>>> mock.__setitem__.call_args_list
[call('b', 'fish'), call('d', 'eggs')]
>>> my_dict
{'a': 1, 'b': 'fish', 'c': 3, 'd': 'eggs'}

```

Mock subclasses and their attributes

There are various reasons why you might want to subclass `Mock`. One reason might be to add helper methods. Here's a silly example:

```
>>> class MyMock(MagicMock):
...     def has_been_called(self):
...         return self.called
...
>>> mymock = MyMock(return_value=None)
>>> mymock
<MyMock id='...'>
>>> mymock.has_been_called()
False
>>> mymock()
>>> mymock.has_been_called()
True
```

The standard behaviour for `Mock` instances is that attributes and the return value mocks are of the same type as the mock they are accessed on. This ensures that `Mock` attributes are `Mocks` and `MagicMock` attributes are `MagicMocks`². So if you're subclassing to add helper methods then they'll also be available on the attributes and return value mock of instances of your subclass.

```
>>> mymock.foo
<MyMock name='mock.foo' id='...'>
>>> mymock.foo.has_been_called()
False
>>> mymock.foo()
<MyMock name='mock.foo()' id='...'>
>>> mymock.foo.has_been_called()
True
```

Sometimes this is inconvenient. For example, [one user](#) is subclassing mock to created a [Twisted adaptor](#). Having this applied to attributes too actually causes errors.

`Mock` (in all its flavours) uses a method called `_get_child_mock` to create these "sub-mocks" for attributes and return values. You can prevent your subclass being used for attributes by overriding this method. The signature is that it takes arbitrary keyword arguments (`**kwargs`) which are then passed onto the mock constructor:

```
>>> class Subclass(MagicMock):
...     def _get_child_mock(self, /, **kwargs):
...         return MagicMock(**kwargs)
...
>>> mymock = Subclass()
>>> mymock.foo
<MagicMock name='mock.foo' id='...'>
>>> assert isinstance(mymock, Subclass)
>>> assert not isinstance(mymock.foo, Subclass)
>>> assert not isinstance(mymock(), Subclass)
```

² An exception to this rule are the non-callable mocks. Attributes use the callable variant because otherwise non-callable mocks couldn't have callable methods.

Mocking imports with patch.dict

One situation where mocking can be hard is where you have a local import inside a function. These are harder to mock because they aren't using an object from the module namespace that we can patch out.

Generally local imports are to be avoided. They are sometimes done to prevent circular dependencies, for which there is *usually* a much better way to solve the problem (refactor the code) or to prevent "up front costs" by delaying the import. This can also be solved in better ways than an unconditional local import (store the module as a class or module attribute and only do the import on first use).

That aside there is a way to use `mock` to affect the results of an import. Importing fetches an *object* from the `sys.modules` dictionary. Note that it fetches an *object*, which need not be a module. Importing a module for the first time results in a module object being put in `sys.modules`, so usually when you import something you get a module back. This need not be the case however.

This means you can use `patch.dict()` to temporarily put a mock in place in `sys.modules`. Any imports whilst this patch is active will fetch the mock. When the patch is complete (the decorated function exits, the with statement body is complete or `patcher.stop()` is called) then whatever was there previously will be restored safely.

Here's an example that mocks out the 'fooble' module.

```
>>> import sys
>>> mock = Mock()
>>> with patch.dict('sys.modules', {'fooble': mock}):
...     import fooble
...     fooble.blob()
...
<Mock name='mock.blob()' id='...'>
>>> assert 'fooble' not in sys.modules
>>> mock.blob.assert_called_once_with()
```

As you can see the import `fooble` succeeds, but on exit there is no 'fooble' left in `sys.modules`.

This also works for the `from module import name` form:

```
>>> mock = Mock()
>>> with patch.dict('sys.modules', {'fooble': mock}):
...     from fooble import blob
...     blob.blip()
...
<Mock name='mock.blob.blip()' id='...'>
>>> mock.blob.blip.assert_called_once_with()
```

With slightly more work you can also mock package imports:

```
>>> mock = Mock()
>>> modules = {'package': mock, 'package.module': mock.module}
>>> with patch.dict('sys.modules', modules):
...     from package.module import fooble
...     fooble()
...
<Mock name='mock.module.fooble()' id='...'>
>>> mock.module.fooble.assert_called_once_with()
```

Tracking order of calls and less verbose call assertions

The `Mock` class allows you to track the *order* of method calls on your mock objects through the `method_calls` attribute. This doesn't allow you to track the order of calls between separate mock objects, however we can use `mock_calls` to achieve the same effect.

Because mocks track calls to child mocks in `mock_calls`, and accessing an arbitrary attribute of a mock creates a child mock, we can create our separate mocks from a parent one. Calls to those child mock will then all be recorded, in order, in the `mock_calls` of the parent:

```
>>> manager = Mock()
>>> mock_foo = manager.foo
>>> mock_bar = manager.bar
```

```
>>> mock_foo.something()
<Mock name='mock.foo.something()' id='...'>
>>> mock_bar.other.thing()
<Mock name='mock.bar.other.thing()' id='...'>
```

```
>>> manager.mock_calls
[call.foo.something(), call.bar.other.thing()]
```

We can then assert about the calls, including the order, by comparing with the `mock_calls` attribute on the manager mock:

```
>>> expected_calls = [call.foo.something(), call.bar.other.thing()]
>>> manager.mock_calls == expected_calls
True
```

If `patch` is creating, and putting in place, your mocks then you can attach them to a manager mock using the `attach_mock()` method. After attaching calls will be recorded in `mock_calls` of the manager.

```
>>> manager = MagicMock()
>>> with patch('mymodule.Class1') as MockClass1:
...     with patch('mymodule.Class2') as MockClass2:
...         manager.attach_mock(MockClass1, 'MockClass1')
...         manager.attach_mock(MockClass2, 'MockClass2')
...         MockClass1().foo()
...         MockClass2().bar()
<MagicMock name='mock.MockClass1().foo()' id='...'>
<MagicMock name='mock.MockClass2().bar()' id='...'>
>>> manager.mock_calls
[call.MockClass1(),
call.MockClass1().foo(),
call.MockClass2(),
call.MockClass2().bar()]
```

If many calls have been made, but you're only interested in a particular sequence of them then an alternative is to use the `assert_has_calls()` method. This takes a list of calls (constructed with the `call` object). If that sequence of calls are in `mock_calls` then the assert succeeds.

```
>>> m = MagicMock()
>>> m().foo().bar().baz()
<MagicMock name='mock().foo().bar().baz()' id='...'>
>>> m.one().two().three()
<MagicMock name='mock.one().two().three()' id='...'>
>>> calls = call.one().two().three().call_list()
>>> m.assert_has_calls(calls)
```

Even though the chained call `m.one().two().three()` aren't the only calls that have been made to the mock, the assert still succeeds.

Sometimes a mock may have several calls made to it, and you are only interested in asserting about *some* of those calls. You may not even care about the order. In this case you can pass `any_order=True` to `assert_has_calls`:

```
>>> m = MagicMock()
>>> m(1), m.two(2, 3), m.seven(7), m.fifty('50')
(...)
>>> calls = [call.fifty('50'), call(1), call.seven(7)]
>>> m.assert_has_calls(calls, any_order=True)
```

More complex argument matching

Using the same basic concept as [ANY](#) we can implement matchers to do more complex assertions on objects used as arguments to mocks.

Suppose we expect some object to be passed to a mock that by default compares equal based on object identity (which is the Python default for user defined classes). To use `assert_called_with()` we would need to pass in the exact same object. If we are only interested in some of the attributes of this object then we can create a matcher that will check these attributes for us.

You can see in this example how a 'standard' call to `assert_called_with` isn't sufficient:

```
>>> class Foo:
...     def __init__(self, a, b):
...         self.a, self.b = a, b
...
>>> mock = Mock(return_value=None)
>>> mock(Foo(1, 2))
>>> mock.assert_called_with(Foo(1, 2))
Traceback (most recent call last):
...
AssertionError: Expected: call(<__main__.Foo object at 0x...>)
Actual call: call(<__main__.Foo object at 0x...>)
```

A comparison function for our `Foo` class might look something like this:

```
>>> def compare(self, other):
...     if not type(self) == type(other):
...         return False
...     if self.a != other.a:
...         return False
...     if self.b != other.b:
...         return False
...     return True
...
```

And a matcher object that can use comparison functions like this for its equality operation would look something like this:

```
>>> class Matcher:
...     def __init__(self, compare, some_obj):
...         self.compare = compare
...         self.some_obj = some_obj
...     def __eq__(self, other):
...         return self.compare(self.some_obj, other)
...
```

Putting all this together:

```
>>> match_foo = Matcher(compare, Foo(1, 2))
>>> mock.assert_called_with(match_foo)
```

The `Matcher` is instantiated with our compare function and the `Foo` object we want to compare against. In `assert_called_with` the `Matcher` equality method will be called, which compares the object the mock was called with against the one we created our matcher with. If they match then `assert_called_with` passes, and if they don't an `AssertionError` is raised:

```
>>> match_wrong = Matcher(compare, Foo(3, 4))
>>> mock.assert_called_with(match_wrong)
Traceback (most recent call last):
...
AssertionError: Expected: ((<Matcher object at 0x...>,), {})
Called with: ((<Foo object at 0x...>,), {})
```

With a bit of tweaking you could have the comparison function raise the `AssertionError` directly and provide a more useful failure message.

As of version 1.5, the Python testing library `PyHamcrest` provides similar functionality, that may be useful here, in the form of its equality matcher (`hamcrest.library.integration.match_equality`).

26.8 2to3 --- 自動將 Python 2 的程式碼轉成 Python 3

`2to3` is a Python program that reads Python 2.x source code and applies a series of *fixers* to transform it into valid Python 3.x code. The standard library contains a rich set of fixers that will handle almost all code. `2to3` supporting library `lib2to3` is, however, a flexible and generic library, so it is possible to write your own fixers for `2to3`.

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。：The `lib2to3` module was marked pending for deprecation in Python 3.9 (raising `PendingDeprecationWarning` on import) and fully deprecated in Python 3.11 (raising `DeprecationWarning`). The `2to3` tool is part of that. It will be removed in Python 3.13.

26.8.1 使用 2to3

`2to3` will usually be installed with the Python interpreter as a script. It is also located in the `Tools/scripts` directory of the Python root.

`2to3`'s basic arguments are a list of files or directories to transform. The directories are recursively traversed for Python sources.

這邊有簡單的 Python 2 的原始檔案 `example.py`:

```
def greet(name):
    print "Hello, {0}!".format(name)
print "What's your name?"
name = raw_input()
greet(name)
```

It can be converted to Python 3.x code via `2to3` on the command line:

```
$ 2to3 example.py
```

A diff against the original source file is printed. `2to3` can also write the needed modifications right back to the source file. (A backup of the original file is made unless `-n` is also given.) Writing the changes back is enabled with the `-w` flag:

```
$ 2to3 -w example.py
```

After transformation, `example.py` looks like this:

```
def greet(name):
    print("Hello, {0}!".format(name))
print("What's your name?")
```

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```
name = input()
greet(name)
```

Comments and exact indentation are preserved throughout the translation process.

By default, 2to3 runs a set of *predefined fixers*. The `-l` flag lists all available fixers. An explicit set of fixers to run can be given with `-f`. Likewise the `-x` explicitly disables a fixer. The following example runs only the imports and has_key fixers:

```
$ 2to3 -f imports -f has_key example.py
```

This command runs every fixer except the apply fixer:

```
$ 2to3 -x apply example.py
```

Some fixers are *explicit*, meaning they aren't run by default and must be listed on the command line to be run. Here, in addition to the default fixers, the idioms fixer is run:

```
$ 2to3 -f all -f idioms example.py
```

Notice how passing `all` enables all default fixers.

Sometimes 2to3 will find a place in your source code that needs to be changed, but 2to3 cannot fix automatically. In this case, 2to3 will print a warning beneath the diff for a file. You should address the warning in order to have compliant 3.x code.

2to3 can also refactor doctests. To enable this mode, use the `-d` flag. Note that *only* doctests will be refactored. This also doesn't require the module to be valid Python. For example, doctest like examples in a reST document could also be refactored with this option.

The `-v` option enables output of more information on the translation process.

Since some print statements can be parsed as function calls or statements, 2to3 cannot always read files containing the print function. When 2to3 detects the presence of the `from __future__ import print_function` compiler directive, it modifies its internal grammar to interpret `print()` as a function. This change can also be enabled manually with the `-p` flag. Use `-p` to run fixers on code that already has had its print statements converted. Also `-e` can be used to make `exec()` a function.

The `-o` or `--output-dir` option allows specification of an alternate directory for processed output files to be written to. The `-n` flag is required when using this as backup files do not make sense when not overwriting the input files.

在 3.2.3 版新加入: 新增 `-o` 選項。

The `-W` or `--write-unchanged-files` flag tells 2to3 to always write output files even if no changes were required to the file. This is most useful with `-o` so that an entire Python source tree is copied with translation from one directory to another. This option implies the `-w` flag as it would not make sense otherwise.

在 3.2.3 版新加入: The `-W` flag was added.

The `--add-suffix` option specifies a string to append to all output filenames. The `-n` flag is required when specifying this as backups are not necessary when writing to different filenames. Example:

```
$ 2to3 -n -W --add-suffix=3 example.py
```

Will cause a converted file named `example.py3` to be written.

在 3.2.3 版新加入: The `--add-suffix` option was added.

To translate an entire project from one directory tree to another use:

```
$ 2to3 --output-dir=python3-version/mycode -W -n python2-version/mycode
```


26.8.2 Fixers

Each step of transforming code is encapsulated in a fixer. The command `2to3 -l` lists them. As *documented above*, each can be turned on and off individually. They are described here in more detail.

apply

Removes usage of `apply()`. For example `apply(function, *args, **kwargs)` is converted to `function(*args, **kwargs)`.

asserts

Replaces deprecated `unittest` method names with the correct ones.

從	到
<code>failUnlessEqual(a, b)</code>	<code>assertEqual(a, b)</code>
<code>assertEquals(a, b)</code>	<code>assertEqual(a, b)</code>
<code>failIfEqual(a, b)</code>	<code>assertNotEqual(a, b)</code>
<code>assertNotEquals(a, b)</code>	<code>assertNotEqual(a, b)</code>
<code>failUnless(a)</code>	<code>assertTrue(a)</code>
<code>assert_(a)</code>	<code>assertTrue(a)</code>
<code>failIf(a)</code>	<code>assertFalse(a)</code>
<code>failUnlessRaises(exc, cal)</code>	<code>assertRaises(exc, cal)</code>
<code>failUnlessAlmostEqual(a, b)</code>	<code>assertAlmostEqual(a, b)</code>
<code>assertAlmostEquals(a, b)</code>	<code>assertAlmostEqual(a, b)</code>
<code>failIfAlmostEqual(a, b)</code>	<code>assertNotAlmostEqual(a, b)</code>
<code>assertNotAlmostEquals(a, b)</code>	<code>assertNotAlmostEqual(a, b)</code>

basestring

Converts `basestring` to `str`.

buffer

Converts `buffer` to `memoryview`. This fixer is optional because the `memoryview` API is similar but not exactly the same as that of `buffer`.

dict

Fixes dictionary iteration methods. `dict.iteritems()` is converted to `dict.items()`, `dict.iterkeys()` to `dict.keys()`, and `dict.itervalues()` to `dict.values()`. Similarly, `dict.viewitems()`, `dict.viewkeys()` and `dict.viewvalues()` are converted respectively to `dict.items()`, `dict.keys()` and `dict.values()`. It also wraps existing usages of `dict.items()`, `dict.keys()`, and `dict.values()` in a call to `list`.

except

Converts `except X, T` to `except X as T`.

exec

Converts the `exec` statement to the `exec()` function.

execfile

Removes usage of `execfile()`. The argument to `execfile()` is wrapped in calls to `open()`, `compile()`, and `exec()`.

exitfunc

Changes assignment of `sys.exitfunc` to use of the `atexit` module.

filter

Wraps `filter()` usage in a `list` call.

funcattrs

Fixes function attributes that have been renamed. For example, `my_function.func_closure` is converted to `my_function.__closure__`.

future

Removes from `__future__ import new_feature` statements.

getcwd

Renames `os.getcwd()` to `os.getcwd()`.

has_key

Changes `dict.has_key(key)` to `key in dict`.

idioms

This optional fixer performs several transformations that make Python code more idiomatic. Type comparisons like `type(x) is SomeClass` and `type(x) == SomeClass` are converted to `isinstance(x, SomeClass)`. `while 1` becomes `while True`. This fixer also tries to make use of `sorted()` in appropriate places. For example, this block

```
L = list(some_iterable)
L.sort()
```

is changed to

```
L = sorted(some_iterable)
```

import

Detects sibling imports and converts them to relative imports.

imports

Handles module renames in the standard library.

imports2

Handles other modules renames in the standard library. It is separate from the `imports` fixer only because of technical limitations.

input

Converts `input(prompt)` to `eval(input(prompt))`.

intern

Converts `intern()` to `sys.intern()`.

isinstance

Fixes duplicate types in the second argument of `isinstance()`. For example, `isinstance(x, (int, int))` is converted to `isinstance(x, int)` and `isinstance(x, (int, float, int))` is converted to `isinstance(x, (int, float))`.

itertools_imports

Removes imports of `itertools.ifilter()`, `itertools.izip()`, and `itertools.imap()`. Imports of `itertools.ifilterfalse()` are also changed to `itertools.filterfalse()`.

itertools

Changes usage of `itertools.ifilter()`, `itertools.izip()`, and `itertools.imap()` to their built-in equivalents. `itertools.ifilterfalse()` is changed to `itertools.filterfalse()`.

long

Renames `long` to `int`.

map

Wraps `map()` in a `list` call. It also changes `map(None, x)` to `list(x)`. Using `from future_builtins import map` disables this fixer.

metaclass

Converts the old metaclass syntax (`__metaclass__ = Meta` in the class body) to the new (`class X(metaclass=Meta)`).

methodattrs

Fixes old method attribute names. For example, `meth.im_func` is converted to `meth.__func__`.

ne

Converts the old not-equal syntax, `<>`, to `!=`.

next

Converts the use of iterator's `next()` methods to the `next()` function. It also renames `next()` methods to `__next__()`.

nonzero

Renames definitions of methods called `__nonzero__()` to `__bool__()`.

numliterals

Converts octal literals into the new syntax.

operator

Converts calls to various functions in the `operator` module to other, but equivalent, function calls. When needed, the appropriate `import` statements are added, e.g. `import collections.abc`. The following mapping are made:

從	到
<code>operator.isCallable(obj)</code>	<code>callable(obj)</code>
<code>operator.sequenceIncludes(obj)</code>	<code>operator.contains(obj)</code>
<code>operator.isSequenceType(obj)</code>	<code>isinstance(obj, collections.abc.Sequence)</code>
<code>operator.isMappingType(obj)</code>	<code>isinstance(obj, collections.abc.Mapping)</code>
<code>operator.isNumberType(obj)</code>	<code>isinstance(obj, numbers.Number)</code>
<code>operator.repeat(obj, n)</code>	<code>operator.mul(obj, n)</code>
<code>operator.irepeat(obj, n)</code>	<code>operator.imul(obj, n)</code>

paren

Add extra parenthesis where they are required in list comprehensions. For example, `[x for x in 1, 2]` becomes `[x for x in (1, 2)]`.

print

Converts the `print` statement to the `print()` function.

raise

Converts `raise E, V` to `raise E(V)`, and `raise E, V, T` to `raise E(V).with_traceback(T)`. If `E` is a tuple, the translation will be incorrect because substituting tuples for exceptions has been removed in 3.0.

raw_input

Converts `raw_input()` to `input()`.

reduce

Handles the move of `reduce()` to `functools.reduce()`.

reload

Converts `reload()` to `importlib.reload()`.

renames

Changes `sys.maxint` to `sys.maxsize`.

repr

Replaces backtick `repr` with the `repr()` function.

set_literal

Replaces use of the `set` constructor with set literals. This fixer is optional.

standarderror

Renames `StandardError` to `Exception`.

sys_exc

Changes the deprecated `sys.exc_value`, `sys.exc_type`, `sys.exc_traceback` to use `sys.exc_info()`.

throw

Fixes the API change in generator's `throw()` method.

tuple_params

Removes implicit tuple parameter unpacking. This fixer inserts temporary variables.

types

Fixes code broken from the removal of some members in the `types` module.

unicode

Renames `unicode` to `str`.

urllib

Handles the rename of `urllib` and `urllib2` to the `urllib` package.

ws_comma

Removes excess whitespace from comma separated items. This fixer is optional.

xrange

Renames `xrange()` to `range()` and wraps existing `range()` calls with `list`.

xreadlines

Changes `for x in file.xreadlines()` to `for x in file`.

zip

Wraps `zip()` usage in a `list` call. This is disabled when `from future_builtins import zip` appears.

26.8.3 lib2to3 --- 2to3's library

原始碼: [Lib/lib2to3/](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: Python 3.9 switched to a PEG parser (see [PEP 617](#)) while `lib2to3` is using a less flexible LL(1) parser. Python 3.10 includes new language syntax that is not parsable by `lib2to3`'s LL(1) parser (see [PEP 634](#)). The `lib2to3` module was marked pending for deprecation in Python 3.9 (raising `PendingDeprecationWarning` on import) and fully deprecated in Python 3.11 (raising `DeprecationWarning`). It will be removed from the standard library in Python 3.13. Consider third-party alternatives such as [LibCST](#) or [parso](#).

備^F: The `lib2to3` API should be considered unstable and may change drastically in the future.

26.9 test --- Regression tests package for Python

備註: The `test` package is meant for internal use by Python only. It is documented for the benefit of the core developers of Python. Any use of this package outside of Python’s standard library is discouraged as code mentioned here can change or be removed without notice between releases of Python.

The `test` package contains all regression tests for Python as well as the modules `test.support` and `test.regrtest`. `test.support` is used to enhance your tests while `test.regrtest` drives the testing suite.

Each module in the `test` package whose name starts with `test_` is a testing suite for a specific module or feature. All new tests should be written using the `unittest` or `doctest` module. Some older tests are written using a “traditional” testing style that compares output printed to `sys.stdout`; this style of test is considered deprecated.

也參考:

`unittest` 模組

Writing PyUnit regression tests.

`doctest` 模組

Tests embedded in documentation strings.

26.9.1 Writing Unit Tests for the `test` package

It is preferred that tests that use the `unittest` module follow a few guidelines. One is to name the test module by starting it with `test_` and end it with the name of the module being tested. The test methods in the test module should start with `test_` and end with a description of what the method is testing. This is needed so that the methods are recognized by the test driver as test methods. Also, no documentation string for the method should be included. A comment (such as `# Tests function returns only True or False`) should be used to provide documentation for test methods. This is done because documentation strings get printed out if they exist and thus what test is being run is not stated.

A basic boilerplate is often used:

```
import unittest
from test import support

class MyTestCase1(unittest.TestCase):

    # Only use setUp() and tearDown() if necessary

    def setUp(self):
        ... code to execute in preparation for tests ...

    def tearDown(self):
        ... code to execute to clean up after tests ...

    def test_feature_one(self):
        # Test feature one.
        ... testing code ...

    def test_feature_two(self):
        # Test feature two.
        ... testing code ...

    ... more test methods ...

class MyTestCase2(unittest.TestCase):
    ... same structure as MyTestCase1 ...
```

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```
... more test classes ...

if __name__ == '__main__':
    unittest.main()
```

This code pattern allows the testing suite to be run by `test.regrtest`, on its own as a script that supports the `unittest` CLI, or via the `python -m unittest` CLI.

The goal for regression testing is to try to break code. This leads to a few guidelines to be followed:

- The testing suite should exercise all classes, functions, and constants. This includes not just the external API that is to be presented to the outside world but also “private” code.
- Whitebox testing (examining the code being tested when the tests are being written) is preferred. Blackbox testing (testing only the published user interface) is not complete enough to make sure all boundary and edge cases are tested.
- Make sure all possible values are tested including invalid ones. This makes sure that not only all valid values are acceptable but also that improper values are handled correctly.
- Exhaust as many code paths as possible. Test where branching occurs and thus tailor input to make sure as many different paths through the code are taken.
- Add an explicit test for any bugs discovered for the tested code. This will make sure that the error does not crop up again if the code is changed in the future.
- Make sure to clean up after your tests (such as close and remove all temporary files).
- If a test is dependent on a specific condition of the operating system then verify the condition already exists before attempting the test.
- Import as few modules as possible and do it as soon as possible. This minimizes external dependencies of tests and also minimizes possible anomalous behavior from side-effects of importing a module.
- Try to maximize code reuse. On occasion, tests will vary by something as small as what type of input is used. Minimize code duplication by subclassing a basic test class with a class that specifies the input:

```
class TestFuncAcceptsSequencesMixin:

    func = mySuperWhammyFunction

    def test_func(self):
        self.func(self.arg)

class AcceptLists(TestFuncAcceptsSequencesMixin, unittest.TestCase):
    arg = [1, 2, 3]

class AcceptStrings(TestFuncAcceptsSequencesMixin, unittest.TestCase):
    arg = 'abc'

class AcceptTuples(TestFuncAcceptsSequencesMixin, unittest.TestCase):
    arg = (1, 2, 3)
```

When using this pattern, remember that all classes that inherit from `unittest.TestCase` are run as tests. The `TestFuncAcceptsSequencesMixin` class in the example above does not have any data and so can't be run by itself, thus it does not inherit from `unittest.TestCase`.

也參考:

Test Driven Development

A book by Kent Beck on writing tests before code.

26.9.2 Running tests using the command-line interface

The `test` package can be run as a script to drive Python's regression test suite, thanks to the `-m` option: **python -m test**. Under the hood, it uses `test.regrtest`; the call **python -m test.regrtest** used in previous Python versions still works. Running the script by itself automatically starts running all regression tests in the `test` package. It does this by finding all modules in the package whose name starts with `test_`, importing them, and executing the function `test_main()` if present or loading the tests via `unittest.TestLoader.loadTestsFromModule` if `test_main` does not exist. The names of tests to execute may also be passed to the script. Specifying a single regression test (**python -m test test_spam**) will minimize output and only print whether the test passed or failed.

Running `test` directly allows what resources are available for tests to use to be set. You do this by using the `-u` command-line option. Specifying `all` as the value for the `-u` option enables all possible resources: **python -m test -uall**. If all but one resource is desired (a more common case), a comma-separated list of resources that are not desired may be listed after `all`. The command **python -m test -uall,-audio,-largefile** will run `test` with all resources except the `audio` and `largefile` resources. For a list of all resources and more command-line options, run **python -m test -h**.

Some other ways to execute the regression tests depend on what platform the tests are being executed on. On Unix, you can run **make test** at the top-level directory where Python was built. On Windows, executing **rt.bat** from your `PCbuild` directory will run all regression tests.

26.10 test.support --- Utilities for the Python test suite

The `test.support` module provides support for Python's regression test suite.

備F: `test.support` is not a public module. It is documented here to help Python developers write tests. The API of this module is subject to change without backwards compatibility concerns between releases.

This module defines the following exceptions:

exception `test.support.TestFailed`

Exception to be raised when a test fails. This is deprecated in favor of `unittest`-based tests and `unittest.TestCase`'s assertion methods.

exception `test.support.ResourceDenied`

Subclass of `unittest.SkipTest`. Raised when a resource (such as a network connection) is not available. Raised by the `requires()` function.

The `test.support` module defines the following constants:

`test.support.verbose`

True when verbose output is enabled. Should be checked when more detailed information is desired about a running test. `verbose` is set by `test.regrtest`.

`test.support.is_jython`

True if the running interpreter is Jython.

`test.support.is_android`

True if the system is Android.

`test.support.unix_shell`

Path for shell if not on Windows; otherwise None.

`test.support.LOOPBACK_TIMEOUT`

Timeout in seconds for tests using a network server listening on the network local loopback interface like 127.0.0.1.

The timeout is long enough to prevent test failure: it takes into account that the client and the server can run in different threads or even different processes.

The timeout should be long enough for `connect()`, `recv()` and `send()` methods of `socket.socket`.

Its default value is 5 seconds.

另請參 F `INTERNET_TIMEOUT`。

`test.support.INTERNET_TIMEOUT`

Timeout in seconds for network requests going to the internet.

The timeout is short enough to prevent a test to wait for too long if the internet request is blocked for whatever reason.

Usually, a timeout using `INTERNET_TIMEOUT` should not mark a test as failed, but skip the test instead: see `transient_internet()`.

Its default value is 1 minute.

另請參 F `LOOPBACK_TIMEOUT`。

`test.support.SHORT_TIMEOUT`

Timeout in seconds to mark a test as failed if the test takes "too long".

The timeout value depends on the `regtest --timeout` command line option.

If a test using `SHORT_TIMEOUT` starts to fail randomly on slow buildbots, use `LONG_TIMEOUT` instead.

Its default value is 30 seconds.

`test.support.LONG_TIMEOUT`

Timeout in seconds to detect when a test hangs.

It is long enough to reduce the risk of test failure on the slowest Python buildbots. It should not be used to mark a test as failed if the test takes "too long". The timeout value depends on the `regtest --timeout` command line option.

Its default value is 5 minutes.

See also `LOOPBACK_TIMEOUT`, `INTERNET_TIMEOUT` and `SHORT_TIMEOUT`.

`test.support.PGO`

Set when tests can be skipped when they are not useful for PGO.

`test.support.PIPE_MAX_SIZE`

A constant that is likely larger than the underlying OS pipe buffer size, to make writes blocking.

`test.support.SOCK_MAX_SIZE`

A constant that is likely larger than the underlying OS socket buffer size, to make writes blocking.

`test.support.TEST_SUPPORT_DIR`

Set to the top level directory that contains `test.support`.

`test.support.TEST_HOME_DIR`

Set to the top level directory for the test package.

`test.support.TEST_DATA_DIR`

Set to the data directory within the test package.

`test.support.MAX_Py_ssize_t`

Set to `sys.maxsize` for big memory tests.

`test.support.max_memuse`

Set by `set_memlimit()` as the memory limit for big memory tests. Limited by `MAX_Py_ssize_t`.

`test.support.real_max_memuse`

Set by `set_memlimit()` as the memory limit for big memory tests. Not limited by `MAX_Py_ssize_t`.

`test.support.MISSING_C_DOCSTRINGS`

Set to True if Python is built without docstrings (the `WITH_DOC_STRINGS` macro is not defined). See the configure `--without-doc-strings` option.

See also the `HAVE_DOCSTRINGS` variable.

`test.support.HAVE_DOCSTRINGS`

Set to True if function docstrings are available. See the `python -OO` option, which strips docstrings of functions implemented in Python.

See also the `MISSING_C_DOCSTRINGS` variable.

`test.support.TEST_HTTP_URL`

Define the URL of a dedicated HTTP server for the network tests.

`test.support.ALWAYS_EQ`

Object that is equal to anything. Used to test mixed type comparison.

`test.support.NEVER_EQ`

Object that is not equal to anything (even to `ALWAYS_EQ`). Used to test mixed type comparison.

`test.support.LARGEST`

Object that is greater than anything (except itself). Used to test mixed type comparison.

`test.support.SMALLEST`

Object that is less than anything (except itself). Used to test mixed type comparison.

The `test.support` module defines the following functions:

`test.support.busy_retry (timeout, err_msg=None, /, *, error=True)`

Run the loop body until `break` stops the loop.

After `timeout` seconds, raise an `AssertionError` if `error` is true, or just stop the loop if `error` is false.

Example:

```
for _ in support.busy_retry(support.SHORT_TIMEOUT):
    if check():
        break
```

Example of `error=False` usage:

```
for _ in support.busy_retry(support.SHORT_TIMEOUT, error=False):
    if check():
        break
else:
    raise RuntimeError('my custom error')
```

`test.support.sleeping_retry (timeout, err_msg=None, /, *, init_delay=0.010, max_delay=1.0, error=True)`

Wait strategy that applies exponential backoff.

Run the loop body until `break` stops the loop. Sleep at each loop iteration, but not at the first iteration. The sleep delay is doubled at each iteration (up to `max_delay` seconds).

See `busy_retry()` documentation for the parameters usage.

Example raising an exception after `SHORT_TIMEOUT` seconds:

```
for _ in support.sleeping_retry(support.SHORT_TIMEOUT):
    if check():
        break
```

Example of `error=False` usage:

```
for _ in support.sleeping_retry(support.SHORT_TIMEOUT, error=False):
    if check():
        break
else:
    raise RuntimeError('my custom error')
```

`test.support.is_resource_enabled(resource)`

Return True if *resource* is enabled and available. The list of available resources is only set when *test.regrtest* is executing the tests.

`test.support.python_is_optimized()`

Return True if Python was not built with `-O0` or `-Og`.

`test.support.with_pymalloc()`

Return `_testcapi.WITH_PYMALLOC`.

`test.support.requires(resource, msg=None)`

Raise *ResourceDenied* if *resource* is not available. *msg* is the argument to *ResourceDenied* if it is raised. Always returns True if called by a function whose `__name__` is `'__main__'`. Used when tests are executed by *test.regrtest*.

`test.support.sortdict(dict)`

Return a repr of *dict* with keys sorted.

`test.support.findfile(filename, subdir=None)`

Return the path to the file named *filename*. If no match is found *filename* is returned. This does not equal a failure since it could be the path to the file.

Setting *subdir* indicates a relative path to use to find the file rather than looking directly in the path directories.

`test.support.setswitchinterval(interval)`

Set the *sys.setswitchinterval()* to the given *interval*. Defines a minimum interval for Android systems to prevent the system from hanging.

`test.support.check_impl_detail(**guards)`

Use this check to guard CPython's implementation-specific tests or to run them only on the implementations guarded by the arguments. This function returns True or False depending on the host platform. Example usage:

```
check_impl_detail()           # Only on CPython (default).
check_impl_detail(jython=True) # Only on Jython.
check_impl_detail(cpython=False) # Everywhere except CPython.
```

`test.support.set_memlimit(limit)`

Set the values for *max_memuse* and *real_max_memuse* for big memory tests.

`test.support.record_original_stdout(stdout)`

Store the value from *stdout*. It is meant to hold the stdout at the time the *regrtest* began.

`test.support.get_original_stdout()`

Return the original stdout set by *record_original_stdout()* or `sys.stdout` if it's not set.

`test.support.args_from_interpreter_flags()`

Return a list of command line arguments reproducing the current settings in `sys.flags` and `sys.warnoptions`.

`test.support.optim_args_from_interpreter_flags()`

Return a list of command line arguments reproducing the current optimization settings in `sys.flags`.

`test.support.captured_stdin()`

`test.support.captured_stdout()`

`test.support.captured_stderr()`

A context managers that temporarily replaces the named stream with `io.StringIO` object.

Example use with output streams:

```
with captured_stdout() as stdout, captured_stderr() as stderr:
    print("hello")
    print("error", file=sys.stderr)
assert stdout.getvalue() == "hello\n"
assert stderr.getvalue() == "error\n"
```

Example use with input stream:

```
with captured_stdin() as stdin:
    stdin.write('hello\n')
    stdin.seek(0)
    # call test code that consumes from sys.stdin
    captured = input()
self.assertEqual(captured, "hello")
```

`test.support.disable_faulthandler()`

A context manager that temporary disables `faulthandler`.

`test.support.gc_collect()`

Force as many objects as possible to be collected. This is needed because timely deallocation is not guaranteed by the garbage collector. This means that `__del__` methods may be called later than expected and weakrefs may remain alive for longer than expected.

`test.support.disable_gc()`

A context manager that disables the garbage collector on entry. On exit, the garbage collector is restored to its prior state.

`test.support.swap_attr(obj, attr, new_val)`

Context manager to swap out an attribute with a new object.

用法:

```
with swap_attr(obj, "attr", 5):
    ...
```

This will set `obj.attr` to 5 for the duration of the `with` block, restoring the old value at the end of the block. If `attr` doesn't exist on `obj`, it will be created and then deleted at the end of the block.

The old value (or `None` if it doesn't exist) will be assigned to the target of the "as" clause, if there is one.

`test.support.swap_item(obj, attr, new_val)`

Context manager to swap out an item with a new object.

用法:

```
with swap_item(obj, "item", 5):
    ...
```

This will set `obj["item"]` to 5 for the duration of the `with` block, restoring the old value at the end of the block. If `item` doesn't exist on `obj`, it will be created and then deleted at the end of the block.

The old value (or `None` if it doesn't exist) will be assigned to the target of the "as" clause, if there is one.

`test.support.flush_std_streams()`

Call the `flush()` method on `sys.stdout` and then on `sys.stderr`. It can be used to make sure that the logs order is consistent before writing into `stderr`.

在 3.11 版新加入.

`test.support.print_warning(msg)`

Print a warning into `sys.__stderr__`. Format the message as: `f"Warning -- {msg}"`. If `msg` is made of multiple lines, add `"Warning -- "` prefix to each line.

在 3.9 版新加入。

`test.support.wait_process(pid, *, exitcode, timeout=None)`

Wait until process `pid` completes and check that the process exit code is `exitcode`.

Raise an `AssertionError` if the process exit code is not equal to `exitcode`.

If the process runs longer than `timeout` seconds (`SHORT_TIMEOUT` by default), kill the process and raise an `AssertionError`. The timeout feature is not available on Windows.

在 3.9 版新加入。

`test.support.calcobjsize(fmt)`

Return the size of the `PyObject` whose structure members are defined by `fmt`. The returned value includes the size of the Python object header and alignment.

`test.support.calcvobjsize(fmt)`

Return the size of the `PyVarObject` whose structure members are defined by `fmt`. The returned value includes the size of the Python object header and alignment.

`test.support.checksizeof(test, o, size)`

For testcase `test`, assert that the `sys.getsizeof` for `o` plus the GC header size equals `size`.

`@test.support.anticipate_failure(condition)`

A decorator to conditionally mark tests with `unittest.expectedFailure()`. Any use of this decorator should have an associated comment identifying the relevant tracker issue.

`test.support.system_must_validate_cert(f)`

A decorator that skips the decorated test on TLS certification validation failures.

`@test.support.run_with_locale(catstr, *locales)`

A decorator for running a function in a different locale, correctly resetting it after it has finished. `catstr` is the locale category as a string (for example `"LC_ALL"`). The `locales` passed will be tried sequentially, and the first valid locale will be used.

`@test.support.run_with_tz(tz)`

A decorator for running a function in a specific timezone, correctly resetting it after it has finished.

`@test.support.requires_freebsd_version(*min_version)`

Decorator for the minimum version when running test on FreeBSD. If the FreeBSD version is less than the minimum, the test is skipped.

`@test.support.requires_linux_version(*min_version)`

Decorator for the minimum version when running test on Linux. If the Linux version is less than the minimum, the test is skipped.

`@test.support.requires_mac_version(*min_version)`

Decorator for the minimum version when running test on macOS. If the macOS version is less than the minimum, the test is skipped.

`@test.support.requires_ieee_754`

Decorator for skipping tests on non-IEEE 754 platforms.

`@test.support.requires_zlib`

Decorator for skipping tests if `zlib` doesn't exist.

`@test.support.requires_gzip`

Decorator for skipping tests if `gzip` doesn't exist.

`@test.support.requires_bz2`
 Decorator for skipping tests if `bz2` doesn't exist.

`@test.support.requires_lzma`
 Decorator for skipping tests if `lzma` doesn't exist.

`@test.support.requires_resource(resource)`
 Decorator for skipping tests if `resource` is not available.

`@test.support.requires_docstrings`
 Decorator for only running the test if `HAVE_DOCSTRINGS`.

`@test.support.cpython_only`
 Decorator for tests only applicable to CPython.

`@test.support.impl_detail(msg=None, **guards)`
 Decorator for invoking `check_impl_detail()` on `guards`. If that returns `False`, then uses `msg` as the reason for skipping the test.

`@test.support.no_tracing`
 Decorator to temporarily turn off tracing for the duration of the test.

`@test.support.refcount_test`
 Decorator for tests which involve reference counting. The decorator does not run the test if it is not run by CPython. Any trace function is unset for the duration of the test to prevent unexpected refcounts caused by the trace function.

`@test.support.bigmemtest(size, memuse, dry_run=True)`
 Decorator for bigmem tests.

size is a requested size for the test (in arbitrary, test-interpreted units.) *memuse* is the number of bytes per unit for the test, or a good estimate of it. For example, a test that needs two byte buffers, of 4 GiB each, could be decorated with `@bigmemtest(size=_4G, memuse=2)`.

The *size* argument is normally passed to the decorated test method as an extra argument. If *dry_run* is `True`, the value passed to the test method may be less than the requested value. If *dry_run* is `False`, it means the test doesn't support dummy runs when `-M` is not specified.

`@test.support.bigaddrspace_test`
 Decorator for tests that fill the address space.

`test.support.check_syntax_error(testcase, statement, errtext="", *, lineno=None, offset=None)`
 Test for syntax errors in *statement* by attempting to compile *statement*. *testcase* is the `unittest` instance for the test. *errtext* is the regular expression which should match the string representation of the raised `SyntaxError`. If *lineno* is not `None`, compares to the line of the exception. If *offset* is not `None`, compares to the offset of the exception.

`test.support.open_urlresource(url, *args, **kw)`
 Open *url*. If open fails, raises `TestFailed`.

`test.support.reap_children()`
 Use this at the end of `test_main` whenever sub-processes are started. This will help ensure that no extra children (zombies) stick around to hog resources and create problems when looking for reflinks.

`test.support.get_attribute(obj, name)`
 Get an attribute, raising `unittest.SkipTest` if `AttributeError` is raised.

`test.support.catch_unraisable_exception()`
 Context manager catching unraisable exception using `sys.unraisablehook()`.

Storing the exception value (`cm.unraisable.exc_value`) creates a reference cycle. The reference cycle is broken explicitly when the context manager exits.

Storing the object (`cm.unraisable.object`) can resurrect it if it is set to an object which is being finalized. Exiting the context manager clears the stored object.

用法：

```
with support.catch_unraisable_exception() as cm:
    # code creating an "unraisable exception"
    ...

    # check the unraisable exception: use cm.unraisable
    ...

# cm.unraisable attribute no longer exists at this point
# (to break a reference cycle)
```

在 3.8 版新加入。

`test.support.load_package_tests(pkg_dir, loader, standard_tests, pattern)`

Generic implementation of the `unittest` `load_tests` protocol for use in test packages. `pkg_dir` is the root directory of the package; `loader`, `standard_tests`, and `pattern` are the arguments expected by `load_tests`. In simple cases, the test package's `__init__.py` can be the following:

```
import os
from test.support import load_package_tests

def load_tests(*args):
    return load_package_tests(os.path.dirname(__file__), *args)
```

`test.support.detect_api_mismatch(ref_api, other_api, *, ignore=())`

Returns the set of attributes, functions or methods of `ref_api` not found on `other_api`, except for a defined list of items to be ignored in this check specified in `ignore`.

By default this skips private attributes beginning with `'_'` but includes all magic methods, i.e. those starting and ending in `'__'`.

在 3.5 版新加入。

`test.support.patch(test_instance, object_to_patch, attr_name, new_value)`

Override `object_to_patch.attr_name` with `new_value`. Also add cleanup procedure to `test_instance` to restore `object_to_patch` for `attr_name`. The `attr_name` should be a valid attribute for `object_to_patch`.

`test.support.run_in_subinterp(code)`

Run `code` in subinterpreter. Raise `unittest.SkipTest` if `tracemalloc` is enabled.

`test.support.check_free_after_iterating(test, iter, cls, args=())`

Assert instances of `cls` are deallocated after iterating.

`test.support.missing_compiler_executable(cmd_names=[])`

Check for the existence of the compiler executables whose names are listed in `cmd_names` or all the compiler executables when `cmd_names` is empty and return the first missing executable or `None` when none is found missing.

`test.support.check__all__(test_case, module, name_of_module=None, extra=(), not_exported=())`

Assert that the `__all__` variable of `module` contains all public names.

The module's public names (its API) are detected automatically based on whether they match the public name convention and were defined in `module`.

The `name_of_module` argument can specify (as a string or tuple thereof) what module(s) an API could be defined in order to be detected as a public API. One case for this is when `module` imports part of its public API from other modules, possibly a C backend (like `csv` and its `_csv`).

The `extra` argument can be a set of names that wouldn't otherwise be automatically detected as "public", like objects without a proper `__module__` attribute. If provided, it will be added to the automatically detected ones.

The `not_exported` argument can be a set of names that must not be treated as part of the public API even though their names indicate otherwise.

用法範例：

```
import bar
import foo
import unittest
from test import support

class MiscTestCase(unittest.TestCase):
    def test__all__(self):
        support.check__all__(self, foo)

class OtherTestCase(unittest.TestCase):
    def test__all__(self):
        extra = {'BAR_CONST', 'FOO_CONST'}
        not_exported = {'baz'} # Undocumented name.
        # bar imports part of its API from _bar.
        support.check__all__(self, bar, ('bar', '_bar'),
                               extra=extra, not_exported=not_exported)
```

在 3.6 版新加入。

`test.support.skip_if_broken_multiprocessing_synchronize()`

Skip tests if the `multiprocessing.synchronize` module is missing, if there is no available semaphore implementation, or if creating a lock raises an `OSError`.

在 3.10 版新加入。

`test.support.check_disallow_instantiation(test_case, tp, *args, **kwargs)`

Assert that type `tp` cannot be instantiated using `args` and `kwargs`.

在 3.10 版新加入。

`test.support.adjust_int_max_str_digits(max_digits)`

This function returns a context manager that will change the global `sys.set_int_max_str_digits()` setting for the duration of the context to allow execution of test code that needs a different limit on the number of digits when converting between an integer and string.

在 3.11 版新加入。

The `test.support` module defines the following classes:

class `test.support.SuppressCrashReport`

A context manager used to try to prevent crash dialog popups on tests that are expected to crash a subprocess.

On Windows, it disables Windows Error Reporting dialogs using `SetErrorMode`.

On UNIX, `resource.setrlimit()` is used to set `resource.RLIMIT_CORE`'s soft limit to 0 to prevent coredump file creation.

On both platforms, the old value is restored by `__exit__()`.

class `test.support.SaveSignals`

Class to save and restore signal handlers registered by the Python signal handler.

save (*self*)

Save the signal handlers to a dictionary mapping signal numbers to the current signal handler.

restore (*self*)

Set the signal numbers from the `save()` dictionary to the saved handler.

class `test.support.Matcher`

matches (*self*, *d*, ***kwargs*)

Try to match a single dict with the supplied arguments.

match_value (*self*, *k*, *dv*, *v*)

Try to match a single stored value (*dv*) with a supplied value (*v*).

26.11 test.support.socket_helper --- Utilities for socket tests

The `test.support.socket_helper` module provides support for socket tests.

在 3.9 版新加入.

`test.support.socket_helper.IPV6_ENABLED`

Set to True if IPv6 is enabled on this host, False otherwise.

`test.support.socket_helper.find_unused_port` (*family=socket.AF_INET*,
socktype=socket.SOCK_STREAM)

Returns an unused port that should be suitable for binding. This is achieved by creating a temporary socket with the same family and type as the `sock` parameter (default is `AF_INET`, `SOCK_STREAM`), and binding it to the specified host address (defaults to `0.0.0.0`) with the port set to 0, eliciting an unused ephemeral port from the OS. The temporary socket is then closed and deleted, and the ephemeral port is returned.

Either this method or `bind_port()` should be used for any tests where a server socket needs to be bound to a particular port for the duration of the test. Which one to use depends on whether the calling code is creating a Python socket, or if an unused port needs to be provided in a constructor or passed to an external program (i.e. the `-accept` argument to openssl's `s_server` mode). Always prefer `bind_port()` over `find_unused_port()` where possible. Using a hard coded port is discouraged since it can make multiple instances of the test impossible to run simultaneously, which is a problem for buildbots.

`test.support.socket_helper.bind_port` (*sock*, *host=HOST*)

Bind the socket to a free port and return the port number. Relies on ephemeral ports in order to ensure we are using an unbound port. This is important as many tests may be running simultaneously, especially in a buildbot environment. This method raises an exception if the `sock.family` is `AF_INET` and `sock.type` is `SOCK_STREAM`, and the socket has `SO_REUSEADDR` or `SO_REUSEPORT` set on it. Tests should never set these socket options for TCP/IP sockets. The only case for setting these options is testing multicasting via multiple UDP sockets.

Additionally, if the `SO_EXCLUSIVEADDRUSE` socket option is available (i.e. on Windows), it will be set on the socket. This will prevent anyone else from binding to our host/port for the duration of the test.

`test.support.socket_helper.bind_unix_socket` (*sock*, *addr*)

Bind a Unix socket, raising `unittest.SkipTest` if `PermissionError` is raised.

`@test.support.socket_helper.skip_unless_bind_unix_socket`

A decorator for running tests that require a functional `bind()` for Unix sockets.

`test.support.socket_helper.transient_internet` (*resource_name*, ***, *timeout=30.0*, *errnos=()*)

A context manager that raises `ResourceDenied` when various issues with the internet connection manifest themselves as exceptions.

26.12 `test.support.script_helper` --- Utilities for the Python execution tests

The `test.support.script_helper` module provides support for Python's script execution tests.

`test.support.script_helper.interpreter_requires_environment()`

Return True if `sys.executable` interpreter requires environment variables in order to be able to run at all.

This is designed to be used with `@unittest.skipIf()` to annotate tests that need to use an `assert_python*()` function to launch an isolated mode (`-I`) or no environment mode (`-E`) sub-interpreter process.

A normal build & test does not run into this situation but it can happen when trying to run the standard library test suite from an interpreter that doesn't have an obvious home with Python's current home finding logic.

Setting `PYTHONHOME` is one way to get most of the testsuite to run in that situation. `PYTHONPATH` or `PYTHONUSERSITE` are other common environment variables that might impact whether or not the interpreter can start.

`test.support.script_helper.run_python_until_end(*args, **env_vars)`

Set up the environment based on `env_vars` for running the interpreter in a subprocess. The values can include `__isolated`, `__cleanenv`, `__cwd`, and `TERM`.

在 3.9 版的變更: The function no longer strips whitespaces from `stderr`.

`test.support.script_helper.assert_python_ok(*args, **env_vars)`

Assert that running the interpreter with `args` and optional environment variables `env_vars` succeeds (`rc == 0`) and return a (return code, stdout, stderr) tuple.

If the `__cleanenv` keyword-only parameter is set, `env_vars` is used as a fresh environment.

Python is started in isolated mode (command line option `-I`), except if the `__isolated` keyword-only parameter is set to False.

在 3.9 版的變更: The function no longer strips whitespaces from `stderr`.

`test.support.script_helper.assert_python_failure(*args, **env_vars)`

Assert that running the interpreter with `args` and optional environment variables `env_vars` fails (`rc != 0`) and return a (return code, stdout, stderr) tuple.

更多選項請見 `assert_python_ok()`。

在 3.9 版的變更: The function no longer strips whitespaces from `stderr`.

`test.support.script_helper.spawn_python(*args, stdout=subprocess.PIPE, stderr=subprocess.STDOUT, **kw)`

Run a Python subprocess with the given arguments.

`kw` is extra keyword args to pass to `subprocess.Popen()`. Returns a `subprocess.Popen` object.

`test.support.script_helper.kill_python(p)`

Run the given `subprocess.Popen` process until completion and return stdout.

`test.support.script_helper.make_script(script_dir, script_basename, source, omit_suffix=False)`

Create script containing `source` in path `script_dir` and `script_basename`. If `omit_suffix` is False, append `.py` to the name. Return the full script path.

`test.support.script_helper.make_zip_script(zip_dir, zip_basename, script_name, name_in_zip=None)`

Create zip file at `zip_dir` and `zip_basename` with extension `zip` which contains the files in `script_name`. `name_in_zip` is the archive name. Return a tuple containing (full path, full path of archive name).

`test.support.script_helper.make_pkg(pkg_dir, init_source=)`

Create a directory named *pkg_dir* containing an `__init__` file with *init_source* as its contents.

`test.support.script_helper.make_zip_pkg(zip_dir, zip_basename, pkg_name, script_basename, source, depth=1, compiled=False)`

Create a zip package directory with a path of *zip_dir* and *zip_basename* containing an empty `__init__` file and a file *script_basename* containing the *source*. If *compiled* is `True`, both source files will be compiled and added to the zip package. Return a tuple of the full zip path and the archive name for the zip file.

26.13 `test.support.bytecode_helper` --- Support tools for testing correct bytecode generation

The `test.support.bytecode_helper` module provides support for testing and inspecting bytecode generation.

在 3.9 版新加入.

The module defines the following class:

class `test.support.bytecode_helper.BytecodeTestCase` (`unittest.TestCase`)

This class has custom assertion methods for inspecting bytecode.

`BytecodeTestCase.get_disassembly_as_string(co)`

Return the disassembly of *co* as string.

`BytecodeTestCase.assertInBytecode(x, opname, argval=_UNSPECIFIED)`

Return *instr* if *opname* is found, otherwise throws `AssertionError`.

`BytecodeTestCase.assertNotInBytecode(x, opname, argval=_UNSPECIFIED)`

Throws `AssertionError` if *opname* is found.

26.14 `test.support.threading_helper` --- Utilities for threading tests

The `test.support.threading_helper` module provides support for threading tests.

在 3.10 版新加入.

`test.support.threading_helper.join_thread(thread, timeout=None)`

Join a *thread* within *timeout*. Raise an `AssertionError` if thread is still alive after *timeout* seconds.

@`test.support.threading_helper.reap_threads`

Decorator to ensure the threads are cleaned up even if the test fails.

`test.support.threading_helper.start_threads(threads, unlock=None)`

Context manager to start *threads*, which is a sequence of threads. *unlock* is a function called after the threads are started, even if an exception was raised; an example would be `threading.Event.set()`. `start_threads` will attempt to join the started threads upon exit.

`test.support.threading_helper.threading_cleanup(*original_values)`

Cleanup up threads not specified in *original_values*. Designed to emit a warning if a test leaves running threads in the background.

`test.support.threading_helper.threading_setup()`

Return current thread count and copy of dangling threads.

`test.support.threading_helper.wait_threads_exit (timeout=None)`

Context manager to wait until all threads created in the `with` statement exit.

`test.support.threading_helper.catch_threading_exception()`

Context manager catching `threading.Thread` exception using `threading.excepthook()`.

Attributes set when an exception is caught:

- `exc_type`
- `exc_value`
- `exc_traceback`
- `thread`

參閱 `threading.excepthook()` 文件。

These attributes are deleted at the context manager exit.

用法:

```
with threading_helper.catch_threading_exception() as cm:
    # code spawning a thread which raises an exception
    ...

    # check the thread exception, use cm attributes:
    # exc_type, exc_value, exc_traceback, thread
    ...

# exc_type, exc_value, exc_traceback, thread attributes of cm no longer
# exists at this point
# (to avoid reference cycles)
```

在 3.8 版新加入。

26.15 test.support.os_helper --- Utilities for os tests

The `test.support.os_helper` module provides support for os tests.

在 3.10 版新加入。

`test.support.os_helper.FS_NONASCII`

A non-ASCII character encodable by `os.fsencode()`.

`test.support.os_helper.SAVEDCWD`

Set to `os.getcwd()`.

`test.support.os_helper.TESTFN`

Set to a name that is safe to use as the name of a temporary file. Any temporary file that is created should be closed and unlinked (removed).

`test.support.os_helper.TESTFN_NONASCII`

Set to a filename containing the `FS_NONASCII` character, if it exists. This guarantees that if the filename exists, it can be encoded and decoded with the default filesystem encoding. This allows tests that require a non-ASCII filename to be easily skipped on platforms where they can't work.

`test.support.os_helper.TESTFN_UNENCODABLE`

Set to a filename (str type) that should not be able to be encoded by file system encoding in strict mode. It may be None if it's not possible to generate such a filename.

`test.support.os_helper.TESTFN_UNDECODABLE`

Set to a filename (bytes type) that should not be able to be decoded by file system encoding in strict mode. It may be None if it's not possible to generate such a filename.

`test.support.os_helper.TESTFN_UNICODE`

Set to a non-ASCII name for a temporary file.

class `test.support.os_helper.EnvironmentVarGuard`

Class used to temporarily set or unset environment variables. Instances can be used as a context manager and have a complete dictionary interface for querying/modifying the underlying `os.environ`. After exit from the context manager all changes to environment variables done through this instance will be rolled back.

在 3.1 版的變更: Added dictionary interface.

class `test.support.os_helper.FakePath(path)`

Simple *path-like object*. It implements the `__fspath__()` method which just returns the *path* argument. If *path* is an exception, it will be raised in `__fspath__()`.

`EnvironmentVarGuard.set(envvar, value)`

Temporarily set the environment variable *envvar* to the value of *value*.

`EnvironmentVarGuard.unset(envvar)`

Temporarily unset the environment variable *envvar*.

`test.support.os_helper.can_symlink()`

Return True if the OS supports symbolic links, False otherwise.

`test.support.os_helper.can_xattr()`

Return True if the OS supports xattr, False otherwise.

`test.support.os_helper.change_cwd(path, quiet=False)`

A context manager that temporarily changes the current working directory to *path* and yields the directory.

If *quiet* is False, the context manager raises an exception on error. Otherwise, it issues only a warning and keeps the current working directory the same.

`test.support.os_helper.create_empty_file(filename)`

Create an empty file with *filename*. If it already exists, truncate it.

`test.support.os_helper.fd_count()`

Count the number of open file descriptors.

`test.support.os_helper.fs_is_case_insensitive(directory)`

Return True if the file system for *directory* is case-insensitive.

`test.support.os_helper.make_bad_fd()`

Create an invalid file descriptor by opening and closing a temporary file, and returning its descriptor.

`test.support.os_helper.rmdir(filename)`

Call `os.rmdir()` on *filename*. On Windows platforms, this is wrapped with a wait loop that checks for the existence of the file, which is needed due to antivirus programs that can hold files open and prevent deletion.

`test.support.os_helper.rmtree(path)`

Call `shutil.rmtree()` on *path* or call `os.lstat()` and `os.rmdir()` to remove a path and its contents. As with `rmdir()`, on Windows platforms this is wrapped with a wait loop that checks for the existence of the files.

`@test.support.os_helper.skip_unless_symlink`

A decorator for running tests that require support for symbolic links.

`@test.support.os_helper.skip_unless_xattr`

A decorator for running tests that require support for xattr.

```
test.support.os_helper.temp_cwd (name='tempcwd', quiet=False)
```

A context manager that temporarily creates a new directory and changes the current working directory (CWD).

The context manager creates a temporary directory in the current directory with name *name* before temporarily changing the current working directory. If *name* is `None`, the temporary directory is created using `tempfile.mkdtemp()`.

If *quiet* is `False` and it is not possible to create or change the CWD, an error is raised. Otherwise, only a warning is raised and the original CWD is used.

```
test.support.os_helper.temp_dir (path=None, quiet=False)
```

A context manager that creates a temporary directory at *path* and yields the directory.

If *path* is `None`, the temporary directory is created using `tempfile.mkdtemp()`. If *quiet* is `False`, the context manager raises an exception on error. Otherwise, if *path* is specified and cannot be created, only a warning is issued.

```
test.support.os_helper.temp_umask (umask)
```

A context manager that temporarily sets the process umask.

```
test.support.os_helper.unlink (filename)
```

Call `os.unlink()` on *filename*. As with `rmdir()`, on Windows platforms, this is wrapped with a wait loop that checks for the existence of the file.

26.16 test.support.import_helper --- Utilities for import tests

The `test.support.import_helper` module provides support for import tests.

在 3.10 版新加入.

```
test.support.import_helper.forget (module_name)
```

Remove the module named *module_name* from `sys.modules` and delete any byte-compiled files of the module.

```
test.support.import_helper.import_fresh_module (name, fresh=(), blocked=(),
                                                deprecated=False)
```

This function imports and returns a fresh copy of the named Python module by removing the named module from `sys.modules` before doing the import. Note that unlike `reload()`, the original module is not affected by this operation.

fresh is an iterable of additional module names that are also removed from the `sys.modules` cache before doing the import.

blocked is an iterable of module names that are replaced with `None` in the module cache during the import to ensure that attempts to import them raise `ImportError`.

The named module and any modules named in the *fresh* and *blocked* parameters are saved before starting the import and then reinserted into `sys.modules` when the fresh import is complete.

Module and package deprecation messages are suppressed during this import if *deprecated* is `True`.

This function will raise `ImportError` if the named module cannot be imported.

用法範例:

```
# Get copies of the warnings module for testing without affecting the
# version being used by the rest of the test suite. One copy uses the
# C implementation, the other is forced to use the pure Python fallback
# implementation
py_warnings = import_fresh_module('warnings', blocked=['_warnings'])
c_warnings = import_fresh_module('warnings', fresh=['_warnings'])
```

在 3.1 版新加入.

`test.support.import_helper.import_module(name, deprecated=False, *, required_on=())`

This function imports and returns the named module. Unlike a normal import, this function raises `unittest.SkipTest` if the module cannot be imported.

Module and package deprecation messages are suppressed during this import if `deprecated` is `True`. If a module is required on a platform but optional for others, set `required_on` to an iterable of platform prefixes which will be compared against `sys.platform`.

在 3.1 版新加入。

`test.support.import_helper.modules_setup()`

Return a copy of `sys.modules`.

`test.support.import_helper.modules_cleanup(oldmodules)`

Remove modules except for `oldmodules` and encodings in order to preserve internal cache.

`test.support.import_helper.unload(name)`

Delete `name` from `sys.modules`.

`test.support.import_helper.make_legacy_pyc(source)`

Move a **PEP 3147/PEP 488** pyc file to its legacy pyc location and return the file system path to the legacy pyc file. The `source` value is the file system path to the source file. It does not need to exist, however the PEP 3147/488 pyc file must exist.

class `test.support.import_helper.CleanImport(*module_names)`

A context manager to force import to return a new module reference. This is useful for testing module-level behaviors, such as the emission of a `DeprecationWarning` on import. Example usage:

```
with CleanImport('foo'):
    importlib.import_module('foo') # New reference.
```

class `test.support.import_helper.DirsOnSysPath(*paths)`

A context manager to temporarily add directories to `sys.path`.

This makes a copy of `sys.path`, appends any directories given as positional arguments, then reverts `sys.path` to the copied settings when the context ends.

Note that *all* `sys.path` modifications in the body of the context manager, including replacement of the object, will be reverted at the end of the block.

26.17 test.support.warnings_helper --- Utilities for warnings tests

The `test.support.warnings_helper` module provides support for warnings tests.

在 3.10 版新加入。

`test.support.warnings_helper.ignore_warnings(*, category)`

Suppress warnings that are instances of `category`, which must be `Warning` or a subclass. Roughly equivalent to `warnings.catch_warnings()` with `warnings.simplefilter('ignore', category=category)`. For example:

```
@warning_helper.ignore_warnings(category=DeprecationWarning)
def test_suppress_warning():
    # do something
```

在 3.8 版新加入。

`test.support.warnings_helper.check_no_resource_warning(testcase)`

Context manager to check that no `ResourceWarning` was raised. You must remove the object which may emit `ResourceWarning` before the end of the context manager.

`test.support.warnings_helper.check_syntax_warning(testcase, statement, errtext="", *, lineno=1, offset=None)`

Test for syntax warning in `statement` by attempting to compile `statement`. Test also that the `SyntaxWarning` is emitted only once, and that it will be converted to a `SyntaxError` when turned into error. `testcase` is the `unittest` instance for the test. `errtext` is the regular expression which should match the string representation of the emitted `SyntaxWarning` and raised `SyntaxError`. If `lineno` is not `None`, compares to the line of the warning and exception. If `offset` is not `None`, compares to the offset of the exception.

在 3.8 版新加入.

`test.support.warnings_helper.check_warnings(*filters, quiet=True)`

A convenience wrapper for `warnings.catch_warnings()` that makes it easier to test that a warning was correctly raised. It is approximately equivalent to calling `warnings.catch_warnings(record=True)` with `warnings.simplefilter()` set to `always` and with the option to automatically validate the results that are recorded.

`check_warnings` accepts 2-tuples of the form `("message regexp", WarningCategory)` as positional arguments. If one or more `filters` are provided, or if the optional keyword argument `quiet` is `False`, it checks to make sure the warnings are as expected: each specified filter must match at least one of the warnings raised by the enclosed code or the test fails, and if any warnings are raised that do not match any of the specified filters the test fails. To disable the first of these checks, set `quiet` to `True`.

If no arguments are specified, it defaults to:

```
check_warnings(("", Warning), quiet=True)
```

In this case all warnings are caught and no errors are raised.

On entry to the context manager, a `WarningRecorder` instance is returned. The underlying warnings list from `catch_warnings()` is available via the recorder object's `warnings` attribute. As a convenience, the attributes of the object representing the most recent warning can also be accessed directly through the recorder object (see example below). If no warning has been raised, then any of the attributes that would otherwise be expected on an object representing a warning will return `None`.

The recorder object also has a `reset()` method, which clears the warnings list.

The context manager is designed to be used like this:

```
with check_warnings(("assertion is always true", SyntaxWarning),
                    ("", UserWarning)):
    exec('assert(False, "Hey!")')
    warnings.warn(UserWarning("Hide me!"))
```

In this case if either warning was not raised, or some other warning was raised, `check_warnings()` would raise an error.

When a test needs to look more deeply into the warnings, rather than just checking whether or not they occurred, code like this can be used:

```
with check_warnings(quiet=True) as w:
    warnings.warn("foo")
    assert str(w.args[0]) == "foo"
    warnings.warn("bar")
    assert str(w.args[0]) == "bar"
    assert str(w.warnings[0].args[0]) == "foo"
    assert str(w.warnings[1].args[0]) == "bar"
    w.reset()
    assert len(w.warnings) == 0
```

Here all warnings will be caught, and the test code tests the captured warnings directly.

在 3.2 版的變更: New optional arguments *filters* and *quiet*.

class `test.support.warnings_helper.WarningsRecorder`

Class used to record warnings for unit tests. See documentation of `check_warnings()` above for more details.

除錯與效能分析

這些函式庫幫助你進行 Python 程式開發：除錯器允許你在程式碼中單步 (step) 執行、分析堆疊框 (stack frames) 以及設置中斷點 (breakpoints) 等，效能分析工具執行程式碼提供關於執行時間的詳細分析，讓你找到程式中的瓶頸 (bottlenecks)。事件稽核 (auditing events) 提供執行時期行為的可見性，否則的話可能需要更侵入性的除錯或修補。

27.1 稽核事件表

This table contains all events raised by `sys.audit()` or `PySys_Audit()` calls throughout the CPython runtime and the standard library. These calls were added in 3.8 or later (see [PEP 578](#)).

請參考 `sys.addaudithook()` 及 `PySys_AddAuditHook()` 來了解如何處理這些事件。

CPython 實作細節：這張表是從 CPython 文件生成的，可能不包含其它實作所觸發的事件。請參考你的運行環境 (runtime) 特定文件來了解實際會觸發的事件。

Audit event	Arguments
<code>array.__new__</code>	<code>typecode, initializer</code>
<code>builtins.breakpoint</code>	<code>breakpointhook</code>
<code>builtins.id</code>	<code>id</code>
<code>builtins.input</code>	<code>prompt</code>
<code>builtins.input/result</code>	<code>result</code>
<code>code.__new__</code>	<code>code, filename, name, argcount, posonlyargcount, kwonlyargcount, nloc</code>
<code>compile</code>	<code>source, filename</code>
<code>cpython.PyInterpreterState_Clear</code>	
<code>cpython.PyInterpreterState_New</code>	
<code>cpython._PySys_ClearAuditHooks</code>	
<code>cpython.run_command</code>	<code>command</code>
<code>cpython.run_file</code>	<code>filename</code>
<code>cpython.run_interactivehook</code>	<code>hook</code>
<code>cpython.run_module</code>	<code>module-name</code>
<code>cpython.run_startup</code>	<code>filename</code>
<code>cpython.run_stdin</code>	
<code>ctypes.addressof</code>	<code>obj</code>
<code>ctypes.call_function</code>	<code>func_pointer, arguments</code>

表格 1 – 繼續上一頁

Audit event	Arguments
ctypes.cdata	address
ctypes.cdata/buffer	pointer, size, offset
ctypes.create_string_buffer	init, size
ctypes.create_unicode_buffer	init, size
ctypes.dlopen	name
ctypes.dlsym	library, name
ctypes.dlsym/handle	handle, name
ctypes.get_errno	
ctypes.get_last_error	
ctypes.seh_exception	code
ctypes.set_errno	errno
ctypes.set_last_error	error
ctypes.string_at	address, size
ctypes.wstring_at	address, size
ensurepip.bootstrap	root
exec	code_object
fcntl.fcntl	fd, cmd, arg
fcntl.flock	fd, operation
fcntl.ioctl	fd, request, arg
fcntl.lockf	fd, cmd, len, start, whence
ftplib.connect	self, host, port
ftplib.sendcmd	self, cmd
function.__new__	code
gc.get_objects	generation
gc.get_referents	objs
gc.get_referrers	objs
glob.glob	pathname, recursive
glob.glob/2	pathname, recursive, root_dir, dir_fd
http.client.connect	self, host, port
http.client.send	self, data
imaplib.open	self, host, port
imaplib.send	self, data
import	module, filename, sys.path, sys.meta_path, sys.path_hooks
marshal.dumps	value, version
marshal.load	
marshal.loads	bytes
mmap.__new__	fileno, length, access, offset
msvcrt.get_osfhandle	fd
msvcrt.locking	fd, mode, nbytes
msvcrt.open_osfhandle	handle, flags
nntplib.connect	self, host, port
nntplib.putline	self, line
object.__delattr__	obj, name
object.__getattr__	obj, name
object.__setattr__	obj, name, value
open	file, mode, flags
os.add_dll_directory	path
os.chdir	path
os.chflags	path, flags
os.chmod	path, mode, dir_fd
os.chown	path, uid, gid, dir_fd
os.exec	path, args, env
os.fork	
os.forkpty	
os.fwalk	top, topdown, onerror, follow_symlinks, dir_fd

表格 1 – 繼續上一頁

Audit event	Arguments
os.getxattr	path, attribute
os.kill	pid, sig
os.killpg	pgid, sig
os.link	src, dst, src_dir_fd, dst_dir_fd
os.listdir	path
os.listxattr	path
os.lockf	fd, cmd, len
os.mkdir	path, mode, dir_fd
os.posix_spawn	path, argv, env
os.putenv	key, value
os.remove	path, dir_fd
os.removexattr	path, attribute
os.rename	src, dst, src_dir_fd, dst_dir_fd
os.rmdir	path, dir_fd
os.scandir	path
os.setxattr	path, attribute, value, flags
os.spawn	mode, path, args, env
os.startfile	path, operation
os.startfile/2	path, operation, arguments, cwd, show_cmd
os.symlink	src, dst, dir_fd
os.system	command
os.truncate	fd, length
os.unsetenv	key
os.utime	path, times, ns, dir_fd
os.walk	top, topdown, onerror, followlinks
pathlib.Path.glob	self, pattern
pathlib.Path.rglob	self, pattern
pdb.Pdb	
pickle.find_class	module, name
poplib.connect	self, host, port
poplib.putline	self, line
pty.spawn	argv
resource.prlimit	pid, resource, limits
resource.setrlimit	resource, limits
setopencodehook	
shutil.chown	path, user, group
shutil.copyfile	src, dst
shutil.copymode	src, dst
shutil.copystat	src, dst
shutil.copypath	src, dst
shutil.rmtree	path, dir_fd
shutil.unpack_archive	filename, extract_dir, format
signal.pthread_kill	thread_id, signalnum
smtplib.connect	self, host, port
smtplib.send	self, data
socket.__new__	self, family, type, protocol
socket.bind	self, address
socket.connect	self, address
socket.getaddrinfo	host, port, family, type, protocol
socket.gethostbyaddr	ip_address
socket.gethostbyname	hostname
socket.gethostname	
socket.getnameinfo	sockaddr

表格 1 – 繼續上一頁

Audit event	Arguments
socket.getservbyname	servicename, protocolname
socket.getservbyport	port, protocolname
socket.sendmsg	self, address
socket.sendto	self, address
socket.sethostname	name
sqlite3.connect	database
sqlite3.connect/handle	connection_handle
sqlite3.enable_load_extension	connection, enabled
sqlite3.load_extension	connection, path
subprocess.Popen	executable, args, cwd, env
sys._current_exceptions	
sys._current_frames	
sys._getframe	frame
sys.addaudithook	
sys.excepthook	hook, type, value, traceback
sys.set_asyncgen_hooks_finalizer	
sys.set_asyncgen_hooks_firstiter	
sys.setprofile	
sys.settrace	
sys.unraisablehook	hook, unraisable
syslog.closelog	
syslog.openlog	ident, logoption, facility
syslog.setlogmask	maskpri
syslog.syslog	priority, message
telnetlib.Telnet.open	self, host, port
telnetlib.Telnet.write	self, buffer
tempfile.mkdtemp	fullpath
tempfile.mkstemp	fullpath
urllib.Request	fullurl, data, headers, method
webbrowser.open	url
winreg.ConnectRegistry	computer_name, key
winreg.CreateKey	key, sub_key, access
winreg.DeleteKey	key, sub_key, access
winreg.DeleteValue	key, value
winreg.DisableReflectionKey	key
winreg.EnableReflectionKey	key
winreg.EnumKey	key, index
winreg.EnumValue	key, index
winreg.ExpandEnvironmentStrings	str
winreg.LoadKey	key, sub_key, file_name
winreg.OpenKey	key, sub_key, access
winreg.OpenKey/result	key
winreg.PyHKEY.Detach	key
winreg.QueryInfoKey	key
winreg.QueryReflectionKey	key
winreg.QueryValue	key, sub_key, value_name
winreg.SaveKey	key, file_name
winreg.SetValue	key, sub_key, type, value

下列事件是 F 部觸發的，與任何 CPython 的公開 API F 無關 F：

稽核事件	引數
<code>_winapi.CreateFile</code>	<code>file_name, desired_access, share_mode, creation_disposition, flags_and_attributes</code>
<code>_winapi.CreateJunctio</code>	<code>src_path, dst_path</code>
<code>_winapi.CreateNameec</code>	<code>name, open_mode, pipe_mode</code>
<code>_winapi.CreatePipe</code>	
<code>_winapi.CreateProces</code>	<code>application_name, command_line, current_directory</code>
<code>_winapi.OpenProcess</code>	<code>process_id, desired_access</code>
<code>_winapi.TerminatePrc</code>	<code>handle, exit_code</code>
<code>ctypes.PyObj_FromPt</code>	<code>obj</code>

27.2 bdb --- Debugger framework

原始碼: [Lib/bdb.py](#)

The *bdb* module handles basic debugger functions, like setting breakpoints or managing execution via the debugger.

The following exception is defined:

exception `bdb.BdbQuit`

Exception raised by the *Bdb* class for quitting the debugger.

The *bdb* module also defines two classes:

class `bdb.Breakpoint` (*self, file, line, temporary=False, cond=None, funcname=None*)

This class implements temporary breakpoints, ignore counts, disabling and (re-)enabling, and conditionals.

Breakpoints are indexed by number through a list called *bpbynumber* and by (*file*, *line*) pairs through *bplist*. The former points to a single instance of class *Breakpoint*. The latter points to a list of such instances since there may be more than one breakpoint per line.

When creating a breakpoint, its associated *file name* should be in canonical form. If a *funcname* is defined, a breakpoint *hit* will be counted when the first line of that function is executed. A *conditional* breakpoint always counts a *hit*.

Breakpoint instances have the following methods:

deleteMe ()

Delete the breakpoint from the list associated to a file/line. If it is the last breakpoint in that position, it also deletes the entry for the file/line.

enable ()

Mark the breakpoint as enabled.

disable ()

Mark the breakpoint as disabled.

bpformat ()

Return a string with all the information about the breakpoint, nicely formatted:

- Breakpoint number.
- Temporary status (del or keep).
- File/line position.
- Break condition.
- Number of times to ignore.

- Number of times hit.

在 3.2 版新加入.

bpprint (*out=None*)

Print the output of *bpformat* () to the file *out*, or if it is *None*, to standard output.

Breakpoint instances have the following attributes:

file

File name of the *Breakpoint*.

line

Line number of the *Breakpoint* within *file*.

temporary

True if a *Breakpoint* at (file, line) is temporary.

cond

Condition for evaluating a *Breakpoint* at (file, line).

funcname

Function name that defines whether a *Breakpoint* is hit upon entering the function.

enabled

True if *Breakpoint* is enabled.

bpbynumber

Numeric index for a single instance of a *Breakpoint*.

bplist

Dictionary of *Breakpoint* instances indexed by (*file*, *line*) tuples.

ignore

Number of times to ignore a *Breakpoint*.

hits

Count of the number of times a *Breakpoint* has been hit.

class `bdb.Bdb` (*skip=None*)

The *Bdb* class acts as a generic Python debugger base class.

This class takes care of the details of the trace facility; a derived class should implement user interaction. The standard debugger class (*pdb.Pdb*) is an example.

The *skip* argument, if given, must be an iterable of glob-style module name patterns. The debugger will not step into frames that originate in a module that matches one of these patterns. Whether a frame is considered to originate in a certain module is determined by the `__name__` in the frame globals.

在 3.1 版的變更: Added the *skip* parameter.

The following methods of *Bdb* normally don't need to be overridden.

canonic (*filename*)

Return canonical form of *filename*.

For real file names, the canonical form is an operating-system-dependent, *case-normalized absolute path*. A *filename* with angle brackets, such as "<stdin>" generated in interactive mode, is returned unchanged.

reset ()

Set the *botframe*, *stopframe*, *returnframe* and *quitting* attributes with values ready to start debugging.

trace_dispatch (*frame, event, arg*)

This function is installed as the trace function of debugged frames. Its return value is the new trace function (in most cases, that is, itself).

The default implementation decides how to dispatch a frame, depending on the type of event (passed as a string) that is about to be executed. *event* can be one of the following:

- "line": A new line of code is going to be executed.
- "call": A function is about to be called, or another code block entered.
- "return": A function or other code block is about to return.
- "exception": An exception has occurred.
- "c_call": A C function is about to be called.
- "c_return": A C function has returned.
- "c_exception": A C function has raised an exception.

For the Python events, specialized functions (see below) are called. For the C events, no action is taken.

The *arg* parameter depends on the previous event.

See the documentation for `sys.settrace()` for more information on the trace function. For more information on code and frame objects, refer to types.

dispatch_line (*frame*)

If the debugger should stop on the current line, invoke the `user_line()` method (which should be overridden in subclasses). Raise a `BdbQuit` exception if the `quitting` flag is set (which can be set from `user_line()`). Return a reference to the `trace_dispatch()` method for further tracing in that scope.

dispatch_call (*frame, arg*)

If the debugger should stop on this function call, invoke the `user_call()` method (which should be overridden in subclasses). Raise a `BdbQuit` exception if the `quitting` flag is set (which can be set from `user_call()`). Return a reference to the `trace_dispatch()` method for further tracing in that scope.

dispatch_return (*frame, arg*)

If the debugger should stop on this function return, invoke the `user_return()` method (which should be overridden in subclasses). Raise a `BdbQuit` exception if the `quitting` flag is set (which can be set from `user_return()`). Return a reference to the `trace_dispatch()` method for further tracing in that scope.

dispatch_exception (*frame, arg*)

If the debugger should stop at this exception, invokes the `user_exception()` method (which should be overridden in subclasses). Raise a `BdbQuit` exception if the `quitting` flag is set (which can be set from `user_exception()`). Return a reference to the `trace_dispatch()` method for further tracing in that scope.

Normally derived classes don't override the following methods, but they may if they want to redefine the definition of stopping and breakpoints.

is_skipped_line (*module_name*)

Return True if *module_name* matches any skip pattern.

stop_here (*frame*)

Return True if *frame* is below the starting frame in the stack.

break_here (*frame*)

Return True if there is an effective breakpoint for this line.

Check whether a line or function breakpoint exists and is in effect. Delete temporary breakpoints based on information from `effective()`.

break_anywhere (*frame*)

Return True if any breakpoint exists for *frame*'s filename.

Derived classes should override these methods to gain control over debugger operation.

user_call (*frame*, *argument_list*)

Called from `dispatch_call()` if a break might stop inside the called function.

user_line (*frame*)

Called from `dispatch_line()` when either `stop_here()` or `break_here()` returns True.

user_return (*frame*, *return_value*)

Called from `dispatch_return()` when `stop_here()` returns True.

user_exception (*frame*, *exc_info*)

Called from `dispatch_exception()` when `stop_here()` returns True.

do_clear (*arg*)

Handle how a breakpoint must be removed when it is a temporary one.

This method must be implemented by derived classes.

Derived classes and clients can call the following methods to affect the stepping state.

set_step ()

Stop after one line of code.

set_next (*frame*)

Stop on the next line in or below the given frame.

set_return (*frame*)

Stop when returning from the given frame.

set_until (*frame*, *lineno=None*)

Stop when the line with the *lineno* greater than the current one is reached or when returning from current frame.

set_trace ([*frame*])

Start debugging from *frame*. If *frame* is not specified, debugging starts from caller's frame.

set_continue ()

Stop only at breakpoints or when finished. If there are no breakpoints, set the system trace function to None.

set_quit ()

Set the quitting attribute to True. This raises `BdbQuit` in the next call to one of the `dispatch_*()` methods.

Derived classes and clients can call the following methods to manipulate breakpoints. These methods return a string containing an error message if something went wrong, or None if all is well.

set_break (*filename*, *lineno*, *temporary=False*, *cond=None*, *funcname=None*)

Set a new breakpoint. If the *lineno* line doesn't exist for the *filename* passed as argument, return an error message. The *filename* should be in canonical form, as described in the `canonic()` method.

clear_break (*filename*, *lineno*)

Delete the breakpoints in *filename* and *lineno*. If none were set, return an error message.

clear_bpbynumber (*arg*)

Delete the breakpoint which has the index *arg* in the `Breakpoint.bpbynumber`. If *arg* is not numeric or out of range, return an error message.

clear_all_file_breaks (*filename*)

Delete all breakpoints in *filename*. If none were set, return an error message.

clear_all_breaks ()

Delete all existing breakpoints. If none were set, return an error message.

get_bpbynumber (arg)

Return a breakpoint specified by the given number. If *arg* is a string, it will be converted to a number. If *arg* is a non-numeric string, if the given breakpoint never existed or has been deleted, a *ValueError* is raised.

在 3.2 版新加入.

get_break (filename, lineno)

Return True if there is a breakpoint for *lineno* in *filename*.

get_breaks (filename, lineno)

Return all breakpoints for *lineno* in *filename*, or an empty list if none are set.

get_file_breaks (filename)

Return all breakpoints in *filename*, or an empty list if none are set.

get_all_breaks ()

Return all breakpoints that are set.

Derived classes and clients can call the following methods to get a data structure representing a stack trace.

get_stack (f, t)

Return a list of (frame, lineno) tuples in a stack trace, and a size.

The most recently called frame is last in the list. The size is the number of frames below the frame where the debugger was invoked.

format_stack_entry (frame_lineno, lprefix=': ')

Return a string with information about a stack entry, which is a (frame, lineno) tuple. The return string contains:

- The canonical filename which contains the frame.
- The function name or "<lambda>".
- The input arguments.
- The return value.
- The line of code (if it exists).

The following two methods can be called by clients to use a debugger to debug a *statement*, given as a string.

run (cmd, globals=None, locals=None)

Debug a statement executed via the *exec ()* function. *globals* defaults to `__main__.__dict__`, *locals* defaults to *globals*.

runeval (expr, globals=None, locals=None)

Debug an expression executed via the *eval ()* function. *globals* and *locals* have the same meaning as in *run ()*.

runcctx (cmd, globals, locals)

For backwards compatibility. Calls the *run ()* method.

runcall (func, /, *args, **kwargs)

Debug a single function call, and return its result.

Finally, the module defines the following functions:

`bdb.checkfuncname(b, frame)`

Return True if we should break here, depending on the way the *Breakpoint* `b` was set.

If it was set via line number, it checks if `b.line` is the same as the one in `frame`. If the breakpoint was set via *function name*, we have to check we are in the right *frame* (the right function) and if we are on its first executable line.

`bdb.effective(file, line, frame)`

Return (active breakpoint, delete temporary flag) or (None, None) as the breakpoint to act upon.

The *active breakpoint* is the first entry in `bplist` for the (`file`, `line`) (which must exist) that is *enabled*, for which `checkfuncname()` is True, and that has neither a False *condition* nor positive *ignore* count. The *flag*, meaning that a temporary breakpoint should be deleted, is False only when the *cond* cannot be evaluated (in which case, *ignore* count is ignored).

If no such entry exists, then (None, None) is returned.

`bdb.set_trace()`

Start debugging with a *Bdb* instance from caller's frame.

27.3 faulthandler --- Dump the Python traceback

在 3.3 版新加入。

This module contains functions to dump Python tracebacks explicitly, on a fault, after a timeout, or on a user signal. Call `faulthandler.enable()` to install fault handlers for the SIGSEGV, SIGFPE, SIGABRT, SIGBUS, and SIGILL signals. You can also enable them at startup by setting the PYTHONFAULTHANDLER environment variable or by using the `-X faulthandler` command line option.

The fault handler is compatible with system fault handlers like Apport or the Windows fault handler. The module uses an alternative stack for signal handlers if the `sigaltstack()` function is available. This allows it to dump the traceback even on a stack overflow.

The fault handler is called on catastrophic cases and therefore can only use signal-safe functions (e.g. it cannot allocate memory on the heap). Because of this limitation traceback dumping is minimal compared to normal Python tracebacks:

- Only ASCII is supported. The `backslashreplace` error handler is used on encoding.
- Each string is limited to 500 characters.
- Only the filename, the function name and the line number are displayed. (no source code)
- It is limited to 100 frames and 100 threads.
- The order is reversed: the most recent call is shown first.

By default, the Python traceback is written to `sys.stderr`. To see tracebacks, applications must be run in the terminal. A log file can alternatively be passed to `faulthandler.enable()`.

The module is implemented in C, so tracebacks can be dumped on a crash or when Python is deadlocked.

The *Python Development Mode* calls `faulthandler.enable()` at Python startup.

也參考:

Module `pdb`

Interactive source code debugger for Python programs.

Module `traceback`

Standard interface to extract, format and print stack traces of Python programs.

27.3.1 Dumping the traceback

`faulthandler.dump_traceback (file=sys.stderr, all_threads=True)`

Dump the tracebacks of all threads into *file*. If *all_threads* is `False`, dump only the current thread.

也参考:

`traceback.print_tb()`, which can be used to print a traceback object.

在 3.5 版的變更: Added support for passing file descriptor to this function.

27.3.2 Fault handler state

`faulthandler.enable (file=sys.stderr, all_threads=True)`

Enable the fault handler: install handlers for the `SIGSEGV`, `SIGFPE`, `SIGABRT`, `SIGBUS` and `SIGILL` signals to dump the Python traceback. If *all_threads* is `True`, produce tracebacks for every running thread. Otherwise, dump only the current thread.

The *file* must be kept open until the fault handler is disabled: see *issue with file descriptors*.

在 3.5 版的變更: Added support for passing file descriptor to this function.

在 3.6 版的變更: On Windows, a handler for Windows exception is also installed.

在 3.10 版的變更: The dump now mentions if a garbage collector collection is running if *all_threads* is `true`.

`faulthandler.disable()`

Disable the fault handler: uninstall the signal handlers installed by *enable()*.

`faulthandler.is_enabled()`

Check if the fault handler is enabled.

27.3.3 Dumping the tracebacks after a timeout

`faulthandler.dump_traceback_later (timeout, repeat=False, file=sys.stderr, exit=False)`

Dump the tracebacks of all threads, after a timeout of *timeout* seconds, or every *timeout* seconds if *repeat* is `True`. If *exit* is `True`, call `_exit()` with `status=1` after dumping the tracebacks. (Note `_exit()` exits the process immediately, which means it doesn't do any cleanup like flushing file buffers.) If the function is called twice, the new call replaces previous parameters and resets the timeout. The timer has a sub-second resolution.

The *file* must be kept open until the traceback is dumped or *cancel_dump_traceback_later()* is called: see *issue with file descriptors*.

This function is implemented using a watchdog thread.

在 3.5 版的變更: Added support for passing file descriptor to this function.

在 3.7 版的變更: This function is now always available.

`faulthandler.cancel_dump_traceback_later()`

Cancel the last call to *dump_traceback_later()*.

27.3.4 Dumping the traceback on a user signal

`faulthandler.register` (*signum*, *file=sys.stderr*, *all_threads=True*, *chain=False*)

Register a user signal: install a handler for the *signum* signal to dump the traceback of all threads, or of the current thread if *all_threads* is `False`, into *file*. Call the previous handler if *chain* is `True`.

The *file* must be kept open until the signal is unregistered by `unregister()`: see *issue with file descriptors*.

Not available on Windows.

在 3.5 版的變更: Added support for passing file descriptor to this function.

`faulthandler.unregister` (*signum*)

Unregister a user signal: uninstall the handler of the *signum* signal installed by `register()`. Return `True` if the signal was registered, `False` otherwise.

Not available on Windows.

27.3.5 Issue with file descriptors

`enable()`, `dump_traceback_later()` and `register()` keep the file descriptor of their *file* argument. If the file is closed and its file descriptor is reused by a new file, or if `os.dup2()` is used to replace the file descriptor, the traceback will be written into a different file. Call these functions again each time that the file is replaced.

27.3.6 范例

Example of a segmentation fault on Linux with and without enabling the fault handler:

```
$ python3 -c "import ctypes; ctypes.string_at(0)"
Segmentation fault

$ python3 -q -X faulthandler
>>> import ctypes
>>> ctypes.string_at(0)
Fatal Python error: Segmentation fault

Current thread 0x00007fb899f39700 (most recent call first):
  File "/home/python/cpython/Lib/ctypes/__init__.py", line 486 in string_at
  File "<stdin>", line 1 in <module>
Segmentation fault
```

27.4 pdb --- The Python Debugger

原始碼: [Lib/pdb.py](#)

The module `pdb` defines an interactive source code debugger for Python programs. It supports setting (conditional) breakpoints and single stepping at the source line level, inspection of stack frames, source code listing, and evaluation of arbitrary Python code in the context of any stack frame. It also supports post-mortem debugging and can be called under program control.

The debugger is extensible -- it is actually defined as the class `Pdb`. This is currently undocumented but easily understood by reading the source. The extension interface uses the modules `bdb` and `cmd`.

也參考:

Module `faulthandler`

Used to dump Python tracebacks explicitly, on a fault, after a timeout, or on a user signal.

Module `traceback`

Standard interface to extract, format and print stack traces of Python programs.

The typical usage to break into the debugger is to insert:

```
import pdb; pdb.set_trace()
```

Or:

```
breakpoint()
```

at the location you want to break into the debugger, and then run the program. You can then step through the code following this statement, and continue running without the debugger using the `continue` command.

在 3.7 版的變更: The built-in `breakpoint()`, when called with defaults, can be used instead of `import pdb; pdb.set_trace()`.

```
def double(x):
    breakpoint()
    return x * 2
val = 3
print(f"{val} * 2 is {double(val)}")
```

The debugger's prompt is `(Pdb)`, which is the indicator that you are in debug mode:

```
> ... (3) double()
-> return x * 2
(Pdb) p x
3
(Pdb) continue
3 * 2 is 6
```

在 3.3 版的變更: Tab-completion via the `readline` module is available for commands and command arguments, e.g. the current global and local names are offered as arguments of the `p` command.

You can also invoke `pdb` from the command line to debug other scripts. For example:

```
python -m pdb myscript.py
```

When invoked as a module, `pdb` will automatically enter post-mortem debugging if the program being debugged exits abnormally. After post-mortem debugging (or after normal exit of the program), `pdb` will restart the program. Automatic restarting preserves `pdb`'s state (such as breakpoints) and in most cases is more useful than quitting the debugger upon program's exit.

在 3.2 版的變更: Added the `-c` option to execute commands as if given in a `.pdbrc` file; see *Debugger Commands*.

在 3.7 版的變更: Added the `-m` option to execute modules similar to the way `python -m` does. As with a script, the debugger will pause execution just before the first line of the module.

Typical usage to execute a statement under control of the debugger is:

```
>>> import pdb
>>> def f(x):
...     print(1 / x)
>>> pdb.run("f(2)")
> <string>(1)<module>()
(Pdb) continue
0.5
>>>
```

The typical usage to inspect a crashed program is:

```

>>> import pdb
>>> def f(x):
...     print(1 / x)
...
>>> f(0)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "<stdin>", line 2, in f
ZeroDivisionError: division by zero
>>> pdb.pm()
> <stdin>(2) f()
(Pdb) p x
0
(Pdb)

```

The module defines the following functions; each enters the debugger in a slightly different way:

`pdb.run(statement, globals=None, locals=None)`

Execute the *statement* (given as a string or a code object) under debugger control. The debugger prompt appears before any code is executed; you can set breakpoints and type *continue*, or you can step through the statement using *step* or *next* (all these commands are explained below). The optional *globals* and *locals* arguments specify the environment in which the code is executed; by default the dictionary of the module `__main__` is used. (See the explanation of the built-in *exec()* or *eval()* functions.)

`pdb.runeval(expression, globals=None, locals=None)`

Evaluate the *expression* (given as a string or a code object) under debugger control. When *runeval()* returns, it returns the value of the *expression*. Otherwise this function is similar to *run()*.

`pdb.runcall(function, *args, **kwargs)`

Call the *function* (a function or method object, not a string) with the given arguments. When *runcall()* returns, it returns whatever the function call returned. The debugger prompt appears as soon as the function is entered.

`pdb.set_trace(*, header=None)`

Enter the debugger at the calling stack frame. This is useful to hard-code a breakpoint at a given point in a program, even if the code is not otherwise being debugged (e.g. when an assertion fails). If given, *header* is printed to the console just before debugging begins.

在 3.7 版的變更: The keyword-only argument *header*.

`pdb.post_mortem(traceback=None)`

Enter post-mortem debugging of the given *traceback* object. If no *traceback* is given, it uses the one of the exception that is currently being handled (an exception must be being handled if the default is to be used).

`pdb.pm()`

Enter post-mortem debugging of the traceback found in `sys.last_traceback`.

The *run** functions and *set_trace()* are aliases for instantiating the *Pdb* class and calling the method of the same name. If you want to access further features, you have to do this yourself:

class `pdb.Pdb` (*completekey='tab', stdin=None, stdout=None, skip=None, nosigint=False, readrc=True*)

Pdb is the debugger class.

The *completekey*, *stdin* and *stdout* arguments are passed to the underlying *cmd.Cmd* class; see the description there.

The *skip* argument, if given, must be an iterable of glob-style module name patterns. The debugger will not step into frames that originate in a module that matches one of these patterns.¹

By default, *Pdb* sets a handler for the SIGINT signal (which is sent when the user presses Ctrl-C on the console) when you give a *continue* command. This allows you to break into the debugger again by pressing Ctrl-C. If you want *Pdb* not to touch the SIGINT handler, set *nosigint* to true.

¹ Whether a frame is considered to originate in a certain module is determined by the `__name__` in the frame `globals`.

d(own) [count]

Move the current frame *count* (default one) levels down in the stack trace (to a newer frame).

u(p) [count]

Move the current frame *count* (default one) levels up in the stack trace (to an older frame).

b(reak) [(*[filename:]lineno* | *function*) [, *condition*]]

With a *lineno* argument, set a break there in the current file. With a *function* argument, set a break at the first executable statement within that function. The line number may be prefixed with a filename and a colon, to specify a breakpoint in another file (probably one that hasn't been loaded yet). The file is searched on *sys.path*. Note that each breakpoint is assigned a number to which all the other breakpoint commands refer.

If a second argument is present, it is an expression which must evaluate to true before the breakpoint is honored.

Without argument, list all breaks, including for each breakpoint, the number of times that breakpoint has been hit, the current ignore count, and the associated condition if any.

tbreak [(*[filename:]lineno* | *function*) [, *condition*]]

Temporary breakpoint, which is removed automatically when it is first hit. The arguments are the same as for *break*.

cl(ear) [*filename:lineno* | *bpnumber* ...]

With a *filename:lineno* argument, clear all the breakpoints at this line. With a space separated list of breakpoint numbers, clear those breakpoints. Without argument, clear all breaks (but first ask confirmation).

disable [*bpnumber* ...]

Disable the breakpoints given as a space separated list of breakpoint numbers. Disabling a breakpoint means it cannot cause the program to stop execution, but unlike clearing a breakpoint, it remains in the list of breakpoints and can be (re-)enabled.

enable [*bpnumber* ...]

Enable the breakpoints specified.

ignore *bpnumber* [*count*]

Set the ignore count for the given breakpoint number. If *count* is omitted, the ignore count is set to 0. A breakpoint becomes active when the ignore count is zero. When non-zero, the *count* is decremented each time the breakpoint is reached and the breakpoint is not disabled and any associated condition evaluates to true.

condition *bpnumber* [*condition*]

Set a new *condition* for the breakpoint, an expression which must evaluate to true before the breakpoint is honored. If *condition* is absent, any existing condition is removed; i.e., the breakpoint is made unconditional.

commands [*bpnumber*]

Specify a list of commands for breakpoint number *bpnumber*. The commands themselves appear on the following lines. Type a line containing just *end* to terminate the commands. An example:

```
(Pdb) commands 1
(com) p some_variable
(com) end
(Pdb)
```

To remove all commands from a breakpoint, type *commands* and follow it immediately with *end*; that is, give no commands.

With no *bpnumber* argument, *commands* refers to the last breakpoint set.

You can use breakpoint commands to start your program up again. Simply use the *continue* command, or *step*, or any other command that resumes execution.

Specifying any command resuming execution (currently *continue*, *step*, *next*, *return*, *jump*, *quit* and their abbreviations) terminates the command list (as if that command was immediately followed by *end*). This is because any time you resume execution (even with a simple *next* or *step*), you may encounter another breakpoint—which could have its own command list, leading to ambiguities about which list to execute.

If you use the `silent` command in the command list, the usual message about stopping at a breakpoint is not printed. This may be desirable for breakpoints that are to print a specific message and then continue. If none of the other commands print anything, you see no sign that the breakpoint was reached.

s (step)

Execute the current line, stop at the first possible occasion (either in a function that is called or on the next line in the current function).

n (ext)

Continue execution until the next line in the current function is reached or it returns. (The difference between `next` and `step` is that `step` stops inside a called function, while `next` executes called functions at (nearly) full speed, only stopping at the next line in the current function.)

unt (il) [lineno]

Without argument, continue execution until the line with a number greater than the current one is reached.

With `lineno`, continue execution until a line with a number greater or equal to `lineno` is reached. In both cases, also stop when the current frame returns.

在 3.2 版的變更: Allow giving an explicit line number.

r (eturn)

Continue execution until the current function returns.

c (ontinue)

Continue execution, only stop when a breakpoint is encountered.

j (ump) lineno

Set the next line that will be executed. Only available in the bottom-most frame. This lets you jump back and execute code again, or jump forward to skip code that you don't want to run.

It should be noted that not all jumps are allowed -- for instance it is not possible to jump into the middle of a `for` loop or out of a `finally` clause.

l (ist) [first[, last]]

List source code for the current file. Without arguments, list 11 lines around the current line or continue the previous listing. With `.` as argument, list 11 lines around the current line. With one argument, list 11 lines around at that line. With two arguments, list the given range; if the second argument is less than the first, it is interpreted as a count.

The current line in the current frame is indicated by `->`. If an exception is being debugged, the line where the exception was originally raised or propagated is indicated by `>>`, if it differs from the current line.

在 3.2 版的變更: Added the `>>` marker.

ll | longlist

List all source code for the current function or frame. Interesting lines are marked as for `list`.

在 3.2 版新加入.

a (rgs)

Print the arguments of the current function and their current values.

p expression

Evaluate `expression` in the current context and print its value.

備F: `print()` can also be used, but is not a debugger command --- this executes the Python `print()` function.

pp expression

Like the `p` command, except the value of `expression` is pretty-printed using the `pprint` module.

whatis *expression*

Print the type of *expression*.

source *expression*

Try to get source code of *expression* and display it.

在 3.2 版新加入.

display [*expression*]

Display the value of *expression* if it changed, each time execution stops in the current frame.

Without *expression*, list all display expressions for the current frame.

備 F: Display evaluates *expression* and compares to the result of the previous evaluation of *expression*, so when the result is mutable, display may not be able to pick up the changes.

Example:

```
lst = []
breakpoint()
pass
lst.append(1)
print(lst)
```

Display won't realize `lst` has been changed because the result of evaluation is modified in place by `lst.append(1)` before being compared:

```
> example.py(3) <module>()
-> pass
(Pdb) display lst
display lst: []
(Pdb) n
> example.py(4) <module>()
-> lst.append(1)
(Pdb) n
> example.py(5) <module>()
-> print(lst)
(Pdb)
```

You can do some tricks with copy mechanism to make it work:

```
> example.py(3) <module>()
-> pass
(Pdb) display lst[:]
display lst[:]: []
(Pdb) n
> example.py(4) <module>()
-> lst.append(1)
(Pdb) n
> example.py(5) <module>()
-> print(lst)
display lst[:]: [1] [old: []]
(Pdb)
```

在 3.2 版新加入.

undisplay [*expression*]

Do not display *expression* anymore in the current frame. Without *expression*, clear all display expressions for the current frame.

在 3.2 版新加入.

interact

Start an interactive interpreter (using the `code` module) whose global namespace contains all the (global and local) names found in the current scope.

在 3.2 版新加入。

alias [name [command]]

Create an alias called *name* that executes *command*. The *command* must *not* be enclosed in quotes. Replaceable parameters can be indicated by %1, %2, and so on, while %* is replaced by all the parameters. If *command* is omitted, the current alias for *name* is shown. If no arguments are given, all aliases are listed.

Aliases may be nested and can contain anything that can be legally typed at the pdb prompt. Note that internal pdb commands *can* be overridden by aliases. Such a command is then hidden until the alias is removed. Aliasing is recursively applied to the first word of the command line; all other words in the line are left alone.

As an example, here are two useful aliases (especially when placed in the `.pdbrc` file):

```
# Print instance variables (usage "pi classInst")
alias pi for k in %1.__dict__.keys(): print(f"%1.{k} = {%1.__dict__[k]}")
# Print instance variables in self
alias ps pi self
```

unalias name

Delete the specified alias *name*.

! statement

Execute the (one-line) *statement* in the context of the current stack frame. The exclamation point can be omitted unless the first word of the statement resembles a debugger command. To set a global variable, you can prefix the assignment command with a `global` statement on the same line, e.g.:

```
(Pdb) global list_options; list_options = ['-l']
(Pdb)
```

run [args ...]**restart** [args ...]

Restart the debugged Python program. If *args* is supplied, it is split with `shlex` and the result is used as the new `sys.argv`. History, breakpoints, actions and debugger options are preserved. `restart` is an alias for `run`.

q(uit)

Quit from the debugger. The program being executed is aborted.

debug code

Enter a recursive debugger that steps through *code* (which is an arbitrary expression or statement to be executed in the current environment).

retval

Print the return value for the last return of the current function.

解

27.5 The Python Profilers

原始碼: [Lib/profile.py](#) 與 [Lib/pstats.py](#)

27.5.1 Introduction to the profilers

`cProfile` and `profile` provide *deterministic profiling* of Python programs. A *profile* is a set of statistics that describes how often and for how long various parts of the program executed. These statistics can be formatted into reports via the `pstats` module.

The Python standard library provides two different implementations of the same profiling interface:

1. `cProfile` is recommended for most users; it's a C extension with reasonable overhead that makes it suitable for profiling long-running programs. Based on `lsprof`, contributed by Brett Rosen and Ted Czotter.
2. `profile`, a pure Python module whose interface is imitated by `cProfile`, but which adds significant overhead to profiled programs. If you're trying to extend the profiler in some way, the task might be easier with this module. Originally designed and written by Jim Roskind.

備註: The profiler modules are designed to provide an execution profile for a given program, not for benchmarking purposes (for that, there is `timeit` for reasonably accurate results). This particularly applies to benchmarking Python code against C code: the profilers introduce overhead for Python code, but not for C-level functions, and so the C code would seem faster than any Python one.

27.5.2 Instant User's Manual

This section is provided for users that "don't want to read the manual." It provides a very brief overview, and allows a user to rapidly perform profiling on an existing application.

To profile a function that takes a single argument, you can do:

```
import cProfile
import re
cProfile.run('re.compile("foo|bar")')
```

(Use `profile` instead of `cProfile` if the latter is not available on your system.)

The above action would run `re.compile()` and print profile results like the following:

```
214 function calls (207 primitive calls) in 0.002 seconds

Ordered by: cumulative time

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
1      0.000    0.000    0.002    0.002 {built-in method builtins.exec}
1      0.000    0.000    0.001    0.001 <string>:1(<module>)
1      0.000    0.000    0.001    0.001 __init__.py:250(compile)
1      0.000    0.000    0.001    0.001 __init__.py:289(_compile)
1      0.000    0.000    0.000    0.000 _compiler.py:759(compile)
1      0.000    0.000    0.000    0.000 _parser.py:937(parse)
1      0.000    0.000    0.000    0.000 _compiler.py:598(_code)
1      0.000    0.000    0.000    0.000 _parser.py:435(_parse_sub)
```

The first line indicates that 214 calls were monitored. Of those calls, 207 were *primitive*, meaning that the call was not induced via recursion. The next line: Ordered by: cumulative time indicates the output is sorted by the `cumtime` values. The column headings include:

ncalls

for the number of calls.

tottime

for the total time spent in the given function (and excluding time made in calls to sub-functions)

percall

is the quotient of `tottime` divided by `ncalls`

cumtime

is the cumulative time spent in this and all subfunctions (from invocation till exit). This figure is accurate *even* for recursive functions.

percall

is the quotient of `cumtime` divided by primitive calls

filename:lineno(function)

provides the respective data of each function

When there are two numbers in the first column (for example 3/1), it means that the function recursed. The second value is the number of primitive calls and the former is the total number of calls. Note that when the function does not recurse, these two values are the same, and only the single figure is printed.

Instead of printing the output at the end of the profile run, you can save the results to a file by specifying a filename to the `run()` function:

```
import cProfile
import re
cProfile.run('re.compile("foo|bar")', 'restats')
```

The `pstats.Stats` class reads profile results from a file and formats them in various ways.

The files `cProfile` and `profile` can also be invoked as a script to profile another script. For example:

```
python -m cProfile [-o output_file] [-s sort_order] (-m module | myscript.py)
```

`-o` writes the profile results to a file instead of to stdout

`-s` specifies one of the `sort_stats()` sort values to sort the output by. This only applies when `-o` is not supplied.

`-m` specifies that a module is being profiled instead of a script.

在 3.7 版新加入: Added the `-m` option to `cProfile`.

在 3.8 版新加入: Added the `-m` option to `profile`.

The `pstats` module's `Stats` class has a variety of methods for manipulating and printing the data saved into a profile results file:

```
import pstats
from pstats import SortKey
p = pstats.Stats('restats')
p.strip_dirs().sort_stats(-1).print_stats()
```

The `strip_dirs()` method removed the extraneous path from all the module names. The `sort_stats()` method sorted all the entries according to the standard module/line/name string that is printed. The `print_stats()` method printed out all the statistics. You might try the following sort calls:

```
p.sort_stats(SortKey.NAME)
p.print_stats()
```

The first call will actually sort the list by function name, and the second call will print out the statistics. The following are some interesting calls to experiment with:

```
p.sort_stats(SortKey.CUMULATIVE).print_stats(10)
```

This sorts the profile by cumulative time in a function, and then only prints the ten most significant lines. If you want to understand what algorithms are taking time, the above line is what you would use.

If you were looking to see what functions were looping a lot, and taking a lot of time, you would do:

```
p.sort_stats(SortKey.TIME).print_stats(10)
```

to sort according to time spent within each function, and then print the statistics for the top ten functions.

You might also try:

```
p.sort_stats(SortKey.FILENAME).print_stats('__init__')
```

This will sort all the statistics by file name, and then print out statistics for only the class init methods (since they are spelled with `__init__` in them). As one final example, you could try:

```
p.sort_stats(SortKey.TIME, SortKey.CUMULATIVE).print_stats(.5, 'init')
```

This line sorts statistics with a primary key of time, and a secondary key of cumulative time, and then prints out some of the statistics. To be specific, the list is first culled down to 50% (re: `.5`) of its original size, then only lines containing `init` are maintained, and that sub-sub-list is printed.

If you wondered what functions called the above functions, you could now (`p` is still sorted according to the last criteria) do:

```
p.print_callers(.5, 'init')
```

and you would get a list of callers for each of the listed functions.

If you want more functionality, you're going to have to read the manual, or guess what the following functions do:

```
p.print_callees()
p.add('restats')
```

Invoked as a script, the `pstats` module is a statistics browser for reading and examining profile dumps. It has a simple line-oriented interface (implemented using `cmd`) and interactive help.

27.5.3 profile and cProfile Module Reference

Both the `profile` and `cProfile` modules provide the following functions:

`profile.run(command, filename=None, sort=-1)`

This function takes a single argument that can be passed to the `exec()` function, and an optional file name. In all cases this routine executes:

```
exec(command, __main__.__dict__, __main__.__dict__)
```

and gathers profiling statistics from the execution. If no file name is present, then this function automatically creates a `Stats` instance and prints a simple profiling report. If the sort value is specified, it is passed to this `Stats` instance to control how the results are sorted.

`profile.runctx(command, globals, locals, filename=None, sort=-1)`

This function is similar to `run()`, with added arguments to supply the globals and locals dictionaries for the `command` string. This routine executes:

```
exec(command, globals, locals)
```

and gathers profiling statistics as in the `run()` function above.

class `profile.Profile(timer=None, timeunit=0.0, subcalls=True, builtins=True)`

This class is normally only used if more precise control over profiling is needed than what the `cProfile.run()` function provides.

A custom timer can be supplied for measuring how long code takes to run via the `timer` argument. This must be a function that returns a single number representing the current time. If the number is an integer, the `timeunit` specifies a multiplier that specifies the duration of each unit of time. For example, if the timer returns times measured in thousands of seconds, the time unit would be `.001`.

Directly using the `Profile` class allows formatting profile results without writing the profile data to a file:

```

import cProfile, pstats, io
from pstats import SortKey
pr = cProfile.Profile()
pr.enable()
# ... do something ...
pr.disable()
s = io.StringIO()
sortby = SortKey.CUMULATIVE
ps = pstats.Stats(pr, stream=s).sort_stats(sortby)
ps.print_stats()
print(s.getvalue())

```

The *Profile* class can also be used as a context manager (supported only in *cProfile* module. see *Context Manager Types*):

```

import cProfile

with cProfile.Profile() as pr:
    # ... do something ...

pr.print_stats()

```

在 3.8 版的變更: Added context manager support.

enable()

Start collecting profiling data. Only in *cProfile*.

disable()

Stop collecting profiling data. Only in *cProfile*.

create_stats()

Stop collecting profiling data and record the results internally as the current profile.

print_stats (*sort=-1*)

Create a *Stats* object based on the current profile and print the results to stdout.

dump_stats (*filename*)

Write the results of the current profile to *filename*.

run (*cmd*)

Profile the *cmd* via *exec()*.

runctx (*cmd, globals, locals*)

Profile the *cmd* via *exec()* with the specified global and local environment.

runcall (*func, /, *args, **kwargs*)

Profile *func(*args, **kwargs)*

Note that profiling will only work if the called command/function actually returns. If the interpreter is terminated (e.g. via a *sys.exit()* call during the called command/function execution) no profiling results will be printed.

27.5.4 The Stats Class

Analysis of the profiler data is done using the `Stats` class.

class `pstats.Stats` (*filenames or profile, stream=sys.stdout)

This class constructor creates an instance of a “statistics object” from a *filename* (or list of filenames) or from a `Profile` instance. Output will be printed to the stream specified by *stream*.

The file selected by the above constructor must have been created by the corresponding version of `profile` or `cProfile`. To be specific, there is *no* file compatibility guaranteed with future versions of this profiler, and there is no compatibility with files produced by other profilers, or the same profiler run on a different operating system. If several files are provided, all the statistics for identical functions will be coalesced, so that an overall view of several processes can be considered in a single report. If additional files need to be combined with data in an existing `Stats` object, the `add()` method can be used.

Instead of reading the profile data from a file, a `cProfile.Profile` or `profile.Profile` object can be used as the profile data source.

`Stats` objects have the following methods:

strip_dirs ()

This method for the `Stats` class removes all leading path information from file names. It is very useful in reducing the size of the printout to fit within (close to) 80 columns. This method modifies the object, and the stripped information is lost. After performing a strip operation, the object is considered to have its entries in a “random” order, as it was just after object initialization and loading. If `strip_dirs()` causes two function names to be indistinguishable (they are on the same line of the same filename, and have the same function name), then the statistics for these two entries are accumulated into a single entry.

add (*filenames)

This method of the `Stats` class accumulates additional profiling information into the current profiling object. Its arguments should refer to filenames created by the corresponding version of `profile.run()` or `cProfile.run()`. Statistics for identically named (re: file, line, name) functions are automatically accumulated into single function statistics.

dump_stats (filename)

Save the data loaded into the `Stats` object to a file named *filename*. The file is created if it does not exist, and is overwritten if it already exists. This is equivalent to the method of the same name on the `profile.Profile` and `cProfile.Profile` classes.

sort_stats (*keys)

This method modifies the `Stats` object by sorting it according to the supplied criteria. The argument can be either a string or a `SortKey` enum identifying the basis of a sort (example: 'time', 'name', `SortKey.TIME` or `SortKey.NAME`). The `SortKey` enums argument have advantage over the string argument in that it is more robust and less error prone.

When more than one key is provided, then additional keys are used as secondary criteria when there is equality in all keys selected before them. For example, `sort_stats(SortKey.NAME, SortKey.FILE)` will sort all the entries according to their function name, and resolve all ties (identical function names) by sorting by file name.

For the string argument, abbreviations can be used for any key names, as long as the abbreviation is unambiguous.

The following are the valid string and `SortKey`:

Valid String Arg	Valid enum Arg	Meaning
'calls'	SortKey.CALLS	call count
'cumulative'	SortKey.CUMULATIVE	cumulative time
'cumtime'	N/A	cumulative time
'file'	N/A	file name (檔案名稱)
'filename'	SortKey.FILENAME	file name (檔案名稱)
'module'	N/A	file name (檔案名稱)
'ncalls'	N/A	call count
'pcalls'	SortKey.PCALLS	primitive call count
'line'	SortKey.LINE	line number
'name'	SortKey.NAME	function name
'nfl'	SortKey.NFL	name/file/line
'stdname'	SortKey.STDNAME	standard name
'time'	SortKey.TIME	internal time
'tottime'	N/A	internal time

Note that all sorts on statistics are in descending order (placing most time consuming items first), where as name, file, and line number searches are in ascending order (alphabetical). The subtle distinction between `SortKey.NFL` and `SortKey.STDNAME` is that the standard name is a sort of the name as printed, which means that the embedded line numbers get compared in an odd way. For example, lines 3, 20, and 40 would (if the file names were the same) appear in the string order 20, 3 and 40. In contrast, `SortKey.NFL` does a numeric compare of the line numbers. In fact, `sort_stats(SortKey.NFL)` is the same as `sort_stats(SortKey.NAME, SortKey.FILENAME, SortKey.LINE)`.

For backward-compatibility reasons, the numeric arguments `-1`, `0`, `1`, and `2` are permitted. They are interpreted as `'stdname'`, `'calls'`, `'time'`, and `'cumulative'` respectively. If this old style format (numeric) is used, only one sort key (the numeric key) will be used, and additional arguments will be silently ignored.

在 3.7 版新加入: Added the `SortKey` enum.

reverse_order()

This method for the `Stats` class reverses the ordering of the basic list within the object. Note that by default ascending vs descending order is properly selected based on the sort key of choice.

print_stats(*restrictions)

This method for the `Stats` class prints out a report as described in the `profile.run()` definition.

The order of the printing is based on the last `sort_stats()` operation done on the object (subject to caveats in `add()` and `strip_dirs()`).

The arguments provided (if any) can be used to limit the list down to the significant entries. Initially, the list is taken to be the complete set of profiled functions. Each restriction is either an integer (to select a count of lines), or a decimal fraction between 0.0 and 1.0 inclusive (to select a percentage of lines), or a string that will interpreted as a regular expression (to pattern match the standard name that is printed). If several restrictions are provided, then they are applied sequentially. For example:

```
print_stats(.1, 'foo:')
```

would first limit the printing to first 10% of list, and then only print functions that were part of filename `.*foo:.` In contrast, the command:

```
print_stats('foo:', .1)
```

would limit the list to all functions having file names `.*foo:.`, and then proceed to only print the first 10% of them.

print_callers(*restrictions)

This method for the `Stats` class prints a list of all functions that called each function in the profiled database. The ordering is identical to that provided by `print_stats()`, and the definition of the

restricting argument is also identical. Each caller is reported on its own line. The format differs slightly depending on the profiler that produced the stats:

- With `profile`, a number is shown in parentheses after each caller to show how many times this specific call was made. For convenience, a second non-parenthesized number repeats the cumulative time spent in the function at the right.
- With `cProfile`, each caller is preceded by three numbers: the number of times this specific call was made, and the total and cumulative times spent in the current function while it was invoked by this specific caller.

print_callees (*restrictions)

This method for the `Stats` class prints a list of all function that were called by the indicated function. Aside from this reversal of direction of calls (re: called vs was called by), the arguments and ordering are identical to the `print_callers()` method.

get_stats_profile()

This method returns an instance of `StatsProfile`, which contains a mapping of function names to instances of `FunctionProfile`. Each `FunctionProfile` instance holds information related to the function's profile such as how long the function took to run, how many times it was called, etc...

在 3.9 版新加入: Added the following dataclasses: `StatsProfile`, `FunctionProfile`. Added the following function: `get_stats_profile`.

27.5.5 What Is Deterministic Profiling?

Deterministic profiling is meant to reflect the fact that all *function call*, *function return*, and *exception* events are monitored, and precise timings are made for the intervals between these events (during which time the user's code is executing). In contrast, *statistical profiling* (which is not done by this module) randomly samples the effective instruction pointer, and deduces where time is being spent. The latter technique traditionally involves less overhead (as the code does not need to be instrumented), but provides only relative indications of where time is being spent.

In Python, since there is an interpreter active during execution, the presence of instrumented code is not required in order to do deterministic profiling. Python automatically provides a *hook* (optional callback) for each event. In addition, the interpreted nature of Python tends to add so much overhead to execution, that deterministic profiling tends to only add small processing overhead in typical applications. The result is that deterministic profiling is not that expensive, yet provides extensive run time statistics about the execution of a Python program.

Call count statistics can be used to identify bugs in code (surprising counts), and to identify possible inline-expansion points (high call counts). Internal time statistics can be used to identify "hot loops" that should be carefully optimized. Cumulative time statistics should be used to identify high level errors in the selection of algorithms. Note that the unusual handling of cumulative times in this profiler allows statistics for recursive implementations of algorithms to be directly compared to iterative implementations.

27.5.6 限制

One limitation has to do with accuracy of timing information. There is a fundamental problem with deterministic profilers involving accuracy. The most obvious restriction is that the underlying "clock" is only ticking at a rate (typically) of about .001 seconds. Hence no measurements will be more accurate than the underlying clock. If enough measurements are taken, then the "error" will tend to average out. Unfortunately, removing this first error induces a second source of error.

The second problem is that it "takes a while" from when an event is dispatched until the profiler's call to get the time actually *gets* the state of the clock. Similarly, there is a certain lag when exiting the profiler event handler from the time that the clock's value was obtained (and then squirreled away), until the user's code is once again executing. As a result, functions that are called many times, or call many functions, will typically accumulate this error. The error that accumulates in this fashion is typically less than the accuracy of the clock (less than one clock tick), but it *can* accumulate and become very significant.

The problem is more important with `profile` than with the lower-overhead `cProfile`. For this reason, `profile` provides a means of calibrating itself for a given platform so that this error can be probabilistically (on the average) removed. After the profiler is calibrated, it will be more accurate (in a least square sense), but it will sometimes produce negative numbers (when call counts are exceptionally low, and the gods of probability work against you :-).) Do *not* be alarmed by negative numbers in the profile. They should *only* appear if you have calibrated your profiler, and the results are actually better than without calibration.

27.5.7 校正

The profiler of the `profile` module subtracts a constant from each event handling time to compensate for the overhead of calling the time function, and socking away the results. By default, the constant is 0. The following procedure can be used to obtain a better constant for a given platform (see 限制).

```
import profile
pr = profile.Profile()
for i in range(5):
    print(pr.calibrate(10000))
```

The method executes the number of Python calls given by the argument, directly and again under the profiler, measuring the time for both. It then computes the hidden overhead per profiler event, and returns that as a float. For example, on a 1.8Ghz Intel Core i5 running macOS, and using Python's `time.process_time()` as the timer, the magical number is about 4.04e-6.

The object of this exercise is to get a fairly consistent result. If your computer is *very* fast, or your timer function has poor resolution, you might have to pass 100000, or even 1000000, to get consistent results.

When you have a consistent answer, there are three ways you can use it:

```
import profile

# 1. Apply computed bias to all Profile instances created hereafter.
profile.Profile.bias = your_computed_bias

# 2. Apply computed bias to a specific Profile instance.
pr = profile.Profile()
pr.bias = your_computed_bias

# 3. Specify computed bias in instance constructor.
pr = profile.Profile(bias=your_computed_bias)
```

If you have a choice, you are better off choosing a smaller constant, and then your results will "less often" show up as negative in profile statistics.

27.5.8 Using a custom timer

If you want to change how current time is determined (for example, to force use of wall-clock time or elapsed process time), pass the timing function you want to the `Profile` class constructor:

```
pr = profile.Profile(your_time_func)
```

The resulting profiler will then call `your_time_func`. Depending on whether you are using `profile.Profile` or `cProfile.Profile`, `your_time_func`'s return value will be interpreted differently:

`profile.Profile`

`your_time_func` should return a single number, or a list of numbers whose sum is the current time (like what `os.times()` returns). If the function returns a single time number, or the list of returned numbers has length 2, then you will get an especially fast version of the dispatch routine.

Be warned that you should calibrate the profiler class for the timer function that you choose (see 校正). For most machines, a timer that returns a lone integer value will provide the best results in terms of low overhead

during profiling. (*os.times()* is *pretty* bad, as it returns a tuple of floating point values). If you want to substitute a better timer in the cleanest fashion, derive a class and hardwire a replacement dispatch method that best handles your timer call, along with the appropriate calibration constant.

cProfile.Profile

your_time_func should return a single number. If it returns integers, you can also invoke the class constructor with a second argument specifying the real duration of one unit of time. For example, if *your_integer_time_func* returns times measured in thousands of seconds, you would construct the *Profile* instance as follows:

```
pr = cProfile.Profile(your_integer_time_func, 0.001)
```

As the *cProfile.Profile* class cannot be calibrated, custom timer functions should be used with care and should be as fast as possible. For the best results with a custom timer, it might be necessary to hard-code it in the C source of the internal *_lsprof* module.

Python 3.3 adds several new functions in *time* that can be used to make precise measurements of process or wall-clock time. For example, see *time.perf_counter()*.

27.6 timeit --- 測量小量程式片段的執行時間

原始碼: [Lib/timeit.py](#)

This module provides a simple way to time small bits of Python code. It has both a 命令執行列介面 as well as a *callable* one. It avoids a number of common traps for measuring execution times. See also Tim Peters' introduction to the "Algorithms" chapter in the second edition of *Python Cookbook*, published by O'Reilly.

27.6.1 基礎范例

The following example shows how the 命令執行列介面 can be used to compare three different expressions:

```
$ python3 -m timeit '"-".join(str(n) for n in range(100))'
10000 loops, best of 5: 30.2 usec per loop
$ python3 -m timeit '"-".join([str(n) for n in range(100)])'
10000 loops, best of 5: 27.5 usec per loop
$ python3 -m timeit '"-".join(map(str, range(100)))'
10000 loops, best of 5: 23.2 usec per loop
```

This can be achieved from the *Python Interface* with:

```
>>> import timeit
>>> timeit.timeit('"-".join(str(n) for n in range(100))', number=10000)
0.3018611848820001
>>> timeit.timeit('"-".join([str(n) for n in range(100)])', number=10000)
0.2727368790656328
>>> timeit.timeit('"-".join(map(str, range(100)))', number=10000)
0.23702679807320237
```

A callable can also be passed from the *Python Interface*:

```
>>> timeit.timeit(lambda: '"-".join(map(str, range(100)))', number=10000)
0.19665591977536678
```

Note however that *timeit()* will automatically determine the number of repetitions only when the command-line interface is used. In the 範例 section you can find more advanced examples.

27.6.2 Python Interface

The module defines three convenience functions and a public class:

`timeit.timeit(stmt='pass', setup='pass', timer=<default timer>, number=1000000, globals=None)`

Create a `Timer` instance with the given statement, `setup` code and `timer` function and run its `timeit()` method with `number` executions. The optional `globals` argument specifies a namespace in which to execute the code.

在 3.5 版的變更: 新增 `globals` 選用參數。

`timeit.repeat(stmt='pass', setup='pass', timer=<default timer>, repeat=5, number=1000000, globals=None)`

Create a `Timer` instance with the given statement, `setup` code and `timer` function and run its `repeat()` method with the given `repeat` count and `number` executions. The optional `globals` argument specifies a namespace in which to execute the code.

在 3.5 版的變更: 新增 `globals` 選用參數。

在 3.7 版的變更: Default value of `repeat` changed from 3 to 5.

`timeit.default_timer()`

The default timer, which is always `time.perf_counter()`, returns float seconds. An alternative, `time.perf_counter_ns`, returns integer nanoseconds.

在 3.3 版的變更: `time.perf_counter()` is now the default timer.

class `timeit.Timer(stmt='pass', setup='pass', timer=<timer function>, globals=None)`

Class for timing execution speed of small code snippets.

The constructor takes a statement to be timed, an additional statement used for setup, and a timer function. Both statements default to `'pass'`; the timer function is platform-dependent (see the module doc string). `stmt` and `setup` may also contain multiple statements separated by `;` or newlines, as long as they don't contain multi-line string literals. The statement will by default be executed within `timeit`'s namespace; this behavior can be controlled by passing a namespace to `globals`.

To measure the execution time of the first statement, use the `timeit()` method. The `repeat()` and `autorange()` methods are convenience methods to call `timeit()` multiple times.

The execution time of `setup` is excluded from the overall timed execution run.

The `stmt` and `setup` parameters can also take objects that are callable without arguments. This will embed calls to them in a timer function that will then be executed by `timeit()`. Note that the timing overhead is a little larger in this case because of the extra function calls.

在 3.5 版的變更: 新增 `globals` 選用參數。

`timeit(number=1000000)`

Time `number` executions of the main statement. This executes the setup statement once, and then returns the time it takes to execute the main statement a number of times. The default timer returns seconds as a float. The argument is the number of times through the loop, defaulting to one million. The main statement, the setup statement and the timer function to be used are passed to the constructor.

備F: By default, `timeit()` temporarily turns off *garbage collection* during the timing. The advantage of this approach is that it makes independent timings more comparable. The disadvantage is that GC may be an important component of the performance of the function being measured. If so, GC can be re-enabled as the first statement in the `setup` string. For example:

```
timeit.Timer('for i in range(10): oct(i)', 'gc.enable()').timeit()
```

autorange (`callback=None`)

Automatically determine how many times to call `timeit()`.

This is a convenience function that calls `timeit()` repeatedly so that the total time ≥ 0.2 second, returning the eventual (number of loops, time taken for that number of loops). It calls `timeit()` with increasing numbers from the sequence 1, 2, 5, 10, 20, 50, ... until the time taken is at least 0.2 seconds.

If `callback` is given and is not `None`, it will be called after each trial with two arguments: `callback(number, time_taken)`.

在 3.6 版新加入。

repeat (*repeat*=5, *number*=1000000)

Call `timeit()` a few times.

This is a convenience function that calls the `timeit()` repeatedly, returning a list of results. The first argument specifies how many times to call `timeit()`. The second argument specifies the *number* argument for `timeit()`.

備 F: It's tempting to calculate mean and standard deviation from the result vector and report these. However, this is not very useful. In a typical case, the lowest value gives a lower bound for how fast your machine can run the given code snippet; higher values in the result vector are typically not caused by variability in Python's speed, but by other processes interfering with your timing accuracy. So the `min()` of the result is probably the only number you should be interested in. After that, you should look at the entire vector and apply common sense rather than statistics.

在 3.7 版的變更: Default value of *repeat* changed from 3 to 5.

print_exc (*file*=None)

Helper to print a traceback from the timed code.

Typical use:

```
t = Timer(...)           # outside the try/except
try:
    t.timeit(...)         # or t.repeat(...)
except Exception:
    t.print_exc()
```

The advantage over the standard traceback is that source lines in the compiled template will be displayed. The optional *file* argument directs where the traceback is sent; it defaults to `sys.stderr`.

27.6.3 命令執行列介面

When called as a program from the command line, the following form is used:

```
python -m timeit [-n N] [-r N] [-u U] [-s S] [-h] [statement ...]
```

Where the following options are understood:

-n N, --number=N

how many times to execute 'statement'

-r N, --repeat=N

how many times to repeat the timer (default 5)

-s S, --setup=S

statement to be executed once initially (default pass)

-p, --process

measure process time, not wallclock time, using `time.process_time()` instead of `time.perf_counter()`, which is the default

在 3.3 版新加入。

-u, --unit=U
 specify a time unit for timer output; can select `nsec`, `usec`, `msec`, or `sec`
 在 3.5 版新加入。

-v, --verbose
 print raw timing results; repeat for more digits precision

-h, --help
 print a short usage message and exit

A multi-line statement may be given by specifying each line as a separate statement argument; indented lines are possible by enclosing an argument in quotes and using leading spaces. Multiple `-s` options are treated similarly.

If `-n` is not given, a suitable number of loops is calculated by trying increasing numbers from the sequence 1, 2, 5, 10, 20, 50, ... until the total time is at least 0.2 seconds.

`default_timer()` measurements can be affected by other programs running on the same machine, so the best thing to do when accurate timing is necessary is to repeat the timing a few times and use the best time. The `-r` option is good for this; the default of 5 repetitions is probably enough in most cases. You can use `time.process_time()` to measure CPU time.

備 F: There is a certain baseline overhead associated with executing a pass statement. The code here doesn't try to hide it, but you should be aware of it. The baseline overhead can be measured by invoking the program without arguments, and it might differ between Python versions.

27.6.4 范例

It is possible to provide a setup statement that is executed only once at the beginning:

```
$ python -m timeit -s 'text = "sample string"; char = "g"' 'char in text'
5000000 loops, best of 5: 0.0877 usec per loop
$ python -m timeit -s 'text = "sample string"; char = "g"' 'text.find(char)'
1000000 loops, best of 5: 0.342 usec per loop
```

In the output, there are three fields. The loop count, which tells you how many times the statement body was run per timing loop repetition. The repetition count ('best of 5') which tells you how many times the timing loop was repeated, and finally the time the statement body took on average within the best repetition of the timing loop. That is, the time the fastest repetition took divided by the loop count.

```
>>> import timeit
>>> timeit.timeit('char in text', setup='text = "sample string"; char = "g"')
0.41440500499993504
>>> timeit.timeit('text.find(char)', setup='text = "sample string"; char = "g"')
1.7246671520006203
```

The same can be done using the `Timer` class and its methods:

```
>>> import timeit
>>> t = timeit.Timer('char in text', setup='text = "sample string"; char = "g"')
>>> t.timeit()
0.3955516149999312
>>> t.repeat()
[0.40183617287970225, 0.37027556854118704, 0.38344867356679524, 0.3712595970846668,
↪ 0.37866875250654886]
```

The following examples show how to time expressions that contain multiple lines. Here we compare the cost of using `hasattr()` vs. `try/except` to test for missing and present object attributes:


```
$ python -m timeit 'try: ' ' str.__bool__' 'except AttributeError:' ' ' pass'
20000 loops, best of 5: 15.7 usec per loop
$ python -m timeit 'if hasattr(str, "__bool__"): pass'
50000 loops, best of 5: 4.26 usec per loop

$ python -m timeit 'try: ' ' int.__bool__' 'except AttributeError:' ' ' pass'
200000 loops, best of 5: 1.43 usec per loop
$ python -m timeit 'if hasattr(int, "__bool__"): pass'
100000 loops, best of 5: 2.23 usec per loop
```

```
>>> import timeit
>>> # attribute is missing
>>> s = """\
... try:
...     str.__bool__
... except AttributeError:
...     pass
... """
>>> timeit.timeit(stmt=s, number=100000)
0.9138244460009446
>>> s = "if hasattr(str, '__bool__'): pass"
>>> timeit.timeit(stmt=s, number=100000)
0.5829014980008651
>>>
>>> # attribute is present
>>> s = """\
... try:
...     int.__bool__
... except AttributeError:
...     pass
... """
>>> timeit.timeit(stmt=s, number=100000)
0.04215312199994514
>>> s = "if hasattr(int, '__bool__'): pass"
>>> timeit.timeit(stmt=s, number=100000)
0.08588060699912603
```

To give the `timeit` module access to functions you define, you can pass a *setup* parameter which contains an import statement:

```
def test():
    """Stupid test function"""
    L = [i for i in range(100)]

if __name__ == '__main__':
    import timeit
    print(timeit.timeit("test()", setup="from __main__ import test"))
```

Another option is to pass `globals()` to the *globals* parameter, which will cause the code to be executed within your current global namespace. This can be more convenient than individually specifying imports:

```
def f(x):
    return x**2
def g(x):
    return x**4
def h(x):
    return x**8

import timeit
print(timeit.timeit('[func(42) for func in (f,g,h)]', globals=globals()))
```


27.7 `trace` --- Trace or track Python statement execution

原始碼: [Lib/trace.py](#)

The `trace` module allows you to trace program execution, generate annotated statement coverage listings, print caller/callee relationships and list functions executed during a program run. It can be used in another program or from the command line.

也參考:

Coverage.py

A popular third-party coverage tool that provides HTML output along with advanced features such as branch coverage.

27.7.1 Command-Line Usage

The `trace` module can be invoked from the command line. It can be as simple as

```
python -m trace --count -C . somefile.py ...
```

The above will execute `somefile.py` and generate annotated listings of all Python modules imported during the execution into the current directory.

--help

Display usage and exit.

--version

Display the version of the module and exit.

在 3.8 版新加入: Added `--module` option that allows to run an executable module.

Main options

At least one of the following options must be specified when invoking `trace`. The `--listfuncs` option is mutually exclusive with the `--trace` and `--count` options. When `--listfuncs` is provided, neither `--count` nor `--trace` are accepted, and vice versa.

-c, --count

Produce a set of annotated listing files upon program completion that shows how many times each statement was executed. See also `--coverdir`, `--file` and `--no-report` below.

-t, --trace

Display lines as they are executed.

-l, --listfuncs

Display the functions executed by running the program.

-r, --report

Produce an annotated list from an earlier program run that used the `--count` and `--file` option. This does not execute any code.

-T, --trackcalls

Display the calling relationships exposed by running the program.

Modifiers

- f, --file=<file>**
Name of a file to accumulate counts over several tracing runs. Should be used with the `--count` option.
- C, --coverdir=<dir>**
Directory where the report files go. The coverage report for `package.module` is written to file `dir/package/module.cover`.
- m, --missing**
When generating annotated listings, mark lines which were not executed with `>>>>>`.
- s, --summary**
When using `--count` or `--report`, write a brief summary to stdout for each file processed.
- R, --no-report**
Do not generate annotated listings. This is useful if you intend to make several runs with `--count`, and then produce a single set of annotated listings at the end.
- g, --timing**
Prefix each line with the time since the program started. Only used while tracing.

Filters

These options may be repeated multiple times.

- ignore-module=<mod>**
Ignore each of the given module names and its submodules (if it is a package). The argument can be a list of names separated by a comma.
- ignore-dir=<dir>**
Ignore all modules and packages in the named directory and subdirectories. The argument can be a list of directories separated by `os.pathsep`.

27.7.2 Programmatic Interface

```
class trace.Trace (count=1, trace=1, countfuncs=0, countcallers=0, ignoremods=(), ignoredirs=(),  
                   infile=None, outfile=None, timing=False)
```

Create an object to trace execution of a single statement or expression. All parameters are optional. `count` enables counting of line numbers. `trace` enables line execution tracing. `countfuncs` enables listing of the functions called during the run. `countcallers` enables call relationship tracking. `ignoremods` is a list of modules or packages to ignore. `ignoredirs` is a list of directories whose modules or packages should be ignored. `infile` is the name of the file from which to read stored count information. `outfile` is the name of the file in which to write updated count information. `timing` enables a timestamp relative to when tracing was started to be displayed.

run (*cmd*)

Execute the command and gather statistics from the execution with the current tracing parameters. *cmd* must be a string or code object, suitable for passing into `exec()`.

runctx (*cmd*, *globals*=None, *locals*=None)

Execute the command and gather statistics from the execution with the current tracing parameters, in the defined global and local environments. If not defined, *globals* and *locals* default to empty dictionaries.

runfunc (*func*, /, **args*, ***kws*)

Call *func* with the given arguments under control of the `Trace` object with the current tracing parameters.

results()

Return a *CoverageResults* object that contains the cumulative results of all previous calls to *run*, *runctx* and *runfunc* for the given *Trace* instance. Does not reset the accumulated trace results.

class *trace.CoverageResults*

A container for coverage results, created by *Trace.results()*. Should not be created directly by the user.

update (*other*)

Merge in data from another *CoverageResults* object.

write_results (*show_missing=True, summary=False, coverdir=None*)

Write coverage results. Set *show_missing* to show lines that had no hits. Set *summary* to include in the output the coverage summary per module. *coverdir* specifies the directory into which the coverage result files will be output. If *None*, the results for each source file are placed in its directory.

A simple example demonstrating the use of the programmatic interface:

```
import sys
import trace

# create a Trace object, telling it what to ignore, and whether to
# do tracing or line-counting or both.
tracer = trace.Trace(
    ignoredirs=[sys.prefix, sys.exec_prefix],
    trace=0,
    count=1)

# run the new command using the given tracer
tracer.run('main()')

# make a report, placing output in the current directory
r = tracer.results()
r.write_results(show_missing=True, coverdir=".")
```

27.8 tracemalloc --- Trace memory allocations

在 3.4 版新加入.

原始碼: [Lib/tracemalloc.py](#)

The *tracemalloc* module is a debug tool to trace memory blocks allocated by Python. It provides the following information:

- Traceback where an object was allocated
- Statistics on allocated memory blocks per filename and per line number: total size, number and average size of allocated memory blocks
- Compute the differences between two snapshots to detect memory leaks

To trace most memory blocks allocated by Python, the module should be started as early as possible by setting the *PYTHONTRACEMALLOC* environment variable to 1, or by using *-X tracemalloc* command line option. The *tracemalloc.start()* function can be called at runtime to start tracing Python memory allocations.

By default, a trace of an allocated memory block only stores the most recent frame (1 frame). To store 25 frames at startup: set the *PYTHONTRACEMALLOC* environment variable to 25, or use the *-X tracemalloc=25* command line option.

27.8.1 范例

Display the top 10

Display the 10 files allocating the most memory:

```
import tracemalloc

tracemalloc.start()

# ... run your application ...

snapshot = tracemalloc.take_snapshot()
top_stats = snapshot.statistics('lineno')

print("[ Top 10 ]")
for stat in top_stats[:10]:
    print(stat)
```

Example of output of the Python test suite:

```
[ Top 10 ]
<frozen importlib._bootstrap>:716: size=4855 KiB, count=39328, average=126 B
<frozen importlib._bootstrap>:284: size=521 KiB, count=3199, average=167 B
/usr/lib/python3.4/collections/__init__.py:368: size=244 KiB, count=2315,
↪average=108 B
/usr/lib/python3.4/unittest/case.py:381: size=185 KiB, count=779, average=243 B
/usr/lib/python3.4/unittest/case.py:402: size=154 KiB, count=378, average=416 B
/usr/lib/python3.4/abc.py:133: size=88.7 KiB, count=347, average=262 B
<frozen importlib._bootstrap>:1446: size=70.4 KiB, count=911, average=79 B
<frozen importlib._bootstrap>:1454: size=52.0 KiB, count=25, average=2131 B
<string>:5: size=49.7 KiB, count=148, average=344 B
/usr/lib/python3.4/sysconfig.py:411: size=48.0 KiB, count=1, average=48.0 KiB
```

We can see that Python loaded 4855 KiB data (bytecode and constants) from modules and that the *collections* module allocated 244 KiB to build *namedtuple* types.

更多選項請見 `Snapshot.statistics()`。

Compute differences

Take two snapshots and display the differences:

```
import tracemalloc

tracemalloc.start()

# ... start your application ...

snapshot1 = tracemalloc.take_snapshot()
# ... call the function leaking memory ...
snapshot2 = tracemalloc.take_snapshot()

top_stats = snapshot2.compare_to(snapshot1, 'lineno')

print("[ Top 10 differences ]")
for stat in top_stats[:10]:
    print(stat)
```

Example of output before/after running some tests of the Python test suite:

```
[ Top 10 differences ]
<frozen importlib._bootstrap>:716: size=8173 KiB (+4428 KiB), count=71332 (+39369),
```

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```

↪ average=117 B
/usr/lib/python3.4/linecache.py:127: size=940 KiB (+940 KiB), count=8106 (+8106), ↪
↪ average=119 B
/usr/lib/python3.4/unittest/case.py:571: size=298 KiB (+298 KiB), count=589 (+589),
↪ average=519 B
<frozen importlib._bootstrap>:284: size=1005 KiB (+166 KiB), count=7423 (+1526), ↪
↪ average=139 B
/usr/lib/python3.4/mimetypes.py:217: size=112 KiB (+112 KiB), count=1334 (+1334), ↪
↪ average=86 B
/usr/lib/python3.4/http/server.py:848: size=96.0 KiB (+96.0 KiB), count=1 (+1), ↪
↪ average=96.0 KiB
/usr/lib/python3.4/inspect.py:1465: size=83.5 KiB (+83.5 KiB), count=109 (+109), ↪
↪ average=784 B
/usr/lib/python3.4/unittest/mock.py:491: size=77.7 KiB (+77.7 KiB), count=143 ↪
↪ (+143), average=557 B
/usr/lib/python3.4/urllib/parse.py:476: size=71.8 KiB (+71.8 KiB), count=969 ↪
↪ (+969), average=76 B
/usr/lib/python3.4/contextlib.py:38: size=67.2 KiB (+67.2 KiB), count=126 (+126), ↪
↪ average=546 B

```

We can see that Python has loaded 8173 KiB of module data (bytecode and constants), and that this is 4428 KiB more than had been loaded before the tests, when the previous snapshot was taken. Similarly, the *linecache* module has cached 940 KiB of Python source code to format tracebacks, all of it since the previous snapshot.

If the system has little free memory, snapshots can be written on disk using the *Snapshot.dump()* method to analyze the snapshot offline. Then use the *Snapshot.load()* method reload the snapshot.

Get the traceback of a memory block

Code to display the traceback of the biggest memory block:

```

import tracemalloc

# Store 25 frames
tracemalloc.start(25)

# ... run your application ...

snapshot = tracemalloc.take_snapshot()
top_stats = snapshot.statistics('traceback')

# pick the biggest memory block
stat = top_stats[0]
print("%s memory blocks: %.1f KiB" % (stat.count, stat.size / 1024))
for line in stat.traceback.format():
    print(line)

```

Example of output of the Python test suite (traceback limited to 25 frames):

```

903 memory blocks: 870.1 KiB
File "<frozen importlib._bootstrap>", line 716
File "<frozen importlib._bootstrap>", line 1036
File "<frozen importlib._bootstrap>", line 934
File "<frozen importlib._bootstrap>", line 1068
File "<frozen importlib._bootstrap>", line 619
File "<frozen importlib._bootstrap>", line 1581
File "<frozen importlib._bootstrap>", line 1614
File "/usr/lib/python3.4/doctest.py", line 101
    import pdb
File "<frozen importlib._bootstrap>", line 284

```

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```

File "<frozen importlib._bootstrap>", line 938
File "<frozen importlib._bootstrap>", line 1068
File "<frozen importlib._bootstrap>", line 619
File "<frozen importlib._bootstrap>", line 1581
File "<frozen importlib._bootstrap>", line 1614
File "/usr/lib/python3.4/test/support/__init__.py", line 1728
    import doctest
File "/usr/lib/python3.4/test/test_pickletools.py", line 21
    support.run_doctest(pickletools)
File "/usr/lib/python3.4/test/regrtest.py", line 1276
    test_runner()
File "/usr/lib/python3.4/test/regrtest.py", line 976
    display_failure=not verbose)
File "/usr/lib/python3.4/test/regrtest.py", line 761
    match_tests=ns.match_tests)
File "/usr/lib/python3.4/test/regrtest.py", line 1563
    main()
File "/usr/lib/python3.4/test/__main__.py", line 3
    regrtest.main_in_temp_cwd()
File "/usr/lib/python3.4/runpy.py", line 73
    exec(code, run_globals)
File "/usr/lib/python3.4/runpy.py", line 160
    "__main__", fname, loader, pkg_name)

```

We can see that the most memory was allocated in the `importlib` module to load data (bytecode and constants) from modules: 870.1 KiB. The traceback is where the `importlib` loaded data most recently: on the `import` `pdb` line of the `doctest` module. The traceback may change if a new module is loaded.

Pretty top

Code to display the 10 lines allocating the most memory with a pretty output, ignoring `<frozen importlib._bootstrap>` and `<unknown>` files:

```

import linecache
import os
import tracemalloc

def display_top(snapshot, key_type='lineno', limit=10):
    snapshot = snapshot.filter_traces((
        tracemalloc.Filter(False, "<frozen importlib._bootstrap>"),
        tracemalloc.Filter(False, "<unknown>"),
    ))
    top_stats = snapshot.statistics(key_type)

    print("Top %s lines" % limit)
    for index, stat in enumerate(top_stats[:limit], 1):
        frame = stat.traceback[0]
        print("#%s: %s:%s: %.1f KiB"
              % (index, frame.filename, frame.lineno, stat.size / 1024))
        line = linecache.getline(frame.filename, frame.lineno).strip()
        if line:
            print('    %s' % line)

    other = top_stats[limit:]
    if other:
        size = sum(stat.size for stat in other)
        print("%s other: %.1f KiB" % (len(other), size / 1024))
    total = sum(stat.size for stat in top_stats)
    print("Total allocated size: %.1f KiB" % (total / 1024))

```

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```

tracemalloc.start()

# ... run your application ...

snapshot = tracemalloc.take_snapshot()
display_top(snapshot)

```

Example of output of the Python test suite:

```

Top 10 lines
#1: Lib/base64.py:414: 419.8 KiB
    _b85chars2 = [(a + b) for a in _b85chars for b in _b85chars]
#2: Lib/base64.py:306: 419.8 KiB
    _a85chars2 = [(a + b) for a in _a85chars for b in _a85chars]
#3: collections/__init__.py:368: 293.6 KiB
    exec(class_definition, namespace)
#4: Lib/abc.py:133: 115.2 KiB
    cls = super().__new__(mcls, name, bases, namespace)
#5: unittest/case.py:574: 103.1 KiB
    testMethod()
#6: Lib/linecache.py:127: 95.4 KiB
    lines = fp.readlines()
#7: urllib/parse.py:476: 71.8 KiB
    for a in _hexdig for b in _hexdig}
#8: <string>:5: 62.0 KiB
#9: Lib/_weakrefset.py:37: 60.0 KiB
    self.data = set()
#10: Lib/base64.py:142: 59.8 KiB
    _b32tab2 = [a + b for a in _b32tab for b in _b32tab]
6220 other: 3602.8 KiB
Total allocated size: 5303.1 KiB

```

更多選項請見 `Snapshot.statistics()`。

Record the current and peak size of all traced memory blocks

The following code computes two sums like $0 + 1 + 2 + \dots$ inefficiently, by creating a list of those numbers. This list consumes a lot of memory temporarily. We can use `get_traced_memory()` and `reset_peak()` to observe the small memory usage after the sum is computed as well as the peak memory usage during the computations:

```

import tracemalloc

tracemalloc.start()

# Example code: compute a sum with a large temporary list
large_sum = sum(list(range(100000)))

first_size, first_peak = tracemalloc.get_traced_memory()

tracemalloc.reset_peak()

# Example code: compute a sum with a small temporary list
small_sum = sum(list(range(1000)))

second_size, second_peak = tracemalloc.get_traced_memory()

print(f"first_size=, {first_peak=}")
print(f"second_size=, {second_peak=}")

```

輸出：

```
first_size=664, first_peak=3592984
second_size=804, second_peak=29704
```

Using `reset_peak()` ensured we could accurately record the peak during the computation of `small_sum`, even though it is much smaller than the overall peak size of memory blocks since the `start()` call. Without the call to `reset_peak()`, `second_peak` would still be the peak from the computation `large_sum` (that is, equal to `first_peak`). In this case, both peaks are much higher than the final memory usage, and which suggests we could optimise (by removing the unnecessary call to `list`, and writing `sum(range(...))`).

27.8.2 API

函式

`tracemalloc.clear_traces()`

Clear traces of memory blocks allocated by Python.

另請參 F `stop()`。

`tracemalloc.get_object_traceback(obj)`

Get the traceback where the Python object *obj* was allocated. Return a `Traceback` instance, or `None` if the `tracemalloc` module is not tracing memory allocations or did not trace the allocation of the object.

另請參 F `gc.get_referrers()` 與 `sys.getsizeof()` 函式。

`tracemalloc.get_traceback_limit()`

Get the maximum number of frames stored in the traceback of a trace.

The `tracemalloc` module must be tracing memory allocations to get the limit, otherwise an exception is raised.

The limit is set by the `start()` function.

`tracemalloc.get_traced_memory()`

Get the current size and peak size of memory blocks traced by the `tracemalloc` module as a tuple: (current: int, peak: int).

`tracemalloc.reset_peak()`

Set the peak size of memory blocks traced by the `tracemalloc` module to the current size.

Do nothing if the `tracemalloc` module is not tracing memory allocations.

This function only modifies the recorded peak size, and does not modify or clear any traces, unlike `clear_traces()`. Snapshots taken with `take_snapshot()` before a call to `reset_peak()` can be meaningfully compared to snapshots taken after the call.

另請參 F `get_traced_memory()`。

在 3.9 版新加入。

`tracemalloc.get_tracemalloc_memory()`

Get the memory usage in bytes of the `tracemalloc` module used to store traces of memory blocks. Return an `int`.

`tracemalloc.is_tracing()`

True if the `tracemalloc` module is tracing Python memory allocations, False otherwise.

另請參 F `start()` 與 `stop()` 函式。

`tracemalloc.start(nframe: int = 1)`

Start tracing Python memory allocations: install hooks on Python memory allocators. Collected tracebacks of traces will be limited to *nframe* frames. By default, a trace of a memory block only stores the most recent frame: the limit is 1. *nframe* must be greater or equal to 1.

You can still read the original number of total frames that composed the traceback by looking at the `Traceback.total_nframe` attribute.

Storing more than 1 frame is only useful to compute statistics grouped by 'traceback' or to compute cumulative statistics: see the `Snapshot.compare_to()` and `Snapshot.statistics()` methods.

Storing more frames increases the memory and CPU overhead of the `tracemalloc` module. Use the `get_tracemalloc_memory()` function to measure how much memory is used by the `tracemalloc` module.

The `PYTHONTRACEMALLOC` environment variable (`PYTHONTRACEMALLOC=NFRAME`) and the `-X tracemalloc=NFRAME` command line option can be used to start tracing at startup.

See also `stop()`, `is_tracing()` and `get_traceback_limit()` functions.

`tracemalloc.stop()`

Stop tracing Python memory allocations: uninstall hooks on Python memory allocators. Also clears all previously collected traces of memory blocks allocated by Python.

Call `take_snapshot()` function to take a snapshot of traces before clearing them.

See also `start()`, `is_tracing()` and `clear_traces()` functions.

`tracemalloc.take_snapshot()`

Take a snapshot of traces of memory blocks allocated by Python. Return a new `Snapshot` instance.

The snapshot does not include memory blocks allocated before the `tracemalloc` module started to trace memory allocations.

Tracebacks of traces are limited to `get_traceback_limit()` frames. Use the `nframe` parameter of the `start()` function to store more frames.

The `tracemalloc` module must be tracing memory allocations to take a snapshot, see the `start()` function.

另請參閱 `get_object_traceback()` 函式。

DomainFilter

class `tracemalloc.DomainFilter` (*inclusive*: bool, *domain*: int)

Filter traces of memory blocks by their address space (domain).

在 3.6 版新加入。

inclusive

If *inclusive* is True (include), match memory blocks allocated in the address space *domain*.

If *inclusive* is False (exclude), match memory blocks not allocated in the address space *domain*.

domain

Address space of a memory block (int). Read-only property.

Filter

class `tracemalloc.Filter` (*inclusive*: bool, *filename_pattern*: str, *lineno*: int = None, *all_frames*: bool = False, *domain*: int = None)

Filter on traces of memory blocks.

See the `fnmatch.fnmatch()` function for the syntax of *filename_pattern*. The `'.pyc'` file extension is replaced with `'.py'`.

範例：

- `Filter(True, subprocess.__file__)` only includes traces of the `subprocess` module

- `Filter(False, tracemalloc.__file__)` excludes traces of the *tracemalloc* module
- `Filter(False, "<unknown>")` excludes empty tracebacks

在 3.5 版的變更: The `'.pyo'` file extension is no longer replaced with `'.py'`.

在 3.6 版的變更: 新增 *domain* 屬性。

domain

Address space of a memory block (`int` or `None`).

tracemalloc uses the domain 0 to trace memory allocations made by Python. C extensions can use other domains to trace other resources.

inclusive

If *inclusive* is `True` (include), only match memory blocks allocated in a file with a name matching *filename_pattern* at line number *lineno*.

If *inclusive* is `False` (exclude), ignore memory blocks allocated in a file with a name matching *filename_pattern* at line number *lineno*.

lineno

Line number (`int`) of the filter. If *lineno* is `None`, the filter matches any line number.

filename_pattern

Filename pattern of the filter (`str`). Read-only property.

all_frames

If *all_frames* is `True`, all frames of the traceback are checked. If *all_frames* is `False`, only the most recent frame is checked.

This attribute has no effect if the traceback limit is 1. See the *get_traceback_limit()* function and *Snapshot.traceback_limit* attribute.

Frame

class `tracemalloc.Frame`

Frame of a traceback.

The *Traceback* class is a sequence of *Frame* instances.

filename

Filename (`str`).

lineno

Line number (`int`).

Snapshot

class `tracemalloc.Snapshot`

Snapshot of traces of memory blocks allocated by Python.

The *take_snapshot()* function creates a snapshot instance.

compare_to (*old_snapshot*: *Snapshot*, *key_type*: `str`, *cumulative*: `bool` = `False`)

Compute the differences with an old snapshot. Get statistics as a sorted list of *StatisticDiff* instances grouped by *key_type*.

See the *Snapshot.statistics()* method for *key_type* and *cumulative* parameters.

The result is sorted from the biggest to the smallest by: absolute value of *StatisticDiff.size_diff*, *StatisticDiff.size*, absolute value of *StatisticDiff.count_diff*, *StatisticDiff.count* and then by *StatisticDiff.traceback*.

dump (*filename*)

Write the snapshot into a file.

Use `load()` to reload the snapshot.

filter_traces (*filters*)

Create a new *Snapshot* instance with a filtered *traces* sequence, *filters* is a list of *DomainFilter* and *Filter* instances. If *filters* is an empty list, return a new *Snapshot* instance with a copy of the traces.

All inclusive filters are applied at once, a trace is ignored if no inclusive filters match it. A trace is ignored if at least one exclusive filter matches it.

在 3.6 版的變更: *DomainFilter* instances are now also accepted in *filters*.

classmethod load (*filename*)

Load a snapshot from a file.

另請參 `dump()`。

statistics (*key_type*: `str`, *cumulative*: `bool = False`)

Get statistics as a sorted list of *Statistic* instances grouped by *key_type*:

key_type	描述
'filename'	filename
'lineno'	filename and line number
'traceback'	traceback

If *cumulative* is `True`, cumulate size and count of memory blocks of all frames of the traceback of a trace, not only the most recent frame. The cumulative mode can only be used with *key_type* equals to 'filename' and 'lineno'.

The result is sorted from the biggest to the smallest by: *Statistic.size*, *Statistic.count* and then by *Statistic.traceback*.

traceback_limit

Maximum number of frames stored in the traceback of *traces*: result of the `get_traceback_limit()` when the snapshot was taken.

traces

Traces of all memory blocks allocated by Python: sequence of *Trace* instances.

The sequence has an undefined order. Use the `Snapshot.statistics()` method to get a sorted list of statistics.

Statistic

class `tracemalloc.Statistic`

Statistic on memory allocations.

`Snapshot.statistics()` returns a list of *Statistic* instances.

See also the *StatisticDiff* class.

count

Number of memory blocks (`int`).

size

Total size of memory blocks in bytes (`int`).

traceback

Traceback where the memory block was allocated, *Traceback* instance.

StatisticDiff

class tracemalloc.**StatisticDiff**

Statistic difference on memory allocations between an old and a new *Snapshot* instance.

Snapshot.compare_to() returns a list of *StatisticDiff* instances. See also the *Statistic* class.

count

Number of memory blocks in the new snapshot (*int*): 0 if the memory blocks have been released in the new snapshot.

count_diff

Difference of number of memory blocks between the old and the new snapshots (*int*): 0 if the memory blocks have been allocated in the new snapshot.

size

Total size of memory blocks in bytes in the new snapshot (*int*): 0 if the memory blocks have been released in the new snapshot.

size_diff

Difference of total size of memory blocks in bytes between the old and the new snapshots (*int*): 0 if the memory blocks have been allocated in the new snapshot.

traceback

Traceback where the memory blocks were allocated, *Traceback* instance.

Trace

class tracemalloc.**Trace**

Trace of a memory block.

The *Snapshot.traces* attribute is a sequence of *Trace* instances.

在 3.6 版的變更: 新增 *domain* 屬性。

domain

Address space of a memory block (*int*). Read-only property.

tracemalloc uses the domain 0 to trace memory allocations made by Python. C extensions can use other domains to trace other resources.

size

Size of the memory block in bytes (*int*).

traceback

Traceback where the memory block was allocated, *Traceback* instance.

Traceback

class tracemalloc.**Traceback**

Sequence of *Frame* instances sorted from the oldest frame to the most recent frame.

A traceback contains at least 1 frame. If the tracemalloc module failed to get a frame, the filename "<unknown>" at line number 0 is used.

When a snapshot is taken, tracebacks of traces are limited to *get_traceback_limit()* frames. See the *take_snapshot()* function. The original number of frames of the traceback is stored in the *Traceback.total_nframe* attribute. That allows to know if a traceback has been truncated by the traceback limit.

The `Trace.traceback` attribute is an instance of `Traceback` instance.

在 3.7 版的變更: Frames are now sorted from the oldest to the most recent, instead of most recent to oldest.

total_nframe

Total number of frames that composed the traceback before truncation. This attribute can be set to `None` if the information is not available.

在 3.9 版的變更: The `Traceback.total_nframe` attribute was added.

format (*limit=None, most_recent_first=False*)

Format the traceback as a list of lines. Use the `linecache` module to retrieve lines from the source code. If *limit* is set, format the *limit* most recent frames if *limit* is positive. Otherwise, format the `abs(limit)` oldest frames. If *most_recent_first* is `True`, the order of the formatted frames is reversed, returning the most recent frame first instead of last.

Similar to the `traceback.format_tb()` function, except that `format()` does not include new-lines.

範例:

```
print("Traceback (most recent call first):")
for line in traceback:
    print(line)
```

輸出:

```
Traceback (most recent call first):
  File "test.py", line 9
    obj = Object()
  File "test.py", line 12
    tb = tracemalloc.get_object_traceback(f())
```


These libraries help you with publishing and installing Python software. While these modules are designed to work in conjunction with the [Python Package Index](#), they can also be used with a local index server, or without any index server at all.

28.1 `distutils` --- Building and installing Python modules

`distutils` is deprecated with removal planned for Python 3.12. See the What's New entry for more information.

The `distutils` package provides support for building and installing additional modules into a Python installation. The new modules may be either 100%-pure Python, or may be extension modules written in C, or may be collections of Python packages which include modules coded in both Python and C.

Most Python users will *not* want to use this module directly, but instead use the cross-version tools maintained by the Python Packaging Authority. In particular, `setuptools` is an enhanced alternative to `distutils` that provides:

- support for declaring project dependencies
- additional mechanisms for configuring which files to include in source releases (including plugins for integration with version control systems)
- the ability to declare project "entry points", which can be used as the basis for application plugin systems
- the ability to automatically generate Windows command line executables at installation time rather than needing to prebuild them
- consistent behaviour across all supported Python versions

The recommended `pip` installer runs all `setup.py` scripts with `setuptools`, even if the script itself only imports `distutils`. Refer to the [Python Packaging User Guide](#) for more information.

For the benefits of packaging tool authors and users seeking a deeper understanding of the details of the current packaging and distribution system, the legacy `distutils` based user documentation and API reference remain available:

- [install-index](#)
- [distutils-index](#)

28.2 ensurepip --- Bootstrapping the pip installer

在 3.4 版新加入。

原始碼: [Lib/ensurepip](#)

The `ensurepip` package provides support for bootstrapping the `pip` installer into an existing Python installation or virtual environment. This bootstrapping approach reflects the fact that `pip` is an independent project with its own release cycle, and the latest available stable version is bundled with maintenance and feature releases of the CPython reference interpreter.

In most cases, end users of Python shouldn't need to invoke this module directly (as `pip` should be bootstrapped by default), but it may be needed if installing `pip` was skipped when installing Python (or when creating a virtual environment) or after explicitly uninstalling `pip`.

備註: This module *does not* access the internet. All of the components needed to bootstrap `pip` are included as internal parts of the package.

也參考:

installing-index

The end user guide for installing Python packages

PEP 453: Explicit bootstrapping of pip in Python installations

The original rationale and specification for this module.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

28.2.1 Command line interface

The command line interface is invoked using the interpreter's `-m` switch.

The simplest possible invocation is:

```
python -m ensurepip
```

This invocation will install `pip` if it is not already installed, but otherwise does nothing. To ensure the installed version of `pip` is at least as recent as the one available in `ensurepip`, pass the `--upgrade` option:

```
python -m ensurepip --upgrade
```

By default, `pip` is installed into the current virtual environment (if one is active) or into the system site packages (if there is no active virtual environment). The installation location can be controlled through two additional command line options:

- `--root dir`: Installs `pip` relative to the given root directory rather than the root of the currently active virtual environment (if any) or the default root for the current Python installation.
- `--user`: Installs `pip` into the user site packages directory rather than globally for the current Python installation (this option is not permitted inside an active virtual environment).

By default, the scripts `pipX` and `pipX.Y` will be installed (where `X.Y` stands for the version of Python used to invoke `ensurepip`). The scripts installed can be controlled through two additional command line options:

- `--altinstall`: if an alternate installation is requested, the `pipX` script will *not* be installed.
- `--default-pip`: if a "default `pip`" installation is requested, the `pip` script will be installed in addition to the two regular scripts.

Providing both of the script selection options will trigger an exception.

28.2.2 模組 API

`ensurepip` exposes two functions for programmatic use:

`ensurepip.version()`

Returns a string specifying the available version of pip that will be installed when bootstrapping an environment.

`ensurepip.bootstrap (root=None, upgrade=False, user=False, altinstall=False, default_pip=False, verbosity=0)`

Bootstraps pip into the current or designated environment.

`root` specifies an alternative root directory to install relative to. If `root` is `None`, then installation uses the default install location for the current environment.

`upgrade` indicates whether or not to upgrade an existing installation of an earlier version of pip to the available version.

`user` indicates whether to use the user scheme rather than installing globally.

By default, the scripts `pipX` and `pipX.Y` will be installed (where `X.Y` stands for the current version of Python).

If `altinstall` is set, then `pipX` will *not* be installed.

If `default_pip` is set, then `pip` will be installed in addition to the two regular scripts.

Setting both `altinstall` and `default_pip` will trigger `ValueError`.

`verbosity` controls the level of output to `sys.stdout` from the bootstrapping operation.

引發一個附帶引數 `root` 的稽核事件 `ensurepip.bootstrap`。

備註： The bootstrapping process has side effects on both `sys.path` and `os.environ`. Invoking the command line interface in a subprocess instead allows these side effects to be avoided.

備註： The bootstrapping process may install additional modules required by pip, but other software should not assume those dependencies will always be present by default (as the dependencies may be removed in a future version of pip).

28.3 venv --- Creation of virtual environments

在 3.3 版新加入。

原始碼： [Lib/venv/](#)

`venv` 模組支援建立輕量級的「虛擬環境」，每個環境擁有獨立的 Python 套件組合，安裝在各自的 *site* 路徑底下。一個虛擬環境是以某個已安裝好的 Python 版本當作虛擬環境的「基底」Python，而且可以選擇是否和基底環境的套件隔離，如此一來，只有明確安裝在虛擬環境中的套件才能使用

When used from within a virtual environment, common installation tools such as `pip` will install Python packages into a virtual environment without needing to be told to do so explicitly.

A virtual environment is (amongst other things):

- Used to contain a specific Python interpreter and software libraries and binaries which are needed to support a project (library or application). These are by default isolated from software in other virtual environments and Python interpreters and libraries installed in the operating system.
- Contained in a directory, conventionally either named `venv` or `.venv` in the project directory, or under a container directory for lots of virtual environments, such as `~/.virtualenvs`.
- Not checked into source control systems such as Git.
- Considered as disposable -- it should be simple to delete and recreate it from scratch. You don't place any project code in the environment
- Not considered as movable or copyable -- you just recreate the same environment in the target location.

更多關於 Python 擬環境的背景資訊請見 [PEP 405](#)。

也參考：

[Python Packaging User Guide: Creating and using virtual environments](#)

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

28.3.1 建立擬環境

建立擬環境的方法是透過執行指令 `venv`：

```
python -m venv /path/to/new/virtual/environment
```

執行此命令會建立目標目錄（同時也會建立任何還不存在的父目錄）並在目標目錄中放置一個名 `pyvenv.cfg` 的檔案，其中包含一個指向執行該命令的 Python 安裝路徑的 `home` 鍵（目標目錄的常見名稱 `.venv`）。同時，它會建立一個 `bin`（在 Windows 上 `Scripts`）子目錄，其中包含一個 Python 二進位檔案的副本/符號連結（根據建立環境時使用的平台或引數而定）。此外，它還會建立一個（最初空的）`lib/pythonX.Y/site-packages` 子目錄（在 Windows 上 `Lib\site-packages`）。如果指定的目錄已存在，則將重新使用該目錄。

在 3.5 版的變更：目前建議使用 `venv` 來建立擬環境。

在 3.6 版之後被採用：`pyvenv` 是在 Python 3.3 和 3.4 中建立擬環境的推薦工具，但在 Python 3.6 中已被採用。

在 Windows 上，執行以下命令以使用 `venv`：

```
c:\>c:\Python35\python -m venv c:\path\to\myenv
```

或者，如果你已經將你的 Python 安裝配置了 `PATH` 和 `PATHEXT` 變數，則可以執行以下命令：

```
c:\>python -m venv c:\path\to\myenv
```

如果使用 `-h` 選項執行該命令，將會顯示可用的選項：

```
usage: venv [-h] [--system-site-packages] [--symlinks | --copies] [--clear]
           [--upgrade] [--without-pip] [--prompt PROMPT] [--upgrade-deps]
           ENV_DIR [ENV_DIR ...]
```

Creates virtual Python environments in one or more target directories.

positional arguments:

`ENV_DIR` A directory to create the environment in.

optional arguments:

`-h, --help` show this help message and exit

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```

--system-site-packages    Give the virtual environment access to the system
                           site-packages dir.
--symlinks                Try to use symlinks rather than copies, when symlinks
                           are not the default for the platform.
--copies                  Try to use copies rather than symlinks, even when
                           symlinks are the default for the platform.
--clear                   Delete the contents of the environment directory if it
                           already exists, before environment creation.
--upgrade                 Upgrade the environment directory to use this version
                           of Python, assuming Python has been upgraded in-place.
--without-pip             Skips installing or upgrading pip in the virtual
                           environment (pip is bootstrapped by default)
--prompt PROMPT           Provides an alternative prompt prefix for this
                           environment.
--upgrade-deps            Upgrade core dependencies: pip setuptools to the
                           latest version in PyPI

```

Once an environment has been created, you may wish to activate it, e.g. by sourcing an activate script in its bin directory.

在 3.9 版的變更: 新增 `--upgrade-deps` 選項以將 `pip` 和 `setuptools` 升級至 PyPI 上的最新版本

在 3.4 版的變更: 預設情況下安裝 `pip`, F 新增了 `--without-pip` 和 `--copies` 選項

在 3.4 版的變更: 在較早的版本中, 如果目標目錄已存在, 除非提供了 `--clear` 或 `--upgrade` 選項, 否則會引發錯誤。

備 F: 雖然在 Windows 上支援符號連結, 但 F 不建議使用。特 F 需要注意的是, 在檔案總管中按兩下 `python.exe` 會急切地解析符號連結 F 忽略 F 擬環境。

備 F: 在 Microsoft Windows 上, 可能需要通過設置使用者的執行策略來 F 用 `Activate.ps1` F 本。你可以發出以下 PowerShell 命令來執行此操作:

```
PS C:> Set-ExecutionPolicy -ExecutionPolicy RemoteSigned -Scope CurrentUser
```

有關更多資訊, 請參 F 關於執行策略。

被建立的 `pyvenv.cfg` 檔案還包括了 `include-system-site-packages` 的鍵, 如果使用 `venv` 執行時帶有 `--system-site-packages` 選項, 則設置 F `true`, 否則設置 F `false`。

除非 `--without-pip` 選項被提供, 否則將調用 `ensurepip` 來 F 動 `pip` 到 F 擬環境中。

可以向 `venv` 提供多個路徑, 這樣每個提供的路徑都將根據給定的選項建立一個相同的 F 擬環境。

28.3.2 F 擬環境如何運作

當 Python 直譯器跑在 F 擬環境時, `sys.prefix` 和 `sys.exec_prefix` 會指向 F 擬環境的目錄, 而 `sys.base_prefix` 和 `sys.base_exec_prefix` 會指向建立 F 擬環境的基礎 Python 的目錄。檢查 `sys.prefix != sys.base_prefix` 就可以確定目前的直譯器是否跑在 F 擬環境中。

A virtual environment may be "activated" using a script in its binary directory (bin on POSIX; Scripts on Windows). This will prepend that directory to your PATH, so that running **python** will invoke the environment's Python interpreter and you can run installed scripts without having to use their full path. The invocation of the activation script is platform-specific (<venv> must be replaced by the path to the directory containing the virtual environment):

平台	Shell	Command to activate virtual environment
POSIX	bash/zsh	\$ source <venv>/bin/activate
	fish	\$ source <venv>/bin/activate.fish
	csh/tcsh	\$ source <venv>/bin/activate.csh
	PowerShell	\$ <venv>/bin/Activate.ps1
Windows	cmd.exe	C:\> <venv>\Scripts\activate.bat
	PowerShell	PS C:\> <venv>\Scripts\Activate.ps1

在 3.4 版新加入: **fish** and **csh** activation scripts.

在 3.8 版新加入: PowerShell activation scripts installed under POSIX for PowerShell Core support.

You don't specifically *need* to activate a virtual environment, as you can just specify the full path to that environment's Python interpreter when invoking Python. Furthermore, all scripts installed in the environment should be runnable without activating it.

In order to achieve this, scripts installed into virtual environments have a "shebang" line which points to the environment's Python interpreter, i.e. `#!/<path-to-venv>/bin/python`. This means that the script will run with that interpreter regardless of the value of `PATH`. On Windows, "shebang" line processing is supported if you have the launcher installed. Thus, double-clicking an installed script in a Windows Explorer window should run it with the correct interpreter without the environment needing to be activated or on the `PATH`.

When a virtual environment has been activated, the `VIRTUAL_ENV` environment variable is set to the path of the environment. Since explicitly activating a virtual environment is not required to use it, `VIRTUAL_ENV` cannot be relied upon to determine whether a virtual environment is being used.

警告: Because scripts installed in environments should not expect the environment to be activated, their shebang lines contain the absolute paths to their environment's interpreters. Because of this, environments are inherently non-portable, in the general case. You should always have a simple means of recreating an environment (for example, if you have a requirements file `requirements.txt`, you can invoke `pip install -r requirements.txt` using the environment's `pip` to install all of the packages needed by the environment). If for any reason you need to move the environment to a new location, you should recreate it at the desired location and delete the one at the old location. If you move an environment because you moved a parent directory of it, you should recreate the environment in its new location. Otherwise, software installed into the environment may not work as expected.

You can deactivate a virtual environment by typing `deactivate` in your shell. The exact mechanism is platform-specific and is an internal implementation detail (typically, a script or shell function will be used).

28.3.3 API

上述提到的高階 `method` (方法) 透過簡單的 API 使用, 第三方擬環境建立者提供可以依據他們需求來建立環境的客體化機制: `EnvBuilder` class.

```
class venv.EnvBuilder (system_site_packages=False, clear=False, symlinks=False, upgrade=False,
                      with_pip=False, prompt=None, upgrade_deps=False)
```

進行實例化時, class `EnvBuilder` 接受下列的關鍵字引數:

- `system_site_packages` -- 一個 Boolean (布林值), 表明系統的 Python site-packages 是否可以在環境中可用 (預設 `False`).
- `clear` -- 一個 Boolean, 如果 `true`, 則在建立環境之前, 除目標目錄所有存在的內容。
- `symlinks` -- 一個 Boolean, 表明是否嘗試與 Python 二進位檔案建立符號連結而不是該檔案。
- `upgrade` -- 一個 Boolean, 若 `true`, 則會在執行 Python 時現有的環境進行升級。目的是讓 Python 可以升級到位 (預設 `False`)。

- `with_pip` -- 一個 Boolean，若 `true`，則確保 `pip` 有安裝至該擬環境之中。當有 `--default-pip` 的選項時，會使用 `ensurepip`。
- `prompt` -- 一個 String（字串），該字串會在該擬環境啟動時被使用。（預設 `None`，代表該環境的目錄名稱會被使用）倘若出現特殊字串 `"."`，則當前目錄的 `basename` 會做提示路徑使用。
- `upgrade_deps` -- 更新基礎 `venv` 模組至 PyPI 的最新版本

在 3.4 版的變更: 新增 `with_pip` 參數

在 3.6 版的變更: 新增 `prompt` 參數

在 3.9 版的變更: 新增 `upgrade_deps` 參數

第三方擬環境工具的建立者可以自由地使用 `EnvBuilder` class 作 base class（基底類）使用。

回傳的 `env-builder` 一個物件，且帶有一個 `method create`:

create (*env_dir*)

透過指定將會容納擬環境的目標目錄來建立一個擬環境（對路徑或相對路徑到該目錄），也就是在該目錄中容納擬環境。`create method` 將會在指定的目錄下建立環境，或是觸發適當的例外。

`EnvBuilder` class 的 `create method` 會闡述可用的 Hooks 以客制化 subclass（子類）:

```
def create(self, env_dir):
    """
    Create a virtualized Python environment in a directory.
    env_dir is the target directory to create an environment in.
    """
    env_dir = os.path.abspath(env_dir)
    context = self.ensure_directories(env_dir)
    self.create_configuration(context)
    self.setup_python(context)
    self.setup_scripts(context)
    self.post_setup(context)
```

每個 methods `ensure_directories()`、`create_configuration()`、`setup_python()`、`setup_scripts()` 及 `post_setup()` 都可以被覆寫。

ensure_directories (*env_dir*)

建立還不存在的環境目錄及必要的子目錄，回傳一個情境物件（context object）。這個情境物件只是一個屬性（例如：路徑）的所有者，可被其他 `method` 使用。如果 `EnvBuilder` 已被建立且帶有 `clear=True` 的引數，該環境目錄下的內容將被清空，以及所有必要的子目錄將被重新建立。

回傳的情境物件（context object）其型會是 `types.SimpleNamespace`，包含以下屬性:

- `env_dir` - The location of the virtual environment. Used for `__VENV_DIR__` in activation scripts (see `install_scripts()`).
- `env_name` - The name of the virtual environment. Used for `__VENV_NAME__` in activation scripts (see `install_scripts()`).
- `prompt` - The prompt to be used by the activation scripts. Used for `__VENV_PROMPT__` in activation scripts (see `install_scripts()`).
- `executable` - The underlying Python executable used by the virtual environment. This takes into account the case where a virtual environment is created from another virtual environment.
- `inc_path` - The include path for the virtual environment.
- `lib_path` - The purelib path for the virtual environment.
- `bin_path` - The script path for the virtual environment.

- `bin_name` - The name of the script path relative to the virtual environment location. Used for `__VENV_BIN_NAME__` in activation scripts (see `install_scripts()`).
- `env_exe` - The name of the Python interpreter in the virtual environment. Used for `__VENV_PYTHON__` in activation scripts (see `install_scripts()`).
- `env_exec_cmd` - The name of the Python interpreter, taking into account filesystem redirections. This can be used to run Python in the virtual environment.

在 3.11 版的變更: The `venv sysconfig installation scheme` is used to construct the paths of the created directories.

create_configuration (*context*)

Creates the `pyvenv.cfg` configuration file in the environment.

setup_python (*context*)

Creates a copy or symlink to the Python executable in the environment. On POSIX systems, if a specific executable `python3.x` was used, symlinks to `python` and `python3` will be created pointing to that executable, unless files with those names already exist.

setup_scripts (*context*)

Installs activation scripts appropriate to the platform into the virtual environment.

upgrade_dependencies (*context*)

Upgrades the core venv dependency packages (currently `pip` and `setuptools`) in the environment. This is done by shelling out to the `pip` executable in the environment.

在 3.9 版新加入.

post_setup (*context*)

A placeholder method which can be overridden in third party implementations to pre-install packages in the virtual environment or perform other post-creation steps.

在 3.7.2 版的變更: Windows now uses redirector scripts for `python[w].exe` instead of copying the actual binaries. In 3.7.2 only `setup_python()` does nothing unless running from a build in the source tree.

在 3.7.3 版的變更: Windows copies the redirector scripts as part of `setup_python()` instead of `setup_scripts()`. This was not the case in 3.7.2. When using symlinks, the original executables will be linked.

In addition, `EnvBuilder` provides this utility method that can be called from `setup_scripts()` or `post_setup()` in subclasses to assist in installing custom scripts into the virtual environment.

install_scripts (*context*, *path*)

path is the path to a directory that should contain subdirectories "common", "posix", "nt", each containing scripts destined for the bin directory in the environment. The contents of "common" and the directory corresponding to `os.name` are copied after some text replacement of placeholders:

- `__VENV_DIR__` is replaced with the absolute path of the environment directory.
- `__VENV_NAME__` is replaced with the environment name (final path segment of environment directory).
- `__VENV_PROMPT__` is replaced with the prompt (the environment name surrounded by parentheses and with a following space)
- `__VENV_BIN_NAME__` is replaced with the name of the bin directory (either `bin` or `Scripts`).
- `__VENV_PYTHON__` is replaced with the absolute path of the environment's executable.

The directories are allowed to exist (for when an existing environment is being upgraded).

There is also a module-level convenience function:

```
venv.create(env_dir, system_site_packages=False, clear=False, symlinks=False, with_pip=False,
            prompt=None, upgrade_deps=False)
```


Create an *EnvBuilder* with the given keyword arguments, and call its *create()* method with the *env_dir* argument.

在 3.3 版新加入.

在 3.4 版的變更: 新增 *with_pip* 參數

在 3.6 版的變更: 新增 *prompt* 參數

在 3.9 版的變更: 新增 *upgrade_deps* 參數

28.3.4 An example of extending *EnvBuilder*

The following script shows how to extend *EnvBuilder* by implementing a subclass which installs *setuptools* and *pip* into a created virtual environment:

```
import os
import os.path
from subprocess import Popen, PIPE
import sys
from threading import Thread
from urllib.parse import urlparse
from urllib.request import urlretrieve
import venv

class ExtendedEnvBuilder(venv.EnvBuilder):
    """
    This builder installs setuptools and pip so that you can pip or
    easy_install other packages into the created virtual environment.

    :param nodist: If true, setuptools and pip are not installed into the
        created virtual environment.
    :param nopip: If true, pip is not installed into the created
        virtual environment.
    :param progress: If setuptools or pip are installed, the progress of the
        installation can be monitored by passing a progress
        callable. If specified, it is called with two
        arguments: a string indicating some progress, and a
        context indicating where the string is coming from.
        The context argument can have one of three values:
        'main', indicating that it is called from virtualize()
        itself, and 'stdout' and 'stderr', which are obtained
        by reading lines from the output streams of a subprocess
        which is used to install the app.

        If a callable is not specified, default progress
        information is output to sys.stderr.
    """

    def __init__(self, *args, **kwargs):
        self.nodist = kwargs.pop('nodist', False)
        self.nopip = kwargs.pop('nopip', False)
        self.progress = kwargs.pop('progress', None)
        self.verbose = kwargs.pop('verbose', False)
        super().__init__(*args, **kwargs)

    def post_setup(self, context):
        """
        Set up any packages which need to be pre-installed into the
        virtual environment being created.
```

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```

:param context: The information for the virtual environment
                  creation request being processed.
"""
os.environ['VIRTUAL_ENV'] = context.env_dir
if not self.nodist:
    self.install_setuptools(context)
# Can't install pip without setuptools
if not self.nopip and not self.nodist:
    self.install_pip(context)

def reader(self, stream, context):
    """
    Read lines from a subprocess' output stream and either pass to a progress
    callable (if specified) or write progress information to sys.stderr.
    """
    progress = self.progress
    while True:
        s = stream.readline()
        if not s:
            break
        if progress is not None:
            progress(s, context)
        else:
            if not self.verbose:
                sys.stderr.write('.')
            else:
                sys.stderr.write(s.decode('utf-8'))
            sys.stderr.flush()
    stream.close()

def install_script(self, context, name, url):
    _, _, path, _, _, _ = urlparse(url)
    fn = os.path.split(path)[-1]
    binpath = context.bin_path
    distpath = os.path.join(binpath, fn)
    # Download script into the virtual environment's binaries folder
    urlretrieve(url, distpath)
    progress = self.progress
    if self.verbose:
        term = '\n'
    else:
        term = ''
    if progress is not None:
        progress('Installing %s ...%s' % (name, term), 'main')
    else:
        sys.stderr.write('Installing %s ...%s' % (name, term))
        sys.stderr.flush()
    # Install in the virtual environment
    args = [context.env_exe, fn]
    p = Popen(args, stdout=PIPE, stderr=PIPE, cwd=binpath)
    t1 = Thread(target=self.reader, args=(p.stdout, 'stdout'))
    t1.start()
    t2 = Thread(target=self.reader, args=(p.stderr, 'stderr'))
    t2.start()
    p.wait()
    t1.join()
    t2.join()
    if progress is not None:
        progress('done.', 'main')
    else:
        sys.stderr.write('done.\n')

```

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```

    # Clean up - no longer needed
    os.unlink(distpath)

def install_setuptools(self, context):
    """
    Install setuptools in the virtual environment.

    :param context: The information for the virtual environment
                     creation request being processed.
    """
    url = 'https://bitbucket.org/pypa/setuptools/downloads/ez_setup.py'
    self.install_script(context, 'setuptools', url)
    # clear up the setuptools archive which gets downloaded
    pred = lambda o: o.startswith('setuptools-') and o.endswith('.tar.gz')
    files = filter(pred, os.listdir(context.bin_path))
    for f in files:
        f = os.path.join(context.bin_path, f)
        os.unlink(f)

def install_pip(self, context):
    """
    Install pip in the virtual environment.

    :param context: The information for the virtual environment
                     creation request being processed.
    """
    url = 'https://bootstrap.pypa.io/get-pip.py'
    self.install_script(context, 'pip', url)

def main(args=None):
    compatible = True
    if sys.version_info < (3, 3):
        compatible = False
    elif not hasattr(sys, 'base_prefix'):
        compatible = False
    if not compatible:
        raise ValueError('This script is only for use with '
                          'Python 3.3 or later')
    else:
        import argparse

        parser = argparse.ArgumentParser(prog=__name__,
                                         description='Creates virtual Python '
                                                         'environments in one or '
                                                         'more target '
                                                         'directories.')
        parser.add_argument('dirs', metavar='ENV_DIR', nargs='+',
                            help='A directory in which to create the '
                                  'virtual environment.')
        parser.add_argument('--no-setuptools', default=False,
                            action='store_true', dest='nodist',
                            help="Don't install setuptools or pip in the "
                                  "virtual environment.")
        parser.add_argument('--no-pip', default=False,
                            action='store_true', dest='nopip',
                            help="Don't install pip in the virtual "
                                  "environment.")
        parser.add_argument('--system-site-packages', default=False,
                            action='store_true', dest='system_site',
                            help='Give the virtual environment access to the '
                                  'system site-packages dir.')

```

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```

if os.name == 'nt':
    use_symlinks = False
else:
    use_symlinks = True
parser.add_argument('--symlinks', default=use_symlinks,
                    action='store_true', dest='symlinks',
                    help='Try to use symlinks rather than copies, '
                         'when symlinks are not the default for '
                         'the platform.')
parser.add_argument('--clear', default=False, action='store_true',
                    dest='clear', help='Delete the contents of the '
                                       'virtual environment '
                                       'directory if it already '
                                       'exists, before virtual '
                                       'environment creation.')
parser.add_argument('--upgrade', default=False, action='store_true',
                    dest='upgrade', help='Upgrade the virtual '
                                       'environment directory to '
                                       'use this version of '
                                       'Python, assuming Python '
                                       'has been upgraded '
                                       'in-place.')
parser.add_argument('--verbose', default=False, action='store_true',
                    dest='verbose', help='Display the output '
                                       'from the scripts which '
                                       'install setuptools and pip.')

options = parser.parse_args(args)
if options.upgrade and options.clear:
    raise ValueError('you cannot supply --upgrade and --clear together.')
builder = ExtendedEnvBuilder(system_site_packages=options.system_site,
                             clear=options.clear,
                             symlinks=options.symlinks,
                             upgrade=options.upgrade,
                             nodist=options.nodist,
                             nopip=options.nopip,
                             verbose=options.verbose)

for d in options.dirs:
    builder.create(d)

if __name__ == '__main__':
    rc = 1
    try:
        main()
        rc = 0
    except Exception as e:
        print('Error: %s' % e, file=sys.stderr)
    sys.exit(rc)

```

This script is also available for download [online](#).

28.4 zipapp --- Manage executable Python zip archives

在 3.5 版新加入.

原始碼: [Lib/zipapp.py](#)

This module provides tools to manage the creation of zip files containing Python code, which can be executed directly by the Python interpreter. The module provides both a 命令執行列介面 and a *Python API*.

28.4.1 基本范例

The following example shows how the 命令執行列介面 can be used to create an executable archive from a directory containing Python code. When run, the archive will execute the `main` function from the module `myapp` in the archive.

```
$ python -m zipapp myapp -m "myapp:main"
$ python myapp.pyz
<output from myapp>
```

28.4.2 命令執行列介面

When called as a program from the command line, the following form is used:

```
$ python -m zipapp source [options]
```

If *source* is a directory, this will create an archive from the contents of *source*. If *source* is a file, it should be an archive, and it will be copied to the target archive (or the contents of its shebang line will be displayed if the `--info` option is specified).

The following options are understood:

-o *<output>*, **--output**=*<output>*

Write the output to a file named *output*. If this option is not specified, the output filename will be the same as the input *source*, with the extension `.pyz` added. If an explicit filename is given, it is used as is (so a `.pyz` extension should be included if required).

An output filename must be specified if the *source* is an archive (and in that case, *output* must not be the same as *source*).

-p *<interpreter>*, **--python**=*<interpreter>*

Add a `#!` line to the archive specifying *interpreter* as the command to run. Also, on POSIX, make the archive executable. The default is to write no `#!` line, and not make the file executable.

-m *<mainfn>*, **--main**=*<mainfn>*

Write a `__main__.py` file to the archive that executes *mainfn*. The *mainfn* argument should have the form `"pkg.mod:fn"`, where `"pkg.mod"` is a package/module in the archive, and `"fn"` is a callable in the given module. The `__main__.py` file will execute that callable.

`--main` cannot be specified when copying an archive.

-c, **--compress**

Compress files with the deflate method, reducing the size of the output file. By default, files are stored uncompressed in the archive.

`--compress` has no effect when copying an archive.

在 3.7 版新加入.

--info

Display the interpreter embedded in the archive, for diagnostic purposes. In this case, any other options are ignored and SOURCE must be an archive, not a directory.

-h, --help

Print a short usage message and exit.

28.4.3 Python API

The module defines two convenience functions:

`zipapp.create_archive` (*source*, *target=None*, *interpreter=None*, *main=None*, *filter=None*, *compressed=False*)

Create an application archive from *source*. The source can be any of the following:

- The name of a directory, or a *path-like object* referring to a directory, in which case a new application archive will be created from the content of that directory.
- The name of an existing application archive file, or a *path-like object* referring to such a file, in which case the file is copied to the target (modifying it to reflect the value given for the *interpreter* argument). The file name should include the `.pyz` extension, if required.
- A file object open for reading in bytes mode. The content of the file should be an application archive, and the file object is assumed to be positioned at the start of the archive.

The *target* argument determines where the resulting archive will be written:

- If it is the name of a file, or a *path-like object*, the archive will be written to that file.
- If it is an open file object, the archive will be written to that file object, which must be open for writing in bytes mode.
- If the target is omitted (or `None`), the source must be a directory and the target will be a file with the same name as the source, with a `.pyz` extension added.

The *interpreter* argument specifies the name of the Python interpreter with which the archive will be executed. It is written as a "shebang" line at the start of the archive. On POSIX, this will be interpreted by the OS, and on Windows it will be handled by the Python launcher. Omitting the *interpreter* results in no shebang line being written. If an interpreter is specified, and the target is a filename, the executable bit of the target file will be set.

The *main* argument specifies the name of a callable which will be used as the main program for the archive. It can only be specified if the source is a directory, and the source does not already contain a `__main__.py` file. The *main* argument should take the form `"pkg.module:callable"` and the archive will be run by importing `"pkg.module"` and executing the given callable with no arguments. It is an error to omit *main* if the source is a directory and does not contain a `__main__.py` file, as otherwise the resulting archive would not be executable.

The optional *filter* argument specifies a callback function that is passed a `Path` object representing the path to the file being added (relative to the source directory). It should return `True` if the file is to be added.

The optional *compressed* argument determines whether files are compressed. If set to `True`, files in the archive are compressed with the deflate method; otherwise, files are stored uncompressed. This argument has no effect when copying an existing archive.

If a file object is specified for *source* or *target*, it is the caller's responsibility to close it after calling `create_archive`.

When copying an existing archive, file objects supplied only need `read` and `readline`, or `write` methods. When creating an archive from a directory, if the target is a file object it will be passed to the `zipfile.ZipFile` class, and must supply the methods needed by that class.

在 3.7 版的變更: Added the *filter* and *compressed* parameters.

`zipapp.get_interpreter (archive)`

Return the interpreter specified in the `#!` line at the start of the archive. If there is no `#!` line, return `None`. The *archive* argument can be a filename or a file-like object open for reading in bytes mode. It is assumed to be at the start of the archive.

28.4.4 范例

Pack up a directory into an archive, and run it.

```
$ python -m zipapp myapp
$ python myapp.pyz
<output from myapp>
```

The same can be done using the `create_archive()` function:

```
>>> import zipapp
>>> zipapp.create_archive('myapp', 'myapp.pyz')
```

To make the application directly executable on POSIX, specify an interpreter to use.

```
$ python -m zipapp myapp -p "/usr/bin/env python"
$ ./myapp.pyz
<output from myapp>
```

To replace the shebang line on an existing archive, create a modified archive using the `create_archive()` function:

```
>>> import zipapp
>>> zipapp.create_archive('old_archive.pyz', 'new_archive.pyz', '/usr/bin/python3')
```

To update the file in place, do the replacement in memory using a `BytesIO` object, and then overwrite the source afterwards. Note that there is a risk when overwriting a file in place that an error will result in the loss of the original file. This code does not protect against such errors, but production code should do so. Also, this method will only work if the archive fits in memory:

```
>>> import zipapp
>>> import io
>>> temp = io.BytesIO()
>>> zipapp.create_archive('myapp.pyz', temp, '/usr/bin/python2')
>>> with open('myapp.pyz', 'wb') as f:
>>>     f.write(temp.getvalue())
```

28.4.5 Specifying the Interpreter

Note that if you specify an interpreter and then distribute your application archive, you need to ensure that the interpreter used is portable. The Python launcher for Windows supports most common forms of POSIX `#!` line, but there are other issues to consider:

- If you use `"/usr/bin/env python"` (or other forms of the "python" command, such as `"/usr/bin/python"`), you need to consider that your users may have either Python 2 or Python 3 as their default, and write your code to work under both versions.
- If you use an explicit version, for example `"/usr/bin/env python3"` your application will not work for users who do not have that version. (This may be what you want if you have not made your code Python 2 compatible).
- There is no way to say "python X.Y or later", so be careful of using an exact version like `"/usr/bin/env python3.4"` as you will need to change your shebang line for users of Python 3.5, for example.

Typically, you should use an `"/usr/bin/env python2"` or `"/usr/bin/env python3"`, depending on whether your code is written for Python 2 or 3.

28.4.6 Creating Standalone Applications with zipapp

Using the `zipapp` module, it is possible to create self-contained Python programs, which can be distributed to end users who only need to have a suitable version of Python installed on their system. The key to doing this is to bundle all of the application's dependencies into the archive, along with the application code.

The steps to create a standalone archive are as follows:

1. Create your application in a directory as normal, so you have a `myapp` directory containing a `__main__.py` file, and any supporting application code.
2. Install all of your application's dependencies into the `myapp` directory, using `pip`:

```
$ python -m pip install -r requirements.txt --target myapp
```

(this assumes you have your project requirements in a `requirements.txt` file - if not, you can just list the dependencies manually on the `pip` command line).

3. Package the application using:

```
$ python -m zipapp -p "interpreter" myapp
```

This will produce a standalone executable, which can be run on any machine with the appropriate interpreter available. See *Specifying the Interpreter* for details. It can be shipped to users as a single file.

On Unix, the `myapp.pyz` file is executable as it stands. You can rename the file to remove the `.pyz` extension if you prefer a "plain" command name. On Windows, the `myapp.pyz[w]` file is executable by virtue of the fact that the Python interpreter registers the `.pyz` and `.pyzw` file extensions when installed.

Making a Windows executable

On Windows, registration of the `.pyz` extension is optional, and furthermore, there are certain places that don't recognise registered extensions "transparently" (the simplest example is that `subprocess.run(['myapp'])` won't find your application - you need to explicitly specify the extension).

On Windows, therefore, it is often preferable to create an executable from the `zipapp`. This is relatively easy, although it does require a C compiler. The basic approach relies on the fact that zipfiles can have arbitrary data prepended, and Windows exe files can have arbitrary data appended. So by creating a suitable launcher and tacking the `.pyz` file onto the end of it, you end up with a single-file executable that runs your application.

A suitable launcher can be as simple as the following:

```
#define Py_LIMITED_API 1
#include "Python.h"

#define WIN32_LEAN_AND_MEAN
#include <windows.h>

#ifdef WINDOWS
int WINAPI wWinMain(
    HINSTANCE hInstance,      /* handle to current instance */
    HINSTANCE hPrevInstance,  /* handle to previous instance */
    LPWSTR lpCmdLine,         /* pointer to command line */
    int nCmdShow              /* show state of window */
)
#else
int wmain()
#endif
{
    wchar_t **myargv = _alloca((__argc + 1) * sizeof(wchar_t*));
    myargv[0] = __wargv[0];
    memcpy(myargv + 1, __wargv, __argc * sizeof(wchar_t *));
```

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```

return Py_Main(__argc+1, myargv);
}

```

If you define the `WINDOWS` preprocessor symbol, this will generate a GUI executable, and without it, a console executable.

To compile the executable, you can either just use the standard MSVC command line tools, or you can take advantage of the fact that `distutils` knows how to compile Python source:

```

>>> from distutils.ccompiler import new_compiler
>>> import distutils.sysconfig
>>> import sys
>>> import os
>>> from pathlib import Path

>>> def compile(src):
>>>     src = Path(src)
>>>     cc = new_compiler()
>>>     exe = src.stem
>>>     cc.add_include_dir(distutils.sysconfig.get_python_inc())
>>>     cc.add_library_dir(os.path.join(sys.base_exec_prefix, 'libs'))
>>>     # First the CLI executable
>>>     objs = cc.compile([str(src)])
>>>     cc.link_executable(objs, exe)
>>>     # Now the GUI executable
>>>     cc.define_macro('WINDOWS')
>>>     objs = cc.compile([str(src)])
>>>     cc.link_executable(objs, exe + 'w')

>>> if __name__ == "__main__":
>>>     compile("zastub.c")

```

The resulting launcher uses the “Limited ABI”, so it will run unchanged with any version of Python 3.x. All it needs is for Python (`python3.dll`) to be on the user’s `PATH`.

For a fully standalone distribution, you can distribute the launcher with your application appended, bundled with the Python “embedded” distribution. This will run on any PC with the appropriate architecture (32 bit or 64 bit).

Caveats

There are some limitations to the process of bundling your application into a single file. In most, if not all, cases they can be addressed without needing major changes to your application.

1. If your application depends on a package that includes a C extension, that package cannot be run from a zip file (this is an OS limitation, as executable code must be present in the filesystem for the OS loader to load it). In this case, you can exclude that dependency from the zipfile, and either require your users to have it installed, or ship it alongside your zipfile and add code to your `__main__.py` to include the directory containing the unzipped module in `sys.path`. In this case, you will need to make sure to ship appropriate binaries for your target architecture(s) (and potentially pick the correct version to add to `sys.path` at runtime, based on the user’s machine).
2. If you are shipping a Windows executable as described above, you either need to ensure that your users have `python3.dll` on their `PATH` (which is not the default behaviour of the installer) or you should bundle your application with the embedded distribution.
3. The suggested launcher above uses the Python embedding API. This means that in your application, `sys.executable` will be your application, and *not* a conventional Python interpreter. Your code and its dependencies need to be prepared for this possibility. For example, if your application uses the `multiprocessing` module, it will need to call `multiprocessing.set_executable()` to let the module know where to find the standard Python interpreter.

28.4.7 The Python Zip Application Archive Format

Python has been able to execute zip files which contain a `__main__.py` file since version 2.6. In order to be executed by Python, an application archive simply has to be a standard zip file containing a `__main__.py` file which will be run as the entry point for the application. As usual for any Python script, the parent of the script (in this case the zip file) will be placed on `sys.path` and thus further modules can be imported from the zip file.

The zip file format allows arbitrary data to be prepended to a zip file. The zip application format uses this ability to prepend a standard POSIX “shebang” line to the file (`#!/path/to/interpreter`).

Formally, the Python zip application format is therefore:

1. An optional shebang line, containing the characters `b'#!'` followed by an interpreter name, and then a newline (`b'\n'`) character. The interpreter name can be anything acceptable to the OS “shebang” processing, or the Python launcher on Windows. The interpreter should be encoded in UTF-8 on Windows, and in `sys.getfilesystemencoding()` on POSIX.
2. Standard zipfile data, as generated by the `zipfile` module. The zipfile content *must* include a file called `__main__.py` (which must be in the “root” of the zipfile - i.e., it cannot be in a subdirectory). The zipfile data can be compressed or uncompressed.

If an application archive has a shebang line, it may have the executable bit set on POSIX systems, to allow it to be executed directly.

There is no requirement that the tools in this module are used to create application archives - the module is a convenience, but archives in the above format created by any means are acceptable to Python.

Python Runtime Services

The modules described in this chapter provide a wide range of services related to the Python interpreter and its interaction with its environment. Here's an overview:

29.1 `sys` --- 系統特定的參數與函式

This module provides access to some variables used or maintained by the interpreter and to functions that interact strongly with the interpreter. It is always available.

`sys.abiflags`

On POSIX systems where Python was built with the standard `configure` script, this contains the ABI flags as specified by [PEP 3149](#).

在 3.2 版新加入。

在 3.8 版的變更: Default flags became an empty string (m flag for pymalloc has been removed).

`sys.addaudithook(hook)`

Append the callable *hook* to the list of active auditing hooks for the current (sub)interpreter.

When an auditing event is raised through the `sys.audit()` function, each hook will be called in the order it was added with the event name and the tuple of arguments. Native hooks added by `PySys_AddAuditHook()` are called first, followed by hooks added in the current (sub)interpreter. Hooks can then log the event, raise an exception to abort the operation, or terminate the process entirely.

Note that audit hooks are primarily for collecting information about internal or otherwise unobservable actions, whether by Python or libraries written in Python. They are not suitable for implementing a "sandbox". In particular, malicious code can trivially disable or bypass hooks added using this function. At a minimum, any security-sensitive hooks must be added using the C API `PySys_AddAuditHook()` before initialising the runtime, and any modules allowing arbitrary memory modification (such as `ctypes`) should be completely removed or closely monitored.

Calling `sys.addaudithook()` will itself raise an auditing event named `sys.addaudithook` with no arguments. If any existing hooks raise an exception derived from `RuntimeError`, the new hook will not be

added and the exception suppressed. As a result, callers cannot assume that their hook has been added unless they control all existing hooks.

所有會被 CPython 所引發的事件請參考稽核事件總表、設計相關討論請見 [PEP 578](#)。

在 3.8 版新加入。

在 3.8.1 版的變更: Exceptions derived from `Exception` but not `RuntimeError` are no longer suppressed.

CPython 實作細節: When tracing is enabled (see `settrace()`), Python hooks are only traced if the callable has a `__cantrace__` member that is set to a true value. Otherwise, trace functions will skip the hook.

`sys.argv`

The list of command line arguments passed to a Python script. `argv[0]` is the script name (it is operating system dependent whether this is a full pathname or not). If the command was executed using the `-c` command line option to the interpreter, `argv[0]` is set to the string `'-c'`. If no script name was passed to the Python interpreter, `argv[0]` is the empty string.

To loop over the standard input, or the list of files given on the command line, see the `fileinput` module.

另請參 `sys.orig_argv`。

備: On Unix, command line arguments are passed by bytes from OS. Python decodes them with filesystem encoding and "surrogateescape" error handler. When you need original bytes, you can get it by `[os.fsencode(arg) for arg in sys.argv]`.

`sys.audit(event, *args)`

Raise an auditing event and trigger any active auditing hooks. `event` is a string identifying the event, and `args` may contain optional arguments with more information about the event. The number and types of arguments for a given event are considered a public and stable API and should not be modified between releases.

舉例來, 一個名 `os.chdir` 的稽核事件擁有一個引數 `path`, 其容所要求的新工作目。

`sys.audit()` will call the existing auditing hooks, passing the event name and arguments, and will re-raise the first exception from any hook. In general, if an exception is raised, it should not be handled and the process should be terminated as quickly as possible. This allows hook implementations to decide how to respond to particular events: they can merely log the event or abort the operation by raising an exception.

Hooks are added using the `sys.addaudithook()` or `PySys_AddAuditHook()` functions.

The native equivalent of this function is `PySys_Audit()`. Using the native function is preferred when possible.

所有會被 CPython 所引發的事件請參考稽核事件總表。

在 3.8 版新加入。

`sys.base_exec_prefix`

Set during Python startup, before `site.py` is run, to the same value as `exec_prefix`. If not running in a *virtual environment*, the values will stay the same; if `site.py` finds that a virtual environment is in use, the values of `prefix` and `exec_prefix` will be changed to point to the virtual environment, whereas `base_prefix` and `base_exec_prefix` will remain pointing to the base Python installation (the one which the virtual environment was created from).

在 3.3 版新加入。

`sys.base_prefix`

Set during Python startup, before `site.py` is run, to the same value as `prefix`. If not running in a *virtual environment*, the values will stay the same; if `site.py` finds that a virtual environment is in use, the values of `prefix` and `exec_prefix` will be changed to point to the virtual environment, whereas `base_prefix` and `base_exec_prefix` will remain pointing to the base Python installation (the one which the virtual environment was created from).

在 3.3 版新加入。

`sys.byteorder`

An indicator of the native byte order. This will have the value 'big' on big-endian (most-significant byte first) platforms, and 'little' on little-endian (least-significant byte first) platforms.

`sys.builtin_module_names`

A tuple of strings containing the names of all modules that are compiled into this Python interpreter. (This information is not available in any other way --- `modules.keys()` only lists the imported modules.)

See also the `sys.stdlib_module_names` list.

`sys.call_tracing(func, args)`

Call `func(*args)`, while tracing is enabled. The tracing state is saved, and restored afterwards. This is intended to be called from a debugger from a checkpoint, to recursively debug or profile some other code.

Tracing is suspended while calling a tracing function set by `settrace()` or `setprofile()` to avoid infinite recursion. `call_tracing()` enables explicit recursion of the tracing function.

`sys.copyright`

A string containing the copyright pertaining to the Python interpreter.

`sys._clear_type_cache()`

Clear the internal type cache. The type cache is used to speed up attribute and method lookups. Use the function *only* to drop unnecessary references during reference leak debugging.

This function should be used for internal and specialized purposes only.

`sys._current_frames()`

Return a dictionary mapping each thread's identifier to the topmost stack frame currently active in that thread at the time the function is called. Note that functions in the `traceback` module can build the call stack given such a frame.

This is most useful for debugging deadlock: this function does not require the deadlocked threads' cooperation, and such threads' call stacks are frozen for as long as they remain deadlocked. The frame returned for a non-deadlocked thread may bear no relationship to that thread's current activity by the time calling code examines the frame.

This function should be used for internal and specialized purposes only.

引發一個不附帶引數的稽核事件 `sys._current_frames`。

`sys._current_exceptions()`

Return a dictionary mapping each thread's identifier to the topmost exception currently active in that thread at the time the function is called. If a thread is not currently handling an exception, it is not included in the result dictionary.

This is most useful for statistical profiling.

This function should be used for internal and specialized purposes only.

引發一個不附帶引數的稽核事件 `sys._current_exceptions`。

`sys.breakpointhook()`

This hook function is called by built-in `breakpoint()`. By default, it drops you into the `pdb` debugger, but it can be set to any other function so that you can choose which debugger gets used.

The signature of this function is dependent on what it calls. For example, the default binding (e.g. `pdb.set_trace()`) expects no arguments, but you might bind it to a function that expects additional arguments (positional and/or keyword). The built-in `breakpoint()` function passes its `*args` and `**kws` straight through. Whatever `breakpointhooks()` returns is returned from `breakpoint()`.

The default implementation first consults the environment variable `PYTHONBREAKPOINT`. If that is set to "0" then this function returns immediately; i.e. it is a no-op. If the environment variable is not set, or is set to the empty string, `pdb.set_trace()` is called. Otherwise this variable should name a function to run, using Python's dotted-import nomenclature, e.g. `package.subpackage.module.function`. In this

case, `package.subpackage.module` would be imported and the resulting module must have a callable named `function()`. This is run, passing in `*args` and `**kws`, and whatever `function()` returns, `sys.breakpointhook()` returns to the built-in `breakpoint()` function.

Note that if anything goes wrong while importing the callable named by `PYTHONBREAKPOINT`, a `RuntimeWarning` is reported and the breakpoint is ignored.

Also note that if `sys.breakpointhook()` is overridden programmatically, `PYTHONBREAKPOINT` is *not* consulted.

在 3.7 版新加入。

`sys._debugmallocstats()`

Print low-level information to stderr about the state of CPython's memory allocator.

If Python is built in debug mode (configure `--with-pydebug` option), it also performs some expensive internal consistency checks.

在 3.3 版新加入。

CPython 實作細節： This function is specific to CPython. The exact output format is not defined here, and may change.

`sys.dllhandle`

Integer specifying the handle of the Python DLL.

適用：Windows。

`sys.displayhook(value)`

If `value` is not `None`, this function prints `repr(value)` to `sys.stdout`, and saves `value` in `builtins._`. If `repr(value)` is not encodable to `sys.stdout.encoding` with `sys.stdout.errors` error handler (which is probably `'strict'`), encode it to `sys.stdout.encoding` with `'backslashreplace'` error handler.

`sys.displayhook` is called on the result of evaluating an *expression* entered in an interactive Python session. The display of these values can be customized by assigning another one-argument function to `sys.displayhook`.

Pseudo-code:

```
def displayhook(value):
    if value is None:
        return
    # Set '_' to None to avoid recursion
    builtins._ = None
    text = repr(value)
    try:
        sys.stdout.write(text)
    except UnicodeEncodeError:
        bytes = text.encode(sys.stdout.encoding, 'backslashreplace')
        if hasattr(sys.stdout, 'buffer'):
            sys.stdout.buffer.write(bytes)
        else:
            text = bytes.decode(sys.stdout.encoding, 'strict')
            sys.stdout.write(text)
    sys.stdout.write("\n")
    builtins._ = value
```

在 3.2 版的變更: Use `'backslashreplace'` error handler on `UnicodeEncodeError`.

`sys.dont_write_bytecode`

If this is true, Python won't try to write `.pyc` files on the import of source modules. This value is initially set to `True` or `False` depending on the `-B` command line option and the `PYTHONDONTWRITEBYTECODE` environment variable, but you can set it yourself to control bytecode file generation.

sys._emscripten_info

A *named tuple* holding information about the environment on the *wasm32-emscripten* platform. The named tuple is provisional and may change in the future.

_emscripten_info.emscripten_version

Emscripten version as tuple of ints (major, minor, micro), e.g. (3, 1, 8).

_emscripten_info.runtime

運行環境字串，例如 瀏覽器使用者代理 (browser user agent) 'Node.js v14.18.2' 或 'UNKNOWN'。

_emscripten_info.pthreads

True if Python is compiled with Emscripten pthreads support.

_emscripten_info.shared_memory

True if Python is compiled with shared memory support.

適用：Emscripten。

在 3.11 版新加入。

sys.pycache_prefix

If this is set (not None), Python will write bytecode-cache .pyc files to (and read them from) a parallel directory tree rooted at this directory, rather than from __pycache__ directories in the source code tree. Any __pycache__ directories in the source code tree will be ignored and new .pyc files written within the pycache prefix. Thus if you use *compileall* as a pre-build step, you must ensure you run it with the same pycache prefix (if any) that you will use at runtime.

A relative path is interpreted relative to the current working directory.

This value is initially set based on the value of the `-X pycache_prefix=PATH` command-line option or the `PYTHONPYCACHEPREFIX` environment variable (command-line takes precedence). If neither are set, it is None.

在 3.8 版新加入。

sys.excepthook (type, value, traceback)

This function prints out a given traceback and exception to `sys.stderr`.

When an exception other than *SystemExit* is raised and uncaught, the interpreter calls `sys.excepthook` with three arguments, the exception class, exception instance, and a traceback object. In an interactive session this happens just before control is returned to the prompt; in a Python program this happens just before the program exits. The handling of such top-level exceptions can be customized by assigning another three-argument function to `sys.excepthook`.

引發一個附帶引數 `hook`、`type`、`value`、`traceback` 的稽核事件 `sys.excepthook`。

也參考：

The `sys.unraisablehook()` function handles unraisable exceptions and the `threading.excepthook()` function handles exception raised by `threading.Thread.run()`.

sys.__breakpointhook__**sys.__displayhook__****sys.__excepthook__****sys.__unraisablehook__**

These objects contain the original values of `breakpointhook`, `displayhook`, `excepthook`, and `unraisablehook` at the start of the program. They are saved so that `breakpointhook`, `displayhook` and `excepthook`, `unraisablehook` can be restored in case they happen to get replaced with broken or alternative objects.

在 3.7 版新加入：__breakpointhook__

在 3.8 版新加入：__unraisablehook__

sys.exception()

This function, when called while an exception handler is executing (such as an `except` or `except*` clause), returns the exception instance that was caught by this handler. When exception handlers are nested within one another, only the exception handled by the innermost handler is accessible.

If no exception handler is executing, this function returns `None`.

在 3.11 版新加入。

sys.exc_info()

This function returns the old-style representation of the handled exception. If an exception `e` is currently handled (so `exception()` would return `e`), `exc_info()` returns the tuple `(type(e), e, e.__traceback__)`. That is, a tuple containing the type of the exception (a subclass of `BaseException`), the exception itself, and a traceback object which typically encapsulates the call stack at the point where the exception last occurred.

If no exception is being handled anywhere on the stack, this function return a tuple containing three `None` values.

在 3.11 版的變更: The `type` and `traceback` fields are now derived from the value (the exception instance), so when an exception is modified while it is being handled, the changes are reflected in the results of subsequent calls to `exc_info()`.

sys.exec_prefix

A string giving the site-specific directory prefix where the platform-dependent Python files are installed; by default, this is also `'/usr/local'`. This can be set at build time with the `--exec-prefix` argument to the **configure** script. Specifically, all configuration files (e.g. the `pyconfig.h` header file) are installed in the directory `exec_prefix/lib/pythonX.Y/config`, and shared library modules are installed in `exec_prefix/lib/pythonX.Y/lib-dynload`, where `X.Y` is the version number of Python, for example 3.2.

備 F: If a *virtual environment* is in effect, this value will be changed in `site.py` to point to the virtual environment. The value for the Python installation will still be available, via `base_exec_prefix`.

sys.executable

A string giving the absolute path of the executable binary for the Python interpreter, on systems where this makes sense. If Python is unable to retrieve the real path to its executable, `sys.executable` will be an empty string or `None`.

sys.exit([arg])

Raise a `SystemExit` exception, signaling an intention to exit the interpreter.

The optional argument `arg` can be an integer giving the exit status (defaulting to zero), or another type of object. If it is an integer, zero is considered “successful termination” and any nonzero value is considered “abnormal termination” by shells and the like. Most systems require it to be in the range 0–127, and produce undefined results otherwise. Some systems have a convention for assigning specific meanings to specific exit codes, but these are generally underdeveloped; Unix programs generally use 2 for command line syntax errors and 1 for all other kind of errors. If another type of object is passed, `None` is equivalent to passing zero, and any other object is printed to `stderr` and results in an exit code of 1. In particular, `sys.exit("some error message")` is a quick way to exit a program when an error occurs.

Since `exit()` ultimately “only” raises an exception, it will only exit the process when called from the main thread, and the exception is not intercepted. Cleanup actions specified by finally clauses of `try` statements are honored, and it is possible to intercept the exit attempt at an outer level.

在 3.6 版的變更: If an error occurs in the cleanup after the Python interpreter has caught `SystemExit` (such as an error flushing buffered data in the standard streams), the exit status is changed to 120.

sys.flags

The *named tuple flags* exposes the status of command line flags. The attributes are read only.

<code>flags.debug</code>	<code>-d</code>
<code>flags.inspect</code>	<code>-i</code>
<code>flags.interactive</code>	<code>-i</code>
<code>flags.isolated</code>	<code>-I</code>
<code>flags.optimize</code>	<code>-O</code> 或 <code>-OO</code>
<code>flags.dont_write_bytecode</code>	<code>-B</code>
<code>flags.no_user_site</code>	<code>-s</code>
<code>flags.no_site</code>	<code>-S</code>
<code>flags.ignore_environment</code>	<code>-E</code>
<code>flags.verbose</code>	<code>-v</code>
<code>flags.bytes_warning</code>	<code>-b</code>
<code>flags.quiet</code>	<code>-q</code>
<code>flags.hash_randomization</code>	<code>-R</code>
<code>flags.dev_mode</code>	<code>-X dev</code> (<i>Python</i> 開發模式)
<code>flags.utf8_mode</code>	<code>-X utf8</code>
<code>flags.safe_path</code>	<code>-P</code>
<code>flags.int_max_str_digits</code>	<code>-X int_max_str_digits</code> (<i>integer string conversion length limitation</i>)
<code>flags.warn_default_encoding</code>	<code>-X warn_default_encoding</code>

在 3.2 版的變更: 新增 `quiet` 屬性, 用於新的 `-q` 旗標。

在 3.2.3 版新加入: `hash_randomization` 屬性。

在 3.3 版的變更: 移除過時的 `division_warning` 屬性。

在 3.4 版的變更: 新增 `isolated` 屬性, 用於 `-I isolated` 旗標。

在 3.7 版的變更: Added the `dev_mode` attribute for the new *Python Development Mode* and the `utf8_mode` attribute for the new `-X utf8` flag.

在 3.10 版的變更: Added `warn_default_encoding` attribute for `-X warn_default_encoding` flag.

在 3.11 版的變更: 新增 `safe_path` 屬性, 用於 `-P` 選項。

在 3.11 版的變更: 新增 `int_max_str_digits` 屬性。

`sys.float_info`

A *named tuple* holding information about the float type. It contains low level information about the precision and internal representation. The values correspond to the various floating-point constants defined in the standard header file `float.h` for the 'C' programming language; see section 5.2.4.2.2 of the 1999 ISO/IEC C standard [C99], 'Characteristics of floating types', for details.

表格 1: Attributes of the float_info named tuple

屬性	float.h macro	解釋
<code>float_info.epsilon</code>	DBL_EPSILON	difference between 1.0 and the least value greater than 1.0 that is representable as a float. 另請參 F <code>math.ulp()</code> 。
<code>float_info.dig</code>	DBL_DIG	The maximum number of decimal digits that can be faithfully represented in a float; see below.
<code>float_info.mant_dig</code>	DBL_MANT_DIG	Float precision: the number of base-radix digits in the significand of a float.
<code>float_info.max</code>	DBL_MAX	The maximum representable positive finite float.
<code>float_info.max_exp</code>	DBL_MAX_EXP	The maximum integer e such that radix^{e-1} is a representable finite float.
<code>float_info.max_10_exp</code>	DBL_MAX_10_EXP	The maximum integer e such that 10^e is in the range of representable finite floats.
<code>float_info.min</code>	DBL_MIN	The minimum representable positive <i>normalized</i> float. Use <code>math.ulp(0.0)</code> to get the smallest positive <i>denormalized</i> representable float.
<code>float_info.min_exp</code>	DBL_MIN_EXP	The minimum integer e such that radix^{e-1} is a normalized float.
<code>float_info.min_10_exp</code>	DBL_MIN_10_EXP	The minimum integer e such that 10^e is a normalized float.
<code>float_info.radix</code>	FLT_RADIX	The radix of exponent representation.
<code>float_info.rounds</code>	FLT_ROUNDS	An integer representing the rounding mode for floating-point arithmetic. This reflects the value of the system FLT_ROUNDS macro at interpreter startup time: <ul style="list-style-type: none"> • -1: indeterminate • 0: toward zero • 1: to nearest • 2: toward positive infinity • 3: toward negative infinity All other values for FLT_ROUNDS characterize implementation-defined rounding behavior.

The attribute `sys.float_info.dig` needs further explanation. If s is any string representing a decimal number with at most `sys.float_info.dig` significant digits, then converting s to a float and back again will recover a string representing the same decimal value:

```
>>> import sys
>>> sys.float_info.dig
```

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```

15
>>> s = '3.14159265358979'      # decimal string with 15 significant digits
>>> format(float(s), '.15g')    # convert to float and back -> same value
'3.14159265358979'

```

But for strings with more than `sys.float_info.dig` significant digits, this isn't always true:

```

>>> s = '9876543211234567'    # 16 significant digits is too many!
>>> format(float(s), '.16g')    # conversion changes value
'9876543211234568'

```

`sys.float_repr_style`

A string indicating how the `repr()` function behaves for floats. If the string has value `'short'` then for a finite float `x`, `repr(x)` aims to produce a short string with the property that `float(repr(x)) == x`. This is the usual behaviour in Python 3.1 and later. Otherwise, `float_repr_style` has value `'legacy'` and `repr(x)` behaves in the same way as it did in versions of Python prior to 3.1.

在 3.1 版新加入。

`sys.getallocatedblocks()`

Return the number of memory blocks currently allocated by the interpreter, regardless of their size. This function is mainly useful for tracking and debugging memory leaks. Because of the interpreter's internal caches, the result can vary from call to call; you may have to call `_clear_type_cache()` and `gc.collect()` to get more predictable results.

If a Python build or implementation cannot reasonably compute this information, `getallocatedblocks()` is allowed to return 0 instead.

在 3.4 版新加入。

`sys.getandroidapilevel()`

Return the build time API version of Android as an integer.

適用：Android。

在 3.7 版新加入。

`sys.getdefaultencoding()`

Return the name of the current default string encoding used by the Unicode implementation.

`sys.getdlopenflags()`

Return the current value of the flags that are used for `dlopen()` calls. Symbolic names for the flag values can be found in the `os` module (RTLD_XXX constants, e.g. `os.RTLD_LAZY`).

適用：Unix。

`sys.getfilesystemencoding()`

Get the *filesystem encoding*: the encoding used with the *filesystem error handler* to convert between Unicode filenames and bytes filenames. The filesystem error handler is returned from `getfilesystemencodeerrors()`.

For best compatibility, str should be used for filenames in all cases, although representing filenames as bytes is also supported. Functions accepting or returning filenames should support either str or bytes and internally convert to the system's preferred representation.

`os.fsencode()` and `os.fsdecode()` should be used to ensure that the correct encoding and errors mode are used.

The *filesystem encoding and error handler* are configured at Python startup by the `PyConfig_Read()` function: see `filesystem_encoding` and `filesystem_errors` members of `PyConfig`.

在 3.2 版的變更: `getfilesystemencoding()` 的結果不再 None。

在 3.6 版的變更: Windows is no longer guaranteed to return 'mbcs'. See [PEP 529](#) and [_enablelegacywindowsfsencoding\(\)](#) for more information.

在 3.7 版的變更: Return 'utf-8' if the *Python UTF-8 Mode* is enabled.

`sys.getfilesystemencoding()`

Get the *filesystem error handler*: the error handler used with the *filesystem encoding* to convert between Unicode filenames and bytes filenames. The filesystem encoding is returned from [getfilesystemencoding\(\)](#).

[os.fsencode\(\)](#) and [os.fsdecode\(\)](#) should be used to ensure that the correct encoding and errors mode are used.

The *filesystem encoding and error handler* are configured at Python startup by the `PyConfig_Read()` function: see `filesystem_encoding` and `filesystem_errors` members of `PyConfig`.

在 3.6 版新加入。

`sys.get_int_max_str_digits()`

Returns the current value for the *integer string conversion length limitation*. See also [set_int_max_str_digits\(\)](#).

在 3.11 版新加入。

`sys.getrefcount(object)`

Return the reference count of the *object*. The count returned is generally one higher than you might expect, because it includes the (temporary) reference as an argument to [getrefcount\(\)](#).

Note that the returned value may not actually reflect how many references to the object are actually held. Consequently, do not rely on the returned value to be accurate, other than a value of 0 or 1.

`sys.getrecursionlimit()`

Return the current value of the recursion limit, the maximum depth of the Python interpreter stack. This limit prevents infinite recursion from causing an overflow of the C stack and crashing Python. It can be set by [setrecursionlimit\(\)](#).

`sys.getsizeof(object[, default])`

Return the size of an object in bytes. The object can be any type of object. All built-in objects will return correct results, but this does not have to hold true for third-party extensions as it is implementation specific.

Only the memory consumption directly attributed to the object is accounted for, not the memory consumption of objects it refers to.

If given, *default* will be returned if the object does not provide means to retrieve the size. Otherwise a *TypeError* will be raised.

[getsizeof\(\)](#) calls the object's `__sizeof__` method and adds an additional garbage collector overhead if the object is managed by the garbage collector.

See [recursive sizeof recipe](#) for an example of using [getsizeof\(\)](#) recursively to find the size of containers and all their contents.

`sys.getswitchinterval()`

Return the interpreter's "thread switch interval"; see [setswitchinterval\(\)](#).

在 3.2 版新加入。

`sys._getframe([depth])`

Return a frame object from the call stack. If optional integer *depth* is given, return the frame object that many calls below the top of the stack. If that is deeper than the call stack, *ValueError* is raised. The default for *depth* is zero, returning the frame at the top of the call stack.

引發一個附帶引數 *frame* 的稽核事件 `sys._getframe`。

CPython 實作細節: This function should be used for internal and specialized purposes only. It is not guaranteed to exist in all implementations of Python.

`sys.getprofile()`

Get the profiler function as set by `setprofile()`.

`sys.gettrace()`

Get the trace function as set by `settrace()`.

CPython 實作細節： The `gettrace()` function is intended only for implementing debuggers, profilers, coverage tools and the like. Its behavior is part of the implementation platform, rather than part of the language definition, and thus may not be available in all Python implementations.

`sys.getwindowsversion()`

Return a named tuple describing the Windows version currently running. The named elements are *major*, *minor*, *build*, *platform*, *service_pack*, *service_pack_minor*, *service_pack_major*, *suite_mask*, *product_type* and *platform_version*. *service_pack* contains a string, *platform_version* a 3-tuple and all other values are integers. The components can also be accessed by name, so `sys.getwindowsversion()[0]` is equivalent to `sys.getwindowsversion().major`. For compatibility with prior versions, only the first 5 elements are retrievable by indexing.

platform will be 2 (VER_PLATFORM_WIN32_NT).

product_type may be one of the following values:

Constant	Meaning
1 (VER_NT_WORKSTATION)	The system is a workstation.
2 (VER_NT_DOMAIN_CONTROLLER)	The system is a domain controller.
3 (VER_NT_SERVER)	The system is a server, but not a domain controller.

This function wraps the Win32 `GetVersionEx()` function; see the Microsoft documentation on `OSVERSIONINFOEX()` for more information about these fields.

platform_version returns the major version, minor version and build number of the current operating system, rather than the version that is being emulated for the process. It is intended for use in logging rather than for feature detection.

備註： *platform_version* derives the version from `kernel32.dll` which can be of a different version than the OS version. Please use `platform` module for achieving accurate OS version.

適用：Windows。

在 3.2 版的變更: Changed to a named tuple and added *service_pack_minor*, *service_pack_major*, *suite_mask*, and *product_type*.

在 3.6 版的變更: 新增 *platform_version*

`sys.get_asyncgen_hooks()`

Returns an *asyncgen_hooks* object, which is similar to a *namedtuple* of the form (*firstiter*, *finalizer*), where *firstiter* and *finalizer* are expected to be either `None` or functions which take an *asynchronous generator iterator* as an argument, and are used to schedule finalization of an asynchronous generator by an event loop.

在 3.6 版新加入: 更多細節請見 **PEP 525**。

備註： This function has been added on a provisional basis (see **PEP 411** for details.)

`sys.get_coroutine_origin_tracking_depth()`

Get the current coroutine origin tracking depth, as set by `set_coroutine_origin_tracking_depth()`.

在 3.7 版新加入。

備註: This function has been added on a provisional basis (see [PEP 411](#) for details.) Use it only for debugging purposes.

`sys.hash_info`

A *named tuple* giving parameters of the numeric hash implementation. For more details about hashing of numeric types, see *Hashing of numeric types*.

`hash_info.width`

The width in bits used for hash values

`hash_info.modulus`

The prime modulus P used for numeric hash scheme

`hash_info.inf`

The hash value returned for a positive infinity

`hash_info.nan`

(This attribute is no longer used)

`hash_info.imag`

The multiplier used for the imaginary part of a complex number

`hash_info.algorithm`

The name of the algorithm for hashing of str, bytes, and memoryview

`hash_info.hash_bits`

The internal output size of the hash algorithm

`hash_info.seed_bits`

The size of the seed key of the hash algorithm

在 3.2 版新加入。

在 3.4 版的變更: 新增 *algorithm*、*hash_bits* 與 *seed_bits*

`sys.hexversion`

The version number encoded as a single integer. This is guaranteed to increase with each version, including proper support for non-production releases. For example, to test that the Python interpreter is at least version 1.5.2, use:

```
if sys.hexversion >= 0x010502F0:
    # use some advanced feature
    ...
else:
    # use an alternative implementation or warn the user
    ...
```

This is called `hexversion` since it only really looks meaningful when viewed as the result of passing it to the built-in `hex()` function. The *named tuple* `sys.version_info` may be used for a more human-friendly encoding of the same information.

More details of `hexversion` can be found at [apiabiversion](#).

`sys.implementation`

An object containing information about the implementation of the currently running Python interpreter. The following attributes are required to exist in all Python implementations.

name is the implementation's identifier, e.g. 'cpython'. The actual string is defined by the Python implementation, but it is guaranteed to be lower case.

version is a named tuple, in the same format as `sys.version_info`. It represents the version of the Python *implementation*. This has a distinct meaning from the specific version of the Python *language* to which the currently running interpreter conforms, which `sys.version_info` represents. For example, for PyPy 1.8

`sys.implementation.version` might be `sys.version_info(1, 8, 0, 'final', 0)`, whereas `sys.version_info` would be `sys.version_info(2, 7, 2, 'final', 0)`. For CPython they are the same value, since it is the reference implementation.

`hexversion` is the implementation version in hexadecimal format, like `sys.hexversion`.

`cache_tag` is the tag used by the import machinery in the filenames of cached modules. By convention, it would be a composite of the implementation's name and version, like `'cpython-33'`. However, a Python implementation may use some other value if appropriate. If `cache_tag` is set to `None`, it indicates that module caching should be disabled.

`sys.implementation` may contain additional attributes specific to the Python implementation. These non-standard attributes must start with an underscore, and are not described here. Regardless of its contents, `sys.implementation` will not change during a run of the interpreter, nor between implementation versions. (It may change between Python language versions, however.) See [PEP 421](#) for more information.

在 3.3 版新加入。

備 F: The addition of new required attributes must go through the normal PEP process. See [PEP 421](#) for more information.

`sys.int_info`

A *named tuple* that holds information about Python's internal representation of integers. The attributes are read only.

`int_info.bits_per_digit`

The number of bits held in each digit. Python integers are stored internally in base $2^{**int_info.bits_per_digit}$.

`int_info.sizeof_digit`

The size in bytes of the C type used to represent a digit.

`int_info.default_max_str_digits`

The default value for `sys.get_int_max_str_digits()` when it is not otherwise explicitly configured.

`int_info.str_digits_check_threshold`

The minimum non-zero value for `sys.set_int_max_str_digits()`, `PYTHONINTMAXSTRDIGITS`, or `-X int_max_str_digits`.

在 3.1 版新加入。

在 3.11 版的變更: Added `default_max_str_digits` and `str_digits_check_threshold`.

`sys.__interactivehook__`

When this attribute exists, its value is automatically called (with no arguments) when the interpreter is launched in interactive mode. This is done after the `PYTHONSTARTUP` file is read, so that you can set this hook there. The `site` module *sets this*.

引發一個附帶引數 `hook` 的稽核事件 `cpython.run_interactivehook`。

在 3.4 版新加入。

`sys.intern(string)`

Enter *string* in the table of "interned" strings and return the interned string -- which is *string* itself or a copy. Interning strings is useful to gain a little performance on dictionary lookup -- if the keys in a dictionary are interned, and the lookup key is interned, the key comparisons (after hashing) can be done by a pointer compare instead of a string compare. Normally, the names used in Python programs are automatically interned, and the dictionaries used to hold module, class or instance attributes have interned keys.

Interned strings are not immortal; you must keep a reference to the return value of `intern()` around to benefit from it.

`sys.is_finalizing()`

Return *True* if the Python interpreter is *shutting down*, *False* otherwise.

在 3.5 版新加入。

`sys.last_type`

`sys.last_value`

`sys.last_traceback`

These three variables are not always defined; they are set when an exception is not handled and the interpreter prints an error message and a stack traceback. Their intended use is to allow an interactive user to import a debugger module and engage in post-mortem debugging without having to re-execute the command that caused the error. (Typical use is `import pdb; pdb.pm()` to enter the post-mortem debugger; see *pdb* module for more information.)

The meaning of the variables is the same as that of the return values from *exc_info()* above.

`sys.maxsize`

An integer giving the maximum value a variable of type `Py_ssize_t` can take. It's usually $2^{31} - 1$ on a 32-bit platform and $2^{63} - 1$ on a 64-bit platform.

`sys.maxunicode`

An integer giving the value of the largest Unicode code point, i.e. 1114111 (0x10FFFF in hexadecimal).

在 3.3 版的變更: Before **PEP 393**, `sys.maxunicode` used to be either 0xFFFF or 0x10FFFF, depending on the configuration option that specified whether Unicode characters were stored as UCS-2 or UCS-4.

`sys.meta_path`

A list of *meta path finder* objects that have their *find_spec()* methods called to see if one of the objects can find the module to be imported. By default, it holds entries that implement Python's default import semantics. The *find_spec()* method is called with at least the absolute name of the module being imported. If the module to be imported is contained in a package, then the parent package's `__path__` attribute is passed in as a second argument. The method returns a *module spec*, or *None* if the module cannot be found.

也參考:

`importlib.abc.MetaPathFinder`

The abstract base class defining the interface of finder objects on *meta_path*.

`importlib.machinery.ModuleSpec`

The concrete class which *find_spec()* should return instances of.

在 3.4 版的變更: *Module specs* were introduced in Python 3.4, by **PEP 451**. Earlier versions of Python looked for a method called *find_module()*. This is still called as a fallback if a *meta_path* entry doesn't have a *find_spec()* method.

`sys.modules`

This is a dictionary that maps module names to modules which have already been loaded. This can be manipulated to force reloading of modules and other tricks. However, replacing the dictionary will not necessarily work as expected and deleting essential items from the dictionary may cause Python to fail. If you want to iterate over this global dictionary always use `sys.modules.copy()` or `tuple(sys.modules)` to avoid exceptions as its size may change during iteration as a side effect of code or activity in other threads.

`sys.orig_argv`

The list of the original command line arguments passed to the Python executable.

The elements of `sys.orig_argv` are the arguments to the Python interpreter, while the elements of `sys.argv` are the arguments to the user's program. Arguments consumed by the interpreter itself will be present in `sys.orig_argv` and missing from `sys.argv`.

在 3.10 版新加入。

sys.path

A list of strings that specifies the search path for modules. Initialized from the environment variable PYTHONPATH, plus an installation-dependent default.

By default, as initialized upon program startup, a potentially unsafe path is prepended to `sys.path` (before the entries inserted as a result of PYTHONPATH):

- `python -m module` command line: prepend the current working directory.
- `python script.py` command line: prepend the script's directory. If it's a symbolic link, resolve symbolic links.
- `python -c code` and `python` (REPL) command lines: prepend an empty string, which means the current working directory.

To not prepend this potentially unsafe path, use the `-P` command line option or the PYTHONSAFEPATH environment variable.

A program is free to modify this list for its own purposes. Only strings should be added to `sys.path`; all other data types are ignored during import.

也參考:

- Module `site` This describes how to use .pth files to extend `sys.path`.

sys.path_hooks

A list of callables that take a path argument to try to create a *finder* for the path. If a finder can be created, it is to be returned by the callable, else raise `ImportError`.

Originally specified in **PEP 302**.

sys.path_importer_cache

A dictionary acting as a cache for *finder* objects. The keys are paths that have been passed to `sys.path_hooks` and the values are the finders that are found. If a path is a valid file system path but no finder is found on `sys.path_hooks` then `None` is stored.

Originally specified in **PEP 302**.

在 3.3 版的變更: `None` is stored instead of `imp.NullImporter` when no finder is found.

sys.platform

This string contains a platform identifier that can be used to append platform-specific components to `sys.path`, for instance.

For Unix systems, except on Linux and AIX, this is the lowercased OS name as returned by `uname -s` with the first part of the version as returned by `uname -r` appended, e.g. 'sunos5' or 'freebsd8', *at the time when Python was built*. Unless you want to test for a specific system version, it is therefore recommended to use the following idiom:

```
if sys.platform.startswith('freebsd'):
    # FreeBSD-specific code here...
elif sys.platform.startswith('linux'):
    # Linux-specific code here...
elif sys.platform.startswith('aix'):
    # AIX-specific code here...
```

For other systems, the values are:

System	platform value
AIX	'aix'
Emscripten	'emscripten'
Linux	'linux'
WASI	'wasi'
Windows	'win32'
Windows/Cygwin	'cygwin'
macOS	'darwin'

在 3.3 版的變更: On Linux, `sys.platform` doesn't contain the major version anymore. It is always 'linux', instead of 'linux2' or 'linux3'. Since older Python versions include the version number, it is recommended to always use the `startswith` idiom presented above.

在 3.8 版的變更: On AIX, `sys.platform` doesn't contain the major version anymore. It is always 'aix', instead of 'aix5' or 'aix7'. Since older Python versions include the version number, it is recommended to always use the `startswith` idiom presented above.

也參考:

`os.name` has a coarser granularity. `os.uname()` gives system-dependent version information.

The `platform` module provides detailed checks for the system's identity.

`sys.platlibdir`

Name of the platform-specific library directory. It is used to build the path of standard library and the paths of installed extension modules.

It is equal to "lib" on most platforms. On Fedora and SuSE, it is equal to "lib64" on 64-bit platforms which gives the following `sys.path` paths (where X.Y is the Python major.minor version):

- `/usr/lib64/pythonX.Y/`: Standard library (like `os.py` of the `os` module)
- `/usr/lib64/pythonX.Y/lib-dynload/`: C extension modules of the standard library (like the `errno` module, the exact filename is platform specific)
- `/usr/lib/pythonX.Y/site-packages/` (always use `lib`, not `sys.platlibdir`): Third-party modules
- `/usr/lib64/pythonX.Y/site-packages/`: C extension modules of third-party packages

在 3.9 版新加入.

`sys.prefix`

A string giving the site-specific directory prefix where the platform independent Python files are installed; on Unix, the default is `/usr/local`. This can be set at build time with the `--prefix` argument to the `configure` script. See [Installation paths](#) for derived paths.

備註: If a *virtual environment* is in effect, this value will be changed in `site.py` to point to the virtual environment. The value for the Python installation will still be available, via `base_prefix`.

`sys.ps1`

`sys.ps2`

Strings specifying the primary and secondary prompt of the interpreter. These are only defined if the interpreter is in interactive mode. Their initial values in this case are '`>>>`' and '`...`'. If a non-string object is assigned to either variable, its `str()` is re-evaluated each time the interpreter prepares to read a new interactive command; this can be used to implement a dynamic prompt.

`sys.setdlopenflags(n)`

Set the flags used by the interpreter for `dlopen()` calls, such as when the interpreter loads extension modules. Among other things, this will enable a lazy resolving of symbols when importing a module,

if called as `sys.setdlopenflags(0)`. To share symbols across extension modules, call as `sys.setdlopenflags(os.RTLD_GLOBAL)`. Symbolic names for the flag values can be found in the `os` module (`RTLD_XXX` constants, e.g. `os.RTLD_LAZY`).

適用：Unix。

`sys.set_int_max_str_digits(maxdigits)`

Set the *integer string conversion length limitation* used by this interpreter. See also `get_int_max_str_digits()`.

在 3.11 版新加入。

`sys.setprofile(profilefunc)`

Set the system's profile function, which allows you to implement a Python source code profiler in Python. See chapter *The Python Profilers* for more information on the Python profiler. The system's profile function is called similarly to the system's trace function (see `settrace()`), but it is called with different events, for example it isn't called for each executed line of code (only on call and return, but the return event is reported even when an exception has been set). The function is thread-specific, but there is no way for the profiler to know about context switches between threads, so it does not make sense to use this in the presence of multiple threads. Also, its return value is not used, so it can simply return `None`. Error in the profile function will cause itself unset.

備 F: The same tracing mechanism is used for `setprofile()` as `settrace()`. To trace calls with `setprofile()` inside a tracing function (e.g. in a debugger breakpoint), see `call_tracing()`.

Profile functions should have three arguments: *frame*, *event*, and *arg*. *frame* is the current stack frame. *event* is a string: `'call'`, `'return'`, `'c_call'`, `'c_return'`, or `'c_exception'`. *arg* depends on the event type.

The events have the following meaning:

'call'

A function is called (or some other code block entered). The profile function is called; *arg* is `None`.

'return'

A function (or other code block) is about to return. The profile function is called; *arg* is the value that will be returned, or `None` if the event is caused by an exception being raised.

'c_call'

A C function is about to be called. This may be an extension function or a built-in. *arg* is the C function object.

'c_return'

A C function has returned. *arg* is the C function object.

'c_exception'

A C function has raised an exception. *arg* is the C function object.

引發一個不附帶引數的稽核事件 `sys.setprofile`。

`sys.setrecursionlimit(limit)`

Set the maximum depth of the Python interpreter stack to *limit*. This limit prevents infinite recursion from causing an overflow of the C stack and crashing Python.

The highest possible limit is platform-dependent. A user may need to set the limit higher when they have a program that requires deep recursion and a platform that supports a higher limit. This should be done with care, because a too-high limit can lead to a crash.

If the new limit is too low at the current recursion depth, a `RecursionError` exception is raised.

在 3.5.1 版的變更: A `RecursionError` exception is now raised if the new limit is too low at the current recursion depth.

`sys.setswitchinterval(interval)`

Set the interpreter's thread switch interval (in seconds). This floating-point value determines the ideal duration of the "timeslices" allocated to concurrently running Python threads. Please note that the actual value can be higher, especially if long-running internal functions or methods are used. Also, which thread becomes scheduled at the end of the interval is the operating system's decision. The interpreter doesn't have its own scheduler.

在 3.2 版新加入。

`sys.settrace(tracefunc)`

Set the system's trace function, which allows you to implement a Python source code debugger in Python. The function is thread-specific; for a debugger to support multiple threads, it must register a trace function using `settrace()` for each thread being debugged or use `threading.settrace()`.

Trace functions should have three arguments: *frame*, *event*, and *arg*. *frame* is the current stack frame. *event* is a string: 'call', 'line', 'return', 'exception' or 'opcode'. *arg* depends on the event type.

The trace function is invoked (with *event* set to 'call') whenever a new local scope is entered; it should return a reference to a local trace function to be used for the new scope, or `None` if the scope shouldn't be traced.

The local trace function should return a reference to itself, or to another function which would then be used as the local trace function for the scope.

If there is any error occurred in the trace function, it will be unset, just like `settrace(None)` is called.

備註: Tracing is disabled while calling the trace function (e.g. a function set by `settrace()`). For recursive tracing see `call_tracing()`.

The events have the following meaning:

'call'

A function is called (or some other code block entered). The global trace function is called; *arg* is `None`; the return value specifies the local trace function.

'line'

The interpreter is about to execute a new line of code or re-execute the condition of a loop. The local trace function is called; *arg* is `None`; the return value specifies the new local trace function. See `Objects/lnotab_notes.txt` for a detailed explanation of how this works. Per-line events may be disabled for a frame by setting `f_trace_lines` to `False` on that frame.

'return'

A function (or other code block) is about to return. The local trace function is called; *arg* is the value that will be returned, or `None` if the event is caused by an exception being raised. The trace function's return value is ignored.

'exception'

An exception has occurred. The local trace function is called; *arg* is a tuple (exception, value, traceback); the return value specifies the new local trace function.

'opcode'

The interpreter is about to execute a new opcode (see `dis` for opcode details). The local trace function is called; *arg* is `None`; the return value specifies the new local trace function. Per-opcode events are not emitted by default: they must be explicitly requested by setting `f_trace_opcodes` to `True` on the frame.

Note that as an exception is propagated down the chain of callers, an 'exception' event is generated at each level.

For more fine-grained usage, it's possible to set a trace function by assigning `frame.f_trace = tracefunc` explicitly, rather than relying on it being set indirectly via the return value from an already installed trace function. This is also required for activating the trace function on the current frame, which

`settrace()` doesn't do. Note that in order for this to work, a global tracing function must have been installed with `settrace()` in order to enable the runtime tracing machinery, but it doesn't need to be the same tracing function (e.g. it could be a low overhead tracing function that simply returns `None` to disable itself immediately on each frame).

For more information on code and frame objects, refer to types.

Raises an *auditing event* `sys.settrace` with no arguments.

CPython 實作細節： The `settrace()` function is intended only for implementing debuggers, profilers, coverage tools and the like. Its behavior is part of the implementation platform, rather than part of the language definition, and thus may not be available in all Python implementations.

在 3.7 版的變更: 'opcode' event type added; `f_trace_lines` and `f_trace_opcodes` attributes added to frames

`sys.set_asyncgen_hooks([firstiter], [finalizer])`

Accepts two optional keyword arguments which are callables that accept an *asynchronous generator iterator* as an argument. The *firstiter* callable will be called when an asynchronous generator is iterated for the first time. The *finalizer* will be called when an asynchronous generator is about to be garbage collected.

引發一個不附帶引數的稽核事件 `sys.set_asyncgen_hooks_firstiter`.

引發一個不附帶引數的稽核事件 `sys.set_asyncgen_hooks_finalizer`.

Two auditing events are raised because the underlying API consists of two calls, each of which must raise its own event.

在 3.6 版新加入: See **PEP 525** for more details, and for a reference example of a *finalizer* method see the implementation of `asyncio.Loop.shutdown_asyncgens` in `Lib/asyncio/base_events.py`

備[Ⓔ]: This function has been added on a provisional basis (see **PEP 411** for details.)

`sys.set_coroutine_origin_tracking_depth(depth)`

Allows enabling or disabling coroutine origin tracking. When enabled, the `cr_origin` attribute on coroutine objects will contain a tuple of (filename, line number, function name) tuples describing the traceback where the coroutine object was created, with the most recent call first. When disabled, `cr_origin` will be `None`.

To enable, pass a *depth* value greater than zero; this sets the number of frames whose information will be captured. To disable, pass set *depth* to zero.

This setting is thread-specific.

在 3.7 版新加入.

備[Ⓔ]: This function has been added on a provisional basis (see **PEP 411** for details.) Use it only for debugging purposes.

`sys._enablelegacywindowsfsencoding()`

Changes the *filesystem encoding and error handler* to 'mbcs' and 'replace' respectively, for consistency with versions of Python prior to 3.6.

This is equivalent to defining the `PYTHONLEGACYWINDOWSFSENCODING` environment variable before launching Python.

See also `sys.getfilesystemencoding()` and `sys.getfilesystemencodeerrors()`.

適用: Windows。

在 3.6 版新加入: 更多細節請見 **PEP 529**。

`sys.stdin`

`sys.stdout`

sys.stderr

File objects used by the interpreter for standard input, output and errors:

- `stdin` is used for all interactive input (including calls to `input()`);
- `stdout` is used for the output of `print()` and *expression* statements and for the prompts of `input()`;
- The interpreter's own prompts and its error messages go to `stderr`.

These streams are regular *text files* like those returned by the `open()` function. Their parameters are chosen as follows:

- The encoding and error handling are initialized from `PyConfig.stdio_encoding` and `PyConfig.stdio_errors`.

On Windows, UTF-8 is used for the console device. Non-character devices such as disk files and pipes use the system locale encoding (i.e. the ANSI codepage). Non-console character devices such as NUL (i.e. where `isatty()` returns `True`) use the value of the console input and output codepages at startup, respectively for `stdin` and `stdout/stderr`. This defaults to the system *locale encoding* if the process is not initially attached to a console.

The special behaviour of the console can be overridden by setting the environment variable `PYTHONLEGACYWINDOWSSTDIO` before starting Python. In that case, the console codepages are used as for any other character device.

Under all platforms, you can override the character encoding by setting the `PYTHONIOENCODING` environment variable before starting Python or by using the new `-X utf8` command line option and `PYTHONUTF8` environment variable. However, for the Windows console, this only applies when `PYTHONLEGACYWINDOWSSTDIO` is also set.

- When interactive, the `stdout` stream is line-buffered. Otherwise, it is block-buffered like regular text files. The `stderr` stream is line-buffered in both cases. You can make both streams unbuffered by passing the `-u` command-line option or setting the `PYTHONUNBUFFERED` environment variable.

在 3.9 版的變更: Non-interactive `stderr` is now line-buffered instead of fully buffered.

備 F: To write or read binary data from/to the standard streams, use the underlying binary *buffer* object. For example, to write bytes to `stdout`, use `sys.stdout.buffer.write(b'abc')`.

However, if you are writing a library (and do not control in which context its code will be executed), be aware that the standard streams may be replaced with file-like objects like `io.StringIO` which do not support the `buffer` attribute.

sys.__stdin__**sys.__stdout__****sys.__stderr__**

These objects contain the original values of `stdin`, `stderr` and `stdout` at the start of the program. They are used during finalization, and could be useful to print to the actual standard stream no matter if the `sys.std*` object has been redirected.

It can also be used to restore the actual files to known working file objects in case they have been overwritten with a broken object. However, the preferred way to do this is to explicitly save the previous stream before replacing it, and restore the saved object.

備 F: Under some conditions `stdin`, `stdout` and `stderr` as well as the original values `__stdin__`, `__stdout__` and `__stderr__` can be `None`. It is usually the case for Windows GUI apps that aren't connected to a console and Python apps started with `pythonw`.

sys.stdlib_module_names

A frozenset of strings containing the names of standard library modules.

It is the same on all platforms. Modules which are not available on some platforms and modules disabled at Python build are also listed. All module kinds are listed: pure Python, built-in, frozen and extension modules. Test modules are excluded.

For packages, only the main package is listed: sub-packages and sub-modules are not listed. For example, the `email` package is listed, but the `email.mime` sub-package and the `email.message` sub-module are not listed.

See also the `sys.builtin_module_names` list.

在 3.10 版新加入.

`sys.thread_info`

A *named tuple* holding information about the thread implementation.


`thread_info.name`

The name of the thread implementation:

- `"nt"`: Windows threads
- `"pthread"`: POSIX threads
- `"pthread-stubs"`: stub POSIX threads (on WebAssembly platforms without threading support)
- `"solaris"`: Solaris threads

`thread_info.lock`

The name of the lock implementation:

- `"semaphore"`: a lock uses a semaphore
- `"mutex+cond"`: a lock uses a mutex and a condition variable
-  `None` 表示此資訊未知

`thread_info.version`

The name and version of the thread library. It is a string, or `None` if this information is unknown.

在 3.3 版新加入.

`sys.tracebacklimit`

When this variable is set to an integer value, it determines the maximum number of levels of traceback information printed when an unhandled exception occurs. The default is 1000. When set to 0 or less, all traceback information is suppressed and only the exception type and value are printed.

`sys.unraisablehook` (*unraisable*, /)

處理一個不可被引發的例外。

Called when an exception has occurred but there is no way for Python to handle it. For example, when a destructor raises an exception or during garbage collection (`gc.collect()`).

The *unraisable* argument has the following attributes:

- `exc_type`: Exception type.
- `exc_value`: Exception value, can be `None`.
- `exc_traceback`: Exception traceback, can be `None`.
- `err_msg`: Error message, can be `None`.
- `object`: Object causing the exception, can be `None`.

The default hook formats `err_msg` and `object` as: `f'{err_msg}: {object!r}'`; use "Exception ignored in" error message if `err_msg` is `None`.

`sys.unraisablehook()` can be overridden to control how unraisable exceptions are handled.

也參考:

`excepthook()` which handles uncaught exceptions.

警告: Storing `exc_value` using a custom hook can create a reference cycle. It should be cleared explicitly to break the reference cycle when the exception is no longer needed.

Storing `object` using a custom hook can resurrect it if it is set to an object which is being finalized. Avoid storing `object` after the custom hook completes to avoid resurrecting objects.

Raise an auditing event `sys.unraisablehook` with arguments *hook*, *unraisable* when an exception that cannot be handled occurs. The *unraisable* object is the same as what will be passed to the hook. If no hook has been set, *hook* may be `None`.

在 3.8 版新加入。

`sys.version`

A string containing the version number of the Python interpreter plus additional information on the build number and compiler used. This string is displayed when the interactive interpreter is started. Do not extract version information out of it, rather, use `version_info` and the functions provided by the `platform` module.

`sys.api_version`

The C API version for this interpreter. Programmers may find this useful when debugging version conflicts between Python and extension modules.

`sys.version_info`

A tuple containing the five components of the version number: *major*, *minor*, *micro*, *releaselevel*, and *serial*. All values except *releaselevel* are integers; the release level is 'alpha', 'beta', 'candidate', or 'final'. The `version_info` value corresponding to the Python version 2.0 is (2, 0, 0, 'final', 0). The components can also be accessed by name, so `sys.version_info[0]` is equivalent to `sys.version_info.major` and so on.

在 3.1 版的變更: 新增了附名的元件屬性。

`sys.warnoptions`

This is an implementation detail of the warnings framework; do not modify this value. Refer to the `warnings` module for more information on the warnings framework.

`sys.winver`

The version number used to form registry keys on Windows platforms. This is stored as string resource 1000 in the Python DLL. The value is normally the major and minor versions of the running Python interpreter. It is provided in the `sys` module for informational purposes; modifying this value has no effect on the registry keys used by Python.

適用: Windows。

`sys._xoptions`

A dictionary of the various implementation-specific flags passed through the `-X` command-line option. Option names are either mapped to their values, if given explicitly, or to `True`. Example:

```
$ ./python -Xa=b -Xc
Python 3.2a3+ (py3k, Oct 16 2010, 20:14:50)
[GCC 4.4.3] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import sys
>>> sys._xoptions
{'a': 'b', 'c': True}
```


CPython 實作細節： This is a CPython-specific way of accessing options passed through `-X`. Other implementations may export them through other means, or not at all.

在 3.2 版新加入.

引用

29.2 `sysconfig` --- Provide access to Python's configuration information

在 3.2 版新加入.

原始碼: `Lib/sysconfig.py`

The `sysconfig` module provides access to Python's configuration information like the list of installation paths and the configuration variables relevant for the current platform.

29.2.1 Configuration variables

A Python distribution contains a `Makefile` and a `pyconfig.h` header file that are necessary to build both the Python binary itself and third-party C extensions compiled using `distutils`.

`sysconfig` puts all variables found in these files in a dictionary that can be accessed using `get_config_vars()` or `get_config_var()`.

Notice that on Windows, it's a much smaller set.

`sysconfig.get_config_vars(*args)`

With no arguments, return a dictionary of all configuration variables relevant for the current platform.

With arguments, return a list of values that result from looking up each argument in the configuration variable dictionary.

For each argument, if the value is not found, return `None`.

`sysconfig.get_config_var(name)`

Return the value of a single variable `name`. Equivalent to `get_config_vars().get(name)`.

If `name` is not found, return `None`.

用法範例：

```
>>> import sysconfig
>>> sysconfig.get_config_var('Py_ENABLE_SHARED')
0
>>> sysconfig.get_config_var('LIBDIR')
'/usr/local/lib'
>>> sysconfig.get_config_vars('AR', 'CXX')
['ar', 'g++']
```


29.2.2 Installation paths

Python uses an installation scheme that differs depending on the platform and on the installation options. These schemes are stored in `sysconfig` under unique identifiers based on the value returned by `os.name`. The schemes are used by package installers to determine where to copy files to.

Python currently supports nine schemes:

- `posix_prefix`: scheme for POSIX platforms like Linux or macOS. This is the default scheme used when Python or a component is installed.
- `posix_home`: scheme for POSIX platforms, when the `home` option is used. This scheme defines paths located under a specific home prefix.
- `posix_user`: scheme for POSIX platforms, when the `user` option is used. This scheme defines paths located under the user's home directory (`site.USER_BASE`).
- `posix_venv`: scheme for *Python virtual environments* on POSIX platforms; by default it is the same as `posix_prefix`.
- `nt`: scheme for Windows. This is the default scheme used when Python or a component is installed.
- `nt_user`: scheme for Windows, when the `user` option is used.
- `nt_venv`: scheme for *Python virtual environments* on Windows; by default it is the same as `nt`.
- `venv`: a scheme with values from either `posix_venv` or `nt_venv` depending on the platform Python runs on.
- `osx_framework_user`: scheme for macOS, when the `user` option is used.

Each scheme is itself composed of a series of paths and each path has a unique identifier. Python currently uses eight paths:

- `stdlib`: directory containing the standard Python library files that are not platform-specific.
- `platstdlib`: directory containing the standard Python library files that are platform-specific.
- `platlib`: directory for site-specific, platform-specific files.
- `purelib`: directory for site-specific, non-platform-specific files ('pure' Python).
- `include`: directory for non-platform-specific header files for the Python C-API.
- `platinclude`: directory for platform-specific header files for the Python C-API.
- `scripts`: directory for script files.
- `data`: directory for data files.

29.2.3 User scheme

This scheme is designed to be the most convenient solution for users that don't have write permission to the global site-packages directory or don't want to install into it.

Files will be installed into subdirectories of `site.USER_BASE` (written as `userbase` hereafter). This scheme installs pure Python modules and extension modules in the same location (also known as `site.USER_SITE`).

posix_user

Path	Installation directory
<i>stdlib</i>	<i>userbase/lib/pythonX.Y</i>
<i>platstdlib</i>	<i>userbase/lib/pythonX.Y</i>
<i>platlib</i>	<i>userbase/lib/pythonX.Y/site-packages</i>
<i>purelib</i>	<i>userbase/lib/pythonX.Y/site-packages</i>
<i>include</i>	<i>userbase/include/pythonX.Y</i>
<i>scripts</i>	<i>userbase/bin</i>
<i>data</i>	<i>userbase</i>

nt_user

Path	Installation directory
<i>stdlib</i>	<i>userbase\PythonXY</i>
<i>platstdlib</i>	<i>userbase\PythonXY</i>
<i>platlib</i>	<i>userbase\PythonXY\site-packages</i>
<i>purelib</i>	<i>userbase\PythonXY\site-packages</i>
<i>include</i>	<i>userbase\PythonXY\Include</i>
<i>scripts</i>	<i>userbase\PythonXY\Scripts</i>
<i>data</i>	<i>userbase</i>

osx_framework_user

Path	Installation directory
<i>stdlib</i>	<i>userbase/lib/python</i>
<i>platstdlib</i>	<i>userbase/lib/python</i>
<i>platlib</i>	<i>userbase/lib/python/site-packages</i>
<i>purelib</i>	<i>userbase/lib/python/site-packages</i>
<i>include</i>	<i>userbase/include/pythonX.Y</i>
<i>scripts</i>	<i>userbase/bin</i>
<i>data</i>	<i>userbase</i>

29.2.4 Home scheme

The idea behind the “home scheme” is that you build and maintain a personal stash of Python modules. This scheme’s name is derived from the idea of a “home” directory on Unix, since it’s not unusual for a Unix user to make their home directory have a layout similar to `/usr/` or `/usr/local/`. This scheme can be used by anyone, regardless of the operating system they are installing for.

posix_home

Path	Installation directory
<i>stdlib</i>	<i>home/lib/python</i>
<i>platstdlib</i>	<i>home/lib/python</i>
<i>platlib</i>	<i>home/lib/python</i>
<i>purelib</i>	<i>home/lib/python</i>
<i>include</i>	<i>home/include/python</i>
<i>platinclude</i>	<i>home/include/python</i>
<i>scripts</i>	<i>home/bin</i>
<i>data</i>	<i>home</i>

29.2.5 Prefix scheme

The “prefix scheme” is useful when you wish to use one Python installation to perform the build/install (i.e., to run the setup script), but install modules into the third-party module directory of a different Python installation (or something that looks like a different Python installation). If this sounds a trifle unusual, it is---that’s why the user and home schemes come before. However, there are at least two known cases where the prefix scheme will be useful.

First, consider that many Linux distributions put Python in `/usr`, rather than the more traditional `/usr/local`. This is entirely appropriate, since in those cases Python is part of “the system” rather than a local add-on. However, if you are installing Python modules from source, you probably want them to go in `/usr/local/lib/python2.X` rather than `/usr/lib/python2.X`.

Another possibility is a network filesystem where the name used to write to a remote directory is different from the name used to read it: for example, the Python interpreter accessed as `/usr/local/bin/python` might search for modules in `/usr/local/lib/python2.X`, but those modules would have to be installed to, say, `/mnt/@server/export/lib/python2.X`.

posix_prefix

Path	Installation directory
<i>stdlib</i>	<i>prefix/lib/pythonX.Y</i>
<i>platstdlib</i>	<i>prefix/lib/pythonX.Y</i>
<i>platlib</i>	<i>prefix/lib/pythonX.Y/site-packages</i>
<i>purelib</i>	<i>prefix/lib/pythonX.Y/site-packages</i>
<i>include</i>	<i>prefix/include/pythonX.Y</i>
<i>platinclude</i>	<i>prefix/include/pythonX.Y</i>
<i>scripts</i>	<i>prefix/bin</i>
<i>data</i>	<i>prefix</i>

`nt`

Path	Installation directory
<i>stdlib</i>	<i>prefix</i> \Lib
<i>platstdlib</i>	<i>prefix</i> \Lib
<i>platlib</i>	<i>prefix</i> \Lib\site-packages
<i>purelib</i>	<i>prefix</i> \Lib\site-packages
<i>include</i>	<i>prefix</i> \Include
<i>platinclude</i>	<i>prefix</i> \Include
<i>scripts</i>	<i>prefix</i> \Scripts
<i>data</i>	<i>prefix</i>

29.2.6 Installation path functions

`sysconfig` provides some functions to determine these installation paths.

`sysconfig.get_scheme_names()`

Return a tuple containing all schemes currently supported in `sysconfig`.

`sysconfig.get_default_scheme()`

Return the default scheme name for the current platform.

在 3.10 版新加入: This function was previously named `_get_default_scheme()` and considered an implementation detail.

在 3.11 版的變更: When Python runs from a virtual environment, the `venv` scheme is returned.

`sysconfig.get_preferred_scheme(key)`

Return a preferred scheme name for an installation layout specified by `key`.

`key` must be either "prefix", "home", or "user".

The return value is a scheme name listed in `get_scheme_names()`. It can be passed to `sysconfig` functions that take a `scheme` argument, such as `get_paths()`.

在 3.10 版新加入.

在 3.11 版的變更: When Python runs from a virtual environment and `key="prefix"`, the `venv` scheme is returned.

`sysconfig._get_preferred_schemes()`

Return a dict containing preferred scheme names on the current platform. Python implementers and redistributors may add their preferred schemes to the `_INSTALL_SCHEMES` module-level global value, and modify this function to return those scheme names, to e.g. provide different schemes for system and language package managers to use, so packages installed by either do not mix with those by the other.

End users should not use this function, but `get_default_scheme()` and `get_preferred_scheme()` instead.

在 3.10 版新加入.

`sysconfig.get_path_names()`

Return a tuple containing all path names currently supported in `sysconfig`.

`sysconfig.get_path(name[, scheme[, vars[, expand]]])`

Return an installation path corresponding to the path `name`, from the install scheme named `scheme`.

`name` has to be a value from the list returned by `get_path_names()`.

`sysconfig` stores installation paths corresponding to each path name, for each platform, with variables to be expanded. For instance the `stdlib` path for the `nt` scheme is: `{base}/Lib`.

`get_path()` will use the variables returned by `get_config_vars()` to expand the path. All variables have default values for each platform so one may call this function and get the default value.

If *scheme* is provided, it must be a value from the list returned by `get_scheme_names()`. Otherwise, the default scheme for the current platform is used.

If *vars* is provided, it must be a dictionary of variables that will update the dictionary returned by `get_config_vars()`.

If *expand* is set to `False`, the path will not be expanded using the variables.

If *name* is not found, raise a `KeyError`.

`sysconfig.get_paths([scheme[, vars[, expand]]])`

Return a dictionary containing all installation paths corresponding to an installation scheme. See `get_path()` for more information.

If *scheme* is not provided, will use the default scheme for the current platform.

If *vars* is provided, it must be a dictionary of variables that will update the dictionary used to expand the paths.

If *expand* is set to `false`, the paths will not be expanded.

If *scheme* is not an existing scheme, `get_paths()` will raise a `KeyError`.

29.2.7 其他函式

`sysconfig.get_python_version()`

Return the MAJOR.MINOR Python version number as a string. Similar to `'%d.%d' % sys.version_info[:2]`.

`sysconfig.get_platform()`

Return a string that identifies the current platform.

This is used mainly to distinguish platform-specific build directories and platform-specific built distributions. Typically includes the OS name and version and the architecture (as supplied by `'os.uname()'`), although the exact information included depends on the OS; e.g., on Linux, the kernel version isn't particularly important.

Examples of returned values:

- linux-i586
- linux-alpha (?)
- solaris-2.6-sun4u

Windows will return one of:

- win-amd64 (64bit Windows on AMD64, aka x86_64, Intel64, and EM64T)
- win32 (all others - specifically, `sys.platform` is returned)

macOS can return:

- macosx-10.6-ppc
- macosx-10.4-ppc64
- macosx-10.3-i386
- macosx-10.4-fat

For other non-POSIX platforms, currently just returns `sys.platform`.

`sysconfig.is_python_build()`

Return `True` if the running Python interpreter was built from source and is being run from its built location, and not from a location resulting from e.g. running `make install` or installing via a binary installer.

`sysconfig.parse_config_h(fp[, vars])`

Parse a `config.h`-style file.

fp is a file-like object pointing to the `config.h`-like file.

A dictionary containing name/value pairs is returned. If an optional dictionary is passed in as the second argument, it is used instead of a new dictionary, and updated with the values read in the file.

`sysconfig.get_config_h_filename()`

Return the path of `pyconfig.h`.

`sysconfig.get_makefile_filename()`

Return the path of `Makefile`.

29.2.8 Using `sysconfig` as a script

You can use `sysconfig` as a script with Python's `-m` option:

```
$ python -m sysconfig
Platform: "macosx-10.4-i386"
Python version: "3.2"
Current installation scheme: "posix_prefix"

Paths:
    data = "/usr/local"
    include = "/Users/tarek/Dev/svn.python.org/py3k/Include"
    platinclude = "."
    platlib = "/usr/local/lib/python3.2/site-packages"
    platstdlib = "/usr/local/lib/python3.2"
    purelib = "/usr/local/lib/python3.2/site-packages"
    scripts = "/usr/local/bin"
    stdlib = "/usr/local/lib/python3.2"

Variables:
    AC_APPLE_UNIVERSAL_BUILD = "0"
    AIX_GENUINE_CPLUSPLUS = "0"
    AR = "ar"
    ARFLAGS = "rc"
    ...
```

This call will print in the standard output the information returned by `get_platform()`, `get_python_version()`, `get_path()` and `get_config_vars()`.

29.3 builtins --- 建物件

該模組提供對 Python 所有'建'識符號的直接存取；例如 `builtins.open` 是建函式 `open()` 的全名。請參建函式和建常數的文件。

大多數應用程式通常不會顯式地存取此模組，但在提供與建值同名之物件的模組中可能很有用，不過其中還會需要建該名稱。例如，在一個將建 `open()` 包裝起來以實現另一版本 `open()` 函式的模組中，這個模組可以直接被使用：

```
import builtins

def open(path):
    f = builtins.open(path, 'r')
    return UpperCaser(f)
```

(繼續下一頁)

(繼續上一頁)

```
class UpperCaser:
    '''Wrapper around a file that converts output to uppercase.'''

    def __init__(self, f):
        self._f = f

    def read(self, count=-1):
        return self._f.read(count).upper()

    # ...
```

有個實作細節是，大多數模組都將名稱 `__builtins__` 作其全域性變數的一部分以提使用。`__builtins__` 的值通常是這個模組或者這個模組的 `__dict__` 屬性值。由於這是一個實作細節，因此 Python 的其他實作可能不會使用它。

29.4 `__main__` --- Top-level code environment

In Python, the special name `__main__` is used for two important constructs:

1. the name of the top-level environment of the program, which can be checked using the `__name__ == '__main__'` expression; and
2. the `__main__.py` file in Python packages.

Both of these mechanisms are related to Python modules; how users interact with them and how they interact with each other. They are explained in detail below. If you're new to Python modules, see the tutorial section `tut-modules` for an introduction.

29.4.1 `__name__ == '__main__'`

When a Python module or package is imported, `__name__` is set to the module's name. Usually, this is the name of the Python file itself without the `.py` extension:

```
>>> import configparser
>>> configparser.__name__
'configparser'
```

If the file is part of a package, `__name__` will also include the parent package's path:

```
>>> from concurrent.futures import process
>>> process.__name__
'concurrent.futures.process'
```

However, if the module is executed in the top-level code environment, its `__name__` is set to the string `'__main__'`.

What is the "top-level code environment"?

`__main__` is the name of the environment where top-level code is run. "Top-level code" is the first user-specified Python module that starts running. It's "top-level" because it imports all other modules that the program needs. Sometimes "top-level code" is called an *entry point* to the application.

The top-level code environment can be:

- the scope of an interactive prompt:

```
>>> __name__  
'__main__'
```

- the Python module passed to the Python interpreter as a file argument:

```
$ python3 helloworld.py  
Hello, world!
```

- the Python module or package passed to the Python interpreter with the `-m` argument:

```
$ python3 -m tarfile  
usage: tarfile.py [-h] [-v] (...)
```

- Python code read by the Python interpreter from standard input:

```
$ echo "import this" | python3  
The Zen of Python, by Tim Peters  
  
Beautiful is better than ugly.  
Explicit is better than implicit.  
...
```

- Python code passed to the Python interpreter with the `-c` argument:

```
$ python3 -c "import this"  
The Zen of Python, by Tim Peters  
  
Beautiful is better than ugly.  
Explicit is better than implicit.  
...
```

In each of these situations, the top-level module's `__name__` is set to `'__main__'`.

As a result, a module can discover whether or not it is running in the top-level environment by checking its own `__name__`, which allows a common idiom for conditionally executing code when the module is not initialized from an import statement:

```
if __name__ == '__main__':  
    # Execute when the module is not initialized from an import statement.  
    ...
```

也参考:

For a more detailed look at how `__name__` is set in all situations, see the tutorial section `tut-modules`.

Idiomatic Usage

Some modules contain code that is intended for script use only, like parsing command-line arguments or fetching data from standard input. If a module like this was imported from a different module, for example to unit test it, the script code would unintentionally execute as well.

This is where using the `if __name__ == '__main__':` code block comes in handy. Code within this block won't run unless the module is executed in the top-level environment.

Putting as few statements as possible in the block below `if __name__ == '__main__':` can improve code clarity and correctness. Most often, a function named `main` encapsulates the program's primary behavior:

```
# echo.py

import shlex
import sys

def echo(phrase: str) -> None:
    """A dummy wrapper around print."""
    # for demonstration purposes, you can imagine that there is some
    # valuable and reusable logic inside this function
    print(phrase)

def main() -> int:
    """Echo the input arguments to standard output"""
    phrase = shlex.join(sys.argv)
    echo(phrase)
    return 0

if __name__ == '__main__':
    sys.exit(main()) # next section explains the use of sys.exit
```

Note that if the module didn't encapsulate code inside the `main` function but instead put it directly within the `if __name__ == '__main__':` block, the `phrase` variable would be global to the entire module. This is error-prone as other functions within the module could be unintentionally using the global variable instead of a local name. A `main` function solves this problem.

Using a `main` function has the added benefit of the `echo` function itself being isolated and importable elsewhere. When `echo.py` is imported, the `echo` and `main` functions will be defined, but neither of them will be called, because `__name__ != '__main__'`.

Packaging Considerations

`main` functions are often used to create command-line tools by specifying them as entry points for console scripts. When this is done, `pip` inserts the function call into a template script, where the return value of `main` is passed into `sys.exit()`. For example:

```
sys.exit(main())
```

Since the call to `main` is wrapped in `sys.exit()`, the expectation is that your function will return some value acceptable as an input to `sys.exit()`; typically, an integer or `None` (which is implicitly returned if your function does not have a return statement).

By proactively following this convention ourselves, our module will have the same behavior when run directly (i.e. `python3 echo.py`) as it will have if we later package it as a console script entry-point in a `pip`-installable package.

In particular, be careful about returning strings from your `main` function. `sys.exit()` will interpret a string argument as a failure message, so your program will have an exit code of 1, indicating failure, and the string will be written to `sys.stderr`. The `echo.py` example from earlier exemplifies using the `sys.exit(main())` convention.

也參考:

[Python Packaging User Guide](#) contains a collection of tutorials and references on how to distribute and install Python packages with modern tools.

29.4.2 `__main__.py` in Python Packages

If you are not familiar with Python packages, see section [tut-packages](#) of the tutorial. Most commonly, the `__main__.py` file is used to provide a command-line interface for a package. Consider the following hypothetical package, “bandclass”:

```
bandclass
├── __init__.py
├── __main__.py
└── student.py
```

`__main__.py` will be executed when the package itself is invoked directly from the command line using the `-m` flag. For example:

```
$ python3 -m bandclass
```

This command will cause `__main__.py` to run. How you utilize this mechanism will depend on the nature of the package you are writing, but in this hypothetical case, it might make sense to allow the teacher to search for students:

```
# bandclass/__main__.py

import sys
from .student import search_students

student_name = sys.argv[1] if len(sys.argv) >= 2 else ''
print(f'Found student: {search_students(student_name)}')
```

Note that `from .student import search_students` is an example of a relative import. This import style can be used when referencing modules within a package. For more details, see [intra-package-references](#) in the [tut-modules](#) section of the tutorial.

Idiomatic Usage

The content of `__main__.py` typically isn’t fenced with an `if __name__ == '__main__':` block. Instead, those files are kept short and import functions to execute from other modules. Those other modules can then be easily unit-tested and are properly reusable.

If used, an `if __name__ == '__main__':` block will still work as expected for a `__main__.py` file within a package, because its `__name__` attribute will include the package’s path if imported:

```
>>> import asyncio.__main__
>>> asyncio.__main__.__name__
'asyncio.__main__'
```

This won’t work for `__main__.py` files in the root directory of a `.zip` file though. Hence, for consistency, minimal `__main__.py` like the [venv](#) one mentioned below are preferred.

也參考:

See [venv](#) for an example of a package with a minimal `__main__.py` in the standard library. It doesn’t contain a `if __name__ == '__main__':` block. You can invoke it with `python -m venv [directory]`.

See [runpy](#) for more details on the `-m` flag to the interpreter executable.

See [zipapp](#) for how to run applications packaged as `.zip` files. In this case Python looks for a `__main__.py` file in the root directory of the archive.

29.4.3 import __main__

Regardless of which module a Python program was started with, other modules running within that same program can import the top-level environment's scope (*namespace*) by importing the `__main__` module. This doesn't import a `__main__.py` file but rather whichever module that received the special name `'__main__'`.

Here is an example module that consumes the `__main__` namespace:

```
# namely.py

import __main__

def did_user_define_their_name():
    return 'my_name' in dir(__main__)

def print_user_name():
    if not did_user_define_their_name():
        raise ValueError('Define the variable `my_name`!')

    if '__file__' in dir(__main__):
        print(__main__.my_name, "found in file", __main__.__file__)
    else:
        print(__main__.my_name)
```

Example usage of this module could be as follows:

```
# start.py

import sys

from namely import print_user_name

# my_name = "Dinsdale"

def main():
    try:
        print_user_name()
    except ValueError as ve:
        return str(ve)

if __name__ == "__main__":
    sys.exit(main())
```

Now, if we started our program, the result would look like this:

```
$ python3 start.py
Define the variable `my_name`!
```

The exit code of the program would be 1, indicating an error. Uncommenting the line with `my_name = "Dinsdale"` fixes the program and now it exits with status code 0, indicating success:

```
$ python3 start.py
Dinsdale found in file /path/to/start.py
```

Note that importing `__main__` doesn't cause any issues with unintentionally running top-level code meant for script use which is put in the `if __name__ == "__main__"` block of the `start` module. Why does this work?

Python inserts an empty `__main__` module in `sys.modules` at interpreter startup, and populates it by running top-level code. In our example this is the `start` module which runs line by line and imports `namely`. In turn, `namely` imports `__main__` (which is really `start`). That's an import cycle! Fortunately, since the partially populated `__main__` module is present in `sys.modules`, Python passes that to `namely`. See Special considerations for `__main__` in the import system's reference for details on how this works.

The Python REPL is another example of a “top-level environment”, so anything defined in the REPL becomes part of the `__main__` scope:

```
>>> import namely
>>> namely.did_user_define_their_name()
False
>>> namely.print_user_name()
Traceback (most recent call last):
...
ValueError: Define the variable `my_name`!
>>> my_name = 'Jabberwocky'
>>> namely.did_user_define_their_name()
True
>>> namely.print_user_name()
Jabberwocky
```

Note that in this case the `__main__` scope doesn’t contain a `__file__` attribute as it’s interactive.

The `__main__` scope is used in the implementation of `pdb` and `rlcompleter`.

29.5 warnings --- Warning control

原始碼: [Lib/warnings.py](#)

Warning messages are typically issued in situations where it is useful to alert the user of some condition in a program, where that condition (normally) doesn’t warrant raising an exception and terminating the program. For example, one might want to issue a warning when a program uses an obsolete module.

Python programmers issue warnings by calling the `warn()` function defined in this module. (C programmers use `PyErr_WarnEx()`; see [exceptionhandling](#) for details).

Warning messages are normally written to `sys.stderr`, but their disposition can be changed flexibly, from ignoring all warnings to turning them into exceptions. The disposition of warnings can vary based on the [warning category](#), the text of the warning message, and the source location where it is issued. Repetitions of a particular warning for the same source location are typically suppressed.

There are two stages in warning control: first, each time a warning is issued, a determination is made whether a message should be issued or not; next, if a message is to be issued, it is formatted and printed using a user-settable hook.

The determination whether to issue a warning message is controlled by the [warning filter](#), which is a sequence of matching rules and actions. Rules can be added to the filter by calling `filterwarnings()` and reset to its default state by calling `resetwarnings()`.

The printing of warning messages is done by calling `showwarning()`, which may be overridden; the default implementation of this function formats the message by calling `formatwarning()`, which is also available for use by custom implementations.

也參考:

`logging.captureWarnings()` allows you to handle all warnings with the standard logging infrastructure.

29.5.1 Warning Categories

There are a number of built-in exceptions that represent warning categories. This categorization is useful to be able to filter out groups of warnings.

While these are technically *built-in exceptions*, they are documented here, because conceptually they belong to the warnings mechanism.

User code can define additional warning categories by subclassing one of the standard warning categories. A warning category must always be a subclass of the *Warning* class.

The following warnings category classes are currently defined:

Class	描述
<i>Warning</i>	This is the base class of all warning category classes. It is a subclass of <i>Exception</i> .
<i>UserWarning</i>	The default category for <i>warn()</i> .
<i>DeprecationWarning</i>	Base category for warnings about deprecated features when those warnings are intended for other Python developers (ignored by default, unless triggered by code in <code>__main__</code>).
<i>SyntaxWarning</i>	Base category for warnings about dubious syntactic features.
<i>RuntimeWarning</i>	Base category for warnings about dubious runtime features.
<i>FutureWarning</i>	Base category for warnings about deprecated features when those warnings are intended for end users of applications that are written in Python.
<i>PendingDeprecationWarning</i>	Base category for warnings about features that will be deprecated in the future (ignored by default).
<i>ImportWarning</i>	Base category for warnings triggered during the process of importing a module (ignored by default).
<i>UnicodeWarning</i>	Base category for warnings related to Unicode.
<i>BytesWarning</i>	Base category for warnings related to <i>bytes</i> and <i>bytearray</i> .
<i>ResourceWarning</i>	Base category for warnings related to resource usage (ignored by default).

在 3.7 版的變更: Previously *DeprecationWarning* and *FutureWarning* were distinguished based on whether a feature was being removed entirely or changing its behaviour. They are now distinguished based on their intended audience and the way they're handled by the default warnings filters.

29.5.2 The Warnings Filter

The warnings filter controls whether warnings are ignored, displayed, or turned into errors (raising an exception).

Conceptually, the warnings filter maintains an ordered list of filter specifications; any specific warning is matched against each filter specification in the list in turn until a match is found; the filter determines the disposition of the match. Each entry is a tuple of the form *(action, message, category, module, lineno)*, where:

- action* is one of the following strings:

Value	Disposition
"default"	print the first occurrence of matching warnings for each location (module + line number) where the warning is issued
"error"	turn matching warnings into exceptions
"ignore"	never print matching warnings
"always"	always print matching warnings
"module"	print the first occurrence of matching warnings for each module where the warning is issued (regardless of line number)
"once"	print only the first occurrence of matching warnings, regardless of location

- *message* is a string containing a regular expression that the start of the warning message must match, case-insensitively. In `-W` and `PYTHONWARNINGS`, *message* is a literal string that the start of the warning message must contain (case-insensitively), ignoring any whitespace at the start or end of *message*.
- *category* is a class (a subclass of `Warning`) of which the warning category must be a subclass in order to match.
- *module* is a string containing a regular expression that the start of the fully qualified module name must match, case-sensitively. In `-W` and `PYTHONWARNINGS`, *module* is a literal string that the fully qualified module name must be equal to (case-sensitively), ignoring any whitespace at the start or end of *module*.
- *lineno* is an integer that the line number where the warning occurred must match, or 0 to match all line numbers.

Since the `Warning` class is derived from the built-in `Exception` class, to turn a warning into an error we simply raise `category(message)`.

If a warning is reported and doesn't match any registered filter then the "default" action is applied (hence its name).

Describing Warning Filters

The warnings filter is initialized by `-W` options passed to the Python interpreter command line and the `PYTHONWARNINGS` environment variable. The interpreter saves the arguments for all supplied entries without interpretation in `sys.warnoptions`; the `warnings` module parses these when it is first imported (invalid options are ignored, after printing a message to `sys.stderr`).

Individual warnings filters are specified as a sequence of fields separated by colons:

```
action:message:category:module:line
```

The meaning of each of these fields is as described in *The Warnings Filter*. When listing multiple filters on a single line (as for `PYTHONWARNINGS`), the individual filters are separated by commas and the filters listed later take precedence over those listed before them (as they're applied left-to-right, and the most recently applied filters take precedence over earlier ones).

Commonly used warning filters apply to either all warnings, warnings in a particular category, or warnings raised by particular modules or packages. Some examples:

```
default          # Show all warnings (even those ignored by default)
ignore          # Ignore all warnings
error           # Convert all warnings to errors
error::ResourceWarning # Treat ResourceWarning messages as errors
default::DeprecationWarning # Show DeprecationWarning messages
ignore,default::mymodule # Only report warnings triggered by "mymodule"
error::mymodule   # Convert warnings to errors in "mymodule"
```

Default Warning Filter

By default, Python installs several warning filters, which can be overridden by the `-W` command-line option, the `PYTHONWARNINGS` environment variable and calls to `filterwarnings()`.

In regular release builds, the default warning filter has the following entries (in order of precedence):

```
default::DeprecationWarning:__main__
ignore::DeprecationWarning
ignore::PendingDeprecationWarning
ignore::ImportWarning
ignore::ResourceWarning
```

In a debug build, the list of default warning filters is empty.

在 3.2 版的變更: `DeprecationWarning` is now ignored by default in addition to `PendingDeprecationWarning`.

在 3.7 版的變更: `DeprecationWarning` is once again shown by default when triggered directly by code in `__main__`.

在 3.7 版的變更: `BytesWarning` no longer appears in the default filter list and is instead configured via `sys.warnoptions` when `-b` is specified twice.

Overriding the default filter

Developers of applications written in Python may wish to hide *all* Python level warnings from their users by default, and only display them when running tests or otherwise working on the application. The `sys.warnoptions` attribute used to pass filter configurations to the interpreter can be used as a marker to indicate whether or not warnings should be disabled:

```
import sys

if not sys.warnoptions:
    import warnings
    warnings.simplefilter("ignore")
```

Developers of test runners for Python code are advised to instead ensure that *all* warnings are displayed by default for the code under test, using code like:

```
import sys

if not sys.warnoptions:
    import os, warnings
    warnings.simplefilter("default") # Change the filter in this process
    os.environ["PYTHONWARNINGS"] = "default" # Also affect subprocesses
```

Finally, developers of interactive shells that run user code in a namespace other than `__main__` are advised to ensure that `DeprecationWarning` messages are made visible by default, using code like the following (where `user_ns` is the module used to execute code entered interactively):

```
import warnings
warnings.filterwarnings("default", category=DeprecationWarning,
                        module=user_ns.get("__name__"))
```

29.5.3 Temporarily Suppressing Warnings

If you are using code that you know will raise a warning, such as a deprecated function, but do not want to see the warning (even when warnings have been explicitly configured via the command line), then it is possible to suppress the warning using the `catch_warnings` context manager:

```
import warnings

def fxn():
    warnings.warn("deprecated", DeprecationWarning)

with warnings.catch_warnings():
    warnings.simplefilter("ignore")
    fxn()
```

While within the context manager all warnings will simply be ignored. This allows you to use known-deprecated code without having to see the warning while not suppressing the warning for other code that might not be aware of its use of deprecated code. Note: this can only be guaranteed in a single-threaded application. If two or more threads use the `catch_warnings` context manager at the same time, the behavior is undefined.

29.5.4 Testing Warnings

To test warnings raised by code, use the `catch_warnings` context manager. With it you can temporarily mutate the warnings filter to facilitate your testing. For instance, do the following to capture all raised warnings to check:

```
import warnings

def fxn():
    warnings.warn("deprecated", DeprecationWarning)

with warnings.catch_warnings(record=True) as w:
    # Cause all warnings to always be triggered.
    warnings.simplefilter("always")
    # Trigger a warning.
    fxn()
    # Verify some things
    assert len(w) == 1
    assert isinstance(w[-1].category, DeprecationWarning)
    assert "deprecated" in str(w[-1].message)
```

One can also cause all warnings to be exceptions by using `error` instead of `always`. One thing to be aware of is that if a warning has already been raised because of a `once/default` rule, then no matter what filters are set the warning will not be seen again unless the warnings registry related to the warning has been cleared.

Once the context manager exits, the warnings filter is restored to its state when the context was entered. This prevents tests from changing the warnings filter in unexpected ways between tests and leading to indeterminate test results. The `showwarning()` function in the module is also restored to its original value. Note: this can only be guaranteed in a single-threaded application. If two or more threads use the `catch_warnings` context manager at the same time, the behavior is undefined.

When testing multiple operations that raise the same kind of warning, it is important to test them in a manner that confirms each operation is raising a new warning (e.g. set warnings to be raised as exceptions and check the operations raise exceptions, check that the length of the warning list continues to increase after each operation, or else delete the previous entries from the warnings list before each new operation).

29.5.5 Updating Code For New Versions of Dependencies

Warning categories that are primarily of interest to Python developers (rather than end users of applications written in Python) are ignored by default.

Notably, this "ignored by default" list includes `DeprecationWarning` (for every module except `__main__`), which means developers should make sure to test their code with typically ignored warnings made visible in order to receive timely notifications of future breaking API changes (whether in the standard library or third party packages).

In the ideal case, the code will have a suitable test suite, and the test runner will take care of implicitly enabling all warnings when running tests (the test runner provided by the `unittest` module does this).

In less ideal cases, applications can be checked for use of deprecated interfaces by passing `-Wd` to the Python interpreter (this is shorthand for `-W default`) or setting `PYTHONWARNINGS=default` in the environment. This enables default handling for all warnings, including those that are ignored by default. To change what action is taken for encountered warnings you can change what argument is passed to `-W` (e.g. `-W error`). See the `-W` flag for more details on what is possible.

29.5.6 Available Functions

`warnings.warn` (*message*, *category*=None, *stacklevel*=1, *source*=None)

Issue a warning, or maybe ignore it or raise an exception. The *category* argument, if given, must be a [warning category class](#); it defaults to `UserWarning`. Alternatively, *message* can be a `Warning` instance, in which case *category* will be ignored and `message.__class__` will be used. In this case, the message text will be `str(message)`. This function raises an exception if the particular warning issued is changed into an error by the [warnings filter](#). The *stacklevel* argument can be used by wrapper functions written in Python, like this:

```
def deprecation(message):
    warnings.warn(message, DeprecationWarning, stacklevel=2)
```

This makes the warning refer to `deprecation()`'s caller, rather than to the source of `deprecation()` itself (since the latter would defeat the purpose of the warning message).

source, if supplied, is the destroyed object which emitted a `ResourceWarning`.

在 3.6 版的變更: 新增 *source* 參數。

`warnings.warn_explicit` (*message*, *category*, *filename*, *lineno*, *module*=None, *registry*=None, *module_globals*=None, *source*=None)

This is a low-level interface to the functionality of `warn()`, passing in explicitly the message, category, filename and line number, and optionally the module name and the registry (which should be the `__warningregistry__` dictionary of the module). The module name defaults to the filename with `.py` stripped; if no registry is passed, the warning is never suppressed. *message* must be a string and *category* a subclass of `Warning` or *message* may be a `Warning` instance, in which case *category* will be ignored.

module_globals, if supplied, should be the global namespace in use by the code for which the warning is issued. (This argument is used to support displaying source for modules found in zipfiles or other non-filesystem import sources).

source, if supplied, is the destroyed object which emitted a `ResourceWarning`.

在 3.6 版的變更: Add the *source* parameter.

`warnings.showwarning` (*message*, *category*, *filename*, *lineno*, *file*=None, *line*=None)

Write a warning to a file. The default implementation calls `formatwarning(message, category, filename, lineno, line)` and writes the resulting string to *file*, which defaults to `sys.stderr`. You may replace this function with any callable by assigning to `warnings.showwarning`. *line* is a line of source code to be included in the warning message; if *line* is not supplied, `showwarning()` will try to read the line specified by *filename* and *lineno*.

`warnings.formatwarning` (*message*, *category*, *filename*, *lineno*, *line*=None)

Format a warning the standard way. This returns a string which may contain embedded newlines and ends in a newline. *line* is a line of source code to be included in the warning message; if *line* is not supplied, `formatwarning()` will try to read the line specified by *filename* and *lineno*.

`warnings.filterwarnings` (*action*, *message*=",", *category*=Warning, *module*=",", *lineno*=0, *append*=False)

Insert an entry into the list of [warnings filter specifications](#). The entry is inserted at the front by default; if *append* is true, it is inserted at the end. This checks the types of the arguments, compiles the *message* and *module* regular expressions, and inserts them as a tuple in the list of warnings filters. Entries closer to the front of the list override entries later in the list, if both match a particular warning. Omitted arguments default to a value that matches everything.

`warnings.simplefilter` (*action*, *category*=Warning, *lineno*=0, *append*=False)

Insert a simple entry into the list of [warnings filter specifications](#). The meaning of the function parameters is as for `filterwarnings()`, but regular expressions are not needed as the filter inserted always matches any message in any module as long as the category and line number match.

`warnings.resetwarnings` ()

Reset the warnings filter. This discards the effect of all previous calls to `filterwarnings()`, including that of the `-W` command line options and calls to `simplefilter()`.

29.5.7 Available Context Managers

class `warnings.catch_warnings` (*, *record=False*, *module=None*, *action=None*, *category=Warning*, *lineno=0*, *append=False*)

A context manager that copies and, upon exit, restores the warnings filter and the `showwarning()` function. If the *record* argument is *False* (the default) the context manager returns *None* on entry. If *record* is *True*, a list is returned that is progressively populated with objects as seen by a custom `showwarning()` function (which also suppresses output to `sys.stdout`). Each object in the list has attributes with the same names as the arguments to `showwarning()`.

The *module* argument takes a module that will be used instead of the module returned when you import `warnings` whose filter will be protected. This argument exists primarily for testing the `warnings` module itself.

If the *action* argument is not *None*, the remaining arguments are passed to `simplefilter()` as if it were called immediately on entering the context.

備 F: The `catch_warnings` manager works by replacing and then later restoring the module's `showwarning()` function and internal list of filter specifications. This means the context manager is modifying global state and therefore is not thread-safe.

在 3.11 版的變更: Added the *action*, *category*, *lineno*, and *append* parameters.

29.6 dataclasses --- Data Classes

原始碼: `Lib/dataclasses.py`

This module provides a decorator and functions for automatically adding generated *special methods* such as `__init__()` and `__repr__()` to user-defined classes. It was originally described in [PEP 557](#).

The member variables to use in these generated methods are defined using [PEP 526](#) type annotations. For example, this code:

```
from dataclasses import dataclass

@dataclass
class InventoryItem:
    """Class for keeping track of an item in inventory."""
    name: str
    unit_price: float
    quantity_on_hand: int = 0

    def total_cost(self) -> float:
        return self.unit_price * self.quantity_on_hand
```

will add, among other things, a `__init__()` that looks like:

```
def __init__(self, name: str, unit_price: float, quantity_on_hand: int = 0):
    self.name = name
    self.unit_price = unit_price
    self.quantity_on_hand = quantity_on_hand
```

Note that this method is automatically added to the class: it is not directly specified in the `InventoryItem` definition shown above.

在 3.7 版新加入.

29.6.1 Module contents

```
@dataclasses.dataclass (*, init=True, repr=True, eq=True, order=False, unsafe_hash=False,
                        frozen=False, match_args=True, kw_only=False, slots=False,
                        weakref_slot=False)
```

This function is a *decorator* that is used to add generated *special methods* to classes, as described below.

The `@dataclass` decorator examines the class to find *fields*. A *field* is defined as a class variable that has a *type annotation*. With two exceptions described below, nothing in `@dataclass` examines the type specified in the variable annotation.

The order of the fields in all of the generated methods is the order in which they appear in the class definition.

The `@dataclass` decorator will add various "dunder" methods to the class, described below. If any of the added methods already exist in the class, the behavior depends on the parameter, as documented below. The decorator returns the same class that it is called on; no new class is created.

If `@dataclass` is used just as a simple decorator with no parameters, it acts as if it has the default values documented in this signature. That is, these three uses of `@dataclass` are equivalent:

```
@dataclass
class C:
    ...

@dataclass()
class C:
    ...

@dataclass(init=True, repr=True, eq=True, order=False, unsafe_hash=False,
            frozen=False, match_args=True, kw_only=False, slots=False, weakref_slot=False)
class C:
    ...
```

The parameters to `@dataclass` are:

- `init`: If true (the default), a `__init__()` method will be generated.
If the class already defines `__init__()`, this parameter is ignored.
- `repr`: If true (the default), a `__repr__()` method will be generated. The generated repr string will have the class name and the name and repr of each field, in the order they are defined in the class. Fields that are marked as being excluded from the repr are not included. For example: `InventoryItem(name='widget', unit_price=3.0, quantity_on_hand=10)`.
If the class already defines `__repr__()`, this parameter is ignored.
- `eq`: If true (the default), an `__eq__()` method will be generated. This method compares the class as if it were a tuple of its fields, in order. Both instances in the comparison must be of the identical type.
If the class already defines `__eq__()`, this parameter is ignored.
- `order`: If true (the default is False), `__lt__()`, `__le__()`, `__gt__()`, and `__ge__()` methods will be generated. These compare the class as if it were a tuple of its fields, in order. Both instances in the comparison must be of the identical type. If `order` is true and `eq` is false, a `ValueError` is raised.
If the class already defines any of `__lt__()`, `__le__()`, `__gt__()`, or `__ge__()`, then `TypeError` is raised.
- `unsafe_hash`: If False (the default), a `__hash__()` method is generated according to how `eq` and `frozen` are set.

`__hash__()` is used by built-in `hash()`, and when objects are added to hashed collections such as dictionaries and sets. Having a `__hash__()` implies that instances of the class are immutable. Muta-

bility is a complicated property that depends on the programmer's intent, the existence and behavior of `__eq__()`, and the values of the `eq` and `frozen` flags in the `@dataclass` decorator.

By default, `@dataclass` will not implicitly add a `__hash__()` method unless it is safe to do so. Neither will it add or change an existing explicitly defined `__hash__()` method. Setting the class attribute `__hash__ = None` has a specific meaning to Python, as described in the `__hash__()` documentation.

If `__hash__()` is not explicitly defined, or if it is set to `None`, then `@dataclass` *may* add an implicit `__hash__()` method. Although not recommended, you can force `@dataclass` to create a `__hash__()` method with `unsafe_hash=True`. This might be the case if your class is logically immutable but can still be mutated. This is a specialized use case and should be considered carefully.

Here are the rules governing implicit creation of a `__hash__()` method. Note that you cannot both have an explicit `__hash__()` method in your dataclass and set `unsafe_hash=True`; this will result in a `TypeError`.

If `eq` and `frozen` are both true, by default `@dataclass` will generate a `__hash__()` method for you. If `eq` is true and `frozen` is false, `__hash__()` will be set to `None`, marking it unhashable (which it is, since it is mutable). If `eq` is false, `__hash__()` will be left untouched meaning the `__hash__()` method of the superclass will be used (if the superclass is `object`, this means it will fall back to id-based hashing).

- `frozen`: If true (the default is `False`), assigning to fields will generate an exception. This emulates read-only frozen instances. If `__setattr__()` or `__delattr__()` is defined in the class, then `TypeError` is raised. See the discussion below.
- `match_args`: If true (the default is `True`), the `__match_args__` tuple will be created from the list of parameters to the generated `__init__()` method (even if `__init__()` is not generated, see above). If false, or if `__match_args__` is already defined in the class, then `__match_args__` will not be generated.

在 3.10 版新加入.

- `kw_only`: If true (the default value is `False`), then all fields will be marked as keyword-only. If a field is marked as keyword-only, then the only effect is that the `__init__()` parameter generated from a keyword-only field must be specified with a keyword when `__init__()` is called. There is no effect on any other aspect of dataclasses. See the `parameter` glossary entry for details. Also see the `KW_ONLY` section.

在 3.10 版新加入.

- `slots`: If true (the default is `False`), `__slots__` attribute will be generated and new class will be returned instead of the original one. If `__slots__` is already defined in the class, then `TypeError` is raised.

在 3.10 版新加入.

在 3.11 版的變更: If a field name is already included in the `__slots__` of a base class, it will not be included in the generated `__slots__` to prevent overriding them. Therefore, do not use `__slots__` to retrieve the field names of a dataclass. Use `fields()` instead. To be able to determine inherited slots, base class `__slots__` may be any iterable, but *not* an iterator.

- `weakref_slot`: If true (the default is `False`), add a slot named `"__weakref__"`, which is required to make an instance weakref-able. It is an error to specify `weakref_slot=True` without also specifying `slots=True`.

在 3.11 版新加入.

`fields` may optionally specify a default value, using normal Python syntax:

```
@dataclass
class C:
    a: int          # 'a' has no default value
    b: int = 0       # assign a default value for 'b'
```

In this example, both `a` and `b` will be included in the added `__init__()` method, which will be defined as:

```
def __init__(self, a: int, b: int = 0):
```

`TypeError` will be raised if a field without a default value follows a field with a default value. This is true whether this occurs in a single class, or as a result of class inheritance.

`dataclasses.field(*, default=MISSING, default_factory=MISSING, init=True, repr=True, hash=None, compare=True, metadata=None, kw_only=MISSING)`

For common and simple use cases, no other functionality is required. There are, however, some dataclass features that require additional per-field information. To satisfy this need for additional information, you can replace the default field value with a call to the provided `field()` function. For example:

```
@dataclass
class C:
    mylist: list[int] = field(default_factory=list)

c = C()
c.mylist += [1, 2, 3]
```

As shown above, the `MISSING` value is a sentinel object used to detect if some parameters are provided by the user. This sentinel is used because `None` is a valid value for some parameters with a distinct meaning. No code should directly use the `MISSING` value.

The parameters to `field()` are:

- `default`: If provided, this will be the default value for this field. This is needed because the `field()` call itself replaces the normal position of the default value.
- `default_factory`: If provided, it must be a zero-argument callable that will be called when a default value is needed for this field. Among other purposes, this can be used to specify fields with mutable default values, as discussed below. It is an error to specify both `default` and `default_factory`.
- `init`: If true (the default), this field is included as a parameter to the generated `__init__()` method.
- `repr`: If true (the default), this field is included in the string returned by the generated `__repr__()` method.
- `hash`: This can be a bool or `None`. If true, this field is included in the generated `__hash__()` method. If `None` (the default), use the value of `compare`: this would normally be the expected behavior. A field should be considered in the hash if it's used for comparisons. Setting this value to anything other than `None` is discouraged.

One possible reason to set `hash=False` but `compare=True` would be if a field is expensive to compute a hash value for, that field is needed for equality testing, and there are other fields that contribute to the type's hash value. Even if a field is excluded from the hash, it will still be used for comparisons.

- `compare`: If true (the default), this field is included in the generated equality and comparison methods (`__eq__()`, `__gt__()`, et al.).
- `metadata`: This can be a mapping or `None`. `None` is treated as an empty dict. This value is wrapped in `MappingProxyType()` to make it read-only, and exposed on the `Field` object. It is not used at all by Data Classes, and is provided as a third-party extension mechanism. Multiple third-parties can each have their own key, to use as a namespace in the metadata.
- `kw_only`: If true, this field will be marked as keyword-only. This is used when the generated `__init__()` method's parameters are computed.

在 3.10 版新加入。

If the default value of a field is specified by a call to `field()`, then the class attribute for this field will be replaced by the specified default value. If no default is provided, then the class attribute will be deleted. The intent is that after the `@dataclass` decorator runs, the class attributes will all contain the default values for the fields, just as if the default value itself were specified. For example, after:

```
@dataclass
class C:
    x: int
    y: int = field(repr=False)
    z: int = field(repr=False, default=10)
    t: int = 20
```

The class attribute `C.z` will be 10, the class attribute `C.t` will be 20, and the class attributes `C.x` and `C.y` will not be set.

`class dataclasses.Field`

Field objects describe each defined field. These objects are created internally, and are returned by the `fields()` module-level method (see below). Users should never instantiate a `Field` object directly. Its documented attributes are:

- `name`: The name of the field.
- `type`: The type of the field.
- `default`, `default_factory`, `init`, `repr`, `hash`, `compare`, `metadata`, and `kw_only` have the identical meaning and values as they do in the `field()` function.

Other attributes may exist, but they are private and must not be inspected or relied on.

`dataclasses.fields(class_or_instance)`

Returns a tuple of `Field` objects that define the fields for this dataclass. Accepts either a dataclass, or an instance of a dataclass. Raises `TypeError` if not passed a dataclass or instance of one. Does not return pseudo-fields which are `ClassVar` or `InitVar`.

`dataclasses.asdict(obj, *, dict_factory=dict)`

Converts the dataclass `obj` to a dict (by using the factory function `dict_factory`). Each dataclass is converted to a dict of its fields, as `name: value` pairs. dataclasses, dicts, lists, and tuples are recursed into. Other objects are copied with `copy.deepcopy()`.

Example of using `asdict()` on nested dataclasses:

```
@dataclass
class Point:
    x: int
    y: int

@dataclass
class C:
    mylist: list[Point]

p = Point(10, 20)
assert asdict(p) == {'x': 10, 'y': 20}

c = C([Point(0, 0), Point(10, 4)])
assert asdict(c) == {'mylist': [{'x': 0, 'y': 0}, {'x': 10, 'y': 4}]}
```

To create a shallow copy, the following workaround may be used:

```
dict((field.name, getattr(obj, field.name)) for field in fields(obj))
```

`asdict()` raises `TypeError` if `obj` is not a dataclass instance.

`dataclasses.astuple(obj, *, tuple_factory=tuple)`

Converts the dataclass `obj` to a tuple (by using the factory function `tuple_factory`). Each dataclass is converted to a tuple of its field values. dataclasses, dicts, lists, and tuples are recursed into. Other objects are copied with `copy.deepcopy()`.

Continuing from the previous example:

```
assert astuple(p) == (10, 20)
assert astuple(c) == ((0, 0), (10, 4)),)
```

To create a shallow copy, the following workaround may be used:

```
tuple(getattr(obj, field.name) for field in dataclasses.fields(obj))
```

`astuple()` raises `TypeError` if `obj` is not a dataclass instance.

`dataclasses.make_dataclass(cls_name, fields, *, bases=(), namespace=None, init=True, repr=True, eq=True, order=False, unsafe_hash=False, frozen=False, match_args=True, kw_only=False, slots=False, weakref_slot=False)`

Creates a new dataclass with name `cls_name`, fields as defined in `fields`, base classes as given in `bases`, and initialized with a namespace as given in `namespace`. `fields` is an iterable whose elements are each either name, (name, type), or (name, type, Field). If just name is supplied, `typing.Any` is used for type. The values of `init`, `repr`, `eq`, `order`, `unsafe_hash`, `frozen`, `match_args`, `kw_only`, `slots`, and `weakref_slot` have the same meaning as they do in `@dataclass`.

This function is not strictly required, because any Python mechanism for creating a new class with `__annotations__` can then apply the `@dataclass` function to convert that class to a dataclass. This function is provided as a convenience. For example:

```
C = make_dataclass('C',
                  [('x', int),
                   'y',
                   ('z', int, field(default=5))],
                  namespace={'add_one': lambda self: self.x + 1})
```

Is equivalent to:

```
@dataclass
class C:
    x: int
    y: 'typing.Any'
    z: int = 5

    def add_one(self):
        return self.x + 1
```

`dataclasses.replace(obj, /, **changes)`

Creates a new object of the same type as `obj`, replacing fields with values from `changes`. If `obj` is not a Data Class, raises `TypeError`. If values in `changes` do not specify fields, raises `TypeError`.

The newly returned object is created by calling the `__init__()` method of the dataclass. This ensures that `__post_init__`, if present, is also called.

Init-only variables without default values, if any exist, must be specified on the call to `replace()` so that they can be passed to `__init__()` and `__post_init__()`.

It is an error for `changes` to contain any fields that are defined as having `init=False`. A `ValueError` will be raised in this case.

Be forewarned about how `init=False` fields work during a call to `replace()`. They are not copied from the source object, but rather are initialized in `__post_init__()`, if they're initialized at all. It is expected that `init=False` fields will be rarely and judiciously used. If they are used, it might be wise

to have alternate class constructors, or perhaps a custom `replace()` (or similarly named) method which handles instance copying.

`dataclasses.is_dataclass(obj)`

Return `True` if its parameter is a dataclass or an instance of one, otherwise return `False`.

If you need to know if a class is an instance of a dataclass (and not a dataclass itself), then add a further check for not `isinstance(obj, type)`:

```
def is_dataclass_instance(obj):
    return is_dataclass(obj) and not isinstance(obj, type)
```

`dataclasses.MISSING`

A sentinel value signifying a missing default or default_factory.

`dataclasses.KW_ONLY`

A sentinel value used as a type annotation. Any fields after a pseudo-field with the type of `KW_ONLY` are marked as keyword-only fields. Note that a pseudo-field of type `KW_ONLY` is otherwise completely ignored. This includes the name of such a field. By convention, a name of `_` is used for a `KW_ONLY` field. Keyword-only fields signify `__init__()` parameters that must be specified as keywords when the class is instantiated.

In this example, the fields `y` and `z` will be marked as keyword-only fields:

```
@dataclass
class Point:
    x: float
    _: KW_ONLY
    y: float
    z: float

p = Point(0, y=1.5, z=2.0)
```

In a single dataclass, it is an error to specify more than one field whose type is `KW_ONLY`.

在 3.10 版新加入.

exception `dataclasses.FrozenInstanceError`

Raised when an implicitly defined `__setattr__()` or `__delattr__()` is called on a dataclass which was defined with `frozen=True`. It is a subclass of `AttributeError`.

29.6.2 Post-init processing

The generated `__init__()` code will call a method named `__post_init__()`, if `__post_init__()` is defined on the class. It will normally be called as `self.__post_init__()`. However, if any `InitVar` fields are defined, they will also be passed to `__post_init__()` in the order they were defined in the class. If no `__init__()` method is generated, then `__post_init__()` will not automatically be called.

When defined on the class, it will be called by the generated `__init__()`, normally as `self.__post_init__()`. However, if any `InitVar` fields are defined, they will also be passed to `__post_init__()` in the order they were defined in the class. If no `__init__()` method is generated, then `__post_init__()` will not automatically be called.

@dataclass class C:

a: float b: float c: float = field(init=False)

```
def __post_init__(self):
    self.c = self.a + self.b
```

The `__init__()` method generated by `@dataclass` does not call base class `__init__()` methods. If the base class has an `__init__()` method that has to be called, it is common to call this method in a `__post_init__()` method:


```

class Rectangle:
    def __init__(self, height, width):
        self.height = height
        self.width = width

@dataclass
class Square(Rectangle):
    side: float

    def __post_init__(self):
        super().__init__(self.side, self.side)

```

Note, however, that in general the dataclass-generated `__init__()` methods don't need to be called, since the derived dataclass will take care of initializing all fields of any base class that is a dataclass itself.

See the section below on init-only variables for ways to pass parameters to `__post_init__()`. Also see the warning about how `replace()` handles `init=False` fields.

29.6.3 Class variables

One of the few places where `@dataclass` actually inspects the type of a field is to determine if a field is a class variable as defined in [PEP 526](#). It does this by checking if the type of the field is `typing.ClassVar`. If a field is a `ClassVar`, it is excluded from consideration as a field and is ignored by the dataclass mechanisms. Such `ClassVar` pseudo-fields are not returned by the module-level `fields()` function.

29.6.4 Init-only variables

Another place where `@dataclass` inspects a type annotation is to determine if a field is an init-only variable. It does this by seeing if the type of a field is of type `dataclasses.InitVar`. If a field is an `InitVar`, it is considered a pseudo-field called an init-only field. As it is not a true field, it is not returned by the module-level `fields()` function. Init-only fields are added as parameters to the generated `__init__()` method, and are passed to the optional `__post_init__` method. They are not otherwise used by dataclasses.

For example, suppose a field will be initialized from a database, if a value is not provided when creating the class:

```

@dataclass
class C:
    i: int
    j: int | None = None
    database: InitVar[DatabaseType | None] = None

    def __post_init__(self, database):
        if self.j is None and database is not None:
            self.j = database.lookup('j')

c = C(10, database=my_database)

```

In this case, `fields()` will return `Field` objects for `i` and `j`, but not for `database`.

29.6.5 Frozen instances

It is not possible to create truly immutable Python objects. However, by passing `frozen=True` to the `@dataclass` decorator you can emulate immutability. In that case, dataclasses will add `__setattr__()` and `__delattr__()` methods to the class. These methods will raise a `FrozenInstanceError` when invoked.

There is a tiny performance penalty when using `frozen=True`: `__init__()` cannot use simple assignment to initialize fields, and must use `__setattr__()`.

29.6.6 Inheritance

When the dataclass is being created by the `@dataclass` decorator, it looks through all of the class's base classes in reverse MRO (that is, starting at `object`) and, for each dataclass that it finds, adds the fields from that base class to an ordered mapping of fields. After all of the base class fields are added, it adds its own fields to the ordered mapping. All of the generated methods will use this combined, calculated ordered mapping of fields. Because the fields are in insertion order, derived classes override base classes. An example:

```
@dataclass
class Base:
    x: Any = 15.0
    y: int = 0

@dataclass
class C(Base):
    z: int = 10
    x: int = 15
```

The final list of fields is, in order, `x`, `y`, `z`. The final type of `x` is `int`, as specified in class `C`.

The generated `__init__()` method for `C` will look like:

```
def __init__(self, x: int = 15, y: int = 0, z: int = 10):
```

29.6.7 Re-ordering of keyword-only parameters in `__init__()`

After the parameters needed for `__init__()` are computed, any keyword-only parameters are moved to come after all regular (non-keyword-only) parameters. This is a requirement of how keyword-only parameters are implemented in Python: they must come after non-keyword-only parameters.

In this example, `Base.y`, `Base.w`, and `D.t` are keyword-only fields, and `Base.x` and `D.z` are regular fields:

```
@dataclass
class Base:
    x: Any = 15.0
    _: KW_ONLY
    y: int = 0
    w: int = 1

@dataclass
class D(Base):
    z: int = 10
    t: int = field(kw_only=True, default=0)
```

The generated `__init__()` method for `D` will look like:

```
def __init__(self, x: Any = 15.0, z: int = 10, *, y: int = 0, w: int = 1, t: int = 0):
```

Note that the parameters have been re-ordered from how they appear in the list of fields: parameters derived from regular fields are followed by parameters derived from keyword-only fields.

The relative ordering of keyword-only parameters is maintained in the re-ordered `__init__()` parameter list.

29.6.8 Default factory functions

If a `field()` specifies a `default_factory`, it is called with zero arguments when a default value for the field is needed. For example, to create a new instance of a list, use:

```
mylist: list = field(default_factory=list)
```

If a field is excluded from `__init__()` (using `init=False`) and the field also specifies `default_factory`, then the default factory function will always be called from the generated `__init__()` function. This happens because there is no other way to give the field an initial value.

29.6.9 Mutable default values

Python stores default member variable values in class attributes. Consider this example, not using dataclasses:

```
class C:
    x = []
    def add(self, element):
        self.x.append(element)

o1 = C()
o2 = C()
o1.add(1)
o2.add(2)
assert o1.x == [1, 2]
assert o1.x is o2.x
```

Note that the two instances of class C share the same class variable `x`, as expected.

Using dataclasses, *if* this code was valid:

```
@dataclass
class D:
    x: list = []          # This code raises ValueError
    def add(self, element):
        self.x.append(element)
```

它會生成類似的程式碼:

```
class D:
    x = []
    def __init__(self, x=x):
        self.x = x
    def add(self, element):
        self.x.append(element)

assert D().x is D().x
```

This has the same issue as the original example using class C. That is, two instances of class D that do not specify a value for `x` when creating a class instance will share the same copy of `x`. Because dataclasses just use normal Python class creation they also share this behavior. There is no general way for Data Classes to detect this condition. Instead, the `@dataclass` decorator will raise a `ValueError` if it detects an unhashable default parameter. The assumption is that if a value is unhashable, it is mutable. This is a partial solution, but it does protect against many common errors.

Using default factory functions is a way to create new instances of mutable types as default values for fields:

```
@dataclass
class D:
    x: list = field(default_factory=list)

assert D().x is not D().x
```

在 3.11 版的變更: Instead of looking for and disallowing objects of type `list`, `dict`, or `set`, unhashable objects are now not allowed as default values. Unhashability is used to approximate mutability.

29.6.10 Descriptor-typed fields

Fields that are assigned descriptor objects as their default value have the following special behaviors:

- The value for the field passed to the dataclass's `__init__()` method is passed to the descriptor's `__set__()` method rather than overwriting the descriptor object.
- Similarly, when getting or setting the field, the descriptor's `__get__()` or `__set__()` method is called rather than returning or overwriting the descriptor object.
- To determine whether a field contains a default value, `@dataclass` will call the descriptor's `__get__()` method using its class access form: `descriptor.__get__(obj=None, type=cls)`. If the descriptor returns a value in this case, it will be used as the field's default. On the other hand, if the descriptor raises `AttributeError` in this situation, no default value will be provided for the field.

```
class IntConversionDescriptor:
    def __init__(self, *, default):
        self._default = default

    def __set_name__(self, owner, name):
        self._name = "_" + name

    def __get__(self, obj, type):
        if obj is None:
            return self._default

        return getattr(obj, self._name, self._default)

    def __set__(self, obj, value):
        setattr(obj, self._name, int(value))

@dataclass
class InventoryItem:
    quantity_on_hand: IntConversionDescriptor = _
    ↪ IntConversionDescriptor(default=100)

i = InventoryItem()
print(i.quantity_on_hand)      # 100
i.quantity_on_hand = 2.5      # calls __set__ with 2.5
print(i.quantity_on_hand)      # 2
```

Note that if a field is annotated with a descriptor type, but is not assigned a descriptor object as its default value, the field will act like a normal field.

29.7 contextlib --- Utilities for with-statement contexts

原始碼: [Lib/contextlib.py](#)

This module provides utilities for common tasks involving the `with` statement. For more information see also [Context Manager Types](#) and [context-managers](#).

29.7.1 Utilities

Functions and classes provided:

class `contextlib.AbstractContextManager`

An *abstract base class* for classes that implement `object.__enter__()` and `object.__exit__()`. A default implementation for `object.__enter__()` is provided which returns `self` while `object.__exit__()` is an abstract method which by default returns `None`. See also the definition of [Context Manager Types](#).

在 3.6 版新加入.

class `contextlib.AbstractAsyncContextManager`

An *abstract base class* for classes that implement `object.__aenter__()` and `object.__aexit__()`. A default implementation for `object.__aenter__()` is provided which returns `self` while `object.__aexit__()` is an abstract method which by default returns `None`. See also the definition of [async-context-managers](#).

在 3.7 版新加入.

@contextlib.contextmanager

This function is a *decorator* that can be used to define a factory function for `with` statement context managers, without needing to create a class or separate `__enter__()` and `__exit__()` methods.

While many objects natively support use in `with` statements, sometimes a resource needs to be managed that isn't a context manager in its own right, and doesn't implement a `close()` method for use with `contextlib.closing`

An abstract example would be the following to ensure correct resource management:

```
from contextlib import contextmanager

@contextmanager
def managed_resource(*args, **kwargs):
    # Code to acquire resource, e.g.:
    resource = acquire_resource(*args, **kwargs)
    try:
        yield resource
    finally:
        # Code to release resource, e.g.:
        release_resource(resource)
```

The function can then be used like this:

```
>>> with managed_resource(timeout=3600) as resource:
...     # Resource is released at the end of this block,
...     # even if code in the block raises an exception
```

The function being decorated must return a *generator*-iterator when called. This iterator must yield exactly one value, which will be bound to the targets in the `with` statement's `as` clause, if any.

At the point where the generator yields, the block nested in the `with` statement is executed. The generator is then resumed after the block is exited. If an unhandled exception occurs in the block, it is reraised inside the

generator at the point where the `yield` occurred. Thus, you can use a `try...except...finally` statement to trap the error (if any), or ensure that some cleanup takes place. If an exception is trapped merely in order to log it or to perform some action (rather than to suppress it entirely), the generator must reraise that exception. Otherwise the generator context manager will indicate to the `with` statement that the exception has been handled, and execution will resume with the statement immediately following the `with` statement.

`contextmanager()` uses `ContextDecorator` so the context managers it creates can be used as decorators as well as in `with` statements. When used as a decorator, a new generator instance is implicitly created on each function call (this allows the otherwise “one-shot” context managers created by `contextmanager()` to meet the requirement that context managers support multiple invocations in order to be used as decorators).

在 3.2 版的變更: Use of `ContextDecorator`.

@contextlib.asynccontextmanager

Similar to `contextmanager()`, but creates an asynchronous context manager.

This function is a *decorator* that can be used to define a factory function for `async with` statement asynchronous context managers, without needing to create a class or separate `__aenter__()` and `__aexit__()` methods. It must be applied to an *asynchronous generator* function.

一個簡單範例:

```
from contextlib import asynccontextmanager

@asynccontextmanager
async def get_connection():
    conn = await acquire_db_connection()
    try:
        yield conn
    finally:
        await release_db_connection(conn)

async def get_all_users():
    async with get_connection() as conn:
        return conn.query('SELECT ...')
```

在 3.7 版新加入.

Context managers defined with `asynccontextmanager()` can be used either as decorators or with `async with` statements:

```
import time
from contextlib import asynccontextmanager

@asynccontextmanager
async def timeit():
    now = time.monotonic()
    try:
        yield
    finally:
        print(f'it took {time.monotonic() - now}s to run')

@timeit()
async def main():
    # ... async code ...
```

When used as a decorator, a new generator instance is implicitly created on each function call. This allows the otherwise “one-shot” context managers created by `asynccontextmanager()` to meet the requirement that context managers support multiple invocations in order to be used as decorators.

在 3.10 版的變更: Async context managers created with `asynccontextmanager()` can be used as decorators.

`contextlib.closing(thing)`

Return a context manager that closes *thing* upon completion of the block. This is basically equivalent to:

```
from contextlib import contextmanager

@contextmanager
def closing(thing):
    try:
        yield thing
    finally:
        thing.close()
```

And lets you write code like this:

```
from contextlib import closing
from urllib.request import urlopen

with closing(urlopen('https://www.python.org')) as page:
    for line in page:
        print(line)
```

without needing to explicitly close `page`. Even if an error occurs, `page.close()` will be called when the `with` block is exited.

備註: Most types managing resources support the *context manager* protocol, which closes *thing* on leaving the `with` statement. As such, `closing()` is most useful for third party types that don't support context managers. This example is purely for illustration purposes, as `urlopen()` would normally be used in a context manager.

`contextlib.aclosing(thing)`

Return an async context manager that calls the `aclose()` method of *thing* upon completion of the block. This is basically equivalent to:

```
from contextlib import asynccontextmanager

@asynccontextmanager
async def aclosing(thing):
    try:
        yield thing
    finally:
        await thing.aclose()
```

Significantly, `aclosing()` supports deterministic cleanup of async generators when they happen to exit early by `break` or an exception. For example:

```
from contextlib import aclosing

async with aclosing(my_generator()) as values:
    async for value in values:
        if value == 42:
            break
```

This pattern ensures that the generator's async exit code is executed in the same context as its iterations (so that exceptions and context variables work as expected, and the exit code isn't run after the lifetime of some task it depends on).

在 3.10 版新加入.

`contextlib.nullcontext` (*enter_result=None*)

Return a context manager that returns *enter_result* from `__enter__`, but otherwise does nothing. It is intended to be used as a stand-in for an optional context manager, for example:

```
def myfunction(arg, ignore_exceptions=False):
    if ignore_exceptions:
        # Use suppress to ignore all exceptions.
        cm = contextlib.suppress(Exception)
    else:
        # Do not ignore any exceptions, cm has no effect.
        cm = contextlib.nullcontext()
    with cm:
        # Do something
```

一個使用 *enter_result* 的範例:

```
def process_file(file_or_path):
    if isinstance(file_or_path, str):
        # If string, open file
        cm = open(file_or_path)
    else:
        # Caller is responsible for closing file
        cm = nullcontext(file_or_path)

    with cm as file:
        # Perform processing on the file
```

It can also be used as a stand-in for asynchronous context managers:

```
async def send_http(session=None):
    if not session:
        # If no http session, create it with aiohttp
        cm = aiohttp.ClientSession()
    else:
        # Caller is responsible for closing the session
        cm = nullcontext(session)

    async with cm as session:
        # Send http requests with session
```

在 3.7 版新加入.

在 3.10 版的變更: *asynchronous context manager* support was added.

`contextlib.suppress` (**exceptions*)

Return a context manager that suppresses any of the specified exceptions if they occur in the body of a `with` statement and then resumes execution with the first statement following the end of the `with` statement.

As with any other mechanism that completely suppresses exceptions, this context manager should be used only to cover very specific errors where silently continuing with program execution is known to be the right thing to do.

舉例來 F:

```
from contextlib import suppress

with suppress(FileNotFoundError):
    os.remove('somefile.tmp')

with suppress(FileNotFoundError):
    os.remove('someotherfile.tmp')
```

This code is equivalent to:


```

try:
    os.remove('somefile.tmp')
except FileNotFoundError:
    pass

try:
    os.remove('someotherfile.tmp')
except FileNotFoundError:
    pass

```

This context manager is *reentrant*.

在 3.4 版新加入.

`contextlib.redirect_stdout` (*new_target*)

Context manager for temporarily redirecting `sys.stdout` to another file or file-like object.

This tool adds flexibility to existing functions or classes whose output is hardwired to `stdout`.

For example, the output of `help()` normally is sent to `sys.stdout`. You can capture that output in a string by redirecting the output to an `io.StringIO` object. The replacement stream is returned from the `__enter__` method and so is available as the target of the `with` statement:

```

with redirect_stdout(io.StringIO()) as f:
    help(pow)
s = f.getvalue()

```

To send the output of `help()` to a file on disk, redirect the output to a regular file:

```

with open('help.txt', 'w') as f:
    with redirect_stdout(f):
        help(pow)

```

To send the output of `help()` to `sys.stderr`:

```

with redirect_stdout(sys.stderr):
    help(pow)

```

Note that the global side effect on `sys.stdout` means that this context manager is not suitable for use in library code and most threaded applications. It also has no effect on the output of subprocesses. However, it is still a useful approach for many utility scripts.

This context manager is *reentrant*.

在 3.4 版新加入.

`contextlib.redirect_stderr` (*new_target*)

Similar to `redirect_stdout()` but redirecting `sys.stderr` to another file or file-like object.

This context manager is *reentrant*.

在 3.5 版新加入.

`contextlib.chdir` (*path*)

Non parallel-safe context manager to change the current working directory. As this changes a global state, the working directory, it is not suitable for use in most threaded or async contexts. It is also not suitable for most non-linear code execution, like generators, where the program execution is temporarily relinquished -- unless explicitly desired, you should not yield when this context manager is active.

This is a simple wrapper around `chdir()`, it changes the current working directory upon entering and restores the old one on exit.

This context manager is *reentrant*.

在 3.11 版新加入.

class `contextlib.ContextDecorator`

A base class that enables a context manager to also be used as a decorator.

Context managers inheriting from `ContextDecorator` have to implement `__enter__` and `__exit__` as normal. `__exit__` retains its optional exception handling even when used as a decorator.

`ContextDecorator` is used by `contextmanager()`, so you get this functionality automatically.

`ContextDecorator` 範例:

```
from contextlib import ContextDecorator

class mycontext(ContextDecorator):
    def __enter__(self):
        print('Starting')
        return self

    def __exit__(self, *exc):
        print('Finishing')
        return False
```

The class can then be used like this:

```
>>> @mycontext()
... def function():
...     print('The bit in the middle')
...
>>> function()
Starting
The bit in the middle
Finishing

>>> with mycontext():
...     print('The bit in the middle')
...
Starting
The bit in the middle
Finishing
```

This change is just syntactic sugar for any construct of the following form:

```
def f():
    with cm():
        # Do stuff
```

`ContextDecorator` lets you instead write:

```
@cm()
def f():
    # Do stuff
```

It makes it clear that the `cm` applies to the whole function, rather than just a piece of it (and saving an indentation level is nice, too).

Existing context managers that already have a base class can be extended by using `ContextDecorator` as a mixin class:

```
from contextlib import ContextDecorator

class mycontext(ContextBaseClass, ContextDecorator):
    def __enter__(self):
        return self
```

(繼續下一頁)

(繼續上一頁)

```
def __exit__(self, *exc):
    return False
```

備 F: As the decorated function must be able to be called multiple times, the underlying context manager must support use in multiple `with` statements. If this is not the case, then the original construct with the explicit `with` statement inside the function should be used.

在 3.2 版新加入.

class `contextlib.AsyncContextDecorator`

Similar to `ContextDecorator` but only for asynchronous functions.

`AsyncContextDecorator` 範例:

```
from asyncio import run
from contextlib import AsyncContextDecorator

class mycontext(AsyncContextDecorator):
    async def __aenter__(self):
        print('Starting')
        return self

    async def __aexit__(self, *exc):
        print('Finishing')
        return False
```

The class can then be used like this:

```
>>> @mycontext()
... async def function():
...     print('The bit in the middle')
...
>>> run(function())
Starting
The bit in the middle
Finishing

>>> async def function():
...     async with mycontext():
...         print('The bit in the middle')
...
>>> run(function())
Starting
The bit in the middle
Finishing
```

在 3.10 版新加入.

class `contextlib.ExitStack`

A context manager that is designed to make it easy to programmatically combine other context managers and cleanup functions, especially those that are optional or otherwise driven by input data.

For example, a set of files may easily be handled in a single `with` statement as follows:

```
with ExitStack() as stack:
    files = [stack.enter_context(open(fname)) for fname in filenames]
    # All opened files will automatically be closed at the end of
    # the with statement, even if attempts to open files later
    # in the list raise an exception
```

The `__enter__()` method returns the `ExitStack` instance, and performs no additional operations.

Each instance maintains a stack of registered callbacks that are called in reverse order when the instance is closed (either explicitly or implicitly at the end of a `with` statement). Note that callbacks are *not* invoked implicitly when the context stack instance is garbage collected.

This stack model is used so that context managers that acquire their resources in their `__init__` method (such as file objects) can be handled correctly.

Since registered callbacks are invoked in the reverse order of registration, this ends up behaving as if multiple nested `with` statements had been used with the registered set of callbacks. This even extends to exception handling - if an inner callback suppresses or replaces an exception, then outer callbacks will be passed arguments based on that updated state.

This is a relatively low level API that takes care of the details of correctly unwinding the stack of exit callbacks. It provides a suitable foundation for higher level context managers that manipulate the exit stack in application specific ways.

在 3.3 版新加入.

enter_context (*cm*)

Enters a new context manager and adds its `__exit__()` method to the callback stack. The return value is the result of the context manager's own `__enter__()` method.

These context managers may suppress exceptions just as they normally would if used directly as part of a `with` statement.

在 3.11 版的變更: Raises `TypeError` instead of `AttributeError` if *cm* is not a context manager.

push (*exit*)

Adds a context manager's `__exit__()` method to the callback stack.

As `__enter__` is *not* invoked, this method can be used to cover part of an `__enter__()` implementation with a context manager's own `__exit__()` method.

If passed an object that is not a context manager, this method assumes it is a callback with the same signature as a context manager's `__exit__()` method and adds it directly to the callback stack.

By returning true values, these callbacks can suppress exceptions the same way context manager `__exit__()` methods can.

The passed in object is returned from the function, allowing this method to be used as a function decorator.

callback (*callback*, /, **args*, ***kws*)

Accepts an arbitrary callback function and arguments and adds it to the callback stack.

Unlike the other methods, callbacks added this way cannot suppress exceptions (as they are never passed the exception details).

The passed in callback is returned from the function, allowing this method to be used as a function decorator.

pop_all ()

Transfers the callback stack to a fresh `ExitStack` instance and returns it. No callbacks are invoked by this operation - instead, they will now be invoked when the new stack is closed (either explicitly or implicitly at the end of a `with` statement).

For example, a group of files can be opened as an "all or nothing" operation as follows:

```
with ExitStack() as stack:
    files = [stack.enter_context(open(fname)) for fname in filenames]
    # Hold onto the close method, but don't call it yet.
    close_files = stack.pop_all().close
    # If opening any file fails, all previously opened files will be
    # closed automatically. If all files are opened successfully,
    # they will remain open even after the with statement ends.
    # close_files() can then be invoked explicitly to close them all.
```

close()

Immediately unwinds the callback stack, invoking callbacks in the reverse order of registration. For any context managers and exit callbacks registered, the arguments passed in will indicate that no exception occurred.

class `contextlib.AsyncExitStack`

An asynchronous context manager, similar to `ExitStack`, that supports combining both synchronous and asynchronous context managers, as well as having coroutines for cleanup logic.

The `close()` method is not implemented; `aclose()` must be used instead.

coroutine `enter_async_context(cm)`

Similar to `ExitStack.enter_context()` but expects an asynchronous context manager.

在 3.11 版的變更: Raises `TypeError` instead of `AttributeError` if `cm` is not an asynchronous context manager.

push_async_exit(exit)

Similar to `ExitStack.push()` but expects either an asynchronous context manager or a coroutine function.

push_async_callback(callback, /, *args, **kwargs)

Similar to `ExitStack.callback()` but expects a coroutine function.

coroutine `aclose()`

Similar to `ExitStack.close()` but properly handles awaitables.

Continuing the example for `asynccontextmanager()`:

```
async with AsyncExitStack() as stack:
    connections = [await stack.enter_async_context(get_connection())
                    for i in range(5)]
    # All opened connections will automatically be released at the end of
    # the async with statement, even if attempts to open a connection
    # later in the list raise an exception.
```

在 3.7 版新加入.

29.7.2 Examples and Recipes

This section describes some examples and recipes for making effective use of the tools provided by `contextlib`.

Supporting a variable number of context managers

The primary use case for `ExitStack` is the one given in the class documentation: supporting a variable number of context managers and other cleanup operations in a single `with` statement. The variability may come from the number of context managers needed being driven by user input (such as opening a user specified collection of files), or from some of the context managers being optional:

```
with ExitStack() as stack:
    for resource in resources:
        stack.enter_context(resource)
    if need_special_resource():
        special = acquire_special_resource()
        stack.callback(release_special_resource, special)
    # Perform operations that use the acquired resources
```

As shown, `ExitStack` also makes it quite easy to use `with` statements to manage arbitrary resources that don't natively support the context management protocol.

Catching exceptions from `__enter__` methods

It is occasionally desirable to catch exceptions from an `__enter__` method implementation, *without* inadvertently catching exceptions from the `with` statement body or the context manager's `__exit__` method. By using `ExitStack` the steps in the context management protocol can be separated slightly in order to allow this:

```
stack = ExitStack()
try:
    x = stack.enter_context(cm)
except Exception:
    # handle __enter__ exception
else:
    with stack:
        # Handle normal case
```

Actually needing to do this is likely to indicate that the underlying API should be providing a direct resource management interface for use with `try/except/finally` statements, but not all APIs are well designed in that regard. When a context manager is the only resource management API provided, then `ExitStack` can make it easier to handle various situations that can't be handled directly in a `with` statement.

Cleaning up in an `__enter__` implementation

As noted in the documentation of `ExitStack.push()`, this method can be useful in cleaning up an already allocated resource if later steps in the `__enter__()` implementation fail.

Here's an example of doing this for a context manager that accepts resource acquisition and release functions, along with an optional validation function, and maps them to the context management protocol:

```
from contextlib import contextmanager, AbstractContextManager, ExitStack

class ResourceManager(AbstractContextManager):

    def __init__(self, acquire_resource, release_resource, check_resource_ok=None):
        self.acquire_resource = acquire_resource
        self.release_resource = release_resource
        if check_resource_ok is None:
            def check_resource_ok(resource):
                return True
        self.check_resource_ok = check_resource_ok

    @contextmanager
    def _cleanup_on_error(self):
        with ExitStack() as stack:
            stack.push(self)
            yield
        # The validation check passed and didn't raise an exception
        # Accordingly, we want to keep the resource, and pass it
        # back to our caller
        stack.pop_all()

    def __enter__(self):
        resource = self.acquire_resource()
        with self._cleanup_on_error():
            if not self.check_resource_ok(resource):
                msg = "Failed validation for {!r}"
                raise RuntimeError(msg.format(resource))
        return resource

    def __exit__(self, *exc_details):
        # We don't need to duplicate any of our resource release logic
        self.release_resource()
```

Replacing any use of `try-finally` and flag variables

A pattern you will sometimes see is a `try-finally` statement with a flag variable to indicate whether or not the body of the `finally` clause should be executed. In its simplest form (that can't already be handled just by using an `except` clause instead), it looks something like this:

```
cleanup_needed = True
try:
    result = perform_operation()
    if result:
        cleanup_needed = False
finally:
    if cleanup_needed:
        cleanup_resources()
```

As with any `try` statement based code, this can cause problems for development and review, because the setup code and the cleanup code can end up being separated by arbitrarily long sections of code.

`ExitStack` makes it possible to instead register a callback for execution at the end of a `with` statement, and then later decide to skip executing that callback:

```
from contextlib import ExitStack

with ExitStack() as stack:
    stack.callback(cleanup_resources)
    result = perform_operation()
    if result:
        stack.pop_all()
```

This allows the intended cleanup up behaviour to be made explicit up front, rather than requiring a separate flag variable.

If a particular application uses this pattern a lot, it can be simplified even further by means of a small helper class:

```
from contextlib import ExitStack

class Callback(ExitStack):
    def __init__(self, callback, /, *args, **kwds):
        super().__init__()
        self.callback(callback, *args, **kwds)

    def cancel(self):
        self.pop_all()

with Callback(cleanup_resources) as cb:
    result = perform_operation()
    if result:
        cb.cancel()
```

If the resource cleanup isn't already neatly bundled into a standalone function, then it is still possible to use the decorator form of `ExitStack.callback()` to declare the resource cleanup in advance:

```
from contextlib import ExitStack

with ExitStack() as stack:
    @stack.callback
    def cleanup_resources():
        ...
    result = perform_operation()
    if result:
        stack.pop_all()
```

Due to the way the decorator protocol works, a callback function declared this way cannot take any parameters. Instead, any resources to be released must be accessed as closure variables.

Using a context manager as a function decorator

`ContextDecorator` makes it possible to use a context manager in both an ordinary `with` statement and also as a function decorator.

For example, it is sometimes useful to wrap functions or groups of statements with a logger that can track the time of entry and time of exit. Rather than writing both a function decorator and a context manager for the task, inheriting from `ContextDecorator` provides both capabilities in a single definition:

```
from contextlib import ContextDecorator
import logging

logging.basicConfig(level=logging.INFO)

class track_entry_and_exit(ContextDecorator):
    def __init__(self, name):
        self.name = name

    def __enter__(self):
        logging.info('Entering: %s', self.name)

    def __exit__(self, exc_type, exc, exc_tb):
        logging.info('Exiting: %s', self.name)
```

Instances of this class can be used as both a context manager:

```
with track_entry_and_exit('widget loader'):
    print('Some time consuming activity goes here')
    load_widget()
```

And also as a function decorator:

```
@track_entry_and_exit('widget loader')
def activity():
    print('Some time consuming activity goes here')
    load_widget()
```

Note that there is one additional limitation when using context managers as function decorators: there's no way to access the return value of `__enter__()`. If that value is needed, then it is still necessary to use an explicit `with` statement.

也参考:

PEP 343 - "with" 陳述式

The specification, background, and examples for the Python `with` statement.

29.7.3 Single use, reusable and reentrant context managers

Most context managers are written in a way that means they can only be used effectively in a `with` statement once. These single use context managers must be created afresh each time they're used - attempting to use them a second time will trigger an exception or otherwise not work correctly.

This common limitation means that it is generally advisable to create context managers directly in the header of the `with` statement where they are used (as shown in all of the usage examples above).

Files are an example of effectively single use context managers, since the first `with` statement will close the file, preventing any further IO operations using that file object.

Context managers created using `contextmanager()` are also single use context managers, and will complain about the underlying generator failing to yield if an attempt is made to use them a second time:

```
>>> from contextlib import contextmanager
>>> @contextmanager
... def singleuse():
...     print("Before")
...     yield
...     print("After")
...
>>> cm = singleuse()
>>> with cm:
...     pass
...
Before
After
>>> with cm:
...     pass
...
Traceback (most recent call last):
...
RuntimeError: generator didn't yield
```

Reentrant context managers

More sophisticated context managers may be “reentrant”. These context managers can not only be used in multiple with statements, but may also be used *inside* a with statement that is already using the same context manager.

`threading.RLock` is an example of a reentrant context manager, as are `suppress()`, `redirect_stdout()`, and `chdir()`. Here’s a very simple example of reentrant use:

```
>>> from contextlib import redirect_stdout
>>> from io import StringIO
>>> stream = StringIO()
>>> write_to_stream = redirect_stdout(stream)
>>> with write_to_stream:
...     print("This is written to the stream rather than stdout")
...     with write_to_stream:
...         print("This is also written to the stream")
...
>>> print("This is written directly to stdout")
This is written directly to stdout
>>> print(stream.getvalue())
This is written to the stream rather than stdout
This is also written to the stream
```

Real world examples of reentrancy are more likely to involve multiple functions calling each other and hence be far more complicated than this example.

Note also that being reentrant is *not* the same thing as being thread safe. `redirect_stdout()`, for example, is definitely not thread safe, as it makes a global modification to the system state by binding `sys.stdout` to a different stream.

Reusable context managers

Distinct from both single use and reentrant context managers are “reusable” context managers (or, to be completely explicit, “reusable, but not reentrant” context managers, since reentrant context managers are also reusable). These context managers support being used multiple times, but will fail (or otherwise not work correctly) if the specific context manager instance has already been used in a containing with statement.

`threading.Lock` is an example of a reusable, but not reentrant, context manager (for a reentrant lock, it is necessary to use `threading.RLock` instead).

Another example of a reusable, but not reentrant, context manager is `ExitStack`, as it invokes *all* currently registered callbacks when leaving any with statement, regardless of where those callbacks were added:

```
>>> from contextlib import ExitStack
>>> stack = ExitStack()
>>> with stack:
...     stack.callback(print, "Callback: from first context")
...     print("Leaving first context")
...
Leaving first context
Callback: from first context
>>> with stack:
...     stack.callback(print, "Callback: from second context")
...     print("Leaving second context")
...
Leaving second context
Callback: from second context
>>> with stack:
...     stack.callback(print, "Callback: from outer context")
...     with stack:
...         stack.callback(print, "Callback: from inner context")
...         print("Leaving inner context")
...     print("Leaving outer context")
...
Leaving inner context
Callback: from inner context
Callback: from outer context
Leaving outer context
```

As the output from the example shows, reusing a single stack object across multiple with statements works correctly, but attempting to nest them will cause the stack to be cleared at the end of the innermost with statement, which is unlikely to be desirable behaviour.

Using separate `ExitStack` instances instead of reusing a single instance avoids that problem:

```
>>> from contextlib import ExitStack
>>> with ExitStack() as outer_stack:
...     outer_stack.callback(print, "Callback: from outer context")
...     with ExitStack() as inner_stack:
...         inner_stack.callback(print, "Callback: from inner context")
...         print("Leaving inner context")
...     print("Leaving outer context")
...
Leaving inner context
Callback: from inner context
Leaving outer context
Callback: from outer context
```

29.8 abc --- 抽象基底類

原始碼: `Lib/abc.py`

如同在 [PEP 3119](#) 中所述，該模組提供了在 Python 中定義抽象基底類 (ABC) 的基礎元件；若想解什需要在 Python 中增加這個模組，請見 PEP 文件。（也請見 [PEP 3141](#) 以及 `numbers` 模組以解基於 ABC 的數字型階層關。）

The `collections` module has some concrete classes that derive from ABCs; these can, of course, be further derived. In addition, the `collections.abc` submodule has some ABCs that can be used to test whether a class or instance provides a particular interface, for example, if it is *hashable* or if it is a *mapping*.

該模組提供了一個用來定義 ABC 的元類 (metaclass) `ABCMeta` 和另一個以繼承的方式定義 ABC 的工具類 `ABC`:

class `abc.ABC`

A helper class that has `ABCMeta` as its metaclass. With this class, an abstract base class can be created by simply deriving from `ABC` avoiding sometimes confusing metaclass usage, for example:

```
from abc import ABC

class MyABC(ABC):
    pass
```

Note that the type of `ABC` is still `ABCMeta`, therefore inheriting from `ABC` requires the usual precautions regarding metaclass usage, as multiple inheritance may lead to metaclass conflicts. One may also define an abstract base class by passing the metaclass keyword and using `ABCMeta` directly, for example:

```
from abc import ABCMeta

class MyABC(metaclass=ABCMeta):
    pass
```

在 3.4 版新加入。

class `abc.ABCMeta`

用於定義抽象基底類 (ABC) 的元類。

使用該元類以建立一個 ABC。一個 ABC 可以像 mix-in 類一樣直接被子類繼承。你也可以將不相關的具體類（甚至是建類）和 ABC 「擬子類 (virtual subclass)」——這些類以及它們的子類會被建函式 `issubclass()` 識為 ABC 的子類，但是該 ABC 不會出現在其 MRO (Method Resolution Order, 方法解析順序) 中，由該 ABC 所定義的方法實作也不可呼叫（即使透過 `super()` 呼叫也不行）。¹

Classes created with a metaclass of `ABCMeta` have the following method:

register (*subclass*)

將子類加入該 ABC 的「抽象子類」，例如：

```
from abc import ABC

class MyABC(ABC):
    pass

MyABC.register(tuple)

assert issubclass(tuple, MyABC)
assert isinstance((), MyABC)
```

¹ C++ 程式設計師需要注意到 Python 中擬基底類的概念和 C++ 中的不相同。

在 3.3 版的變更: 回傳已的子類, 使其能作類裝飾器。

在 3.4 版的變更: To detect calls to `register()`, you can use the `get_cache_token()` function. 你也可以覆寫 (override) 擬基底類中的這個方法:

`__subclasshook__(subclass)`

(必須定義類方法。)

Check whether *subclass* is considered a subclass of this ABC. This means that you can customize the behavior of `issubclass()` further without the need to call `register()` on every class you want to consider a subclass of the ABC. (This class method is called from the `__subclasscheck__()` method of the ABC.)

This method should return `True`, `False` or `NotImplemented`. If it returns `True`, the *subclass* is considered a subclass of this ABC. If it returns `False`, the *subclass* is not considered a subclass of this ABC, even if it would normally be one. If it returns `NotImplemented`, the subclass check is continued with the usual mechanism.

了對這些概念做一演示, 請見以下定義 ABC 的範例:

```
class Foo:
    def __getitem__(self, index):
        ...
    def __len__(self):
        ...
    def get_iterator(self):
        return iter(self)

class MyIterable(ABC):

    @abstractmethod
    def __iter__(self):
        while False:
            yield None

    def get_iterator(self):
        return self.__iter__()

    @classmethod
    def __subclasshook__(cls, C):
        if cls is MyIterable:
            if any("__iter__" in B.__dict__ for B in C.__mro__):
                return True
            return NotImplemented

MyIterable.register(Foo)
```

The ABC `MyIterable` defines the standard iterable method, `__iter__()`, as an abstract method. The implementation given here can still be called from subclasses. The `get_iterator()` method is also part of the `MyIterable` abstract base class, but it does not have to be overridden in non-abstract derived classes.

這定義的 `__subclasshook__()` 類方法明任何在其 `__dict__` (或在其透過 `__mro__` 列表訪問的基底類) 中具有 `__iter__()` 方法的類也都會被視 `MyIterable`。

Finally, the last line makes `Foo` a virtual subclass of `MyIterable`, even though it does not define an `__iter__()` method (it uses the old-style iterable protocol, defined in terms of `__len__()` and `__getitem__()`). Note that this will not make `get_iterator` available as a method of `Foo`, so it is provided separately.

The `abc` module also provides the following decorator:

`@abc.abstractmethod`

用於表示抽象方法的裝飾器。

Using this decorator requires that the class's metaclass is `ABCMeta` or is derived from it. A class that has a metaclass derived from `ABCMeta` cannot be instantiated unless all of its abstract methods and properties are overridden. The abstract methods can be called using any of the normal 'super' call mechanisms. `abstractmethod()` may be used to declare abstract methods for properties and descriptors.

Dynamically adding abstract methods to a class, or attempting to modify the abstraction status of a method or class once it is created, are only supported using the `update_abstractmethods()` function. The `abstractmethod()` only affects subclasses derived using regular inheritance; "virtual subclasses" registered with the ABC's `register()` method are not affected.

When `abstractmethod()` is applied in combination with other method descriptors, it should be applied as the innermost decorator, as shown in the following usage examples:

```
class C(ABC):
    @abstractmethod
    def my_abstract_method(self, arg1):
        ...

    @classmethod
    @abstractmethod
    def my_abstract_classmethod(cls, arg2):
        ...

    @staticmethod
    @abstractmethod
    def my_abstract_staticmethod(arg3):
        ...

    @property
    @abstractmethod
    def my_abstract_property(self):
        ...

    @my_abstract_property.setter
    @abstractmethod
    def my_abstract_property(self, val):
        ...

    @abstractmethod
    def _get_x(self):
        ...

    @abstractmethod
    def _set_x(self, val):
        ...

    x = property(_get_x, _set_x)
```

In order to correctly interoperate with the abstract base class machinery, the descriptor must identify itself as abstract using `__isabstractmethod__`. In general, this attribute should be `True` if any of the methods used to compose the descriptor are abstract. For example, Python's built-in `property` does the equivalent of:

```
class Descriptor:
    ...
    @property
    def __isabstractmethod__(self):
        return any(getattr(f, '__isabstractmethod__', False) for
                    f in (self._fget, self._fset, self._fdel))
```

備 F: 不同於 Java 抽象方法，這些抽象方法可能具有一個實作。這個實作可在覆寫它的類 F 上透過 `super()` 機制來呼叫。這在使用協作多重繼承 (cooperative multiple-inheritance) 的框架中，可以被用作 `super` 呼叫的一個端點 (end-point)。

The `abc` module also supports the following legacy decorators:

@abc.abstractclassmethod

在 3.2 版新加入。

在 3.3 版之後被用：現在可以讓 `classmethod` 配合 `abstractmethod()` 使用，使得此裝飾器變得冗余。

建 `classmethod()` 的子類，表示一個抽象方法。在其他方面它都類似於 `abstractmethod()`。

這個特例已被用，因現在當 `classmethod()` 裝飾器應用於抽象方法時已會被正確地標識是抽象的：

```
class C(ABC):
    @classmethod
    @abstractmethod
    def my_abstract_classmethod(cls, arg):
        ...
```

@abc.abstractstaticmethod

在 3.2 版新加入。

在 3.3 版之後被用：現在可以讓 `staticmethod` 配合 `abstractmethod()` 使用，使得此裝飾器變得冗余。

建 `staticmethod()` 的子類，表示一個抽象態方法。在其他方面它都類似於 `abstractmethod()`。

這個特例已被用，因現在當 `staticmethod()` 裝飾器應用於抽象方法時已會被正確地標識是抽象的：

```
class C(ABC):
    @staticmethod
    @abstractmethod
    def my_abstract_staticmethod(arg):
        ...
```

@abc.abstractproperty

在 3.3 版之後被用：現在可以讓 `property`、`property.getter()`、`property.setter()` 和 `property.deleter()` 配合 `abstractmethod()` 使用，使得此裝飾器變得冗余。

建 `property()` 的子類，表示一個抽象特性。

這個特例已被用，因現在當 `property()` 裝飾器應用於抽象方法時已會被正確地標識是抽象的：

```
class C(ABC):
    @property
    @abstractmethod
    def my_abstract_property(self):
        ...
```

上面的例子定義了一個唯讀特性；你也可以透過適當地將一個或多個底層方法標記抽象的來定義可讀寫的抽象特性：

```
class C(ABC):
    @property
    def x(self):
        ...

    @x.setter
    @abstractmethod
    def x(self, val):
        ...
```

如果只有某些元件是抽象的，則只需更新那些元件即可在子類中建立具體的特性：

```
class D(C):
    @C.x.setter
    def x(self, val):
        ...
```

The `abc` module also provides the following functions:

`abc.get_cache_token()`

回傳當前 ABC 快取令牌 (cache token)。

此令牌是一個（支援相等性測試的）不透明物件 (opaque object)，用於擬子類標識抽象基底類快取的當前版本。此令牌會在任何 ABC 上每次呼叫 `ABCMeta.register()` 時發生更改。

在 3.4 版新加入。

`abc.update_abstractmethods(cls)`

重新計算一個抽象類之抽象狀態的函式。如果一個類的抽象方法在建立後被實作或被修改，則應當呼叫此函式。通常此函式應在一個類裝飾器部被呼叫。

回傳 `cls`，使其能用作類的裝飾器。

如果 `cls` 不是 `ABCMeta` 的實例則不做任何操作。

備註： 此函式會假定 `cls` 的超類 (superclass) 已經被更新。它不會更新任何子類。

在 3.10 版新加入。

解

29.9 atexit --- Exit handlers

The `atexit` module defines functions to register and unregister cleanup functions. Functions thus registered are automatically executed upon normal interpreter termination. `atexit` runs these functions in the *reverse* order in which they were registered; if you register A, B, and C, at interpreter termination time they will be run in the order C, B, A.

Note: The functions registered via this module are not called when the program is killed by a signal not handled by Python, when a Python fatal internal error is detected, or when `os._exit()` is called.

Note: The effect of registering or unregistering functions from within a cleanup function is undefined.

在 3.7 版的變更: When used with C-API subinterpreters, registered functions are local to the interpreter they were registered in.

`atexit.register(func, *args, **kwargs)`

Register `func` as a function to be executed at termination. Any optional arguments that are to be passed to `func` must be passed as arguments to `register()`. It is possible to register the same function and arguments more than once.

At normal program termination (for instance, if `sys.exit()` is called or the main module's execution completes), all functions registered are called in last in, first out order. The assumption is that lower level modules will normally be imported before higher level modules and thus must be cleaned up later.

If an exception is raised during execution of the exit handlers, a traceback is printed (unless `SystemExit` is raised) and the exception information is saved. After all exit handlers have had a chance to run, the last exception to be raised is re-raised.

This function returns `func`, which makes it possible to use it as a decorator.

`atexit.unregister(func)`

Remove *func* from the list of functions to be run at interpreter shutdown. *unregister()* silently does nothing if *func* was not previously registered. If *func* has been registered more than once, every occurrence of that function in the *atexit* call stack will be removed. Equality comparisons (==) are used internally during unregistration, so function references do not need to have matching identities.

也參考:

readline 模組

Useful example of *atexit* to read and write *readline* history files.

29.9.1 atexit 范例

The following simple example demonstrates how a module can initialize a counter from a file when it is imported and save the counter's updated value automatically when the program terminates without relying on the application making an explicit call into this module at termination.

```
try:
    with open('counterfile') as infile:
        _count = int(infile.read())
except FileNotFoundError:
    _count = 0

def incrcounter(n):
    global _count
    _count = _count + n

def savecounter():
    with open('counterfile', 'w') as outfile:
        outfile.write('%d' % _count)

import atexit

atexit.register(savecounter)
```

Positional and keyword arguments may also be passed to *register()* to be passed along to the registered function when it is called:

```
def goodbye(name, adjective):
    print('Goodbye %s, it was %s to meet you.' % (name, adjective))

import atexit

atexit.register(goodbye, 'Donny', 'nice')
# or:
atexit.register(goodbye, adjective='nice', name='Donny')
```

Usage as a *decorator*:

```
import atexit

@atexit.register
def goodbye():
    print('You are now leaving the Python sector.')
```

This only works with functions that can be called without arguments.

29.10 `traceback` --- Print or retrieve a stack traceback

原始碼: [Lib/traceback.py](#)

This module provides a standard interface to extract, format and print stack traces of Python programs. It exactly mimics the behavior of the Python interpreter when it prints a stack trace. This is useful when you want to print stack traces under program control, such as in a “wrapper” around the interpreter.

The module uses traceback objects --- these are objects of type `types.TracebackType`, which are assigned to the `__traceback__` field of `BaseException` instances.

也參考:

Module `faulthandler`

Used to dump Python tracebacks explicitly, on a fault, after a timeout, or on a user signal.

Module `pdb`

Interactive source code debugger for Python programs.

The module defines the following functions:

`traceback.print_tb(tb, limit=None, file=None)`

Print up to *limit* stack trace entries from traceback object *tb* (starting from the caller’s frame) if *limit* is positive. Otherwise, print the last `abs(limit)` entries. If *limit* is omitted or `None`, all entries are printed. If *file* is omitted or `None`, the output goes to `sys.stderr`; otherwise it should be an open *file* or *file-like object* to receive the output.

在 3.5 版的變更: Added negative *limit* support.

`traceback.print_exception(exc, /, [value, tb,], limit=None, file=None, chain=True)`

Print exception information and stack trace entries from traceback object *tb* to *file*. This differs from `print_tb()` in the following ways:

- if *tb* is not `None`, it prints a header `Traceback (most recent call last):`
- it prints the exception type and *value* after the stack trace
- if `type(value)` is `SyntaxError` and *value* has the appropriate format, it prints the line where the syntax error occurred with a caret indicating the approximate position of the error.

Since Python 3.10, instead of passing *value* and *tb*, an exception object can be passed as the first argument. If *value* and *tb* are provided, the first argument is ignored in order to provide backwards compatibility.

The optional *limit* argument has the same meaning as for `print_tb()`. If *chain* is true (the default), then chained exceptions (the `__cause__` or `__context__` attributes of the exception) will be printed as well, like the interpreter itself does when printing an unhandled exception.

在 3.5 版的變更: The *etype* argument is ignored and inferred from the type of *value*.

在 3.10 版的變更: The *etype* parameter has been renamed to *exc* and is now positional-only.

`traceback.print_exc(limit=None, file=None, chain=True)`

This is a shorthand for `print_exception(sys.exception(), limit, file, chain)`.

`traceback.print_last(limit=None, file=None, chain=True)`

This is a shorthand for `print_exception(sys.last_type, sys.last_value, sys.last_traceback, limit, file, chain)`. In general it will work only after an exception has reached an interactive prompt (see `sys.last_type`).

`traceback.print_stack(f=None, limit=None, file=None)`

Print up to *limit* stack trace entries (starting from the invocation point) if *limit* is positive. Otherwise, print the last `abs(limit)` entries. If *limit* is omitted or `None`, all entries are printed. The optional *f* argument can be used to specify an alternate stack frame to start. The optional *file* argument has the same meaning as for `print_tb()`.

在 3.5 版的變更: Added negative *limit* support.

`traceback.extract_tb(tb, limit=None)`

Return a `StackSummary` object representing a list of "pre-processed" stack trace entries extracted from the traceback object *tb*. It is useful for alternate formatting of stack traces. The optional *limit* argument has the same meaning as for `print_tb()`. A "pre-processed" stack trace entry is a `FrameSummary` object containing attributes *filename*, *lineno*, *name*, and *line* representing the information that is usually printed for a stack trace.

`traceback.extract_stack(f=None, limit=None)`

Extract the raw traceback from the current stack frame. The return value has the same format as for `extract_tb()`. The optional *f* and *limit* arguments have the same meaning as for `print_stack()`.

`traceback.format_list(extracted_list)`

Given a list of tuples or `FrameSummary` objects as returned by `extract_tb()` or `extract_stack()`, return a list of strings ready for printing. Each string in the resulting list corresponds to the item with the same index in the argument list. Each string ends in a newline; the strings may contain internal newlines as well, for those items whose source text line is not `None`.

`traceback.format_exception_only(exc, [value])`

Format the exception part of a traceback using an exception value such as given by `sys.last_value`. The return value is a list of strings, each ending in a newline. The list contains the exception's message, which is normally a single string; however, for `SyntaxError` exceptions, it contains several lines that (when printed) display detailed information about where the syntax error occurred. Following the message, the list contains the exception's *notes*.

Since Python 3.10, instead of passing *value*, an exception object can be passed as the first argument. If *value* is provided, the first argument is ignored in order to provide backwards compatibility.

在 3.10 版的變更: The *etype* parameter has been renamed to *exc* and is now positional-only.

在 3.11 版的變更: The returned list now includes any *notes* attached to the exception.

`traceback.format_exception(exc, [value, tb], limit=None, chain=True)`

Format a stack trace and the exception information. The arguments have the same meaning as the corresponding arguments to `print_exception()`. The return value is a list of strings, each ending in a newline and some containing internal newlines. When these lines are concatenated and printed, exactly the same text is printed as does `print_exception()`.

在 3.5 版的變更: The *etype* argument is ignored and inferred from the type of *value*.

在 3.10 版的變更: This function's behavior and signature were modified to match `print_exception()`.

`traceback.format_exc(limit=None, chain=True)`

This is like `print_exc(limit)` but returns a string instead of printing to a file.

`traceback.format_tb(tb, limit=None)`

A shorthand for `format_list(extract_tb(tb, limit))`.

`traceback.format_stack(f=None, limit=None)`

A shorthand for `format_list(extract_stack(f, limit))`.

`traceback.clear_frames(tb)`

Clears the local variables of all the stack frames in a traceback *tb* by calling the `clear()` method of each frame object.

在 3.4 版新加入.

`traceback.walk_stack(f)`

Walk a stack following `f.f_back` from the given frame, yielding the frame and line number for each frame. If `f` is `None`, the current stack is used. This helper is used with `StackSummary.extract()`.

在 3.5 版新加入。

`traceback.walk_tb(tb)`

Walk a traceback following `tb.next` yielding the frame and line number for each frame. This helper is used with `StackSummary.extract()`.

在 3.5 版新加入。

The module also defines the following classes:

29.10.1 TracebackException Objects

在 3.5 版新加入。

`TracebackException` objects are created from actual exceptions to capture data for later printing in a lightweight fashion.

```
class traceback.TracebackException(exc_type, exc_value, exc_traceback, *, limit=None,  
                                     lookup_lines=True, capture_locals=False, compact=False,  
                                     max_group_width=15, max_group_depth=10)
```

Capture an exception for later rendering. `limit`, `lookup_lines` and `capture_locals` are as for the `StackSummary` class.

If `compact` is true, only data that is required by `TracebackException`'s `format()` method is saved in the class attributes. In particular, the `__context__` field is calculated only if `__cause__` is `None` and `__suppress_context__` is false.

Note that when locals are captured, they are also shown in the traceback.

`max_group_width` and `max_group_depth` control the formatting of exception groups (see `BaseExceptionGroup`). The depth refers to the nesting level of the group, and the width refers to the size of a single exception group's exceptions array. The formatted output is truncated when either limit is exceeded.

在 3.10 版的變更: 新增 `compact` 參數。

在 3.11 版的變更: Added the `max_group_width` and `max_group_depth` parameters.

`__cause__`

A `TracebackException` of the original `__cause__`.

`__context__`

A `TracebackException` of the original `__context__`.

`exceptions`

If `self` represents an `ExceptionGroup`, this field holds a list of `TracebackException` instances representing the nested exceptions. Otherwise it is `None`.

在 3.11 版新加入。

`__suppress_context__`

The `__suppress_context__` value from the original exception.

`__notes__`

The `__notes__` value from the original exception, or `None` if the exception does not have any notes. If it is not `None` is it formatted in the traceback after the exception string.

在 3.11 版新加入。

stack

A *StackSummary* representing the traceback.

exc_type

The class of the original traceback.

filename

For syntax errors - the file name where the error occurred.

lineno

For syntax errors - the line number where the error occurred.

end_lineno

For syntax errors - the end line number where the error occurred. Can be `None` if not present.

在 3.10 版新加入.

text

For syntax errors - the text where the error occurred.

offset

For syntax errors - the offset into the text where the error occurred.

end_offset

For syntax errors - the end offset into the text where the error occurred. Can be `None` if not present.

在 3.10 版新加入.

msg

For syntax errors - the compiler error message.

classmethod from_exception (*exc*, *, *limit=None*, *lookup_lines=True*, *capture_locals=False*)

Capture an exception for later rendering. *limit*, *lookup_lines* and *capture_locals* are as for the *StackSummary* class.

Note that when locals are captured, they are also shown in the traceback.

print (*, *file=None*, *chain=True*)

Print to *file* (default `sys.stderr`) the exception information returned by *format* ().

在 3.11 版新加入.

format (*, *chain=True*)

Format the exception.

If *chain* is not `True`, `__cause__` and `__context__` will not be formatted.

The return value is a generator of strings, each ending in a newline and some containing internal newlines.

print_exception() is a wrapper around this method which just prints the lines to a file.

format_exception_only ()

Format the exception part of the traceback.

The return value is a generator of strings, each ending in a newline.

The generator emits the exception's message followed by its notes (if it has any). The exception message is normally a single string; however, for *SyntaxError* exceptions, it consists of several lines that (when printed) display detailed information about where the syntax error occurred.

在 3.11 版的變更: The exception's *notes* are now included in the output.

29.10.2 StackSummary Objects

在 3.5 版新加入.

StackSummary objects represent a call stack ready for formatting.

class `traceback.StackSummary`

classmethod `extract` (*frame_gen*, *, *limit=None*, *lookup_lines=True*, *capture_locals=False*)

Construct a StackSummary object from a frame generator (such as is returned by `walk_stack()` or `walk_tb()`).

If *limit* is supplied, only this many frames are taken from *frame_gen*. If *lookup_lines* is `False`, the returned `FrameSummary` objects will not have read their lines in yet, making the cost of creating the StackSummary cheaper (which may be valuable if it may not actually get formatted). If *capture_locals* is `True` the local variables in each `FrameSummary` are captured as object representations.

classmethod `from_list` (*a_list*)

Construct a StackSummary object from a supplied list of `FrameSummary` objects or old-style list of tuples. Each tuple should be a 4-tuple with *filename*, *lineno*, *name*, *line* as the elements.

format ()

Returns a list of strings ready for printing. Each string in the resulting list corresponds to a single frame from the stack. Each string ends in a newline; the strings may contain internal newlines as well, for those items with source text lines.

For long sequences of the same frame and line, the first few repetitions are shown, followed by a summary line stating the exact number of further repetitions.

在 3.6 版的變更: Long sequences of repeated frames are now abbreviated.

format_frame_summary (*frame_summary*)

Returns a string for printing one of the frames involved in the stack. This method is called for each `FrameSummary` object to be printed by `StackSummary.format()`. If it returns `None`, the frame is omitted from the output.

在 3.11 版新加入.

29.10.3 FrameSummary Objects

在 3.5 版新加入.

A FrameSummary object represents a single frame in a traceback.

class `traceback.FrameSummary` (*filename*, *lineno*, *name*, *lookup_line=True*, *locals=None*, *line=None*)

Represents a single frame in the traceback or stack that is being formatted or printed. It may optionally have a stringified version of the frame's locals included in it. If *lookup_line* is `False`, the source code is not looked up until the `FrameSummary` has the *line* attribute accessed (which also happens when casting it to a `tuple`). *line* may be directly provided, and will prevent line lookups happening at all. *locals* is an optional local variable dictionary, and if supplied the variable representations are stored in the summary for later display.

FrameSummary instances have the following attributes:

filename

The filename of the source code for this frame. Equivalent to accessing `f.f_code.co_filename` on a frame object *f*.

lineno

The line number of the source code for this frame.

name

Equivalent to accessing `f.f_code.co_name` on a frame object *f*.

line

A string representing the source code for this frame, with leading and trailing whitespace stripped. If the source is not available, it is None.

29.10.4 Traceback Examples

This simple example implements a basic read-eval-print loop, similar to (but less useful than) the standard Python interactive interpreter loop. For a more complete implementation of the interpreter loop, refer to the [code](#) module.

```
import sys, traceback

def run_user_code(envdir):
    source = input(">>> ")
    try:
        exec(source, envdir)
    except Exception:
        print("Exception in user code:")
        print("-"*60)
        traceback.print_exc(file=sys.stdout)
        print("-"*60)

envdir = {}
while True:
    run_user_code(envdir)
```

The following example demonstrates the different ways to print and format the exception and traceback:

```
import sys, traceback

def lumberjack():
    bright_side_of_life()

def bright_side_of_life():
    return tuple()[0]

try:
    lumberjack()
except IndexError:
    exc = sys.exception()
    print("*** print_tb:")
    traceback.print_tb(exc.__traceback__, limit=1, file=sys.stdout)
    print("*** print_exception:")
    traceback.print_exception(exc, limit=2, file=sys.stdout)
    print("*** print_exc:")
    traceback.print_exc(limit=2, file=sys.stdout)
    print("*** format_exc, first and last line:")
    formatted_lines = traceback.format_exc().splitlines()
    print(formatted_lines[0])
    print(formatted_lines[-1])
    print("*** format_exception:")
    print(repr(traceback.format_exception(exc)))
    print("*** extract_tb:")
    print(repr(traceback.extract_tb(exc.__traceback__)))
    print("*** format_tb:")
    print(repr(traceback.format_tb(exc.__traceback__)))
    print("*** tb_lineno:", exc.__traceback__.tb_lineno)
```

The output for the example would look similar to this:

```
*** print_tb:
File "<doctest...>", line 10, in <module>
```

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```

    lumberjack()
*** print_exception:
Traceback (most recent call last):
  File "<doctest...>", line 10, in <module>
    lumberjack()
  File "<doctest...>", line 4, in lumberjack
    bright_side_of_life()
IndexError: tuple index out of range
*** print_exc:
Traceback (most recent call last):
  File "<doctest...>", line 10, in <module>
    lumberjack()
  File "<doctest...>", line 4, in lumberjack
    bright_side_of_life()
IndexError: tuple index out of range
*** format_exc, first and last line:
Traceback (most recent call last):
IndexError: tuple index out of range
*** format_exception:
['Traceback (most recent call last):\n',
 '  File "<doctest default[0]>", line 10, in <module>\n    lumberjack()\n',
 '  File "<doctest default[0]>", line 4, in lumberjack\n    bright_side_of_life()\n
↪',
 '  File "<doctest default[0]>", line 7, in bright_side_of_life\n    return_
↪tuple()[0]\n          ~~~~~~^^^\n',
 'IndexError: tuple index out of range\n']
*** extract_tb:
[<FrameSummary file <doctest...>, line 10 in <module>>,
 <FrameSummary file <doctest...>, line 4 in lumberjack>,
 <FrameSummary file <doctest...>, line 7 in bright_side_of_life>]
*** format_tb:
['  File "<doctest default[0]>", line 10, in <module>\n    lumberjack()\n',
 '  File "<doctest default[0]>", line 4, in lumberjack\n    bright_side_of_life()\n
↪',
 '  File "<doctest default[0]>", line 7, in bright_side_of_life\n    return_
↪tuple()[0]\n          ~~~~~~^^^\n']
*** tb_lineno: 10

```

The following example shows the different ways to print and format the stack:

```

>>> import traceback
>>> def another_function():
...     lumberstack()
...
>>> def lumberstack():
...     traceback.print_stack()
...     print(repr(traceback.extract_stack()))
...     print(repr(traceback.format_stack()))
...
>>> another_function()
File "<doctest>", line 10, in <module>
  another_function()
File "<doctest>", line 3, in another_function
  lumberstack()
File "<doctest>", line 6, in lumberstack
  traceback.print_stack()
[(' <doctest>', 10, '<module>', 'another_function()'),
 (' <doctest>', 3, 'another_function', 'lumberstack()'),
 (' <doctest>', 7, 'lumberstack', 'print(repr(traceback.extract_stack()))')]
['  File "<doctest>", line 10, in <module>\n    another_function()\n',
 '  File "<doctest>", line 3, in another_function\n    lumberstack()\n',

```

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```
' File "<doctest>", line 8, in lumberstack\n    print(repr(traceback.format_
↳ stack()))\n']
```

This last example demonstrates the final few formatting functions:

```
>>> import traceback
>>> traceback.format_list([('spam.py', 3, '<module>', 'spam.eggs()'),
...                        ('eggs.py', 42, 'eggs', 'return "bacon"')])
[' File "spam.py", line 3, in <module>\n    spam.eggs()\n',
 ' File "eggs.py", line 42, in eggs\n    return "bacon"\n']
>>> an_error = IndexError('tuple index out of range')
>>> traceback.format_exception_only(type(an_error), an_error)
['IndexError: tuple index out of range\n']
```

29.11 `__future__` --- Future statement definitions

原始碼: [Lib/__future__.py](#)

Imports of the form `from __future__ import feature` are called future statements. These are special-cased by the Python compiler to allow the use of new Python features in modules containing the future statement before the release in which the feature becomes standard.

While these future statements are given additional special meaning by the Python compiler, they are still executed like any other import statement and the `__future__` exists and is handled by the import system the same way any other Python module would be. This design serves three purposes:

- To avoid confusing existing tools that analyze import statements and expect to find the modules they're importing.
- To document when incompatible changes were introduced, and when they will be --- or were --- made mandatory. This is a form of executable documentation, and can be inspected programmatically via importing `__future__` and examining its contents.
- To ensure that future statements run under releases prior to Python 2.1 at least yield runtime exceptions (the import of `__future__` will fail, because there was no module of that name prior to 2.1).

29.11.1 Module Contents

No feature description will ever be deleted from `__future__`. Since its introduction in Python 2.1 the following features have found their way into the language using this mechanism:

feature	optional in	mandatory in	effect
nested_scopes	2.1.0b1	2.2	PEP 227 : <i>Statically Nested Scopes</i>
generators	2.2.0a1	2.3	PEP 255 : <i>Simple Generators</i>
division	2.2.0a2	3.0	PEP 238 : <i>Changing the Division Operator</i>
absolute_import	2.5.0a1	3.0	PEP 328 : <i>Imports: Multi-Line and Absolute/Relative</i>
with_statement	2.5.0a1	2.6	PEP 343 : <i>The "with" Statement</i>
print_function	2.6.0a2	3.0	PEP 3105 : <i>Make print a function</i>
unicode_literals	2.6.0a2	3.0	PEP 3112 : <i>Bytes literals in Python 3000</i>
generator_stop	3.5.0b1	3.7	PEP 479 : <i>StopIteration handling inside generators</i>
annotations	3.7.0b1	TBD ¹	PEP 563 : <i>Postponed evaluation of annotations</i>

¹ from `__future__ import annotations` was previously scheduled to become mandatory in Python 3.10, but the Python Steering Council twice decided to delay the change ([announcement for Python 3.10](#); [announcement for Python 3.11](#)). No final decision has been made yet. See also [PEP 563](#) and [PEP 649](#).

class `__future__._Feature`

Each statement in `__future__.py` is of the form:

```
FeatureName = _Feature(OptionalRelease, MandatoryRelease,
                        CompilerFlag)
```

where, normally, *OptionalRelease* is less than *MandatoryRelease*, and both are 5-tuples of the same form as `sys.version_info`:

```
(PY_MAJOR_VERSION, # the 2 in 2.1.0a3; an int
 PY_MINOR_VERSION, # the 1; an int
 PY_MICRO_VERSION, # the 0; an int
 PY_RELEASE_LEVEL, # "alpha", "beta", "candidate" or "final"; string
 PY_RELEASE_SERIAL # the 3; an int
)
```

`_Feature.getOptionalRelease()`

OptionalRelease records the first release in which the feature was accepted.

`_Feature.getMandatoryRelease()`

In the case of a *MandatoryRelease* that has not yet occurred, *MandatoryRelease* predicts the release in which the feature will become part of the language.

Else *MandatoryRelease* records when the feature became part of the language; in releases at or after that, modules no longer need a future statement to use the feature in question, but may continue to use such imports.

MandatoryRelease may also be `None`, meaning that a planned feature got dropped or that it is not yet decided.

`_Feature.compiler_flag`

CompilerFlag is the (bitfield) flag that should be passed in the fourth argument to the built-in function `compile()` to enable the feature in dynamically compiled code. This flag is stored in the `_Feature.compiler_flag` attribute on `_Feature` instances.

也參考:**future**

How the compiler treats future imports.

PEP 236 - Back to the `__future__`

The original proposal for the `__future__` mechanism.

29.12 gc --- 垃圾回收器介面 (Garbage Collector interface)

此 module (模組) 提供可選的垃圾回收器介面, 提供的功能包括: 關閉回收器、調整回收頻率、設定除錯選項。它同時提供對回收器有找到但是無法釋放的不可達物件 (unreachable object) 的存取。由於 Python 使用了帶有參照計數的回收器, 如果你確定你的程式不會產生參照圈 (reference cycle), 你可以關閉回收器。可以透過呼叫 `gc.disable()` 關閉自動垃圾回收。若要一個存在記憶體流失的程式 (leaking program) 除錯, 請呼叫 `gc.set_debug(gc.DEBUG_LEAK)`; 需要注意的是, 它包含 `gc.DEBUG_SAVEALL`, 使得被回收的物件會被存放在 `gc.garbage` 中以待檢查。

`gc` module 提供下列函式:

`gc.enable()`

啟用自動垃圾回收。

`gc.disable()`

停用自動垃圾回收。

`gc.isenabled()`

如果用了自動回收則回傳 `True`。

`gc.collect (generation=2)`

若被呼叫時有引數，則動完整垃圾回收。可選的引數 *generation* 可以是一個指明需要回收哪一代垃圾的整數（從 0 到 2）。當引數 *generation* 無效時，會引發 `ValueError` 例外。發現的不可達物件數目會被回傳。

每當執行完整回收或最高代 (2) 回收時，多個建型所維護的空列表會被清空。了特定型的實現，特是 `float`，在某些空列表中非所有項目都會被釋放。

The effect of calling `gc.collect()` while the interpreter is already performing a collection is undefined.

`gc.set_debug (flags)`

設定垃圾回收器的除錯旗標。除錯資訊會被寫入 `sys.stderr`。請見下方的除錯旗標列表，可以使用位元操作 (bit operation) 進行設定以控制除錯程式。

`gc.get_debug ()`

回傳當前設置的除錯旗標。

`gc.get_objects (generation=None)`

回傳一個包含回收器正在追的所有物件的 list，除去所回傳的 list。如果 *generation* 不 `None`，只回傳回收器正在追且屬於該代的物件。

在 3.8 版的變更: 新增 *generation* 參數。

引發一個附帶引數 *generation* 的稽核事件 (auditing event) `gc.get_objects`。

`gc.get_stats ()`

回傳一個包含三個字典物件的 list，每個字典分包含對應代中自從直譯器開始執行後的垃圾回收統計資料。字典的鍵的數目在將來可能會改變，但目前每個字典包含以下項目：

- `collections` 是該代被回收的次數；
- `collected` 是該代中被回收的物件總數；
- `uncollectable` 是在這一代中被發現無法回收的物件總數（因此被移到 *garbage list* 中）。

在 3.4 版新加入。

`gc.set_threshold (threshold0[, threshold1[, threshold2]])`

設定垃圾回收值（回收頻率）。將 *threshold0* 設零會停止回收。

垃圾回收器會根據物件在多少次垃圾回收後仍存來把所有物件分類三代。新建物件會被放在最年輕代（第 0 代）。如果一個物件在一次垃圾回收後仍存，它會被移入下一個較老代。由於第 2 代是最老代，這一代的物件在一次垃圾回收後仍會保留原樣。了確定何時要執行，垃圾回收器會追自上一次回收後物件分配和釋放的數量。當分配數量去釋放數量的結果大於 *threshold0* 時，垃圾回收就會開始。初始時只有第 0 代會被檢查。如果自第 1 代被檢查後第 0 代已被檢查超過 *threshold1* 次，則第 1 代也會被檢查。對於第三代來，情還會更複雜一些，請參 [Collecting the oldest generation](#) 來了解詳情。

`gc.get_count ()`

將當前回收計數以 (`count0`, `count1`, `count2`) 形式的 tuple 回傳。

`gc.get_threshold ()`

將當前回收值以 (`threshold0`, `threshold1`, `threshold2`) 形式的 tuple 回傳。

`gc.get_referrers (*objs)`

回傳包含直接參照 *objs* 中任一個物件的物件 list。這個函式只定位支援垃圾回收的容器；參照了其它物件但不支援垃圾回收的擴充套件型無法被找到。

需要注意的是，已經解除參照的物件，但仍存在於參照圈中未被回收時，該物件仍然會被作參照者出現在回傳的 list 中。若只要獲取當前正在參照的物件，需要在呼叫 `get_referrers()` 之前呼叫 `collect()`。

警告： 在使用 `get_referrers()` 回傳的物件時必須要小心，因其中的一些物件可能仍在建構中而處於暫時無效的狀態。不要把 `get_referrers()` 用於除錯以外的其它目的。

引發一個附帶引數 `objs` 的稽核事件 `gc.get_referrers`。

`gc.get_referents(*objs)`

回傳包含被任意一個引數直接參照之物件的 `list`。回傳的被參照物件是有被引數的 C 語言級 `tp_traverse` 方法（若存在）訪問到的物件，可能不是所有的實際直接可達物件。只有支援垃圾回收的物件支援 `tp_traverse` 方法，且此方法只會訪問涉及參照圈的物件。因此，可以有以下例子：一個整數對於一個引數是直接可達的，這個整數物件有可能出現或不出現在結果的 `list` 當中。

引發一個附帶引數 `objs` 的稽核事件 `gc.get_referents`。

`gc.is_tracked(obj)`

當物件正在被垃圾回收器追蹤時回傳 `True`，否則回傳 `False`。一般來，原子型（atomic type）的實例不會被追蹤，而非原子型（如容器、使用者自己定義的物件）會被追蹤。然而，有一些特定型最佳化會被用來減少垃圾回收器在簡單實例（如只含有原子性的鍵和值的字典）上的足：

```
>>> gc.is_tracked(0)
False
>>> gc.is_tracked("a")
False
>>> gc.is_tracked([])
True
>>> gc.is_tracked({})
False
>>> gc.is_tracked({"a": 1})
False
>>> gc.is_tracked({"a": []})
True
```

在 3.1 版新加入。

`gc.is_finalized(obj)`

如果給定物件已被垃圾回收器終結則回傳 `True`，否則回傳 `False`。

```
>>> x = None
>>> class Lazarus:
...     def __del__(self):
...         global x
...         x = self
...
>>> lazarus = Lazarus()
>>> gc.is_finalized(lazarus)
False
>>> del lazarus
>>> gc.is_finalized(x)
True
```

在 3.9 版新加入。

`gc.freeze()`

凍結 (freeze) 垃圾回收器所追蹤的所有物件；將它們移至永久代忽略所有未來的收集動作。

如果一個行程將在有 `exec()` 的情況下進行 `fork()`，避免子行程中不必要的寫入時將最大化記憶體共享減少整體記憶體使用。這需要避免在父行程的記憶體頁面中建立已釋放的「漏洞」，確保子行程中的 GC 收集不會觸及源自父行程的長壽命物件的 `gc_refs` 計數器。要實現這兩個目標，請在父行程的早期呼叫 `gc.disable()`，在 `fork()` 之前呼叫 `gc.freeze()`，早在子行程中呼叫 `gc.enable()`。

在 3.7 版新加入。

`gc.unfreeze()`

解凍 (unfreeze) 永久代中的物件，[將它們放回到最年老代中](#)。

在 3.7 版新加入。

`gc.get_freeze_count()`

回傳永久代中的物件數量。

在 3.7 版新加入。

以下變數僅供唯讀存取（你可以修改其值但不應該重新[綁結](#) (rebind) 它們）：

`gc.garbage`

一個回收器發現不可達而又無法被釋放的物件（不可回收物件）list。從 Python 3.4 開始，該 list 在大多數時候都應該是空的，除非使用了有非 `NULL tp_del` 槽位的 C 擴充套件型[的實例](#)。

如果設定了 `DEBUG_SAVEALL`，則所有不可達物件將被加進該 list 而不會被釋放。

在 3.2 版的變更：當 *interpreter shutdown* 即直譯器關閉時，若此 list 非空，會[生](#)`ResourceWarning`，在預設情[下](#)此警告不會被提醒。如果設定了 `DEBUG_UNCOLLECTABLE`，所有無法被回收的物件會被印出。

在 3.4 版的變更：Following [PEP 442](#), objects with a `__del__()` method don't end up in `gc.garbage` anymore.

`gc.callbacks`

會被垃圾回收器在回收開始前和完成後呼叫的一系列回呼函式 (callback)。這些回呼函式在被呼叫時附帶兩個引數：*phase* 和 *info*。

phase 可[是](#)以下兩者之一：

”start”：垃圾回收即將開始。

”stop”：垃圾回收已結束。

info 是一個字典，提供回呼函式更多資訊。已有定義的鍵有：

”generation”（代）：正在被回收的最年老的一代。

”collected”（已回收的）：當 *phase* [是](#)”stop” 時，被成功回收的物件的數目。

”uncollectable”（不可回收的）：當 *phase* [是](#)”stop” 時，不能被回收[且](#)被放入 *garbage* 的物件的數目。

應用程式可以把他們自己的回呼函式加入此 list。主要的使用場景有：

收集垃圾回收的統計資料，如：不同代的回收頻率、回收任務所花費的時間。

讓應用程式可以識[別](#)和清理他們自己在 *garbage* 中的不可回收型[的物件](#)。

在 3.3 版新加入。

以下常數是[在](#)了和 `set_debug()` 一起使用所提供：

`gc.DEBUG_STATS`

在回收完成後印出統計資訊。當調校回收頻率設定時，這些資訊會很有用。

`gc.DEBUG_COLLECTABLE`

當發現可回收物件時印出資訊。

`gc.DEBUG_UNCOLLECTABLE`

印出找到的不可回收物件的資訊（指不能被回收器回收的不可達物件）。這些物件會被新增到 *garbage* list 中。

在 3.2 版的變更：當 *interpreter shutdown*（直譯器關閉）時，若 *garbage* list 不是空的，那這些[內容](#)也會被印出。

gc.DEBUG_SAVEALL

設定後，所有回收器找到的不可達物件會被加進 *garbage* 而不是直接被釋放。這在一個記憶體流失的程式除錯時會很有用。

gc.DEBUG_LEAK

要印出記憶體流失程式之相關資訊時，回收器所需的除錯旗標。(等同於 `DEBUG_COLLECTABLE | DEBUG_UNCOLLECTABLE | DEBUG_SAVEALL`)。

29.13 inspect --- Inspect live objects

原始碼: [Lib/inspect.py](#)

The *inspect* module provides several useful functions to help get information about live objects such as modules, classes, methods, functions, tracebacks, frame objects, and code objects. For example, it can help you examine the contents of a class, retrieve the source code of a method, extract and format the argument list for a function, or get all the information you need to display a detailed traceback.

There are four main kinds of services provided by this module: type checking, getting source code, inspecting classes and functions, and examining the interpreter stack.

29.13.1 Types and members

The *getmembers()* function retrieves the members of an object such as a class or module. The functions whose names begin with "is" are mainly provided as convenient choices for the second argument to *getmembers()*. They also help you determine when you can expect to find the following special attributes (see `import-mod-attrs` for module attributes):

Type	屬性	描述
class	<code>__doc__</code>	documentation string
	<code>__name__</code>	name with which this class was defined
	<code>__qualname__</code>	qualified name
	<code>__module__</code>	name of module in which this class was defined
method	<code>__doc__</code>	documentation string
	<code>__name__</code>	name with which this method was defined
	<code>__qualname__</code>	qualified name
	<code>__func__</code>	function object containing implementation of method
	<code>__self__</code>	instance to which this method is bound, or <code>None</code>
函式	<code>__module__</code>	name of module in which this method was defined
	<code>__doc__</code>	documentation string
	<code>__name__</code>	name with which this function was defined
	<code>__qualname__</code>	qualified name
	<code>__code__</code>	code object containing compiled function <i>bytecode</i>
	<code>__defaults__</code>	tuple of any default values for positional or keyword parameters
	<code>__kwdefaults__</code>	mapping of any default values for keyword-only parameters
	<code>__globals__</code>	global namespace in which this function was defined
	<code>__builtins__</code>	builtins namespace
	<code>__annotations__</code>	mapping of parameters names to annotations; "return" key is reserved for return annotation
traceback	<code>__module__</code>	name of module in which this function was defined
	<code>tb_frame</code>	frame object at this level
	<code>tb_lasti</code>	index of last attempted instruction in bytecode
	<code>tb_lineno</code>	current line number in Python source code
frame	<code>tb_next</code>	next inner traceback object (called by this level)
	<code>f_back</code>	next outer frame object (this frame's caller)

表格 2 – 繼續上一頁

Type	屬性	描述
	f_builtins	builtins namespace seen by this frame
	f_code	code object being executed in this frame
	f_globals	global namespace seen by this frame
	f_lasti	index of last attempted instruction in bytecode
	f_lineno	current line number in Python source code
	f_locals	local namespace seen by this frame
	f_trace	tracing function for this frame, or <code>None</code>
code (程式碼)	co_argcount	number of arguments (not including keyword only arguments, * or ** args)
	co_code	string of raw compiled bytecode
	co_cellvars	tuple of names of cell variables (referenced by containing scopes)
	co_consts	tuple of constants used in the bytecode
	co_filename	name of file in which this code object was created
	co_firstlineno	number of first line in Python source code
	co_flags	bitmap of CO_* flags, read more here
	co_lnotab	encoded mapping of line numbers to bytecode indices
	co_freevars	tuple of names of free variables (referenced via a function's closure)
	co_posonlyargcount	number of positional only arguments
	co_kwonlyargcount	number of keyword only arguments (not including ** arg)
	co_name	name with which this code object was defined
	co_qualname	fully qualified name with which this code object was defined
	co_names	tuple of names other than arguments and function locals
	co_nlocals	number of local variables
	co_stacksize	virtual machine stack space required
	co_varnames	tuple of names of arguments and local variables
generator	__name__	name
	__qualname__	qualified name
	gi_frame	frame
	gi_running	is the generator running?
	gi_code	code (程式碼)
coroutine	gi_yieldfrom	object being iterated by <code>yield from</code> , or <code>None</code>
	__name__	name
	__qualname__	qualified name
	cr_await	object being awaited on, or <code>None</code>
	cr_frame	frame
	cr_running	is the coroutine running?
	cr_code	code (程式碼)
	cr_origin	where coroutine was created, or <code>None</code> . See <code>sys.set_coroutine_origin_tracking</code>
builtin	__doc__	documentation string
	__name__	original name of this function or method
	__qualname__	qualified name
	__self__	instance to which a method is bound, or <code>None</code>

在 3.5 版的變更: Add `__qualname__` and `gi_yieldfrom` attributes to generators.

The `__name__` attribute of generators is now set from the function name, instead of the code name, and it can now be modified.

在 3.7 版的變更: Add `cr_origin` attribute to coroutines.

在 3.10 版的變更: Add `__builtins__` attribute to functions.

`inspect.getmembers(object[, predicate])`

Return all the members of an object in a list of (name, value) pairs sorted by name. If the optional *predicate* argument—which will be called with the value object of each member—is supplied, only members for which the predicate returns a true value are included.

備註: `getmembers()` will only return class attributes defined in the metaclass when the argument is a class and those attributes have been listed in the metaclass' custom `__dir__()`.

`inspect.getmembers_static(object[, predicate])`

Return all the members of an object in a list of (name, value) pairs sorted by name without triggering dynamic lookup via the descriptor protocol, `__getattr__` or `__getattribute__`. Optionally, only return members that satisfy a given predicate.

備註: `getmembers_static()` may not be able to retrieve all members that `getmembers` can fetch (like dynamically created attributes) and may find members that `getmembers` can't (like descriptors that raise `AttributeError`). It can also return descriptor objects instead of instance members in some cases.

在 3.11 版新加入.

`inspect.getmodule(path)`

Return the name of the module named by the file *path*, without including the names of enclosing packages. The file extension is checked against all of the entries in `importlib.machinery.all_suffixes()`. If it matches, the final path component is returned with the extension removed. Otherwise, `None` is returned.

Note that this function *only* returns a meaningful name for actual Python modules - paths that potentially refer to Python packages will still return `None`.

在 3.3 版的變更: The function is based directly on `importlib`.

`inspect.ismodule(object)`

Return `True` if the object is a module.

`inspect.isclass(object)`

Return `True` if the object is a class, whether built-in or created in Python code.

`inspect.ismethod(object)`

Return `True` if the object is a bound method written in Python.

`inspect.isfunction(object)`

Return `True` if the object is a Python function, which includes functions created by a `lambda` expression.

`inspect.isgeneratorfunction(object)`

Return `True` if the object is a Python generator function.

在 3.8 版的變更: Functions wrapped in `functools.partial()` now return `True` if the wrapped function is a Python generator function.

`inspect.isgenerator(object)`

Return `True` if the object is a generator.

`inspect.iscoroutinefunction(object)`

Return `True` if the object is a *coroutine function* (a function defined with an `async def` syntax).

在 3.5 版新加入.

在 3.8 版的變更: Functions wrapped in `functools.partial()` now return `True` if the wrapped function is a *coroutine function*.

`inspect.iscoroutine(object)`

Return `True` if the object is a *coroutine* created by an `async def` function.

在 3.5 版新加入.

`inspect.isawaitable(object)`

Return `True` if the object can be used in `await` expression.

Can also be used to distinguish generator-based coroutines from regular generators:

```
import types

def gen():
    yield
@types.coroutine
def gen_coro():
    yield

assert not isinstance(gen(), types.AsyncGeneratorType)
assert isinstance(gen_coro(), types.AsyncGeneratorType)
```

在 3.5 版新加入。

`inspect.isasyncgenfunction(object)`

Return True if the object is an *asynchronous generator* function, for example:

```
>>> async def agen():
...     yield 1
...
>>> inspect.isasyncgenfunction(agen)
True
```

在 3.6 版新加入。

在 3.8 版的變更: Functions wrapped in `functools.partial()` now return True if the wrapped function is a *asynchronous generator* function.

`inspect.isasyncgen(object)`

Return True if the object is an *asynchronous generator iterator* created by an *asynchronous generator* function.

在 3.6 版新加入。

`inspect.istraceback(object)`

Return True if the object is a traceback.

`inspect.isframe(object)`

Return True if the object is a frame.

`inspect.iscode(object)`

Return True if the object is a code.

`inspect.isbuiltin(object)`

Return True if the object is a built-in function or a bound built-in method.

`inspect.ismethodwrapper(object)`

Return True if the type of object is a *MethodWrapperType*.

These are instances of *MethodWrapperType*, such as `__str__()`, `__eq__()` and `__repr__()`.

在 3.11 版新加入。

`inspect.isroutine(object)`

Return True if the object is a user-defined or built-in function or method.

`inspect.isabstract(object)`

Return True if the object is an abstract base class.

`inspect.ismethoddescriptor(object)`

Return True if the object is a method descriptor, but not if `ismethod()`, `isclass()`, `isfunction()` or `isbuiltin()` are true.

This, for example, is true of `int.__add__`. An object passing this test has a `__get__()` method but not a `__set__()` method, but beyond that the set of attributes varies. A `__name__` attribute is usually sensible, and `__doc__` often is.

Methods implemented via descriptors that also pass one of the other tests return `False` from the `ismethoddescriptor()` test, simply because the other tests promise more -- you can, e.g., count on having the `__func__` attribute (etc) when an object passes `ismethod()`.

`inspect.isdatadescriptor(object)`

Return `True` if the object is a data descriptor.

Data descriptors have a `__set__` or a `__delete__` method. Examples are properties (defined in Python), getsets, and members. The latter two are defined in C and there are more specific tests available for those types, which is robust across Python implementations. Typically, data descriptors will also have `__name__` and `__doc__` attributes (properties, getsets, and members have both of these attributes), but this is not guaranteed.

`inspect.isgetsetdescriptor(object)`

Return `True` if the object is a getset descriptor.

CPython 實作細節： getsets are attributes defined in extension modules via `PyGetSetDef` structures. For Python implementations without such types, this method will always return `False`.

`inspect.ismemberdescriptor(object)`

Return `True` if the object is a member descriptor.

CPython 實作細節： Member descriptors are attributes defined in extension modules via `PyMemberDef` structures. For Python implementations without such types, this method will always return `False`.

29.13.2 Retrieving source code

`inspect.getdoc(object)`

Get the documentation string for an object, cleaned up with `cleandoc()`. If the documentation string for an object is not provided and the object is a class, a method, a property or a descriptor, retrieve the documentation string from the inheritance hierarchy. Return `None` if the documentation string is invalid or missing.

在 3.5 版的變更: Documentation strings are now inherited if not overridden.

`inspect.getcomments(object)`

Return in a single string any lines of comments immediately preceding the object's source code (for a class, function, or method), or at the top of the Python source file (if the object is a module). If the object's source code is unavailable, return `None`. This could happen if the object has been defined in C or the interactive shell.

`inspect.getfile(object)`

Return the name of the (text or binary) file in which an object was defined. This will fail with a `TypeError` if the object is a built-in module, class, or function.

`inspect.getmodule(object)`

Try to guess which module an object was defined in. Return `None` if the module cannot be determined.

`inspect.getsourcefile(object)`

Return the name of the Python source file in which an object was defined or `None` if no way can be identified to get the source. This will fail with a `TypeError` if the object is a built-in module, class, or function.

`inspect.getsourcelines(object)`

Return a list of source lines and starting line number for an object. The argument may be a module, class, method, function, traceback, frame, or code object. The source code is returned as a list of the lines corresponding to the object and the line number indicates where in the original source file the first line of code was found. An `OSError` is raised if the source code cannot be retrieved. A `TypeError` is raised if the object is a built-in module, class, or function.

在 3.3 版的變更: `OSError` is raised instead of `IOError`, now an alias of the former.

`inspect.getsource(object)`

Return the text of the source code for an object. The argument may be a module, class, method, function, traceback, frame, or code object. The source code is returned as a single string. An `OSError` is raised if the source code cannot be retrieved. A `TypeError` is raised if the object is a built-in module, class, or function.

在 3.3 版的變更: `OSError` is raised instead of `IOError`, now an alias of the former.

`inspect.cleandoc(doc)`

Clean up indentation from docstrings that are indented to line up with blocks of code.

All leading whitespace is removed from the first line. Any leading whitespace that can be uniformly removed from the second line onwards is removed. Empty lines at the beginning and end are subsequently removed. Also, all tabs are expanded to spaces.

29.13.3 Introspecting callables with the Signature object

在 3.3 版新加入.

The `Signature` object represents the call signature of a callable object and its return annotation. To retrieve a `Signature` object, use the `signature()` function.

`inspect.signature(callable, *, follow_wrapped=True, globals=None, locals=None, eval_str=False)`

Return a `Signature` object for the given `callable`:

```
>>> from inspect import signature
>>> def foo(a, *, b:int, **kwargs):
...     pass

>>> sig = signature(foo)

>>> str(sig)
'(a, *, b: int, **kwargs)'

>>> str(sig.parameters['b'])
'b: int'

>>> sig.parameters['b'].annotation
<class 'int'>
```

Accepts a wide range of Python callables, from plain functions and classes to `functools.partial()` objects.

For objects defined in modules using stringized annotations (from `__future__` import `annotations`), `signature()` will attempt to automatically un-stringize the annotations using `get_annotations()`. The `globals`, `locals`, and `eval_str` parameters are passed into `get_annotations()` when resolving the annotations; see the documentation for `get_annotations()` for instructions on how to use these parameters.

Raises `ValueError` if no signature can be provided, and `TypeError` if that type of object is not supported. Also, if the annotations are stringized, and `eval_str` is not false, the `eval()` call(s) to un-stringize the annotations in `get_annotations()` could potentially raise any kind of exception.

A slash(/) in the signature of a function denotes that the parameters prior to it are positional-only. For more info, see the FAQ entry on positional-only parameters.

在 3.5 版的變更: The `follow_wrapped` parameter was added. Pass `False` to get a signature of `callable` specifically (`callable.__wrapped__` will not be used to unwrap decorated callables.)

在 3.10 版的變更: The `globals`, `locals`, and `eval_str` parameters were added.

備 F: Some callables may not be introspectable in certain implementations of Python. For example, in CPython, some built-in functions defined in C provide no metadata about their arguments.

CPython 實作細節: If the passed object has a `__signature__` attribute, we may use it to create the signature. The exact semantics are an implementation detail and are subject to unannounced changes. Consult the source code for current semantics.

class `inspect.Signature` (*parameters=None*, *, *return_annotation=Signature.empty*)

A *Signature* object represents the call signature of a function and its return annotation. For each parameter accepted by the function it stores a *Parameter* object in its *parameters* collection.

The optional *parameters* argument is a sequence of *Parameter* objects, which is validated to check that there are no parameters with duplicate names, and that the parameters are in the right order, i.e. positional-only first, then positional-or-keyword, and that parameters with defaults follow parameters without defaults.

The optional *return_annotation* argument can be an arbitrary Python object. It represents the "return" annotation of the callable.

Signature objects are *immutable*. Use *Signature.replace()* to make a modified copy.

在 3.5 版的變更: *Signature* objects are now picklable and *hashable*.

empty

A special class-level marker to specify absence of a return annotation.

parameters

An ordered mapping of parameters' names to the corresponding *Parameter* objects. Parameters appear in strict definition order, including keyword-only parameters.

在 3.7 版的變更: Python only explicitly guaranteed that it preserved the declaration order of keyword-only parameters as of version 3.7, although in practice this order had always been preserved in Python 3.

return_annotation

The "return" annotation for the callable. If the callable has no "return" annotation, this attribute is set to *Signature.empty*.

bind (*args, **kwargs)

Create a mapping from positional and keyword arguments to parameters. Returns *BoundArguments* if *args and **kwargs match the signature, or raises a *TypeError*.

bind_partial (*args, **kwargs)

Works the same way as *Signature.bind()*, but allows the omission of some required arguments (mimics *functools.partial()* behavior.) Returns *BoundArguments*, or raises a *TypeError* if the passed arguments do not match the signature.

replace (*[, parameters][, return_annotation])

Create a new *Signature* instance based on the instance *replace()* was invoked on. It is possible to pass different *parameters* and/or *return_annotation* to override the corresponding properties of the base signature. To remove *return_annotation* from the copied *Signature*, pass in *Signature.empty*.

```
>>> def test(a, b):
...     pass
>>> sig = signature(test)
>>> new_sig = sig.replace(return_annotation="new return anno")
>>> str(new_sig)
"(a, b) -> 'new return anno'"
```

classmethod from_callable (*obj*, *, *follow_wrapped=True*, *globals=None*, *locals=None*, *eval_str=False*)

Return a *Signature* (or its subclass) object for a given callable *obj*.

This method simplifies subclassing of *Signature*:

```
class MySignature(Signature):
    pass
sig = MySignature.from_callable(sum)
assert isinstance(sig, MySignature)
```

Its behavior is otherwise identical to that of `signature()`.

在 3.5 版新加入.

在 3.10 版的變更: The `globals`, `locals`, and `eval_str` parameters were added.

class `inspect.Parameter` (`name`, `kind`, *, `default=Parameter.empty`, `annotation=Parameter.empty`)

Parameter objects are *immutable*. Instead of modifying a Parameter object, you can use `Parameter.replace()` to create a modified copy.

在 3.5 版的變更: Parameter objects are now picklable and *hashable*.

empty

A special class-level marker to specify absence of default values and annotations.

name

The name of the parameter as a string. The name must be a valid Python identifier.

CPython 實作細節: CPython generates implicit parameter names of the form `.0` on the code objects used to implement comprehensions and generator expressions.

在 3.6 版的變更: These parameter names are now exposed by this module as names like `implicit0`.

default

The default value for the parameter. If the parameter has no default value, this attribute is set to `Parameter.empty`.

annotation

The annotation for the parameter. If the parameter has no annotation, this attribute is set to `Parameter.empty`.

kind

Describes how argument values are bound to the parameter. The possible values are accessible via `Parameter` (like `Parameter.KEYWORD_ONLY`), and support comparison and ordering, in the following order:

名徵	意義
<code>POSITIONAL_ONLY</code>	Value must be supplied as a positional argument. Positional only parameters are those which appear before a <code>/</code> entry (if present) in a Python function definition.
<code>POSITIONAL_OR_KEYWORD</code>	Value may be supplied as either a keyword or positional argument (this is the standard binding behaviour for functions implemented in Python.)
<code>VAR_POSITIONAL</code>	A tuple of positional arguments that aren't bound to any other parameter. This corresponds to a <code>*args</code> parameter in a Python function definition.
<code>KEYWORD_ONLY</code>	Value must be supplied as a keyword argument. Keyword only parameters are those which appear after a <code>*</code> or <code>*args</code> entry in a Python function definition.
<code>VAR_KEYWORD</code>	A dict of keyword arguments that aren't bound to any other parameter. This corresponds to a <code>**kwargs</code> parameter in a Python function definition.

Example: print all keyword-only arguments without default values:

```
>>> def foo(a, b, *, c, d=10):
...     pass

>>> sig = signature(foo)
>>> for param in sig.parameters.values():
...     if (param.kind == param.KEYWORD_ONLY and
```

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```

...             param.default is param.empty):
...         print('Parameter:', param)
Parameter: c

```

kind.description

Describes a enum value of *Parameter.kind*.

在 3.8 版新加入.

Example: print all descriptions of arguments:

```

>>> def foo(a, b, *, c, d=10):
...     pass

>>> sig = signature(foo)
>>> for param in sig.parameters.values():
...     print(param.kind.description)
positional or keyword
positional or keyword
keyword-only
keyword-only

```

replace(*[, name][, kind][, default][, annotation])

Create a new *Parameter* instance based on the instance replaced was invoked on. To override a *Parameter* attribute, pass the corresponding argument. To remove a default value or/and an annotation from a *Parameter*, pass *Parameter.empty*.

```

>>> from inspect import Parameter
>>> param = Parameter('foo', Parameter.KEYWORD_ONLY, default=42)
>>> str(param)
'foo=42'

>>> str(param.replace()) # Will create a shallow copy of 'param'
'foo=42'

>>> str(param.replace(default=Parameter.empty, annotation='spam'))
'foo: 'spam'

```

在 3.4 版的變更: In Python 3.3 *Parameter* objects were allowed to have name set to None if their kind was set to *POSITIONAL_ONLY*. This is no longer permitted.

class inspect.BoundsArguments

Result of a *Signature.bind()* or *Signature.bind_partial()* call. Holds the mapping of arguments to the function's parameters.

arguments

A mutable mapping of parameters' names to arguments' values. Contains only explicitly bound arguments. Changes in *arguments* will reflect in *args* and *kwargs*.

Should be used in conjunction with *Signature.parameters* for any argument processing purposes.

備 F: Arguments for which *Signature.bind()* or *Signature.bind_partial()* relied on a default value are skipped. However, if needed, use *BoundsArguments.apply_defaults()* to add them.

在 3.9 版的變更: *arguments* is now of type *dict*. Formerly, it was of type *collections.OrderedDict*.

args

A tuple of positional arguments values. Dynamically computed from the *arguments* attribute.

kwargs

A dict of keyword arguments values. Dynamically computed from the *arguments* attribute.

signature

A reference to the parent *Signature* object.

apply_defaults()

Set default values for missing arguments.

For variable-positional arguments (*args) the default is an empty tuple.

For variable-keyword arguments (**kwargs) the default is an empty dict.

```
>>> def foo(a, b='ham', *args): pass
>>> ba = inspect.signature(foo).bind('spam')
>>> ba.apply_defaults()
>>> ba.arguments
{'a': 'spam', 'b': 'ham', 'args': ()}
```

在 3.5 版新加入.

The *args* and *kwargs* properties can be used to invoke functions:

```
def test(a, *, b):
    ...

sig = signature(test)
ba = sig.bind(10, b=20)
test(*ba.args, **ba.kwargs)
```

也參考:

PEP 362 - Function Signature Object.

The detailed specification, implementation details and examples.

29.13.4 Classes and functions

`inspect.getclasstree(classes, unique=False)`

Arrange the given list of classes into a hierarchy of nested lists. Where a nested list appears, it contains classes derived from the class whose entry immediately precedes the list. Each entry is a 2-tuple containing a class and a tuple of its base classes. If the *unique* argument is true, exactly one entry appears in the returned structure for each class in the given list. Otherwise, classes using multiple inheritance and their descendants will appear multiple times.

`inspect.getfullargspec(func)`

Get the names and default values of a Python function's parameters. A *named tuple* is returned:

```
FullArgSpec(args, varargs, varkw, defaults, kwoonlyargs, kwoonlydefaults,
             annotations)
```

args is a list of the positional parameter names. *varargs* is the name of the * parameter or None if arbitrary positional arguments are not accepted. *varkw* is the name of the ** parameter or None if arbitrary keyword arguments are not accepted. *defaults* is an *n*-tuple of default argument values corresponding to the last *n* positional parameters, or None if there are no such defaults defined. *kwoonlyargs* is a list of keyword-only parameter names in declaration order. *kwoonlydefaults* is a dictionary mapping parameter names from *kwoonlyargs* to the default values used if no argument is supplied. *annotations* is a dictionary mapping parameter names to annotations. The special key "return" is used to report the function return value annotation (if any).

Note that *signature()* and *Signature Object* provide the recommended API for callable introspection, and support additional behaviours (like positional-only arguments) that are sometimes encountered in extension

module APIs. This function is retained primarily for use in code that needs to maintain compatibility with the Python 2 `inspect` module API.

在 3.4 版的變更: This function is now based on `signature()`, but still ignores `__wrapped__` attributes and includes the already bound first parameter in the signature output for bound methods.

在 3.6 版的變更: This method was previously documented as deprecated in favour of `signature()` in Python 3.5, but that decision has been reversed in order to restore a clearly supported standard interface for single-source Python 2/3 code migrating away from the legacy `getargspec()` API.

在 3.7 版的變更: Python only explicitly guaranteed that it preserved the declaration order of keyword-only parameters as of version 3.7, although in practice this order had always been preserved in Python 3.

`inspect.getargvalues(frame)`

Get information about arguments passed into a particular frame. A *named tuple* `ArgInfo(args, varargs, keywords, locals)` is returned. *args* is a list of the argument names. *varargs* and *keywords* are the names of the `*` and `**` arguments or `None`. *locals* is the locals dictionary of the given frame.

備 F: This function was inadvertently marked as deprecated in Python 3.5.

`inspect.formatargvalues(args[, varargs, varkw, locals, formatarg, formatvarargs, formatvarkw, formatvalue])`

Format a pretty argument spec from the four values returned by `getargvalues()`. The `format*` arguments are the corresponding optional formatting functions that are called to turn names and values into strings.

備 F: This function was inadvertently marked as deprecated in Python 3.5.

`inspect.getmro(cls)`

Return a tuple of class *cls*'s base classes, including *cls*, in method resolution order. No class appears more than once in this tuple. Note that the method resolution order depends on *cls*'s type. Unless a very peculiar user-defined metatype is in use, *cls* will be the first element of the tuple.

`inspect.getcallargs(func, /, *args, **kwargs)`

Bind the *args* and *kwargs* to the argument names of the Python function or method *func*, as if it was called with them. For bound methods, bind also the first argument (typically named `self`) to the associated instance. A dict is returned, mapping the argument names (including the names of the `*` and `**` arguments, if any) to their values from *args* and *kwargs*. In case of invoking *func* incorrectly, i.e. whenever `func(*args, **kwargs)` would raise an exception because of incompatible signature, an exception of the same type and the same or similar message is raised. For example:

```
>>> from inspect import getcallargs
>>> def f(a, b=1, *pos, **named):
...     pass
...
>>> getcallargs(f, 1, 2, 3) == {'a': 1, 'named': {}, 'b': 2, 'pos': (3,)}
True
>>> getcallargs(f, a=2, x=4) == {'a': 2, 'named': {'x': 4}, 'b': 1, 'pos': ()}
True
>>> getcallargs(f)
Traceback (most recent call last):
...
TypeError: f() missing 1 required positional argument: 'a'
```

在 3.2 版新加入.

在 3.5 版之後被 F 用: Use `Signature.bind()` and `Signature.bind_partial()` instead.

`inspect.getclosurevars(func)`

Get the mapping of external name references in a Python function or method *func* to their current values. A

named tuple ClosureVars(nonlocals, globals, builtins, unbound) is returned. *nonlocals* maps referenced names to lexical closure variables, *globals* to the function's module globals and *builtins* to the builtins visible from the function body. *unbound* is the set of names referenced in the function that could not be resolved at all given the current module globals and builtins.

TypeError is raised if *func* is not a Python function or method.

在 3.3 版新加入.

`inspect.unwrap(func, *, stop=None)`

Get the object wrapped by *func*. It follows the chain of `__wrapped__` attributes returning the last object in the chain.

stop is an optional callback accepting an object in the wrapper chain as its sole argument that allows the unwrapping to be terminated early if the callback returns a true value. If the callback never returns a true value, the last object in the chain is returned as usual. For example, *signature()* uses this to stop unwrapping if any object in the chain has a `__signature__` attribute defined.

ValueError is raised if a cycle is encountered.

在 3.4 版新加入.

`inspect.get_annotations(obj, *, globals=None, locals=None, eval_str=False)`

Compute the annotations dict for an object.

obj may be a callable, class, or module. Passing in an object of any other type raises *TypeError*.

Returns a dict. `get_annotations()` returns a new dict every time it's called; calling it twice on the same object will return two different but equivalent dicts.

This function handles several details for you:

- If *eval_str* is true, values of type *str* will be un-stringized using *eval()*. This is intended for use with stringized annotations (`from __future__ import annotations`).
- If *obj* doesn't have an annotations dict, returns an empty dict. (Functions and methods always have an annotations dict; classes, modules, and other types of callables may not.)
- Ignores inherited annotations on classes. If a class doesn't have its own annotations dict, returns an empty dict.
- All accesses to object members and dict values are done using `getattr()` and `dict.get()` for safety.
- Always, always, always returns a freshly created dict.

eval_str controls whether or not values of type *str* are replaced with the result of calling *eval()* on those values:

- If *eval_str* is true, *eval()* is called on values of type *str*. (Note that `get_annotations` doesn't catch exceptions; if *eval()* raises an exception, it will unwind the stack past the `get_annotations` call.)
- If *eval_str* is false (the default), values of type *str* are unchanged.

globals and *locals* are passed in to *eval()*; see the documentation for *eval()* for more information. If *globals* or *locals* is None, this function may replace that value with a context-specific default, contingent on *type(obj)*:

- If *obj* is a module, *globals* defaults to `obj.__dict__`.
- If *obj* is a class, *globals* defaults to `sys.modules[obj.__module__].__dict__` and *locals* defaults to the *obj* class namespace.
- If *obj* is a callable, *globals* defaults to `obj.__globals__`, although if *obj* is a wrapped function (using *functools.update_wrapper()*) it is first unwrapped.

Calling `get_annotations` is best practice for accessing the annotations dict of any object. See [annotations-howto](#) for more information on annotations best practices.

在 3.10 版新加入.

29.13.5 The interpreter stack

Some of the following functions return *FrameInfo* objects. For backwards compatibility these objects allow tuple-like operations on all attributes except `positions`. This behavior is considered deprecated and may be removed in the future.

class `inspect.FrameInfo`

frame

The frame object that the record corresponds to.

filename

The file name associated with the code being executed by the frame this record corresponds to.

lineno

The line number of the current line associated with the code being executed by the frame this record corresponds to.

function

The function name that is being executed by the frame this record corresponds to.

code_context

A list of lines of context from the source code that's being executed by the frame this record corresponds to.

index

The index of the current line being executed in the *code_context* list.

positions

A *dis.Positions* object containing the start line number, end line number, start column offset, and end column offset associated with the instruction being executed by the frame this record corresponds to.

在 3.5 版的變更: Return a *named tuple* instead of a *tuple*.

在 3.11 版的變更: *FrameInfo* is now a class instance (that is backwards compatible with the previous *named tuple*).

class `inspect.Traceback`

filename

The file name associated with the code being executed by the frame this traceback corresponds to.

lineno

The line number of the current line associated with the code being executed by the frame this traceback corresponds to.

function

The function name that is being executed by the frame this traceback corresponds to.

code_context

A list of lines of context from the source code that's being executed by the frame this traceback corresponds to.

index

The index of the current line being executed in the *code_context* list.

positions

A `dis.Positions` object containing the start line number, end line number, start column offset, and end column offset associated with the instruction being executed by the frame this traceback corresponds to.

在 3.11 版的變更: `Traceback` is now a class instance (that is backwards compatible with the previous *named tuple*).

備 F: Keeping references to frame objects, as found in the first element of the frame records these functions return, can cause your program to create reference cycles. Once a reference cycle has been created, the lifespan of all objects which can be accessed from the objects which form the cycle can become much longer even if Python's optional cycle detector is enabled. If such cycles must be created, it is important to ensure they are explicitly broken to avoid the delayed destruction of objects and increased memory consumption which occurs.

Though the cycle detector will catch these, destruction of the frames (and local variables) can be made deterministic by removing the cycle in a `finally` clause. This is also important if the cycle detector was disabled when Python was compiled or using `gc.disable()`. For example:

```
def handle_stackframe_without_leak():
    frame = inspect.currentframe()
    try:
        # do something with the frame
    finally:
        del frame
```

If you want to keep the frame around (for example to print a traceback later), you can also break reference cycles by using the `frame.clear()` method.

The optional `context` argument supported by most of these functions specifies the number of lines of context to return, which are centered around the current line.

`inspect.getframeinfo(frame, context=1)`

Get information about a frame or traceback object. A `Traceback` object is returned.

在 3.11 版的變更: A `Traceback` object is returned instead of a named tuple.

`inspect.getouterframes(frame, context=1)`

Get a list of `FrameInfo` objects for a frame and all outer frames. These frames represent the calls that lead to the creation of `frame`. The first entry in the returned list represents `frame`; the last entry represents the outermost call on `frame`'s stack.

在 3.5 版的變更: A list of *named tuples* `FrameInfo(frame, filename, lineno, function, code_context, index)` is returned.

在 3.11 版的變更: A list of `FrameInfo` objects is returned.

`inspect.getinnerframes(traceback, context=1)`

Get a list of `FrameInfo` objects for a traceback's frame and all inner frames. These frames represent calls made as a consequence of `frame`. The first entry in the list represents `traceback`; the last entry represents where the exception was raised.

在 3.5 版的變更: A list of *named tuples* `FrameInfo(frame, filename, lineno, function, code_context, index)` is returned.

在 3.11 版的變更: A list of `FrameInfo` objects is returned.

`inspect.currentframe()`

Return the frame object for the caller's stack frame.

CPython 實作細節: This function relies on Python stack frame support in the interpreter, which isn't guaranteed to exist in all implementations of Python. If running in an implementation without Python stack frame support this function returns `None`.

`inspect.stack(context=1)`

Return a list of *FrameInfo* objects for the caller's stack. The first entry in the returned list represents the caller; the last entry represents the outermost call on the stack.

在 3.5 版的變更: A list of *named tuples* *FrameInfo*(frame, filename, lineno, function, code_context, index) is returned.

在 3.11 版的變更: A list of *FrameInfo* objects is returned.

`inspect.trace(context=1)`

Return a list of *FrameInfo* objects for the stack between the current frame and the frame in which an exception currently being handled was raised in. The first entry in the list represents the caller; the last entry represents where the exception was raised.

在 3.5 版的變更: A list of *named tuples* *FrameInfo*(frame, filename, lineno, function, code_context, index) is returned.

在 3.11 版的變更: A list of *FrameInfo* objects is returned.

29.13.6 Fetching attributes statically

Both *getattr()* and *hasattr()* can trigger code execution when fetching or checking for the existence of attributes. Descriptors, like properties, will be invoked and *__getattr__()* and *__getattribute__()* may be called.

For cases where you want passive introspection, like documentation tools, this can be inconvenient. *getattr_static()* has the same signature as *getattr()* but avoids executing code when it fetches attributes.

`inspect.getattr_static(obj, attr, default=None)`

Retrieve attributes without triggering dynamic lookup via the descriptor protocol, *__getattr__()* or *__getattribute__()*.

Note: this function may not be able to retrieve all attributes that *getattr* can fetch (like dynamically created attributes) and may find attributes that *getattr* can't (like descriptors that raise *AttributeError*). It can also return descriptors objects instead of instance members.

If the instance *__dict__* is shadowed by another member (for example a property) then this function will be unable to find instance members.

在 3.2 版新加入.

getattr_static() does not resolve descriptors, for example slot descriptors or getset descriptors on objects implemented in C. The descriptor object is returned instead of the underlying attribute.

You can handle these with code like the following. Note that for arbitrary getset descriptors invoking these may trigger code execution:

```
# example code for resolving the builtin descriptor types
class _foo:
    __slots__ = ['foo']

slot_descriptor = type(_foo.foo)
getset_descriptor = type(type(open(__file__)).name)
wrapper_descriptor = type(str.__dict__['__add__'])
descriptor_types = (slot_descriptor, getset_descriptor, wrapper_descriptor)

result = getattr_static(some_object, 'foo')
if type(result) in descriptor_types:
    try:
        result = result.__get__()
    except AttributeError:
        # descriptors can raise AttributeError to
```

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```
# indicate there is no underlying value
# in which case the descriptor itself will
# have to do
pass
```

29.13.7 Current State of Generators and Coroutines

When implementing coroutine schedulers and for other advanced uses of generators, it is useful to determine whether a generator is currently executing, is waiting to start or resume or execution, or has already terminated. `getgeneratorstate()` allows the current state of a generator to be determined easily.

`inspect.getgeneratorstate(generator)`

Get current state of a generator-iterator.

Possible states are:

- `GEN_CREATED`: Waiting to start execution.
- `GEN_RUNNING`: Currently being executed by the interpreter.
- `GEN_SUSPENDED`: Currently suspended at a yield expression.
- `GEN_CLOSED`: Execution has completed.

在 3.2 版新加入。

`inspect.getcoroutinestate(coroutine)`

Get current state of a coroutine object. The function is intended to be used with coroutine objects created by `async def` functions, but will accept any coroutine-like object that has `cr_running` and `cr_frame` attributes.

Possible states are:

- `CORO_CREATED`: Waiting to start execution.
- `CORO_RUNNING`: Currently being executed by the interpreter.
- `CORO_SUSPENDED`: Currently suspended at an await expression.
- `CORO_CLOSED`: Execution has completed.

在 3.5 版新加入。

The current internal state of the generator can also be queried. This is mostly useful for testing purposes, to ensure that internal state is being updated as expected:

`inspect.getgeneratorlocals(generator)`

Get the mapping of live local variables in *generator* to their current values. A dictionary is returned that maps from variable names to values. This is the equivalent of calling `locals()` in the body of the generator, and all the same caveats apply.

If *generator* is a *generator* with no currently associated frame, then an empty dictionary is returned. `TypeError` is raised if *generator* is not a Python generator object.

CPython 實作細節： This function relies on the generator exposing a Python stack frame for introspection, which isn't guaranteed to be the case in all implementations of Python. In such cases, this function will always return an empty dictionary.

在 3.3 版新加入。

`inspect.getcoroutinelocals(coroutine)`

This function is analogous to `getgeneratorlocals()`, but works for coroutine objects created by `async def` functions.

在 3.5 版新加入。

29.13.8 Code Objects Bit Flags

Python code objects have a `co_flags` attribute, which is a bitmap of the following flags:

`inspect.CO_OPTIMIZED`

The code object is optimized, using fast locals.

`inspect.CO_NEWLOCALS`

If set, a new dict will be created for the frame's `f_locals` when the code object is executed.

`inspect.CO_VARARGS`

The code object has a variable positional parameter (*args-like).

`inspect.CO_VARKEYWORDS`

The code object has a variable keyword parameter (**kwargs-like).

`inspect.CO_NESTED`

The flag is set when the code object is a nested function.

`inspect.CO_GENERATOR`

The flag is set when the code object is a generator function, i.e. a generator object is returned when the code object is executed.

`inspect.CO_COROUTINE`

The flag is set when the code object is a coroutine function. When the code object is executed it returns a coroutine object. See [PEP 492](#) for more details.

在 3.5 版新加入.

`inspect.CO_ITERABLE_COROUTINE`

The flag is used to transform generators into generator-based coroutines. Generator objects with this flag can be used in `await` expression, and can `yield` from coroutine objects. See [PEP 492](#) for more details.

在 3.5 版新加入.

`inspect.CO_ASYNC_GENERATOR`

The flag is set when the code object is an asynchronous generator function. When the code object is executed it returns an asynchronous generator object. See [PEP 525](#) for more details.

在 3.6 版新加入.

備註: The flags are specific to CPython, and may not be defined in other Python implementations. Furthermore, the flags are an implementation detail, and can be removed or deprecated in future Python releases. It's recommended to use public APIs from the `inspect` module for any introspection needs.

29.13.9 Command Line Interface

The `inspect` module also provides a basic introspection capability from the command line.

By default, accepts the name of a module and prints the source of that module. A class or function within the module can be printed instead by appended a colon and the qualified name of the target object.

--details

Print information about the specified object rather than the source code

29.14 `site` --- Site-specific configuration hook

原始碼: [Lib/site.py](#)

This module is automatically imported during initialization. The automatic import can be suppressed using the interpreter's `-S` option.

Importing this module will append site-specific paths to the module search path and add a few builtins, unless `-S` was used. In that case, this module can be safely imported with no automatic modifications to the module search path or additions to the builtins. To explicitly trigger the usual site-specific additions, call the `main()` function.

在 3.3 版的變更: Importing the module used to trigger paths manipulation even when using `-S`.

It starts by constructing up to four directories from a head and a tail part. For the head part, it uses `sys.prefix` and `sys.exec_prefix`; empty heads are skipped. For the tail part, it uses the empty string and then `lib/site-packages` (on Windows) or `lib/pythonX.Y/site-packages` (on Unix and macOS). For each of the distinct head-tail combinations, it sees if it refers to an existing directory, and if so, adds it to `sys.path` and also inspects the newly added path for configuration files.

在 3.5 版的變更: Support for the "site-python" directory has been removed.

If a file named "pyenv.cfg" exists one directory above `sys.executable`, `sys.prefix` and `sys.exec_prefix` are set to that directory and it is also checked for site-packages (`sys.base_prefix` and `sys.base_exec_prefix` will always be the "real" prefixes of the Python installation). If "pyenv.cfg" (a bootstrap configuration file) contains the key "include-system-site-packages" set to anything other than "true" (case-insensitive), the system-level prefixes will not be searched for site-packages; otherwise they will.

A path configuration file is a file whose name has the form `name.pth` and exists in one of the four directories mentioned above; its contents are additional items (one per line) to be added to `sys.path`. Non-existing items are never added to `sys.path`, and no check is made that the item refers to a directory rather than a file. No item is added to `sys.path` more than once. Blank lines and lines beginning with `#` are skipped. Lines starting with `import` (followed by space or tab) are executed.

備 F: An executable line in a `.pth` file is run at every Python startup, regardless of whether a particular module is actually going to be used. Its impact should thus be kept to a minimum. The primary intended purpose of executable lines is to make the corresponding module(s) importable (load 3rd-party import hooks, adjust `PATH` etc). Any other initialization is supposed to be done upon a module's actual import, if and when it happens. Limiting a code chunk to a single line is a deliberate measure to discourage putting anything more complex here.

For example, suppose `sys.prefix` and `sys.exec_prefix` are set to `/usr/local`. The Python `X.Y` library is then installed in `/usr/local/lib/pythonX.Y`. Suppose this has a subdirectory `/usr/local/lib/pythonX.Y/site-packages` with three subsubdirectories, `foo`, `bar` and `spam`, and two path configuration files, `foo.pth` and `bar.pth`. Assume `foo.pth` contains the following:

```
# foo package configuration

foo
bar
bletch
```

and `bar.pth` contains:

```
# bar package configuration

bar
```

Then the following version-specific directories are added to `sys.path`, in this order:

```
/usr/local/lib/pythonX.Y/site-packages/bar
/usr/local/lib/pythonX.Y/site-packages/foo
```

Note that `bletch` is omitted because it doesn't exist; the `bar` directory precedes the `foo` directory because `bar.pth` comes alphabetically before `foo.pth`; and `spam` is omitted because it is not mentioned in either path configuration file.

29.14.1 sitecustomize

After these path manipulations, an attempt is made to import a module named `sitecustomize`, which can perform arbitrary site-specific customizations. It is typically created by a system administrator in the site-packages directory. If this import fails with an `ImportError` or its subclass exception, and the exception's `name` attribute equals to `'sitecustomize'`, it is silently ignored. If Python is started without output streams available, as with `pythonw.exe` on Windows (which is used by default to start IDLE), attempted output from `sitecustomize` is ignored. Any other exception causes a silent and perhaps mysterious failure of the process.

29.14.2 usercustomize

After this, an attempt is made to import a module named `usercustomize`, which can perform arbitrary user-specific customizations, if `ENABLE_USER_SITE` is true. This file is intended to be created in the user site-packages directory (see below), which is part of `sys.path` unless disabled by `-s`. If this import fails with an `ImportError` or its subclass exception, and the exception's `name` attribute equals to `'usercustomize'`, it is silently ignored.

Note that for some non-Unix systems, `sys.prefix` and `sys.exec_prefix` are empty, and the path manipulations are skipped; however the import of `sitecustomize` and `usercustomize` is still attempted.

29.14.3 Readline configuration

On systems that support `readline`, this module will also import and configure the `rlcompleter` module, if Python is started in interactive mode and without the `-S` option. The default behavior is enable tab-completion and to use `~/.python_history` as the history save file. To disable it, delete (or override) the `sys.__interactivehook__` attribute in your `sitecustomize` or `usercustomize` module or your `PYTHONSTARTUP` file.

在 3.4 版的變更: Activation of `rlcompleter` and history was made automatic.

29.14.4 模組內容

`site.PREFIXES`

A list of prefixes for site-packages directories.

`site.ENABLE_USER_SITE`

Flag showing the status of the user site-packages directory. True means that it is enabled and was added to `sys.path`. False means that it was disabled by user request (with `-s` or `PYTHONNOUSERSITE`). None means it was disabled for security reasons (mismatch between user or group id and effective id) or by an administrator.

`site.USER_SITE`

Path to the user site-packages for the running Python. Can be None if `getusersitepackages()` hasn't been called yet. Default value is `~/.local/lib/pythonX.Y/site-packages` for UNIX and non-framework macOS builds, `~/Library/Python/X.Y/lib/python/site-packages` for macOS framework builds, and `%APPDATA%\Python\PythonXY\site-packages` on Windows. This directory is a site directory, which means that `.pth` files in it will be processed.

site.USER_BASE

Path to the base directory for the user site-packages. Can be None if `getuserbase()` hasn't been called yet. Default value is `~/local` for UNIX and macOS non-framework builds, `~/Library/Python/X.Y` for macOS framework builds, and `%APPDATA%\Python` for Windows. This value is used by Distutils to compute the installation directories for scripts, data files, Python modules, etc. for the *user installation scheme*. See also `PYTHONUSERBASE`.

site.main()

Adds all the standard site-specific directories to the module search path. This function is called automatically when this module is imported, unless the Python interpreter was started with the `-S` flag.

在 3.3 版的變更: This function used to be called unconditionally.

site.addsitedir(sitedir, known_paths=None)

Add a directory to `sys.path` and process its `.pth` files. Typically used in *sitecustomize* or *usercustomize* (see above).

site.getsitepackages()

Return a list containing all global site-packages directories.

在 3.2 版新加入.

site.getuserbase()

Return the path of the user base directory, `USER_BASE`. If it is not initialized yet, this function will also set it, respecting `PYTHONUSERBASE`.

在 3.2 版新加入.

site.getusersitepackages()

Return the path of the user-specific site-packages directory, `USER_SITE`. If it is not initialized yet, this function will also set it, respecting `USER_BASE`. To determine if the user-specific site-packages was added to `sys.path` `ENABLE_USER_SITE` should be used.

在 3.2 版新加入.

29.14.5 Command Line Interface

The *site* module also provides a way to get the user directories from the command line:

```
$ python3 -m site --user-site
/home/user/.local/lib/python3.3/site-packages
```

If it is called without arguments, it will print the contents of `sys.path` on the standard output, followed by the value of `USER_BASE` and whether the directory exists, then the same thing for `USER_SITE`, and finally the value of `ENABLE_USER_SITE`.

--user-base

Print the path to the user base directory.

--user-site

Print the path to the user site-packages directory.

If both options are given, user base and user site will be printed (always in this order), separated by `os.pathsep`.

If any option is given, the script will exit with one of these values: 0 if the user site-packages directory is enabled, 1 if it was disabled by the user, 2 if it is disabled for security reasons or by an administrator, and a value greater than 2 if there is an error.

也參考:

- **PEP 370** -- Per user site-packages directory
- *The initialization of the sys.path module search path* -- The initialization of `sys.path`.

Custom Python Interpreters

The modules described in this chapter allow writing interfaces similar to Python's interactive interpreter. If you want a Python interpreter that supports some special feature in addition to the Python language, you should look at the `code` module. (The `codeop` module is lower-level, used to support compiling a possibly incomplete chunk of Python code.)

The full list of modules described in this chapter is:

30.1 `code` --- Interpreter base classes

原始碼: [Lib/code.py](#)

The `code` module provides facilities to implement read-eval-print loops in Python. Two classes and convenience functions are included which can be used to build applications which provide an interactive interpreter prompt.

class `code.InteractiveInterpreter` (*locals=None*)

This class deals with parsing and interpreter state (the user's namespace); it does not deal with input buffering or prompting or input file naming (the filename is always passed in explicitly). The optional *locals* argument specifies the dictionary in which code will be executed; it defaults to a newly created dictionary with key `'__name__'` set to `'__console__'` and key `'__doc__'` set to `None`.

class `code.InteractiveConsole` (*locals=None, filename='<console>'*)

Closely emulate the behavior of the interactive Python interpreter. This class builds on `InteractiveInterpreter` and adds prompting using the familiar `sys.ps1` and `sys.ps2`, and input buffering.

`code.interact` (*banner=None, readfunc=None, local=None, exitmsg=None*)

Convenience function to run a read-eval-print loop. This creates a new instance of `InteractiveConsole` and sets *readfunc* to be used as the `InteractiveConsole.raw_input()` method, if provided. If *local* is provided, it is passed to the `InteractiveConsole` constructor for use as the default namespace for the interpreter loop. The `interact()` method of the instance is then run with *banner* and *exitmsg* passed as the banner and exit message to use, if provided. The console object is discarded after use.

在 3.6 版的變更: 新增 *exitmsg* 參數。

`code.compile_command(source, filename='<input>', symbol='single')`

This function is useful for programs that want to emulate Python's interpreter main loop (a.k.a. the read-eval-print loop). The tricky part is to determine when the user has entered an incomplete command that can be completed by entering more text (as opposed to a complete command or a syntax error). This function *almost* always makes the same decision as the real interpreter main loop.

source is the source string; *filename* is the optional filename from which source was read, defaulting to '<input>'; and *symbol* is the optional grammar start symbol, which should be 'single' (the default), 'eval' or 'exec'.

Returns a code object (the same as `compile(source, filename, symbol)`) if the command is complete and valid; `None` if the command is incomplete; raises `SyntaxError` if the command is complete and contains a syntax error, or raises `OverflowError` or `ValueError` if the command contains an invalid literal.

30.1.1 Interactive Interpreter Objects

`InteractiveInterpreter.runsource(source, filename='<input>', symbol='single')`

Compile and run some source in the interpreter. Arguments are the same as for `compile_command()`; the default for *filename* is '<input>', and for *symbol* is 'single'. One of several things can happen:

- The input is incorrect; `compile_command()` raised an exception (`SyntaxError` or `OverflowError`). A syntax traceback will be printed by calling the `showsyntaxerror()` method. `runsource()` returns `False`.
- The input is incomplete, and more input is required; `compile_command()` returned `None`. `runsource()` returns `True`.
- The input is complete; `compile_command()` returned a code object. The code is executed by calling the `runcode()` (which also handles run-time exceptions, except for `SystemExit`). `runsource()` returns `False`.

The return value can be used to decide whether to use `sys.ps1` or `sys.ps2` to prompt the next line.

`InteractiveInterpreter.runcode(code)`

Execute a code object. When an exception occurs, `showtraceback()` is called to display a traceback. All exceptions are caught except `SystemExit`, which is allowed to propagate.

A note about `KeyboardInterrupt`: this exception may occur elsewhere in this code, and may not always be caught. The caller should be prepared to deal with it.

`InteractiveInterpreter.showsyntaxerror(filename=None)`

Display the syntax error that just occurred. This does not display a stack trace because there isn't one for syntax errors. If *filename* is given, it is stuffed into the exception instead of the default filename provided by Python's parser, because it always uses '<string>' when reading from a string. The output is written by the `write()` method.

`InteractiveInterpreter.showtraceback()`

Display the exception that just occurred. We remove the first stack item because it is within the interpreter object implementation. The output is written by the `write()` method.

在 3.5 版的變更: The full chained traceback is displayed instead of just the primary traceback.

`InteractiveInterpreter.write(data)`

Write a string to the standard error stream (`sys.stderr`). Derived classes should override this to provide the appropriate output handling as needed.

30.1.2 Interactive Console Objects

The `InteractiveConsole` class is a subclass of `InteractiveInterpreter`, and so offers all the methods of the interpreter objects as well as the following additions.

`InteractiveConsole.interact (banner=None, exitmsg=None)`

Closely emulate the interactive Python console. The optional `banner` argument specifies the banner to print before the first interaction; by default it prints a banner similar to the one printed by the standard Python interpreter, followed by the class name of the console object in parentheses (so as not to confuse this with the real interpreter -- since it's so close!).

The optional `exitmsg` argument specifies an exit message printed when exiting. Pass the empty string to suppress the exit message. If `exitmsg` is not given or `None`, a default message is printed.

在 3.4 版的變更: To suppress printing any banner, pass an empty string.

在 3.6 版的變更: Print an exit message when exiting.

`InteractiveConsole.push (line)`

Push a line of source text to the interpreter. The line should not have a trailing newline; it may have internal newlines. The line is appended to a buffer and the interpreter's `runsource()` method is called with the concatenated contents of the buffer as source. If this indicates that the command was executed or invalid, the buffer is reset; otherwise, the command is incomplete, and the buffer is left as it was after the line was appended. The return value is `True` if more input is required, `False` if the line was dealt with in some way (this is the same as `runsource()`).

`InteractiveConsole.resetbuffer ()`

Remove any unhandled source text from the input buffer.

`InteractiveConsole.raw_input (prompt=)`

Write a prompt and read a line. The returned line does not include the trailing newline. When the user enters the EOF key sequence, `EOFError` is raised. The base implementation reads from `sys.stdin`; a subclass may replace this with a different implementation.

30.2 codeop --- Compile Python code

原始碼: [Lib/codeop.py](#)

The `codeop` module provides utilities upon which the Python read-eval-print loop can be emulated, as is done in the `code` module. As a result, you probably don't want to use the module directly; if you want to include such a loop in your program you probably want to use the `code` module instead.

There are two parts to this job:

1. Being able to tell if a line of input completes a Python statement: in short, telling whether to print `'>>>'` or `'...'` next.
2. Remembering which future statements the user has entered, so subsequent input can be compiled with these in effect.

The `codeop` module provides a way of doing each of these things, and a way of doing them both.

To do just the former:

`codeop.compile_command (source, filename='<input>', symbol='single')`

Tries to compile `source`, which should be a string of Python code and return a code object if `source` is valid Python code. In that case, the filename attribute of the code object will be `filename`, which defaults to `'<input>'`. Returns `None` if `source` is not valid Python code, but is a prefix of valid Python code.

If there is a problem with `source`, an exception will be raised. `SyntaxError` is raised if there is invalid Python syntax, and `OverflowError` or `ValueError` if there is an invalid literal.

The *symbol* argument determines whether *source* is compiled as a statement ('single', the default), as a sequence of *statement* ('exec') or as an *expression* ('eval'). Any other value will cause *ValueError* to be raised.

備 註: It is possible (but not likely) that the parser stops parsing with a successful outcome before reaching the end of the source; in this case, trailing symbols may be ignored instead of causing an error. For example, a backslash followed by two newlines may be followed by arbitrary garbage. This will be fixed once the API for the parser is better.

class `codeop.Compile`

Instances of this class have `__call__()` methods identical in signature to the built-in function `compile()`, but with the difference that if the instance compiles program text containing a `__future__` statement, the instance 'remembers' and compiles all subsequent program texts with the statement in force.

class `codeop.CommandCompiler`

Instances of this class have `__call__()` methods identical in signature to `compile_command()`; the difference is that if the instance compiles program text containing a `__future__` statement, the instance 'remembers' and compiles all subsequent program texts with the statement in force.

The modules described in this chapter provide new ways to import other Python modules and hooks for customizing the import process.

The full list of modules described in this chapter is:

31.1 `zipimport` --- Import modules from Zip archives

原始碼: [Lib/zipimport.py](#)

This module adds the ability to import Python modules (`*.py`, `*.pyc`) and packages from ZIP-format archives. It is usually not needed to use the `zipimport` module explicitly; it is automatically used by the built-in import mechanism for `sys.path` items that are paths to ZIP archives.

Typically, `sys.path` is a list of directory names as strings. This module also allows an item of `sys.path` to be a string naming a ZIP file archive. The ZIP archive can contain a subdirectory structure to support package imports, and a path within the archive can be specified to only import from a subdirectory. For example, the path `example.zip/lib/` would only import from the `lib/` subdirectory within the archive.

Any files may be present in the ZIP archive, but importers are only invoked for `.py` and `.pyc` files. ZIP import of dynamic modules (`.pyd`, `.so`) is disallowed. Note that if an archive only contains `.py` files, Python will not attempt to modify the archive by adding the corresponding `.pyc` file, meaning that if a ZIP archive doesn't contain `.pyc` files, importing may be rather slow.

在 3.8 版的變更: Previously, ZIP archives with an archive comment were not supported.

也參考:

PKZIP Application Note

Documentation on the ZIP file format by Phil Katz, the creator of the format and algorithms used.

PEP 273 - Import Modules from Zip Archives

Written by James C. Ahlstrom, who also provided an implementation. Python 2.3 follows the specification in [PEP 273](#), but uses an implementation written by Just van Rossum that uses the import hooks described in [PEP 302](#).

`importlib` - The implementation of the import machinery

Package providing the relevant protocols for all importers to implement.

This module defines an exception:

exception `zipimport.ZipImportError`

Exception raised by zipimporter objects. It's a subclass of `ImportError`, so it can be caught as `ImportError`, too.

31.1.1 zipimporter 物件

`zipimporter` is the class for importing ZIP files.

class `zipimport.zipimporter` (*archivepath*)

Create a new zipimporter instance. *archivepath* must be a path to a ZIP file, or to a specific path within a ZIP file. For example, an *archivepath* of `foo/bar.zip/lib` will look for modules in the `lib` directory inside the ZIP file `foo/bar.zip` (provided that it exists).

`ZipImportError` is raised if *archivepath* doesn't point to a valid ZIP archive.

create_module (*spec*)

Implementation of `importlib.abc.Loader.create_module()` that returns `None` to explicitly request the default semantics.

在 3.10 版新加入.

exec_module (*module*)

Implementation of `importlib.abc.Loader.exec_module()`.

在 3.10 版新加入.

find_loader (*fullname*, *path=None*)

An implementation of `importlib.abc.PathEntryFinder.find_loader()`.

在 3.10 版之後被 用: Use `find_spec()` instead.

find_module (*fullname*, *path=None*)

Search for a module specified by *fullname*. *fullname* must be the fully qualified (dotted) module name. It returns the zipimporter instance itself if the module was found, or `None` if it wasn't. The optional *path* argument is ignored---it's there for compatibility with the importer protocol.

在 3.10 版之後被 用: Use `find_spec()` instead.

find_spec (*fullname*, *target=None*)

An implementation of `importlib.abc.PathEntryFinder.find_spec()`.

在 3.10 版新加入.

get_code (*fullname*)

Return the code object for the specified module. Raise `ZipImportError` if the module couldn't be imported.

get_data (*pathname*)

Return the data associated with *pathname*. Raise `OSError` if the file wasn't found.

在 3.3 版的變更: `IOError` used to be raised, it is now an alias of `OSError`.

get_filename (*fullname*)

Return the value `__file__` would be set to if the specified module was imported. Raise `ZipImportError` if the module couldn't be imported.

在 3.1 版新加入.

get_source (*fullname*)

Return the source code for the specified module. Raise `ZipImportError` if the module couldn't be found, return `None` if the archive does contain the module, but has no source for it.

is_package (*fullname*)

Return True if the module specified by *fullname* is a package. Raise *ZipImportError* if the module couldn't be found.

load_module (*fullname*)

Load the module specified by *fullname*. *fullname* must be the fully qualified (dotted) module name. Returns the imported module on success, raises *ZipImportError* on failure.

在 3.10 版之後被用: Use *exec_module()* instead.

invalidate_caches ()

Clear out the internal cache of information about files found within the ZIP archive.

在 3.10 版新加入.

archive

The file name of the importer's associated ZIP file, without a possible subpath.

prefix

The subpath within the ZIP file where modules are searched. This is the empty string for zipimporter objects which point to the root of the ZIP file.

The *archive* and *prefix* attributes, when combined with a slash, equal the original *archivepath* argument given to the *zipimporter* constructor.

31.1.2 范例

Here is an example that imports a module from a ZIP archive - note that the *zipimport* module is not explicitly used.

```
$ unzip -l example.zip
Archive:  example.zip
  Length      Date    Time    Name
-----
   8467   11-26-02  22:30   jwzthreading.py
-----
   8467                      1 file

$ ./python
Python 2.3 (#1, Aug 1 2003, 19:54:32)
>>> import sys
>>> sys.path.insert(0, 'example.zip') # Add .zip file to front of path
>>> import jwzthreading
>>> jwzthreading.__file__
'example.zip/jwzthreading.py'
```

31.2 pkgutil --- Package extension utility

原始碼: [Lib/pkgutil.py](#)

This module provides utilities for the import system, in particular package support.

class *pkgutil.ModuleInfo* (*module_finder*, *name*, *ispkg*)

A namedtuple that holds a brief summary of a module's info.

在 3.6 版新加入.

`pkgutil.extend_path(path, name)`

Extend the search path for the modules which comprise a package. Intended use is to place the following code in a package's `__init__.py`:

```
from pkgutil import extend_path
__path__ = extend_path(__path__, __name__)
```

For each directory on `sys.path` that has a subdirectory that matches the package name, add the subdirectory to the package's `__path__`. This is useful if one wants to distribute different parts of a single logical package as multiple directories.

It also looks for `*.pkg` files beginning where `*` matches the *name* argument. This feature is similar to `*.pth` files (see the `site` module for more information), except that it doesn't special-case lines starting with `import`. A `*.pkg` file is trusted at face value: apart from checking for duplicates, all entries found in a `*.pkg` file are added to the path, regardless of whether they exist on the filesystem. (This is a feature.)

If the input path is not a list (as is the case for frozen packages) it is returned unchanged. The input path is not modified; an extended copy is returned. Items are only appended to the copy at the end.

It is assumed that `sys.path` is a sequence. Items of `sys.path` that are not strings referring to existing directories are ignored. Unicode items on `sys.path` that cause errors when used as filenames may cause this function to raise an exception (in line with `os.path.isdir()` behavior).

class `pkgutil.ImpImporter` (*dirname=None*)

PEP 302 Finder that wraps Python's "classic" import algorithm.

If *dirname* is a string, a **PEP 302** finder is created that searches that directory. If *dirname* is `None`, a **PEP 302** finder is created that searches the current `sys.path`, plus any modules that are frozen or built-in.

Note that `ImpImporter` does not currently support being used by placement on `sys.meta_path`.

在 3.3 版之後被 用: This emulation is no longer needed, as the standard import mechanism is now fully **PEP 302** compliant and available in `importlib`.

class `pkgutil.ImpLoader` (*fullname, file, filename, etc*)

Loader that wraps Python's "classic" import algorithm.

在 3.3 版之後被 用: This emulation is no longer needed, as the standard import mechanism is now fully **PEP 302** compliant and available in `importlib`.

`pkgutil.find_loader(fullname)`

Retrieve a module *loader* for the given *fullname*.

This is a backwards compatibility wrapper around `importlib.util.find_spec()` that converts most failures to `ImportError` and only returns the loader rather than the full `importlib.machinery.ModuleSpec`.

在 3.3 版的變更: Updated to be based directly on `importlib` rather than relying on the package internal **PEP 302** import emulation.

在 3.4 版的變更: 基於 **PEP 451** 來更新

`pkgutil.get_importer(path_item)`

Retrieve a *finder* for the given *path_item*.

The returned finder is cached in `sys.path_importer_cache` if it was newly created by a path hook.

The cache (or part of it) can be cleared manually if a rescan of `sys.path_hooks` is necessary.

在 3.3 版的變更: Updated to be based directly on `importlib` rather than relying on the package internal **PEP 302** import emulation.

`pkgutil.get_loader(module_or_name)`

Get a *loader* object for *module_or_name*.

If the module or package is accessible via the normal import mechanism, a wrapper around the relevant part of that machinery is returned. Returns `None` if the module cannot be found or imported. If the named module is not already imported, its containing package (if any) is imported, in order to establish the package `__path__`.

在 3.3 版的變更: Updated to be based directly on `importlib` rather than relying on the package internal **PEP 302** import emulation.

在 3.4 版的變更: 基於 **PEP 451** 來更新

`pkgutil.iter_importers (fullname=)`

Yield *finder* objects for the given module name.

If `fullname` contains a `'.'`, the finders will be for the package containing `fullname`, otherwise they will be all registered top level finders (i.e. those on both `sys.meta_path` and `sys.path_hooks`).

If the named module is in a package, that package is imported as a side effect of invoking this function.

If no module name is specified, all top level finders are produced.

在 3.3 版的變更: Updated to be based directly on `importlib` rather than relying on the package internal **PEP 302** import emulation.

`pkgutil.iter_modules (path=None, prefix=)`

Yields *ModuleInfo* for all submodules on `path`, or, if `path` is `None`, all top-level modules on `sys.path`.

`path` should be either `None` or a list of paths to look for modules in.

`prefix` is a string to output on the front of every module name on output.

備F: Only works for a *finder* which defines an `iter_modules()` method. This interface is non-standard, so the module also provides implementations for `importlib.machinery.FileFinder` and `zipimport.zipimporter`.

在 3.3 版的變更: Updated to be based directly on `importlib` rather than relying on the package internal **PEP 302** import emulation.

`pkgutil.walk_packages (path=None, prefix="", onerror=None)`

Yields *ModuleInfo* for all modules recursively on `path`, or, if `path` is `None`, all accessible modules.

`path` should be either `None` or a list of paths to look for modules in.

`prefix` is a string to output on the front of every module name on output.

Note that this function must import all *packages* (not all modules!) on the given `path`, in order to access the `__path__` attribute to find submodules.

`onerror` is a function which gets called with one argument (the name of the package which was being imported) if any exception occurs while trying to import a package. If no `onerror` function is supplied, `ImportErrors` are caught and ignored, while all other exceptions are propagated, terminating the search.

範例:

```
# list all modules python can access
walk_packages()

# list all submodules of ctypes
walk_packages(ctypes.__path__, ctypes.__name__ + '.')

```

備F: Only works for a *finder* which defines an `iter_modules()` method. This interface is non-standard, so the module also provides implementations for `importlib.machinery.FileFinder` and `zipimport.zipimporter`.

在 3.3 版的變更: Updated to be based directly on `importlib` rather than relying on the package internal **PEP 302** import emulation.

`pkgutil.get_data(package, resource)`

Get a resource from a package.

This is a wrapper for the *loader* `get_data` API. The *package* argument should be the name of a package, in standard module format (`foo.bar`). The *resource* argument should be in the form of a relative filename, using `/` as the path separator. The parent directory name `..` is not allowed, and nor is a rooted name (starting with a `/`).

The function returns a binary string that is the contents of the specified resource.

For packages located in the filesystem, which have already been imported, this is the rough equivalent of:

```
d = os.path.dirname(sys.modules[package].__file__)
data = open(os.path.join(d, resource), 'rb').read()
```

If the package cannot be located or loaded, or it uses a *loader* which does not support `get_data`, then `None` is returned. In particular, the *loader* for *namespace packages* does not support `get_data`.

`pkgutil.resolve_name(name)`

Resolve a name to an object.

This functionality is used in numerous places in the standard library (see [bpo-12915](#)) - and equivalent functionality is also in widely used third-party packages such as `setuptools`, `Django` and `Pyramid`.

It is expected that *name* will be a string in one of the following formats, where *W* is shorthand for a valid Python identifier and *dot* stands for a literal period in these pseudo-regexes:

- `W(.W)*`
- `W(.W)*:(W(.W)*)?`

The first form is intended for backward compatibility only. It assumes that some part of the dotted name is a package, and the rest is an object somewhere within that package, possibly nested inside other objects. Because the place where the package stops and the object hierarchy starts can't be inferred by inspection, repeated attempts to import must be done with this form.

In the second form, the caller makes the division point clear through the provision of a single colon: the dotted name to the left of the colon is a package to be imported, and the dotted name to the right is the object hierarchy within that package. Only one import is needed in this form. If it ends with the colon, then a module object is returned.

The function will return an object (which might be a module), or raise one of the following exceptions:

ValueError -- if *name* isn't in a recognised format.

ImportError -- if an import failed when it shouldn't have.

AttributeError -- If a failure occurred when traversing the object hierarchy within the imported package to get to the desired object.

在 3.9 版新加入.

31.3 modulefinder --- Find modules used by a script

原始碼: [Lib/modulefinder.py](#)

This module provides a *ModuleFinder* class that can be used to determine the set of modules imported by a script. `modulefinder.py` can also be run as a script, giving the filename of a Python script as its argument, after which a report of the imported modules will be printed.

`modulefinder.AddPackagePath(pkg_name, path)`

Record that the package named *pkg_name* can be found in the specified *path*.

`modulefinder.ReplacePackage (oldname, newname)`

Allows specifying that the module named *oldname* is in fact the package named *newname*.

class `modulefinder.ModuleFinder (path=None, debug=0, excludes=[], replace_paths=[])`

This class provides `run_script()` and `report()` methods to determine the set of modules imported by a script. *path* can be a list of directories to search for modules; if not specified, `sys.path` is used. *debug* sets the debugging level; higher values make the class print debugging messages about what it's doing. *excludes* is a list of module names to exclude from the analysis. *replace_paths* is a list of (*oldpath*, *newpath*) tuples that will be replaced in module paths.

report ()

Print a report to standard output that lists the modules imported by the script and their paths, as well as modules that are missing or seem to be missing.

run_script (pathname)

Analyze the contents of the *pathname* file, which must contain Python code.

modules

A dictionary mapping module names to modules. See [Example usage of ModuleFinder](#).

31.3.1 Example usage of ModuleFinder

The script that is going to get analyzed later on (`bacon.py`):

```
import re, itertools

try:
    import baconhammeggs
except ImportError:
    pass

try:
    import guido.python.ham
except ImportError:
    pass
```

The script that will output the report of `bacon.py`:

```
from modulefinder import ModuleFinder

finder = ModuleFinder()
finder.run_script('bacon.py')

print('Loaded modules:')
for name, mod in finder.modules.items():
    print('%s: ' % name, end='')
    print(', '.join(list(mod.globalnames.keys())[:3]))

print('-'*50)
print('Modules not imported:')
print('\n'.join(finder.badmodules.keys()))
```

Sample output (may vary depending on the architecture):

```
Loaded modules:
_types:
copyreg:  _inverted_registry, _slotnames, __all__
re._compiler:  isstring, _sre, _optimize_unicode
_sre:
re._constants:  REPEAT_ONE, makedict, AT_END_LINE
```

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```

sys:
re:  __module__, finditer, _expand
itertools:
__main__:  re, itertools, baconhameggs
re._parser:  _PATTERNENDERS, SRE_FLAG_UNICODE
array:
types:  __module__, IntType, TypeType
-----
Modules not imported:
guido.python.ham
baconhameggs

```

31.4 runpy --- Locating and executing Python modules

原始碼: [Lib/runpy.py](#)

The *runpy* module is used to locate and run Python modules without importing them first. Its main use is to implement the `-m` command line switch that allows scripts to be located using the Python module namespace rather than the filesystem.

Note that this is *not* a sandbox module - all code is executed in the current process, and any side effects (such as cached imports of other modules) will remain in place after the functions have returned.

Furthermore, any functions and classes defined by the executed code are not guaranteed to work correctly after a *runpy* function has returned. If that limitation is not acceptable for a given use case, *importlib* is likely to be a more suitable choice than this module.

The *runpy* module provides two functions:

`runpy.run_module(mod_name, init_globals=None, run_name=None, alter_sys=False)`

Execute the code of the specified module and return the resulting module globals dictionary. The module's code is first located using the standard import mechanism (refer to [PEP 302](#) for details) and then executed in a fresh module namespace.

The *mod_name* argument should be an absolute module name. If the module name refers to a package rather than a normal module, then that package is imported and the `__main__` submodule within that package is then executed and the resulting module globals dictionary returned.

The optional dictionary argument *init_globals* may be used to pre-populate the module's globals dictionary before the code is executed. The supplied dictionary will not be modified. If any of the special global variables below are defined in the supplied dictionary, those definitions are overridden by *run_module()*.

The special global variables `__name__`, `__spec__`, `__file__`, `__cached__`, `__loader__` and `__package__` are set in the globals dictionary before the module code is executed (Note that this is a minimal set of variables - other variables may be set implicitly as an interpreter implementation detail).

`__name__` is set to *run_name* if this optional argument is not *None*, to `mod_name + '.__main__'` if the named module is a package and to the *mod_name* argument otherwise.

`__spec__` will be set appropriately for the *actually* imported module (that is, `__spec__.name` will always be *mod_name* or `mod_name + '.__main__'`, never *run_name*).

`__file__`, `__cached__`, `__loader__` and `__package__` are set as normal based on the module spec.

If the argument *alter_sys* is supplied and evaluates to *True*, then `sys.argv[0]` is updated with the value of `__file__` and `sys.modules[__name__]` is updated with a temporary module object for the module being executed. Both `sys.argv[0]` and `sys.modules[__name__]` are restored to their original values before the function returns.

Note that this manipulation of `sys` is not thread-safe. Other threads may see the partially initialised module, as well as the altered list of arguments. It is recommended that the `sys` module be left alone when invoking this function from threaded code.

也參考:

The `-m` option offering equivalent functionality from the command line.

在 3.1 版的變更: Added ability to execute packages by looking for a `__main__` submodule.

在 3.2 版的變更: Added `__cached__` global variable (see [PEP 3147](#)).

在 3.4 版的變更: Updated to take advantage of the module spec feature added by [PEP 451](#). This allows `__cached__` to be set correctly for modules run this way, as well as ensuring the real module name is always accessible as `__spec__.name`.

`runpy.run_path(path_name, init_globals=None, run_name=None)`

Execute the code at the named filesystem location and return the resulting module globals dictionary. As with a script name supplied to the CPython command line, the supplied path may refer to a Python source file, a compiled bytecode file or a valid `sys.path` entry containing a `__main__` module (e.g. a zipfile containing a top-level `__main__.py` file).

For a simple script, the specified code is simply executed in a fresh module namespace. For a valid `sys.path` entry (typically a zipfile or directory), the entry is first added to the beginning of `sys.path`. The function then looks for and executes a `__main__` module using the updated path. Note that there is no special protection against invoking an existing `__main__` entry located elsewhere on `sys.path` if there is no such module at the specified location.

The optional dictionary argument `init_globals` may be used to pre-populate the module's globals dictionary before the code is executed. The supplied dictionary will not be modified. If any of the special global variables below are defined in the supplied dictionary, those definitions are overridden by `run_path()`.

The special global variables `__name__`, `__spec__`, `__file__`, `__cached__`, `__loader__` and `__package__` are set in the globals dictionary before the module code is executed (Note that this is a minimal set of variables - other variables may be set implicitly as an interpreter implementation detail).

`__name__` is set to `run_name` if this optional argument is not `None` and to `'<run_path>'` otherwise.

If the supplied path directly references a script file (whether as source or as precompiled byte code), then `__file__` will be set to the supplied path, and `__spec__`, `__cached__`, `__loader__` and `__package__` will all be set to `None`.

If the supplied path is a reference to a valid `sys.path` entry, then `__spec__` will be set appropriately for the imported `__main__` module (that is, `__spec__.name` will always be `__main__`). `__file__`, `__cached__`, `__loader__` and `__package__` will be set as normal based on the module spec.

A number of alterations are also made to the `sys` module. Firstly, `sys.path` may be altered as described above. `sys.argv[0]` is updated with the value of `path_name` and `sys.modules[__name__]` is updated with a temporary module object for the module being executed. All modifications to items in `sys` are reverted before the function returns.

Note that, unlike `run_module()`, the alterations made to `sys` are not optional in this function as these adjustments are essential to allowing the execution of `sys.path` entries. As the thread-safety limitations still apply, use of this function in threaded code should be either serialised with the import lock or delegated to a separate process.

也參考:

using-on-interface-options for equivalent functionality on the command line (`python path/to/script`).

在 3.2 版新加入.

在 3.4 版的變更: Updated to take advantage of the module spec feature added by [PEP 451](#). This allows `__cached__` to be set correctly in the case where `__main__` is imported from a valid `sys.path` entry rather than being executed directly.

也參考:

PEP 338 -- Executing modules as scripts

PEP written and implemented by Nick Coghlan.

PEP 366 -- Main module explicit relative imports

PEP written and implemented by Nick Coghlan.

PEP 451 -- A ModuleSpec Type for the Import System

PEP written and implemented by Eric Snow

using-on-general - CPython command line details

The `importlib.import_module()` function

31.5 importlib --- The implementation of import

在 3.1 版新加入.

原始碼: `Lib/importlib/__init__.py`

31.5.1 簡介

The purpose of the `importlib` package is three-fold.

One is to provide the implementation of the `import` statement (and thus, by extension, the `__import__()` function) in Python source code. This provides an implementation of `import` which is portable to any Python interpreter. This also provides an implementation which is easier to comprehend than one implemented in a programming language other than Python.

Two, the components to implement `import` are exposed in this package, making it easier for users to create their own custom objects (known generically as an *importer*) to participate in the import process.

Three, the package contains modules exposing additional functionality for managing aspects of Python packages:

- `importlib.metadata` presents access to metadata from third-party distributions.
- `importlib.resources` provides routines for accessing non-code "resources" from Python packages.

也參考:

import

The language reference for the `import` statement.

Packages specification

Original specification of packages. Some semantics have changed since the writing of this document (e.g. redirecting based on `None` in `sys.modules`).

The `__import__()` function

The `import` statement is syntactic sugar for this function.

The initialization of the `sys.path` module search path

The initialization of `sys.path`.

PEP 235

Import on Case-Insensitive Platforms

PEP 263

Defining Python Source Code Encodings

PEP 302

New Import Hooks

PEP 328

Imports: Multi-Line and Absolute/Relative

PEP 366

Main module explicit relative imports

PEP 420

Implicit namespace packages

PEP 451

A ModuleSpec Type for the Import System

PEP 488

Elimination of PYO files

PEP 489

Multi-phase extension module initialization

PEP 552

Deterministic pycs

PEP 3120

Using UTF-8 as the Default Source Encoding

PEP 3147

PYC Repository Directories

31.5.2 函式`importlib.__import__(name, globals=None, locals=None, fromlist=(), level=0)`An implementation of the built-in `__import__()` function.

備 F: Programmatic importing of modules should use `import_module()` instead of this function.

`importlib.import_module(name, package=None)`

Import a module. The *name* argument specifies what module to import in absolute or relative terms (e.g. either `pkg.mod` or `..mod`). If the name is specified in relative terms, then the *package* argument must be set to the name of the package which is to act as the anchor for resolving the package name (e.g. `import_module('..mod', 'pkg.subpkg')` will import `pkg.mod`).

The `import_module()` function acts as a simplifying wrapper around `importlib.__import__()`. This means all semantics of the function are derived from `importlib.__import__()`. The most important difference between these two functions is that `import_module()` returns the specified package or module (e.g. `pkg.mod`), while `__import__()` returns the top-level package or module (e.g. `pkg`).

If you are dynamically importing a module that was created since the interpreter began execution (e.g., created a Python source file), you may need to call `invalidate_caches()` in order for the new module to be noticed by the import system.

在 3.3 版的變更: Parent packages are automatically imported.

`importlib.find_loader(name, path=None)`

Find the loader for a module, optionally within the specified *path*. If the module is in `sys.modules`, then `sys.modules[name].__loader__` is returned (unless the loader would be `None` or is not set, in which case `ValueError` is raised). Otherwise a search using `sys.meta_path` is done. `None` is returned if no loader is found.

A dotted name does not have its parents implicitly imported as that requires loading them and that may not be desired. To properly import a submodule you will need to import all parent packages of the submodule and use the correct argument to *path*.

在 3.3 版新加入.

在 3.4 版的變更: If `__loader__` is not set, raise `ValueError`, just like when the attribute is set to `None`.

在 3.4 版之後被 F 用: Use `importlib.util.find_spec()` instead.


```
importlib.invalidate_caches()
```

Invalidate the internal caches of finders stored at `sys.meta_path`. If a finder implements `invalidate_caches()` then it will be called to perform the invalidation. This function should be called if any modules are created/installed while your program is running to guarantee all finders will notice the new module's existence.

在 3.3 版新加入。

在 3.10 版的變更: Namespace packages created/installed in a different `sys.path` location after the same namespace was already imported are noticed.

```
importlib.reload(module)
```

Reload a previously imported *module*. The argument must be a module object, so it must have been successfully imported before. This is useful if you have edited the module source file using an external editor and want to try out the new version without leaving the Python interpreter. The return value is the module object (which can be different if re-importing causes a different object to be placed in `sys.modules`).

When `reload()` is executed:

- Python module's code is recompiled and the module-level code re-executed, defining a new set of objects which are bound to names in the module's dictionary by reusing the *loader* which originally loaded the module. The `init` function of extension modules is not called a second time.
- As with all other objects in Python the old objects are only reclaimed after their reference counts drop to zero.
- The names in the module namespace are updated to point to any new or changed objects.
- Other references to the old objects (such as names external to the module) are not rebound to refer to the new objects and must be updated in each namespace where they occur if that is desired.

There are a number of other caveats:

When a module is reloaded, its dictionary (containing the module's global variables) is retained. Redefinitions of names will override the old definitions, so this is generally not a problem. If the new version of a module does not define a name that was defined by the old version, the old definition remains. This feature can be used to the module's advantage if it maintains a global table or cache of objects --- with a `try` statement it can test for the table's presence and skip its initialization if desired:

```
try:
    cache
except NameError:
    cache = {}
```

It is generally not very useful to reload built-in or dynamically loaded modules. Reloading `sys`, `__main__`, `builtins` and other key modules is not recommended. In many cases extension modules are not designed to be initialized more than once, and may fail in arbitrary ways when reloaded.

If a module imports objects from another module using `from ... import ...`, calling `reload()` for the other module does not redefine the objects imported from it --- one way around this is to re-execute the `from` statement, another is to use `import` and qualified names (`module.name`) instead.

If a module instantiates instances of a class, reloading the module that defines the class does not affect the method definitions of the instances --- they continue to use the old class definition. The same is true for derived classes.

在 3.4 版新加入。

在 3.7 版的變更: `ModuleNotFoundError` is raised when the module being reloaded lacks a `ModuleSpec`.

31.5.3 `importlib.abc` -- Abstract base classes related to import

原始碼: `Lib/importlib/abc.py`

The `importlib.abc` module contains all of the core abstract base classes used by `import`. Some subclasses of the core abstract base classes are also provided to help in implementing the core ABCs.

ABC hierarchy:

```
object
+-- Finder (deprecated)
+-- MetaPathFinder
+-- PathEntryFinder
+-- Loader
    +-- ResourceLoader -----+
    +-- InspectLoader          |
        +-- ExecutionLoader --+
                                +-- FileLoader
                                +-- SourceLoader
```

class `importlib.abc.Finder`

An abstract base class representing a *finder*.

在 3.3 版之後被⌘用: Use `MetaPathFinder` or `PathEntryFinder` instead.

abstractmethod `find_module` (*fullname*, *path*=None)

An abstract method for finding a *loader* for the specified module. Originally specified in **PEP 302**, this method was meant for use in `sys.meta_path` and in the path-based import subsystem.

在 3.4 版的變更: Returns None when called instead of raising `NotImplementedError`.

在 3.10 版之後被⌘用: Implement `MetaPathFinder.find_spec()` or `PathEntryFinder.find_spec()` instead.

class `importlib.abc.MetaPathFinder`

An abstract base class representing a *meta path finder*.

在 3.3 版新加入.

在 3.10 版的變更: No longer a subclass of `Finder`.

find_spec (*fullname*, *path*, *target*=None)

An abstract method for finding a *spec* for the specified module. If this is a top-level import, *path* will be None. Otherwise, this is a search for a subpackage or module and *path* will be the value of `__path__` from the parent package. If a spec cannot be found, None is returned. When passed in, *target* is a module object that the finder may use to make a more educated guess about what spec to return. `importlib.util.spec_from_loader()` may be useful for implementing concrete `MetaPathFinders`.

在 3.4 版新加入.

find_module (*fullname*, *path*)

A legacy method for finding a *loader* for the specified module. If this is a top-level import, *path* will be None. Otherwise, this is a search for a subpackage or module and *path* will be the value of `__path__` from the parent package. If a loader cannot be found, None is returned.

If `find_spec()` is defined, backwards-compatible functionality is provided.

在 3.4 版的變更: Returns None when called instead of raising `NotImplementedError`. Can use `find_spec()` to provide functionality.

在 3.4 版之後被⌘用: Use `find_spec()` instead.

invalidate_caches()

An optional method which, when called, should invalidate any internal cache used by the finder. Used by `importlib.invalidate_caches()` when invalidating the caches of all finders on `sys.meta_path`.

在 3.4 版的變更: Returns None when called instead of `NotImplemented`.

class importlib.abc.PathEntryFinder

An abstract base class representing a *path entry finder*. Though it bears some similarities to `MetaPathFinder`, `PathEntryFinder` is meant for use only within the path-based import subsystem provided by `importlib.machinery.PathFinder`.

在 3.3 版新加入.

在 3.10 版的變更: No longer a subclass of `Finder`.

find_spec(fullname, target=None)

An abstract method for finding a *spec* for the specified module. The finder will search for the module only within the *path entry* to which it is assigned. If a spec cannot be found, None is returned. When passed in, `target` is a module object that the finder may use to make a more educated guess about what spec to return. `importlib.util.spec_from_loader()` may be useful for implementing concrete `PathEntryFinders`.

在 3.4 版新加入.

find_loader(fullname)

A legacy method for finding a *loader* for the specified module. Returns a 2-tuple of (`loader`, `portion`) where `portion` is a sequence of file system locations contributing to part of a namespace package. The loader may be None while specifying `portion` to signify the contribution of the file system locations to a namespace package. An empty list can be used for `portion` to signify the loader is not part of a namespace package. If `loader` is None and `portion` is the empty list then no loader or location for a namespace package were found (i.e. failure to find anything for the module).

If `find_spec()` is defined then backwards-compatible functionality is provided.

在 3.4 版的變更: Returns (None, []) instead of raising `NotImplementedError`. Uses `find_spec()` when available to provide functionality.

在 3.4 版之後被 F 用: Use `find_spec()` instead.

find_module(fullname)

A concrete implementation of `Finder.find_module()` which is equivalent to `self.find_loader(fullname)[0]`.

在 3.4 版之後被 F 用: Use `find_spec()` instead.

invalidate_caches()

An optional method which, when called, should invalidate any internal cache used by the finder. Used by `importlib.machinery.PathFinder.invalidate_caches()` when invalidating the caches of all cached finders.

class importlib.abc.Loader

An abstract base class for a *loader*. See **PEP 302** for the exact definition for a loader.

Loaders that wish to support resource reading should implement a `get_resource_reader()` method as specified by `importlib.resources.abc.ResourceReader`.

在 3.7 版的變更: Introduced the optional `get_resource_reader()` method.

create_module(spec)

A method that returns the module object to use when importing a module. This method may return None, indicating that default module creation semantics should take place.

在 3.4 版新加入.

在 3.6 版的變更: This method is no longer optional when `exec_module()` is defined.

exec_module (*module*)

An abstract method that executes the module in its own namespace when a module is imported or reloaded. The module should already be initialized when `exec_module()` is called. When this method exists, `create_module()` must be defined.

在 3.4 版新加入。

在 3.6 版的變更: `create_module()` 也必須被定義。

load_module (*fullname*)

A legacy method for loading a module. If the module cannot be loaded, `ImportError` is raised, otherwise the loaded module is returned.

If the requested module already exists in `sys.modules`, that module should be used and reloaded. Otherwise the loader should create a new module and insert it into `sys.modules` before any loading begins, to prevent recursion from the import. If the loader inserted a module and the load fails, it must be removed by the loader from `sys.modules`; modules already in `sys.modules` before the loader began execution should be left alone (see `importlib.util.module_for_loader()`).

The loader should set several attributes on the module (note that some of these attributes can change when a module is reloaded):

- **__name__**
The module's fully qualified name. It is `'__main__'` for an executed module.
- **__file__**
The location the *loader* used to load the module. For example, for modules loaded from a .py file this is the filename. It is not set on all modules (e.g. built-in modules).
- **__cached__**
The filename of a compiled version of the module's code. It is not set on all modules (e.g. built-in modules).
- **__path__**
The list of locations where the package's submodules will be found. Most of the time this is a single directory. The import system passes this attribute to `__import__()` and to finders in the same way as `sys.path` but just for the package. It is not set on non-package modules so it can be used as an indicator that the module is a package.
- **__package__**
The fully qualified name of the package the module is in (or the empty string for a top-level module). If the module is a package then this is the same as `__name__`.
- **__loader__**
The *loader* used to load the module.

When `exec_module()` is available then backwards-compatible functionality is provided.

在 3.4 版的變更: Raise `ImportError` when called instead of `NotImplementedError`. Functionality provided when `exec_module()` is available.

在 3.4 版之後被☑用: The recommended API for loading a module is `exec_module()` (and `create_module()`). Loaders should implement it instead of `load_module()`. The import machinery takes care of all the other responsibilities of `load_module()` when `exec_module()` is implemented.

module_repr (*module*)

A legacy method which when implemented calculates and returns the given module's representation, as a string. The module type's default `__repr__()` will use the result of this method as appropriate.

在 3.3 版新加入。

在 3.4 版的變更: Made optional instead of an abstractmethod.

在 3.4 版之後被☑用: The import machinery now takes care of this automatically.

class `importlib.abc.ResourceLoader`

An abstract base class for a *loader* which implements the optional **PEP 302** protocol for loading arbitrary resources from the storage back-end.

在 3.7 版之後被 F 用: This ABC is deprecated in favour of supporting resource loading through `importlib.resources.abc.ResourceReader`.

abstractmethod `get_data(path)`

An abstract method to return the bytes for the data located at *path*. Loaders that have a file-like storage back-end that allows storing arbitrary data can implement this abstract method to give direct access to the data stored. *OSError* is to be raised if the *path* cannot be found. The *path* is expected to be constructed using a module's `__file__` attribute or an item from a package's `__path__`.

在 3.4 版的變更: Raises *OSError* instead of *NotImplementedError*.

class `importlib.abc.InspectLoader`

An abstract base class for a *loader* which implements the optional **PEP 302** protocol for loaders that inspect modules.

get_code (*fullname*)

Return the code object for a module, or *None* if the module does not have a code object (as would be the case, for example, for a built-in module). Raise an *ImportError* if loader cannot find the requested module.

備 F: While the method has a default implementation, it is suggested that it be overridden if possible for performance.

在 3.4 版的變更: No longer abstract and a concrete implementation is provided.

abstractmethod `get_source(fullname)`

An abstract method to return the source of a module. It is returned as a text string using *universal newlines*, translating all recognized line separators into `'\n'` characters. Returns *None* if no source is available (e.g. a built-in module). Raises *ImportError* if the loader cannot find the module specified.

在 3.4 版的變更: Raises *ImportError* instead of *NotImplementedError*.

is_package (*fullname*)

An optional method to return a true value if the module is a package, a false value otherwise. *ImportError* is raised if the *loader* cannot find the module.

在 3.4 版的變更: Raises *ImportError* instead of *NotImplementedError*.

static `source_to_code(data, path='<string>')`

Create a code object from Python source.

The *data* argument can be whatever the `compile()` function supports (i.e. string or bytes). The *path* argument should be the "path" to where the source code originated from, which can be an abstract concept (e.g. location in a zip file).

With the subsequent code object one can execute it in a module by running `exec(code, module.__dict__)`.

在 3.4 版新加入.

在 3.5 版的變更: Made the method static.

exec_module (*module*)

Implementation of *Loader.exec_module()*.

在 3.4 版新加入.

load_module (*fullname*)

Implementation of *Loader.load_module()*.

在 3.4 版之後被`exec_module()`用: use *exec_module()* instead.

class `importlib.abc.ExecutionLoader`

An abstract base class which inherits from *InspectLoader* that, when implemented, helps a module to be executed as a script. The ABC represents an optional **PEP 302** protocol.

abstractmethod `get_filename` (*fullname*)

An abstract method that is to return the value of `__file__` for the specified module. If no path is available, *ImportError* is raised.

If source code is available, then the method should return the path to the source file, regardless of whether a bytecode was used to load the module.

在 3.4 版的變更: Raises *ImportError* instead of *NotImplementedError*.

class `importlib.abc.FileLoader` (*fullname*, *path*)

An abstract base class which inherits from *ResourceLoader* and *ExecutionLoader*, providing concrete implementations of *ResourceLoader.get_data()* and *ExecutionLoader.get_filename()*.

The *fullname* argument is a fully resolved name of the module the loader is to handle. The *path* argument is the path to the file for the module.

在 3.3 版新加入.

name

The name of the module the loader can handle.

path

Path to the file of the module.

load_module (*fullname*)

Calls super's *load_module()*.

在 3.4 版之後被`exec_module()`用: Use *Loader.exec_module()* instead.

abstractmethod `get_filename` (*fullname*)

Returns *path*.

abstractmethod `get_data` (*path*)

Reads *path* as a binary file and returns the bytes from it.

class `importlib.abc.SourceLoader`

An abstract base class for implementing source (and optionally bytecode) file loading. The class inherits from both *ResourceLoader* and *ExecutionLoader*, requiring the implementation of:

- *ResourceLoader.get_data()*
- *ExecutionLoader.get_filename()*
Should only return the path to the source file; sourceless loading is not supported.

The abstract methods defined by this class are to add optional bytecode file support. Not implementing these optional methods (or causing them to raise *NotImplementedError*) causes the loader to only work with source code. Implementing the methods allows the loader to work with source *and* bytecode files; it does not allow for *sourceless* loading where only bytecode is provided. Bytecode files are an optimization to speed up loading by removing the parsing step of Python's compiler, and so no bytecode-specific API is exposed.

path_stats (*path*)

Optional abstract method which returns a *dict* containing metadata about the specified path. Supported dictionary keys are:

- 'mtime' (mandatory): an integer or floating-point number representing the modification time of the source code;

- 'size' (optional): the size in bytes of the source code.

Any other keys in the dictionary are ignored, to allow for future extensions. If the path cannot be handled, `OSError` is raised.

在 3.3 版新加入.

在 3.4 版的變更: Raise `OSError` instead of `NotImplementedError`.

path_mtime (*path*)

Optional abstract method which returns the modification time for the specified path.

在 3.3 版之後被 用: This method is deprecated in favour of `path_stats()`. You don't have to implement it, but it is still available for compatibility purposes. Raise `OSError` if the path cannot be handled.

在 3.4 版的變更: Raise `OSError` instead of `NotImplementedError`.

set_data (*path*, *data*)

Optional abstract method which writes the specified bytes to a file path. Any intermediate directories which do not exist are to be created automatically.

When writing to the path fails because the path is read-only (`errno.EACCES/PermissionError`), do not propagate the exception.

在 3.4 版的變更: No longer raises `NotImplementedError` when called.

get_code (*fullname*)

Concrete implementation of `InspectLoader.get_code()`.

exec_module (*module*)

Concrete implementation of `Loader.exec_module()`.

在 3.4 版新加入.

load_module (*fullname*)

Concrete implementation of `Loader.load_module()`.

在 3.4 版之後被 用: Use `exec_module()` instead.

get_source (*fullname*)

Concrete implementation of `InspectLoader.get_source()`.

is_package (*fullname*)

Concrete implementation of `InspectLoader.is_package()`. A module is determined to be a package if its file path (as provided by `ExecutionLoader.get_filename()`) is a file named `__init__` when the file extension is removed **and** the module name itself does not end in `__init__`.

31.5.4 importlib.machinery -- Importers and path hooks

原始碼: [Lib/importlib/machinery.py](#)

This module contains the various objects that help `import` find and load modules.

`importlib.machinery.SOURCE_SUFFIXES`

A list of strings representing the recognized file suffixes for source modules.

在 3.3 版新加入.

`importlib.machinery.DEBUG_BYTECODE_SUFFIXES`

A list of strings representing the file suffixes for non-optimized bytecode modules.

在 3.3 版新加入.

在 3.5 版之後被 用: Use `BYTECODE_SUFFIXES` instead.

importlib.machinery.OPTIMIZED_BYTECODE_SUFFIXES

A list of strings representing the file suffixes for optimized bytecode modules.

在 3.3 版新加入。

在 3.5 版之後被⌘用: Use *BYTECODE_SUFFIXES* instead.

importlib.machinery.BYTECODE_SUFFIXES

A list of strings representing the recognized file suffixes for bytecode modules (including the leading dot).

在 3.3 版新加入。

在 3.5 版的變更: The value is no longer dependent on `__debug__`.

importlib.machinery.EXTENSION_SUFFIXES

A list of strings representing the recognized file suffixes for extension modules.

在 3.3 版新加入。

importlib.machinery.all_suffixes()

Returns a combined list of strings representing all file suffixes for modules recognized by the standard import machinery. This is a helper for code which simply needs to know if a filesystem path potentially refers to a module without needing any details on the kind of module (for example, *inspect.getmodulename()*).

在 3.3 版新加入。

class importlib.machinery.BuiltinImporter

An *importer* for built-in modules. All known built-in modules are listed in *sys.builtin_module_names*. This class implements the *importlib.abc.MetaPathFinder* and *importlib.abc.InspectLoader* ABCs.

Only class methods are defined by this class to alleviate the need for instantiation.

在 3.5 版的變更: As part of **PEP 489**, the builtin importer now implements *Loader.create_module()* and *Loader.exec_module()*

class importlib.machinery.FrozenImporter

An *importer* for frozen modules. This class implements the *importlib.abc.MetaPathFinder* and *importlib.abc.InspectLoader* ABCs.

Only class methods are defined by this class to alleviate the need for instantiation.

在 3.4 版的變更: Gained *create_module()* and *exec_module()* methods.

class importlib.machinery.WindowsRegistryFinder

A *Finder* for modules declared in the Windows registry. This class implements the *importlib.abc.MetaPathFinder* ABC.

Only class methods are defined by this class to alleviate the need for instantiation.

在 3.3 版新加入。

在 3.6 版之後被⌘用: Use *site* configuration instead. Future versions of Python may not enable this finder by default.

class importlib.machinery.PathFinder

A *Finder* for *sys.path* and package `__path__` attributes. This class implements the *importlib.abc.MetaPathFinder* ABC.

Only class methods are defined by this class to alleviate the need for instantiation.

classmethod find_spec(fullname, path=None, target=None)

Class method that attempts to find a *spec* for the module specified by *fullname* on *sys.path* or, if defined, on *path*. For each path entry that is searched, *sys.path_importer_cache* is checked. If a non-false object is found then it is used as the *path entry finder* to look for the module being searched for. If no entry is found in *sys.path_importer_cache*, then *sys.path_hooks* is searched for a finder for the path entry and, if found, is stored in *sys.path_importer_cache* along with

being queried about the module. If no finder is ever found then `None` is both stored in the cache and returned.

在 3.4 版新加入.

在 3.5 版的變更: If the current working directory -- represented by an empty string -- is no longer valid then `None` is returned but no value is cached in `sys.path_importer_cache`.

classmethod `find_module` (*fullname*, *path=None*)

A legacy wrapper around `find_spec()`.

在 3.4 版之後被 用: Use `find_spec()` instead.

classmethod `invalidate_caches` ()

Calls `importlib.abc.PathEntryFinder.invalidate_caches()` on all finders stored in `sys.path_importer_cache` that define the method. Otherwise entries in `sys.path_importer_cache` set to `None` are deleted.

在 3.7 版的變更: Entries of `None` in `sys.path_importer_cache` are deleted.

在 3.4 版的變更: Calls objects in `sys.path_hooks` with the current working directory for `' '` (i.e. the empty string).

class `importlib.machinery.FileFinder` (*path*, **loader_details*)

A concrete implementation of `importlib.abc.PathEntryFinder` which caches results from the file system.

The *path* argument is the directory for which the finder is in charge of searching.

The *loader_details* argument is a variable number of 2-item tuples each containing a loader and a sequence of file suffixes the loader recognizes. The loaders are expected to be callables which accept two arguments of the module's name and the path to the file found.

The finder will cache the directory contents as necessary, making stat calls for each module search to verify the cache is not outdated. Because cache staleness relies upon the granularity of the operating system's state information of the file system, there is a potential race condition of searching for a module, creating a new file, and then searching for the module the new file represents. If the operations happen fast enough to fit within the granularity of stat calls, then the module search will fail. To prevent this from happening, when you create a module dynamically, make sure to call `importlib.invalidate_caches()`.

在 3.3 版新加入.

path

The path the finder will search in.

find_spec (*fullname*, *target=None*)

Attempt to find the spec to handle *fullname* within *path*.

在 3.4 版新加入.

find_loader (*fullname*)

Attempt to find the loader to handle *fullname* within *path*.

在 3.10 版之後被 用: Use `find_spec()` instead.

invalidate_caches ()

Clear out the internal cache.

classmethod `path_hook` (**loader_details*)

A class method which returns a closure for use on `sys.path_hooks`. An instance of `FileFinder` is returned by the closure using the path argument given to the closure directly and *loader_details* indirectly.

If the argument to the closure is not an existing directory, `ImportError` is raised.

class `importlib.machinery.SourceFileLoader` (*fullname, path*)

A concrete implementation of `importlib.abc.SourceLoader` by subclassing `importlib.abc.FileLoader` and providing some concrete implementations of other methods.

在 3.3 版新加入。

name

The name of the module that this loader will handle.

path

The path to the source file.

is_package (*fullname*)

Return True if *path* appears to be for a package.

path_stats (*path*)

Concrete implementation of `importlib.abc.SourceLoader.path_stats()`.

set_data (*path, data*)

Concrete implementation of `importlib.abc.SourceLoader.set_data()`.

load_module (*name=None*)

Concrete implementation of `importlib.abc.Loader.load_module()` where specifying the name of the module to load is optional.

在 3.6 版之後被 用: Use `importlib.abc.Loader.exec_module()` instead.

class `importlib.machinery.SourcelessFileLoader` (*fullname, path*)

A concrete implementation of `importlib.abc.FileLoader` which can import bytecode files (i.e. no source code files exist).

Please note that direct use of bytecode files (and thus not source code files) inhibits your modules from being usable by all Python implementations or new versions of Python which change the bytecode format.

在 3.3 版新加入。

name

The name of the module the loader will handle.

path

The path to the bytecode file.

is_package (*fullname*)

Determines if the module is a package based on *path*.

get_code (*fullname*)

Returns the code object for *name* created from *path*.

get_source (*fullname*)

Returns None as bytecode files have no source when this loader is used.

load_module (*name=None*)

Concrete implementation of `importlib.abc.Loader.load_module()` where specifying the name of the module to load is optional.

在 3.6 版之後被 用: Use `importlib.abc.Loader.exec_module()` instead.

class `importlib.machinery.ExtensionFileLoader` (*fullname, path*)

A concrete implementation of `importlib.abc.ExecutionLoader` for extension modules.

The *fullname* argument specifies the name of the module the loader is to support. The *path* argument is the path to the extension module's file.

在 3.3 版新加入。

name

Name of the module the loader supports.

path

Path to the extension module.

create_module (*spec*)

Creates the module object from the given specification in accordance with [PEP 489](#).

在 3.5 版新加入.

exec_module (*module*)

Initializes the given module object in accordance with [PEP 489](#).

在 3.5 版新加入.

is_package (*fullname*)

Returns True if the file path points to a package's `__init__` module based on [EXTENSION_SUFFIXES](#).

get_code (*fullname*)

Returns None as extension modules lack a code object.

get_source (*fullname*)

Returns None as extension modules do not have source code.

get_filename (*fullname*)

Returns *path*.

在 3.4 版新加入.

class `importlib.machinery.NamespaceLoader` (*name, path, path_finder*)

A concrete implementation of `importlib.abc.Loader` for namespace packages. This is an alias for a private class and is only made public for introspecting the `__loader__` attribute on namespace packages:

```
>>> from importlib.machinery import NamespaceLoader
>>> import my_namespace
>>> isinstance(my_namespace.__loader__, NamespaceLoader)
True
>>> import importlib.abc
>>> isinstance(my_namespace.__loader__, importlib.abc.Loader)
True
```

在 3.11 版新加入.

class `importlib.machinery.ModuleSpec` (*name, loader, *, origin=None, loader_state=None, is_package=None*)

A specification for a module's import-system-related state. This is typically exposed as the module's `__spec__` attribute. In the descriptions below, the names in parentheses give the corresponding attribute available directly on the module object, e.g. `module.__spec__.origin == module.__file__`. Note, however, that while the *values* are usually equivalent, they can differ since there is no synchronization between the two objects. For example, it is possible to update the module's `__file__` at runtime and this will not be automatically reflected in the module's `__spec__.origin`, and vice versa.

在 3.4 版新加入.

name

(`__name__`)

The module's fully qualified name. The *finder* should always set this attribute to a non-empty string.

loader`(__loader__)`

The *loader* used to load the module. The *finder* should always set this attribute.

origin`(__file__)`

The location the *loader* should use to load the module. For example, for modules loaded from a .py file this is the filename. The *finder* should always set this attribute to a meaningful value for the *loader* to use. In the uncommon case that there is not one (like for namespace packages), it should be set to `None`.

submodule_search_locations`(__path__)`

The list of locations where the package's submodules will be found. Most of the time this is a single directory. The *finder* should set this attribute to a list, even an empty one, to indicate to the import system that the module is a package. It should be set to `None` for non-package modules. It is set automatically later to a special object for namespace packages.

loader_state

The *finder* may set this attribute to an object containing additional, module-specific data to use when loading the module. Otherwise it should be set to `None`.

cached`(__cached__)`

The filename of a compiled version of the module's code. The *finder* should always set this attribute but it may be `None` for modules that do not need compiled code stored.

parent`(__package__)`

(Read-only) The fully qualified name of the package the module is in (or the empty string for a top-level module). If the module is a package then this is the same as *name*.

has_location

True if the spec's *origin* refers to a loadable location,

False otherwise. This value impacts how *origin* is interpreted and how the module's `__file__` is populated.

31.5.5 `importlib.util` -- Utility code for importers

原始碼: [Lib/importlib/util.py](#)

This module contains the various objects that help in the construction of an *importer*.

`importlib.util.MAGIC_NUMBER`

The bytes which represent the bytecode version number. If you need help with loading/writing bytecode then consider `importlib.abc.SourceLoader`.

在 3.4 版新加入.

`importlib.util.cache_from_source (path, debug_override=None, *, optimization=None)`

Return the **PEP 3147/PEP 488** path to the byte-compiled file associated with the source *path*. For example, if *path* is `/foo/bar/baz.py` the return value would be `/foo/bar/__pycache__/baz.cpython-32.pyc` for Python 3.2. The `cpython-32` string comes from the current magic tag (see `get_tag()`; if `sys.implementation.cache_tag` is not defined then *NotImplementedError* will be raised).

The *optimization* parameter is used to specify the optimization level of the bytecode file. An empty string represents no optimization, so `/foo/bar/baz.py` with an *optimization* of `' '` will result in a bytecode path of `/foo/bar/__pycache__/baz.cpython-32.pyc`. `None` causes the interpreter's optimization level to be used. Any other value's string representation is used, so `/foo/bar/baz.py` with an *optimization* of `2` will lead to the bytecode path of `/foo/bar/__pycache__/baz.cpython-32.opt-2.pyc`. The string representation of *optimization* can only be alphanumeric, else *ValueError* is raised.

The *debug_override* parameter is deprecated and can be used to override the system's value for `__debug__`. A `True` value is the equivalent of setting *optimization* to the empty string. A `False` value is the same as setting *optimization* to `1`. If both *debug_override* and *optimization* are not `None` then *TypeError* is raised.

在 3.4 版新加入。

在 3.5 版的變更: The *optimization* parameter was added and the *debug_override* parameter was deprecated.

在 3.6 版的變更: Accepts a *path-like object*.

`importlib.util.source_from_cache (path)`

Given the *path* to a **PEP 3147** file name, return the associated source code file path. For example, if *path* is `/foo/bar/__pycache__/baz.cpython-32.pyc` the returned path would be `/foo/bar/baz.py`. *path* need not exist, however if it does not conform to **PEP 3147** or **PEP 488** format, a *ValueError* is raised. If `sys.implementation.cache_tag` is not defined, *NotImplementedError* is raised.

在 3.4 版新加入。

在 3.6 版的變更: Accepts a *path-like object*.

`importlib.util.decode_source (source_bytes)`

Decode the given bytes representing source code and return it as a string with universal newlines (as required by `importlib.abc.InspectLoader.get_source()`).

在 3.4 版新加入。

`importlib.util.resolve_name (name, package)`

Resolve a relative module name to an absolute one.

If **name** has no leading dots, then **name** is simply returned. This allows for usage such as `importlib.util.resolve_name('sys', __spec__.parent)` without doing a check to see if the **package** argument is needed.

ImportError is raised if **name** is a relative module name but **package** is a false value (e.g. `None` or the empty string). *ImportError* is also raised if a relative name would escape its containing package (e.g. requesting `..bacon` from within the `spam` package).

在 3.3 版新加入。

在 3.9 版的變更: To improve consistency with import statements, raise *ImportError* instead of *ValueError* for invalid relative import attempts.

`importlib.util.find_spec (name, package=None)`

Find the *spec* for a module, optionally relative to the specified **package** name. If the module is in `sys.modules`, then `sys.modules[name].__spec__` is returned (unless the *spec* would be `None` or is not set, in which case *ValueError* is raised). Otherwise a search using `sys.meta_path` is done. `None` is returned if no *spec* is found.

If **name** is for a submodule (contains a dot), the parent module is automatically imported.

name and **package** work the same as for `import_module()`.

在 3.4 版新加入。

在 3.7 版的變更: Raises `ModuleNotFoundError` instead of `AttributeError` if **package** is in fact not a package (i.e. lacks a `__path__` attribute).

`importlib.util.module_from_spec(spec)`

Create a new module based on **spec** and `spec.loader.create_module`.

If `spec.loader.create_module` does not return `None`, then any pre-existing attributes will not be reset. Also, no `AttributeError` will be raised if triggered while accessing **spec** or setting an attribute on the module.

This function is preferred over using `types.ModuleType` to create a new module as **spec** is used to set as many import-controlled attributes on the module as possible.

在 3.5 版新加入。

`@importlib.util.module_for_loader`

A *decorator* for `importlib.abc.Loader.load_module()` to handle selecting the proper module object to load with. The decorated method is expected to have a call signature taking two positional arguments (e.g. `load_module(self, module)`) for which the second argument will be the module **object** to be used by the loader. Note that the decorator will not work on static methods because of the assumption of two arguments.

The decorated method will take in the **name** of the module to be loaded as expected for a *loader*. If the module is not found in `sys.modules` then a new one is constructed. Regardless of where the module came from, `__loader__` set to **self** and `__package__` is set based on what `importlib.abc.InspectLoader.is_package()` returns (if available). These attributes are set unconditionally to support reloading.

If an exception is raised by the decorated method and a module was added to `sys.modules`, then the module will be removed to prevent a partially initialized module from being left in `sys.modules`. If the module was already in `sys.modules` then it is left alone.

在 3.3 版的變更: `__loader__` and `__package__` are automatically set (when possible).

在 3.4 版的變更: Set `__name__`, `__loader__` `__package__` unconditionally to support reloading.

在 3.4 版之後被 用: The import machinery now directly performs all the functionality provided by this function.

`@importlib.util.set_loader`

A *decorator* for `importlib.abc.Loader.load_module()` to set the `__loader__` attribute on the returned module. If the attribute is already set the decorator does nothing. It is assumed that the first positional argument to the wrapped method (i.e. `self`) is what `__loader__` should be set to.

在 3.4 版的變更: Set `__loader__` if set to `None`, as if the attribute does not exist.

在 3.4 版之後被 用: The import machinery takes care of this automatically.

`@importlib.util.set_package`

A *decorator* for `importlib.abc.Loader.load_module()` to set the `__package__` attribute on the returned module. If `__package__` is set and has a value other than `None` it will not be changed.

在 3.4 版之後被 用: The import machinery takes care of this automatically.

`importlib.util.spec_from_loader(name, loader, *, origin=None, is_package=None)`

A factory function for creating a `ModuleSpec` instance based on a loader. The parameters have the same meaning as they do for `ModuleSpec`. The function uses available *loader* APIs, such as `InspectLoader.is_package()`, to fill in any missing information on the spec.

在 3.4 版新加入。

`importlib.util.spec_from_file_location(name, location, *, loader=None, submodule_search_locations=None)`

A factory function for creating a *ModuleSpec* instance based on the path to a file. Missing information will be filled in on the spec by making use of loader APIs and by the implication that the module will be file-based.

在 3.4 版新加入.

在 3.6 版的變更: Accepts a *path-like object*.

`importlib.util.source_hash(source_bytes)`

Return the hash of *source_bytes* as bytes. A hash-based `.pyc` file embeds the `source_hash()` of the corresponding source file's contents in its header.

在 3.7 版新加入.

class `importlib.util.LazyLoader(loader)`

A class which postpones the execution of the loader of a module until the module has an attribute accessed.

This class **only** works with loaders that define `exec_module()` as control over what module type is used for the module is required. For those same reasons, the loader's `create_module()` method must return `None` or a type for which its `__class__` attribute can be mutated along with not using *slots*. Finally, modules which substitute the object placed into `sys.modules` will not work as there is no way to properly replace the module references throughout the interpreter safely; *ValueError* is raised if such a substitution is detected.

備 F: For projects where startup time is critical, this class allows for potentially minimizing the cost of loading a module if it is never used. For projects where startup time is not essential then use of this class is **heavily** discouraged due to error messages created during loading being postponed and thus occurring out of context.

在 3.5 版新加入.

在 3.6 版的變更: Began calling `create_module()`, removing the compatibility warning for `importlib.machinery.BuiltinImporter` and `importlib.machinery.ExtensionFileLoader`.

classmethod `factory(loader)`

A class method which returns a callable that creates a lazy loader. This is meant to be used in situations where the loader is passed by class instead of by instance.

```
suffixes = importlib.machinery.SOURCE_SUFFIXES
loader = importlib.machinery.SourceFileLoader
lazy_loader = importlib.util.LazyLoader.factory(loader)
finder = importlib.machinery.FileFinder(path, (lazy_loader, suffixes))
```

31.5.6 范例

Importing programmatically

To programmatically import a module, use `importlib.import_module()`.

```
import importlib

itertools = importlib.import_module('itertools')
```

Checking if a module can be imported

If you need to find out if a module can be imported without actually doing the import, then you should use `importlib.util.find_spec()`.

Note that if `name` is a submodule (contains a dot), `importlib.util.find_spec()` will import the parent module.

```
import importlib.util
import sys

# For illustrative purposes.
name = 'itertools'

if name in sys.modules:
    print(f"{name!r} already in sys.modules")
elif (spec := importlib.util.find_spec(name)) is not None:
    # If you chose to perform the actual import ...
    module = importlib.util.module_from_spec(spec)
    sys.modules[name] = module
    spec.loader.exec_module(module)
    print(f"{name!r} has been imported")
else:
    print(f"can't find the {name!r} module")
```

Importing a source file directly

To import a Python source file directly, use the following recipe:

```
import importlib.util
import sys

# For illustrative purposes.
import tokenize
file_path = tokenize.__file__
module_name = tokenize.__name__

spec = importlib.util.spec_from_file_location(module_name, file_path)
module = importlib.util.module_from_spec(spec)
sys.modules[module_name] = module
spec.loader.exec_module(module)
```

Implementing lazy imports

The example below shows how to implement lazy imports:

```
>>> import importlib.util
>>> import sys
>>> def lazy_import(name):
...     spec = importlib.util.find_spec(name)
...     loader = importlib.util.LazyLoader(spec.loader)
...     spec.loader = loader
...     module = importlib.util.module_from_spec(spec)
...     sys.modules[name] = module
...     loader.exec_module(module)
...     return module
...
>>> lazy_typing = lazy_import("typing")
>>> #lazy_typing is a real module object,
```

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```
>>> #but it is not loaded in memory yet.
>>> lazy_typing.TYPE_CHECKING
False
```

Setting up an importer

For deep customizations of import, you typically want to implement an *importer*. This means managing both the *finder* and *loader* side of things. For finders there are two flavours to choose from depending on your needs: a *meta path finder* or a *path entry finder*. The former is what you would put on `sys.meta_path` while the latter is what you create using a *path entry hook* on `sys.path_hooks` which works with `sys.path` entries to potentially create a finder. This example will show you how to register your own importers so that import will use them (for creating an importer for yourself, read the documentation for the appropriate classes defined within this package):

```
import importlib.machinery
import sys

# For illustrative purposes only.
SpamMetaPathFinder = importlib.machinery.PathFinder
SpamPathEntryFinder = importlib.machinery.FileFinder
loader_details = (importlib.machinery.SourceFileLoader,
                  importlib.machinery.SOURCE_SUFFIXES)

# Setting up a meta path finder.
# Make sure to put the finder in the proper location in the list in terms of
# priority.
sys.meta_path.append(SpamMetaPathFinder)

# Setting up a path entry finder.
# Make sure to put the path hook in the proper location in the list in terms
# of priority.
sys.path_hooks.append(SpamPathEntryFinder.path_hook(loader_details))
```

Approximating `importlib.import_module()`

Import itself is implemented in Python code, making it possible to expose most of the import machinery through `importlib`. The following helps illustrate the various APIs that `importlib` exposes by providing an approximate implementation of `importlib.import_module()`:

```
import importlib.util
import sys

def import_module(name, package=None):
    """An approximate implementation of import."""
    absolute_name = importlib.util.resolve_name(name, package)
    try:
        return sys.modules[absolute_name]
    except KeyError:
        pass

    path = None
    if '.' in absolute_name:
        parent_name, _, child_name = absolute_name.rpartition('.')
        parent_module = import_module(parent_name)
        path = parent_module.__spec__.submodule_search_locations
    for finder in sys.meta_path:
        spec = finder.find_spec(absolute_name, path)
        if spec is not None:
```

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```

        break
    else:
        msg = f'No module named {absolute_name!r}'
        raise ModuleNotFoundError(msg, name=absolute_name)
    module = importlib.util.module_from_spec(spec)
    sys.modules[absolute_name] = module
    spec.loader.exec_module(module)
    if path is not None:
        setattr(parent_module, child_name, module)
    return module

```

31.6 importlib.resources -- Package resource reading, opening and access

原始碼: `Lib/importlib/resources/__init__.py`

在 3.7 版新加入。

This module leverages Python's import system to provide access to *resources* within *packages*. If you can import a package, you can access resources within that package. Resources can be opened or read, in either binary or text mode.

Resources are roughly akin to files inside directories, though it's important to keep in mind that this is just a metaphor. Resources and packages **do not** have to exist as physical files and directories on the file system: for example, a package and its resources can be imported from a zip file using `zipimport`.

備註: This module provides functionality similar to `pkg_resources` Basic Resource Access without the performance overhead of that package. This makes reading resources included in packages easier, with more stable and consistent semantics.

The standalone backport of this module provides more information on [using importlib.resources](#) and [migrating from pkg_resources to importlib.resources](#).

Loaders that wish to support resource reading should implement a `get_resource_reader(fullname)` method as specified by `importlib.resources.abc.ResourceReader`.

class `importlib.resources.Package`

Whenever a function accepts a `Package` argument, you can pass in either a *module object* or a module name as a string. You can only pass module objects whose `__spec__.submodule_search_locations` is not `None`.

The `Package` type is defined as `Union[str, ModuleType]`.

`importlib.resources.files(package)`

Returns a *Traversable* object representing the resource container for the package (think directory) and its resources (think files). A *Traversable* may contain other containers (think subdirectories).

package is either a name or a module object which conforms to the *Package* requirements.

在 3.9 版新加入。

`importlib.resources.as_file(traversable)`

Given a *Traversable* object representing a file, typically from `importlib.resources.files()`, return a context manager for use in a `with` statement. The context manager provides a *pathlib.Path* object.

Exiting the context manager cleans up any temporary file created when the resource was extracted from e.g. a zip file.

Use `as_file` when the Traversable methods (`read_text`, etc) are insufficient and an actual file on the file system is required.

在 3.9 版新加入。

31.6.1 已用函式

An older, deprecated set of functions is still available, but is scheduled for removal in a future version of Python. The main drawback of these functions is that they do not support directories: they assume all resources are located directly within a *package*.

`importlib.resources.Resource`

For *resource* arguments of the functions below, you can pass in the name of a resource as a string or a *path-like object*.

The `Resource` type is defined as `Union[str, os.PathLike]`.

`importlib.resources.open_binary(package, resource)`

Open for binary reading the *resource* within *package*.

package is either a name or a module object which conforms to the `Package` requirements. *resource* is the name of the resource to open within *package*; it may not contain path separators and it may not have sub-resources (i.e. it cannot be a directory). This function returns a `typing.BinaryIO` instance, a binary I/O stream open for reading.

在 3.11 版之後被用: Calls to this function can be replaced by:

```
files(package).joinpath(resource).open('rb')
```

`importlib.resources.open_text(package, resource, encoding='utf-8', errors='strict')`

Open for text reading the *resource* within *package*. By default, the resource is opened for reading as UTF-8.

package is either a name or a module object which conforms to the `Package` requirements. *resource* is the name of the resource to open within *package*; it may not contain path separators and it may not have sub-resources (i.e. it cannot be a directory). *encoding* and *errors* have the same meaning as with built-in `open()`.

This function returns a `typing.TextIO` instance, a text I/O stream open for reading.

在 3.11 版之後被用: Calls to this function can be replaced by:

```
files(package).joinpath(resource).open('r', encoding=encoding)
```

`importlib.resources.read_binary(package, resource)`

Read and return the contents of the *resource* within *package* as `bytes`.

package is either a name or a module object which conforms to the `Package` requirements. *resource* is the name of the resource to open within *package*; it may not contain path separators and it may not have sub-resources (i.e. it cannot be a directory). This function returns the contents of the resource as `bytes`.

在 3.11 版之後被用: Calls to this function can be replaced by:

```
files(package).joinpath(resource).read_bytes()
```

`importlib.resources.read_text(package, resource, encoding='utf-8', errors='strict')`

Read and return the contents of *resource* within *package* as a `str`. By default, the contents are read as strict UTF-8.

package is either a name or a module object which conforms to the `Package` requirements. *resource* is the name of the resource to open within *package*; it may not contain path separators and it may not have sub-resources (i.e. it cannot be a directory). *encoding* and *errors* have the same meaning as with built-in `open()`. This function returns the contents of the resource as `str`.

在 3.11 版之後被☑用: Calls to this function can be replaced by:

```
files(package).joinpath(resource).read_text(encoding=encoding)
```

`importlib.resources.path(package, resource)`

Return the path to the *resource* as an actual file system path. This function returns a context manager for use in a `with` statement. The context manager provides a `pathlib.Path` object.

Exiting the context manager cleans up any temporary file created when the resource needs to be extracted from e.g. a zip file.

package is either a name or a module object which conforms to the Package requirements. *resource* is the name of the resource to open within *package*; it may not contain path separators and it may not have sub-resources (i.e. it cannot be a directory).

在 3.11 版之後被☑用: Calls to this function can be replaced using `as_file()`:

```
as_file(files(package).joinpath(resource))
```

`importlib.resources.is_resource(package, name)`

Return `True` if there is a resource named *name* in the package, otherwise `False`. This function does not consider directories to be resources. *package* is either a name or a module object which conforms to the Package requirements.

在 3.11 版之後被☑用: Calls to this function can be replaced by:

```
files(package).joinpath(resource).is_file()
```

`importlib.resources.contents(package)`

Return an iterable over the named items within the package. The iterable returns `str` resources (e.g. files) and non-resources (e.g. directories). The iterable does not recurse into subdirectories.

package is either a name or a module object which conforms to the Package requirements.

在 3.11 版之後被☑用: Calls to this function can be replaced by:

```
(resource.name for resource in files(package).iterdir() if resource.is_file())
```

31.7 importlib.resources.abc -- Abstract base classes for resources

原始碼: `Lib/importlib/resources/abc.py`

在 3.11 版新加入.

class `importlib.resources.abc.ResourceReader`

Superseded by TraversableResources

An *abstract base class* to provide the ability to read *resources*.

From the perspective of this ABC, a *resource* is a binary artifact that is shipped within a package. Typically this is something like a data file that lives next to the `__init__.py` file of the package. The purpose of this class is to help abstract out the accessing of such data files so that it does not matter if the package and its data file(s) are stored in a e.g. zip file versus on the file system.

For any of methods of this class, a *resource* argument is expected to be a *path-like object* which represents conceptually just a file name. This means that no subdirectory paths should be included in the *resource* argument. This is because the location of the package the reader is for, acts as the "directory". Hence the metaphor for directories and file names is packages and resources, respectively. This is also why instances of this class are

expected to directly correlate to a specific package (instead of potentially representing multiple packages or a module).

Loaders that wish to support resource reading are expected to provide a method called `get_resource_reader(fullname)` which returns an object implementing this ABC's interface. If the module specified by `fullname` is not a package, this method should return `None`. An object compatible with this ABC should only be returned when the specified module is a package.

在 3.7 版新加入.

abstractmethod `open_resource(resource)`

Returns an opened, *file-like object* for binary reading of the *resource*.

If the resource cannot be found, `FileNotFoundError` is raised.

abstractmethod `resource_path(resource)`

Returns the file system path to the *resource*.

If the resource does not concretely exist on the file system, raise `FileNotFoundError`.

abstractmethod `is_resource(name)`

Returns `True` if the named *name* is considered a resource. `FileNotFoundError` is raised if *name* does not exist.

abstractmethod `contents()`

Returns an *iterable* of strings over the contents of the package. Do note that it is not required that all names returned by the iterator be actual resources, e.g. it is acceptable to return names for which `is_resource()` would be false.

Allowing non-resource names to be returned is to allow for situations where how a package and its resources are stored are known a priori and the non-resource names would be useful. For instance, returning subdirectory names is allowed so that when it is known that the package and resources are stored on the file system then those subdirectory names can be used directly.

The abstract method returns an iterable of no items.

class `importlib.resources.abc.Traversable`

An object with a subset of `pathlib.Path` methods suitable for traversing directories and opening files.

For a representation of the object on the file-system, use `importlib.resources.as_file()`.

在 3.9 版新加入.

name

Abstract. The base name of this object without any parent references.

abstractmethod `iterdir()`

Yield `Traversable` objects in self.

abstractmethod `is_dir()`

Return `True` if self is a directory.

abstractmethod `is_file()`

Return `True` if self is a file.

abstractmethod `joinpath(child)`

Return `Traversable` child in self.

abstractmethod `__truediv__(child)`

Return `Traversable` child in self.

abstractmethod `open(mode='r', *args, **kwargs)`

mode may be `'r'` or `'rb'` to open as text or binary. Return a handle suitable for reading (same as `pathlib.Path.open`).

When opening as text, accepts encoding parameters such as those accepted by `io.TextIOWrapper`.

read_bytes()

Read contents of self as bytes.

read_text(encoding=None)

Read contents of self as text.

class `importlib.resources.abc.TraversableResources`

An abstract base class for resource readers capable of serving the `importlib.resources.files()` interface. Subclasses `ResourceReader` and provides concrete implementations of the `ResourceReader`'s abstract methods. Therefore, any loader supplying `TraversableResources` also supplies `ResourceReader`.

Loaders that wish to support resource reading are expected to implement this interface.

在 3.9 版新加入。

abstractmethod `files()`

Returns a `importlib.resources.abc.Traversable` object for the loaded package.

31.8 importlib.metadata -- Accessing package metadata

在 3.8 版新加入。

在 3.10 版的變更: `importlib.metadata` is no longer provisional.

原始碼: `Lib/importlib/metadata/__init__.py`

`importlib.metadata` is a library that provides access to the metadata of an installed [Distribution Package](#), such as its entry points or its top-level names ([Import Packages](#), modules, if any). Built in part on Python's import system, this library intends to replace similar functionality in the [entry point API](#) and [metadata API](#) of `pkg_resources`. Along with `importlib.resources`, this package can eliminate the need to use the older and less efficient `pkg_resources` package.

`importlib.metadata` operates on third-party *distribution packages* installed into Python's site-packages directory via tools such as [pip](#). Specifically, it works with distributions with discoverable `dist-info` or `egg-info` directories, and metadata defined by the [Core metadata specifications](#).

重要: These are *not* necessarily equivalent to or correspond 1:1 with the top-level *import package* names that can be imported inside Python code. One *distribution package* can contain multiple *import packages* (and single modules), and one top-level *import package* may map to multiple *distribution packages* if it is a namespace package. You can use `package_distributions()` to get a mapping between them.

By default, distribution metadata can live on the file system or in zip archives on `sys.path`. Through an extension mechanism, the metadata can live almost anywhere.

也參考:

<https://importlib-metadata.readthedocs.io/>

The documentation for `importlib_metadata`, which supplies a backport of `importlib.metadata`. This includes an [API reference](#) for this module's classes and functions, as well as a [migration guide](#) for existing users of `pkg_resources`.

31.8.1 Overview

Let's say you wanted to get the version string for a [Distribution Package](#) you've installed using `pip`. We start by creating a virtual environment and installing something into it:

```
$ python -m venv example
$ source example/bin/activate
(example) $ python -m pip install wheel
```

You can get the version string for `wheel` by running the following:

```
(example) $ python
>>> from importlib.metadata import version
>>> version('wheel')
'0.32.3'
```

You can also get a collection of entry points selectable by properties of the `EntryPoint` (typically `'group'` or `'name'`), such as `console_scripts`, `distutils.commands` and others. Each group contains a collection of [Entry-Point](#) objects.

You can get the *metadata for a distribution*:

```
>>> list(metadata('wheel'))
['Metadata-Version', 'Name', 'Version', 'Summary', 'Home-page', 'Author', 'Author-
→email', 'Maintainer', 'Maintainer-email', 'License', 'Project-URL', 'Project-URL
→', 'Project-URL', 'Keywords', 'Platform', 'Classifier', 'Classifier', 'Classifier
→', 'Classifier', 'Classifier', 'Classifier', 'Classifier', 'Classifier', 'Classifier',
→'Classifier', 'Classifier', 'Classifier', 'Classifier', 'Requires-Python',
→'Provides-Extra', 'Requires-Dist', 'Requires-Dist']
```

You can also get a *distribution's version number*, list its *constituent files*, and get a list of the distribution's *Distribution requirements*.

31.8.2 Functional API

This package provides the following functionality via its public API.

Entry points

The `entry_points()` function returns a collection of entry points. Entry points are represented by `EntryPoint` instances; each `EntryPoint` has a `.name`, `.group`, and `.value` attributes and a `.load()` method to resolve the value. There are also `.module`, `.attr`, and `.extras` attributes for getting the components of the `.value` attribute.

Query all entry points:

```
>>> eps = entry_points()
```

The `entry_points()` function returns an `EntryPoints` object, a collection of all `EntryPoint` objects with names and groups attributes for convenience:

```
>>> sorted(eps.groups)
['console_scripts', 'distutils.commands', 'distutils.setup_keywords', 'egg_info.
→writers', 'setuptools.installation']
```

`EntryPoints` has a `select` method to select entry points matching specific properties. Select entry points in the `console_scripts` group:

```
>>> scripts = eps.select(group='console_scripts')
```

Equivalently, since `entry_points` passes keyword arguments through to `select`:

```
>>> scripts = entry_points(group='console_scripts')
```

Pick out a specific script named “wheel” (found in the wheel project):

```
>>> 'wheel' in scripts.names
True
>>> wheel = scripts['wheel']
```

Equivalently, query for that entry point during selection:

```
>>> (wheel,) = entry_points(group='console_scripts', name='wheel')
>>> (wheel,) = entry_points().select(group='console_scripts', name='wheel')
```

Inspect the resolved entry point:

```
>>> wheel
EntryPoint(name='wheel', value='wheel.cli:main', group='console_scripts')
>>> wheel.module
'wheel.cli'
>>> wheel.attr
'main'
>>> wheel.extras
[]
>>> main = wheel.load()
>>> main
<function main at 0x103528488>
```

The `group` and `name` are arbitrary values defined by the package author and usually a client will wish to resolve all entry points for a particular group. Read [the `setuptools` docs](#) for more information on entry points, their definition, and usage.

Compatibility Note

The “selectable” entry points were introduced in `importlib_metadata` 3.6 and Python 3.10. Prior to those changes, `entry_points` accepted no parameters and always returned a dictionary of entry points, keyed by group. For compatibility, if no parameters are passed to `entry_points`, a `SelectableGroups` object is returned, implementing that dict interface. In the future, calling `entry_points` with no parameters will return an `EntryPoints` object. Users should rely on the selection interface to retrieve entry points by group.

Distribution metadata

Every [Distribution Package](#) includes some metadata, which you can extract using the `metadata()` function:

```
>>> wheel_metadata = metadata('wheel')
```

The keys of the returned data structure, a `PackageMetadata`, name the metadata keywords, and the values are returned unparsed from the distribution metadata:

```
>>> wheel_metadata['Requires-Python']
'>=2.7, !=3.0.*, !=3.1.*, !=3.2.*, !=3.3.*'
```

`PackageMetadata` also presents a `json` attribute that returns all the metadata in a JSON-compatible form per [PEP 566](#):

```
>>> wheel_metadata.json['requires_python']
'>=2.7, !=3.0.*, !=3.1.*, !=3.2.*, !=3.3.*'
```

備 F: The actual type of the object returned by `metadata()` is an implementation detail and should be accessed only through the interface described by the [PackageMetadata protocol](#).

在 3.10 版的變更: The `Description` is now included in the metadata when presented through the payload. Line continuation characters have been removed.

The `json` attribute was added.

Distribution versions

The `version()` function is the quickest way to get a [Distribution Package](#)'s version number, as a string:

```
>>> version('wheel')
'0.32.3'
```

Distribution files

You can also get the full set of files contained within a distribution. The `files()` function takes a [Distribution Package](#) name and returns all of the files installed by this distribution. Each file object returned is a `PackagePath`, a [pathlib.PurePath](#) derived object with additional `dist`, `size`, and `hash` properties as indicated by the metadata. For example:

```
>>> util = [p for p in files('wheel') if 'util.py' in str(p)][0]
>>> util
PackagePath('wheel/util.py')
>>> util.size
859
>>> util.dist
<importlib.metadata._hooks.PathDistribution object at 0x101e0cef0>
>>> util.hash
<FileHash mode: sha256 value: bYkw5oMccfazVCoYQwKkkemoVyMAFoR34mmKBx8R1NI>
```

Once you have the file, you can also read its contents:

```
>>> print(util.read_text())
import base64
import sys
...
def as_bytes(s):
    if isinstance(s, text_type):
        return s.encode('utf-8')
    return s
```

You can also use the `locate` method to get a the absolute path to the file:

```
>>> util.locate()
PosixPath('/home/gustav/example/lib/site-packages/wheel/util.py')
```

In the case where the metadata file listing files (`RECORD` or `SOURCES.txt`) is missing, `files()` will return `None`. The caller may wish to wrap calls to `files()` in [always_iterable](#) or otherwise guard against this condition if the target distribution is not known to have the metadata present.

Distribution requirements

To get the full set of requirements for a [Distribution Package](#), use the `requires()` function:

```
>>> requires('wheel')
["pytest (>=3.0.0) ; extra == 'test'", "pytest-cov ; extra == 'test'"]
```

Mapping import to distribution packages

A convenience method to resolve the [Distribution Package](#) name (or names, in the case of a namespace package) that provide each importable top-level Python module or [Import Package](#):

```
>>> packages_distributions()
{'importlib_metadata': ['importlib-metadata'], 'yaml': ['PyYAML'], 'jaraco': [
↪ 'jaraco.classes', 'jaraco.functools'], ...}
```

在 3.10 版新加入.

31.8.3 Distributions

While the above API is the most common and convenient usage, you can get all of that information from the `Distribution` class. A `Distribution` is an abstract object that represents the metadata for a Python [Distribution Package](#). You can get the `Distribution` instance:

```
>>> from importlib.metadata import distribution
>>> dist = distribution('wheel')
```

Thus, an alternative way to get the version number is through the `Distribution` instance:

```
>>> dist.version
'0.32.3'
```

There are all kinds of additional metadata available on the `Distribution` instance:

```
>>> dist.metadata['Requires-Python']
'>=2.7, !=3.0.*, !=3.1.*, !=3.2.*, !=3.3.*'
>>> dist.metadata['License']
'MIT'
```

The full set of available metadata is not described here. See the [Core metadata specifications](#) for additional details.

31.8.4 Distribution Discovery

By default, this package provides built-in support for discovery of metadata for file system and zip file [Distribution Packages](#). This metadata finder search defaults to `sys.path`, but varies slightly in how it interprets those values from how other import machinery does. In particular:

- `importlib.metadata` does not honor *bytes* objects on `sys.path`.
- `importlib.metadata` will incidentally honor *pathlib.Path* objects on `sys.path` even though such values will be ignored for imports.

31.8.5 Extending the search algorithm

Because [Distribution Package](#) metadata is not available through `sys.path` searches, or package loaders directly, the metadata for a distribution is found through import system [finders](#). To find a distribution package's metadata, `importlib.metadata` queries the list of *meta path finders* on `sys.meta_path`.

By default `importlib.metadata` installs a finder for distribution packages found on the file system. This finder doesn't actually find any *distributions*, but it can find their metadata.

The abstract class `importlib.abc.MetaPathFinder` defines the interface expected of finders by Python's import system. `importlib.metadata` extends this protocol by looking for an optional `find_distributions` callable on the finders from `sys.meta_path` and presents this extended interface as the `DistributionFinder` abstract base class, which defines this abstract method:

```
@abc.abstractmethod
def find_distributions(context=DistributionFinder.Context()):
    """Return an iterable of all Distribution instances capable of
    loading the metadata for packages for the indicated ``context``.
    """
```

The `DistributionFinder.Context` object provides `.path` and `.name` properties indicating the path to search and name to match and may supply other relevant context.

What this means in practice is that to support finding distribution package metadata in locations other than the file system, subclass `Distribution` and implement the abstract methods. Then from a custom finder, return instances of this derived `Distribution` in the `find_distributions()` method.

31.9 The initialization of the `sys.path` module search path

A module search path is initialized when Python starts. This module search path may be accessed at `sys.path`.

The first entry in the module search path is the directory that contains the input script, if there is one. Otherwise, the first entry is the current directory, which is the case when executing the interactive shell, a `-c` command, or `-m` module.

The `PYTHONPATH` environment variable is often used to add directories to the search path. If this environment variable is found then the contents are added to the module search path.

備 F: `PYTHONPATH` will affect all installed Python versions/environments. Be wary of setting this in your shell profile or global environment variables. The [site](#) module offers more nuanced techniques as mentioned below.

The next items added are the directories containing standard Python modules as well as any *extension modules* that these modules depend on. Extension modules are `.pyd` files on Windows and `.so` files on other platforms. The directory with the platform-independent Python modules is called `prefix`. The directory with the extension modules is called `exec_prefix`.

The `PYTHONHOME` environment variable may be used to set the `prefix` and `exec_prefix` locations. Otherwise these directories are found by using the Python executable as a starting point and then looking for various 'landmark' files and directories. Note that any symbolic links are followed so the real Python executable location is used as the search starting point. The Python executable location is called `home`.

Once `home` is determined, the `prefix` directory is found by first looking for `pythonmajorversionminorversion.zip` (`python311.zip`). On Windows the zip archive is searched for in `home` and on Unix the archive is expected to be in `lib`. Note that the expected zip archive location is added to the module search path even if the archive does not exist. If no archive was found, Python on Windows will continue the search for `prefix` by looking for `Lib\os.py`. Python on Unix will look for `lib/pythonmajorversion.minorversion/os.py` (`lib/python3.11/os.py`). On Windows `prefix` and `exec_prefix` are the same, however on other platforms `lib/pythonmajorversion.minorversion/lib-dynload` (`lib/python3.11/lib-dynload`) is searched for and used as an

anchor for `exec_prefix`. On some platforms `lib` may be `lib64` or another value, see `sys.platlibdir` and `PYTHONPLATLIBDIR`.

Once found, `prefix` and `exec_prefix` are available at `sys.prefix` and `sys.exec_prefix` respectively.

Finally, the `site` module is processed and `site-packages` directories are added to the module search path. A common way to customize the search path is to create `sitecustomize` or `usercustomize` modules as described in the `site` module documentation.

備註: Certain command line options may further affect path calculations. See `-E`, `-I`, `-s` and `-S` for further details.

31.9.1 Virtual environments

If Python is run in a virtual environment (as described at [tut-venv](#)) then `prefix` and `exec_prefix` are specific to the virtual environment.

If a `pyvenv.cfg` file is found alongside the main executable, or in the directory one level above the executable, the following variations apply:

- If `home` is an absolute path and `PYTHONHOME` is not set, this path is used instead of the path to the main executable when deducing `prefix` and `exec_prefix`.

31.9.2 `_pth` files

To completely override `sys.path` create a `._pth` file with the same name as the shared library or executable (`python._pth` or `python311._pth`). The shared library path is always known on Windows, however it may not be available on other platforms. In the `._pth` file specify one line for each path to add to `sys.path`. The file based on the shared library name overrides the one based on the executable, which allows paths to be restricted for any program loading the runtime if desired.

When the file exists, all registry and environment variables are ignored, isolated mode is enabled, and `site` is not imported unless one line in the file specifies `import site`. Blank paths and lines starting with `#` are ignored. Each path may be absolute or relative to the location of the file. Import statements other than to `site` are not permitted, and arbitrary code cannot be specified.

Note that `.pth` files (without leading underscore) will be processed normally by the `site` module when `import site` has been specified.

31.9.3 Embedded Python

If Python is embedded within another application `Py_InitializeFromConfig()` and the `PyConfig` structure can be used to initialize Python. The path specific details are described at [init-path-config](#). Alternatively the older `Py_SetPath()` can be used to bypass the initialization of the module search path.

也参考:

- [windows_finding_modules](#) for detailed Windows notes.
- [using-on-unix](#) for Unix details.

Python provides a number of modules to assist in working with the Python language. These modules support tokenizing, parsing, syntax analysis, bytecode disassembly, and various other facilities.

These modules include:

32.1 `ast` --- Abstract Syntax Trees

原始碼: [Lib/ast.py](#)

The `ast` module helps Python applications to process trees of the Python abstract syntax grammar. The abstract syntax itself might change with each Python release; this module helps to find out programmatically what the current grammar looks like.

An abstract syntax tree can be generated by passing `ast.PyCF_ONLY_AST` as a flag to the `compile()` built-in function, or using the `parse()` helper provided in this module. The result will be a tree of objects whose classes all inherit from `ast.AST`. An abstract syntax tree can be compiled into a Python code object using the built-in `compile()` function.

32.1.1 Abstract Grammar

The abstract grammar is currently defined as follows:

```
-- ASDL's 4 builtin types are:
-- identifier, int, string, constant

module Python
{
    mod = Module(stmt* body, type_ignore* type_ignores)
        | Interactive(stmt* body)
        | Expression(expr body)
        | FunctionType(expr* argtypes, expr returns)

    stmt = FunctionDef(identifier name, arguments args,
                      stmt* body, expr* decorator_list, expr? returns,
```

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```

        string? type_comment)
| AsyncFunctionDef(identifier name, arguments args,
                    stmt* body, expr* decorator_list, expr? returns,
                    string? type_comment)

| ClassDef(identifier name,
            expr* bases,
            keyword* keywords,
            stmt* body,
            expr* decorator_list)
| Return(expr? value)

| Delete(expr* targets)
| Assign(expr* targets, expr value, string? type_comment)
| AugAssign(expr target, operator op, expr value)
-- 'simple' indicates that we annotate simple name without parens
| AnnAssign(expr target, expr annotation, expr? value, int simple)

-- use 'orelse' because else is a keyword in target languages
| For(expr target, expr iter, stmt* body, stmt* orelse, string? type_
↪comment)
| AsyncFor(expr target, expr iter, stmt* body, stmt* orelse, string?_
↪type_comment)
| While(expr test, stmt* body, stmt* orelse)
| If(expr test, stmt* body, stmt* orelse)
| With(withitem* items, stmt* body, string? type_comment)
| AsyncWith(withitem* items, stmt* body, string? type_comment)

| Match(expr subject, match_case* cases)

| Raise(expr? exc, expr? cause)
| Try(stmt* body, excepthandler* handlers, stmt* orelse, stmt* finalbody)
| TryStar(stmt* body, excepthandler* handlers, stmt* orelse, stmt*_
↪finalbody)
| Assert(expr test, expr? msg)

| Import(alias* names)
| ImportFrom(identifier? module, alias* names, int? level)

| Global(identifier* names)
| Nonlocal(identifier* names)
| Expr(expr value)
| Pass | Break | Continue

-- col_offset is the byte offset in the utf8 string the parser uses
attributes (int lineno, int col_offset, int? end_lineno, int? end_col_
↪offset)

-- BoolOp() can use left & right?
expr = BoolOp(boolop op, expr* values)
| NamedExpr(expr target, expr value)
| BinOp(expr left, operator op, expr right)
| UnaryOp(unaryop op, expr operand)
| Lambda(arguments args, expr body)
| IfExp(expr test, expr body, expr orelse)
| Dict(expr* keys, expr* values)
| Set(expr* elts)
| ListComp(expr elt, comprehension* generators)
| SetComp(expr elt, comprehension* generators)
| DictComp(expr key, expr value, comprehension* generators)
| GeneratorExp(expr elt, comprehension* generators)

```

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```

-- the grammar constrains where yield expressions can occur
| Await(expr value)
| Yield(expr? value)
| YieldFrom(expr value)
-- need sequences for compare to distinguish between
-- x < 4 < 3 and (x < 4) < 3
| Compare(expr left, cmpop* ops, expr* comparators)
| Call(expr func, expr* args, keyword* keywords)
| FormattedValue(expr value, int conversion, expr? format_spec)
| JoinedStr(expr* values)
| Constant(constant value, string? kind)

-- the following expression can appear in assignment context
| Attribute(expr value, identifier attr, expr_context ctx)
| Subscript(expr value, expr slice, expr_context ctx)
| Starred(expr value, expr_context ctx)
| Name(identifier id, expr_context ctx)
| List(expr* elts, expr_context ctx)
| Tuple(expr* elts, expr_context ctx)

-- can appear only in Subscript
| Slice(expr? lower, expr? upper, expr? step)

-- col_offset is the byte offset in the utf8 string the parser uses
attributes (int lineno, int col_offset, int? end_lineno, int? end_col_
↪offset)

expr_context = Load | Store | Del

boolop = And | Or

operator = Add | Sub | Mult | MatMult | Div | Mod | Pow | LShift
          | RShift | BitOr | BitXor | BitAnd | FloorDiv

unaryop = Invert | Not | UAdd | USub

cmpop = Eq | NotEq | Lt | LtE | Gt | GtE | Is | IsNot | In | NotIn

comprehension = (expr target, expr iter, expr* ifs, int is_async)

excepthandler = ExceptHandler(expr? type, identifier? name, stmt* body)
               attributes (int lineno, int col_offset, int? end_lineno, int?
↪end_col_offset)

arguments = (arg* posonlyargs, arg* args, arg? vararg, arg* kwonlyargs,
            expr* kw_defaults, arg? kwarg, expr* defaults)

arg = (identifier arg, expr? annotation, string? type_comment)
      attributes (int lineno, int col_offset, int? end_lineno, int? end_col_
↪offset)

-- keyword arguments supplied to call (NULL identifier for **kwargs)
keyword = (identifier? arg, expr value)
          attributes (int lineno, int col_offset, int? end_lineno, int? end_
↪col_offset)

-- import name with optional 'as' alias.
alias = (identifier name, identifier? asname)
        attributes (int lineno, int col_offset, int? end_lineno, int? end_col_
↪offset)

```

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```

withitem = (expr context_expr, expr? optional_vars)

match_case = (pattern pattern, expr? guard, stmt* body)

pattern = MatchValue(expr value)
        | MatchSingleton(constant value)
        | MatchSequence(pattern* patterns)
        | MatchMapping(expr* keys, pattern* patterns, identifier? rest)
        | MatchClass(expr cls, pattern* patterns, identifier* kwd_attrs, ↵
↵pattern* kwd_patterns)

        | MatchStar(identifier? name)
        -- The optional "rest" MatchMapping parameter handles capturing extra ↵
↵mapping keys

        | MatchAs(pattern? pattern, identifier? name)
        | MatchOr(pattern* patterns)

        attributes (int lineno, int col_offset, int end_lineno, int end_col_
↵offset)

type_ignore = TypeIgnore(int lineno, string tag)
}

```

32.1.2 Node classes

class ast.AST

This is the base of all AST node classes. The actual node classes are derived from the Parser/Python.asdl file, which is reproduced [above](#). They are defined in the `_ast` C module and re-exported in `ast`.

There is one class defined for each left-hand side symbol in the abstract grammar (for example, `ast.stmt` or `ast.expr`). In addition, there is one class defined for each constructor on the right-hand side; these classes inherit from the classes for the left-hand side trees. For example, `ast.BinOp` inherits from `ast.expr`. For production rules with alternatives (aka "sums"), the left-hand side class is abstract: only instances of specific constructor nodes are ever created.

`_fields`

Each concrete class has an attribute `_fields` which gives the names of all child nodes.

Each instance of a concrete class has one attribute for each child node, of the type as defined in the grammar. For example, `ast.BinOp` instances have an attribute `left` of type `ast.expr`.

If these attributes are marked as optional in the grammar (using a question mark), the value might be `None`. If the attributes can have zero-or-more values (marked with an asterisk), the values are represented as Python lists. All possible attributes must be present and have valid values when compiling an AST with `compile()`.

`lineno`

`col_offset`

`end_lineno`

`end_col_offset`

Instances of `ast.expr` and `ast.stmt` subclasses have `lineno`, `col_offset`, `end_lineno`, and `end_col_offset` attributes. The `lineno` and `end_lineno` are the first and last line numbers of source text span (1-indexed so the first line is line 1) and the `col_offset` and `end_col_offset` are the corresponding UTF-8 byte offsets of the first and last tokens that generated the node. The UTF-8 offset is recorded because the parser uses UTF-8 internally.

Note that the end positions are not required by the compiler and are therefore optional. The end offset is *after* the last symbol, for example one can get the source segment of a one-line expression node using


```
source_line[node.col_offset : node.end_col_offset].
```

The constructor of a class `ast.T` parses its arguments as follows:

- If there are positional arguments, there must be as many as there are items in `T._fields`; they will be assigned as attributes of these names.
- If there are keyword arguments, they will set the attributes of the same names to the given values.

For example, to create and populate an `ast.UnaryOp` node, you could use

```
node = ast.UnaryOp()
node.op = ast.USub()
node.operand = ast.Constant()
node.operand.value = 5
node.operand.lineno = 0
node.operand.col_offset = 0
node.lineno = 0
node.col_offset = 0
```

or the more compact

```
node = ast.UnaryOp(ast.USub(), ast.Constant(5, lineno=0, col_offset=0),
                  lineno=0, col_offset=0)
```

在 3.8 版的變更: Class `ast.Constant` is now used for all constants.

在 3.9 版的變更: Simple indices are represented by their value, extended slices are represented as tuples.

在 3.8 版之後被 用: Old classes `ast.Num`, `ast.Str`, `ast.Bytes`, `ast.NameConstant` and `ast.Ellipsis` are still available, but they will be removed in future Python releases. In the meantime, instantiating them will return an instance of a different class.

在 3.9 版之後被 用: Old classes `ast.Index` and `ast.ExtSlice` are still available, but they will be removed in future Python releases. In the meantime, instantiating them will return an instance of a different class.

備 註: The descriptions of the specific node classes displayed here were initially adapted from the fantastic [Green Tree Snakes](#) project and all its contributors.

Root nodes

class `ast.Module` (*body*, *type_ignores*)

A Python module, as with file input. Node type generated by `ast.parse()` in the default "exec" mode.

body is a *list* of the module's *Statements*.

type_ignores is a *list* of the module's type ignore comments; see `ast.parse()` for more details.

```
>>> print(ast.dump(ast.parse('x = 1'), indent=4))
Module(
  body=[
    Assign(
      targets=[
        Name(id='x', ctx=Store())],
      value=Constant(value=1)],
  type_ignores=[])
```

class `ast.Expression` (*body*)

A single Python expression input. Node type generated by `ast.parse()` when *mode* is "eval".

body is a single node, one of the *expression types*.

```
>>> print(ast.dump(ast.parse('123', mode='eval'), indent=4))
Expression(
  body=Constant(value=123))
```

class `ast.Interactive` (*body*)

A single interactive input, like in `tut-interac`. Node type generated by `ast.parse()` when *mode* is "single".

body is a *list* of *statement nodes*.

```
>>> print(ast.dump(ast.parse('x = 1; y = 2', mode='single'), indent=4))
Interactive(
  body=[
    Assign(
      targets=[
        Name(id='x', ctx=Store())],
      value=Constant(value=1)),
    Assign(
      targets=[
        Name(id='y', ctx=Store())],
      value=Constant(value=2))])
```

class `ast.FunctionType` (*argtypes*, *returns*)

A representation of an old-style type comments for functions, as Python versions prior to 3.5 didn't support [PEP 484](#) annotations. Node type generated by `ast.parse()` when *mode* is "func_type".

Such type comments would look like this:

```
def sum_two_number(a, b):
    # type: (int, int) -> int
    return a + b
```

argtypes is a *list* of *expression nodes*.

returns is a single *expression node*.

```
>>> print(ast.dump(ast.parse('(int, str) -> List[int]', mode='func_type'),
↳indent=4))
FunctionType(
  argtypes=[
    Name(id='int', ctx=Load()),
    Name(id='str', ctx=Load())],
  returns=Subscript(
    value=Name(id='List', ctx=Load()),
    slice=Name(id='int', ctx=Load()),
    ctx=Load()))
```

在 3.8 版新加入.

Literals

class `ast.Constant` (*value*)

A constant value. The *value* attribute of the `Constant` literal contains the Python object it represents. The values represented can be simple types such as a number, string or `None`, but also immutable container types (tuples and frozensets) if all of their elements are constant.

```
>>> print(ast.dump(ast.parse('123', mode='eval'), indent=4))
Expression(
  body=Constant(value=123))
```

class `ast.FormattedValue` (*value*, *conversion*, *format_spec*)

Node representing a single formatting field in an f-string. If the string contains a single formatting field and nothing else the node can be isolated otherwise it appears in *JoinedStr*.

- *value* is any expression node (such as a literal, a variable, or a function call).
- *conversion* is an integer:
 - -1: no formatting
 - 115: !s string formatting
 - 114: !r repr formatting
 - 97: !a ascii formatting
- *format_spec* is a *JoinedStr* node representing the formatting of the value, or None if no format was specified. Both *conversion* and *format_spec* can be set at the same time.

class `ast.JoinedStr` (*values*)

An f-string, comprising a series of *FormattedValue* and *Constant* nodes.

```
>>> print(ast.dump(ast.parse('f"sin({a}) is {sin(a):.3}"', mode='eval'),
↪indent=4))
Expression(
  body=JoinedStr(
    values=[
      Constant(value='sin('),
      FormattedValue(
        value=Name(id='a', ctx=Load()),
        conversion=-1),
      Constant(value=') is '),
      FormattedValue(
        value=Call(
          func=Name(id='sin', ctx=Load()),
          args=[
            Name(id='a', ctx=Load())],
          keywords=[],
          conversion=-1,
          format_spec=JoinedStr(
            values=[
              Constant(value='.3')])))),
    ])
```

class `ast.List` (*elts*, *ctx*)

class `ast.Tuple` (*elts*, *ctx*)

A list or tuple. *elts* holds a list of nodes representing the elements. *ctx* is *Store* if the container is an assignment target (i.e. $(x, y) = \text{something}$), and *Load* otherwise.

```
>>> print(ast.dump(ast.parse('[1, 2, 3]', mode='eval'), indent=4))
Expression(
  body=List(
    elts=[
      Constant(value=1),
      Constant(value=2),
      Constant(value=3)],
    ctx=Load()))
>>> print(ast.dump(ast.parse('(1, 2, 3)', mode='eval'), indent=4))
Expression(
  body=Tuple(
    elts=[
      Constant(value=1),
      Constant(value=2),
      Constant(value=3)],
    ctx=Load()))
```

class `ast.Set (elts)`

A set. `elts` holds a list of nodes representing the set's elements.

```
>>> print(ast.dump(ast.parse('{1, 2, 3}', mode='eval'), indent=4))
Expression(
  body=Set(
    elts=[
      Constant(value=1),
      Constant(value=2),
      Constant(value=3)]))
```

class `ast.Dict (keys, values)`

A dictionary. `keys` and `values` hold lists of nodes representing the keys and the values respectively, in matching order (what would be returned when calling `dictionary.keys()` and `dictionary.values()`).

When doing dictionary unpacking using dictionary literals the expression to be expanded goes in the `values` list, with a `None` at the corresponding position in `keys`.

```
>>> print(ast.dump(ast.parse('{ "a":1, **d }', mode='eval'), indent=4))
Expression(
  body=Dict(
    keys=[
      Constant(value='a'),
      None],
    values=[
      Constant(value=1),
      Name(id='d', ctx=Load())]))
```

Variables

class `ast.Name (id, ctx)`

A variable name. `id` holds the name as a string, and `ctx` is one of the following types.

class `ast.Load`

class `ast.Store`

class `ast.Del`

Variable references can be used to load the value of a variable, to assign a new value to it, or to delete it. Variable references are given a context to distinguish these cases.

```
>>> print(ast.dump(ast.parse('a'), indent=4))
Module(
  body=[
    Expr(
      value=Name(id='a', ctx=Load()))],
  type_ignores=[])

>>> print(ast.dump(ast.parse('a = 1'), indent=4))
Module(
  body=[
    Assign(
      targets=[
        Name(id='a', ctx=Store())],
      value=Constant(value=1)],
    type_ignores=[])

>>> print(ast.dump(ast.parse('del a'), indent=4))
Module(
  body=[
```

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```

Delete(
    targets=[
        Name(id='a', ctx=Del())]],
    type_ignores=[])

```

class `ast.Starred` (*value*, *ctx*)

A `*var` variable reference. *value* holds the variable, typically a *Name* node. This type must be used when building a *Call* node with `*args`.

```

>>> print(ast.dump(ast.parse('a, *b = it'), indent=4))
Module(
  body=[
    Assign(
      targets=[
        Tuple(
          elts=[
            Name(id='a', ctx=Store()),
            Starred(
              value=Name(id='b', ctx=Store()),
              ctx=Store())],
          ctx=Store())],
      value=Name(id='it', ctx=Load()))],
  type_ignores=[])

```

Expressions

class `ast.Expr` (*value*)

When an expression, such as a function call, appears as a statement by itself with its return value not used or stored, it is wrapped in this container. *value* holds one of the other nodes in this section, a *Constant*, a *Name*, a *Lambda*, a *Yield* or *YieldFrom* node.

```

>>> print(ast.dump(ast.parse('-a'), indent=4))
Module(
  body=[
    Expr(
      value=UnaryOp(
        op=USub(),
        operand=Name(id='a', ctx=Load()))],
  type_ignores=[])

```

class `ast.UnaryOp` (*op*, *operand*)

A unary operation. *op* is the operator, and *operand* any expression node.

class `ast.UAdd`

class `ast.USub`

class `ast.Not`

class `ast.Invert`

Unary operator tokens. *Not* is the not keyword, *Invert* is the `~` operator.

```

>>> print(ast.dump(ast.parse('not x', mode='eval'), indent=4))
Expression(
  body=UnaryOp(
    op=Not(),
    operand=Name(id='x', ctx=Load()))

```

class `ast.BinOp` (*left*, *op*, *right*)

A binary operation (like addition or division). *op* is the operator, and *left* and *right* are any expression nodes.

```
>>> print(ast.dump(ast.parse('x + y', mode='eval'), indent=4))
Expression(
  body=BinOp(
    left=Name(id='x', ctx=Load()),
    op=Add(),
    right=Name(id='y', ctx=Load())))
```

```
class ast.Add
```

```
class ast.Sub
```

```
class ast.Mult
```

```
class ast.Div
```

```
class ast.FloorDiv
```

```
class ast.Mod
```

```
class ast.Pow
```

```
class ast.LShift
```

```
class ast.RShift
```

```
class ast.BitOr
```

```
class ast.BitXor
```

```
class ast.BitAnd
```

```
class ast.MatMult
```

Binary operator tokens.

```
class ast.BoolOp(op, values)
```

A boolean operation, 'or' or 'and'. *op* is *Or* or *And*. *values* are the values involved. Consecutive operations with the same operator, such as `a or b or c`, are collapsed into one node with several values.

This doesn't include `not`, which is a *UnaryOp*.

```
>>> print(ast.dump(ast.parse('x or y', mode='eval'), indent=4))
Expression(
  body=BoolOp(
    op=Or(),
    values=[
      Name(id='x', ctx=Load()),
      Name(id='y', ctx=Load())]))
```

```
class ast.And
```

```
class ast.Or
```

Boolean operator tokens.

```
class ast.Compare(left, ops, comparators)
```

A comparison of two or more values. *left* is the first value in the comparison, *ops* the list of operators, and *comparators* the list of values after the first element in the comparison.

```
>>> print(ast.dump(ast.parse('1 <= a < 10', mode='eval'), indent=4))
Expression(
  body=Compare(
    left=Constant(value=1),
    ops=[
      LtE(),
      Lt()],
    comparators=[
      Name(id='a', ctx=Load()),
      Constant(value=10)]))
```

```
class ast.Eq
```

```
class ast.NotEq
```

```

class ast.Lt
class ast.LtE
class ast.Gt
class ast.GtE
class ast.Is
class ast.IsNot
class ast.In
class ast.NotIn

```

Comparison operator tokens.

```
class ast.Call (func, args, keywords)
```

A function call. *func* is the function, which will often be a *Name* or *Attribute* object. Of the arguments:

- *args* holds a list of the arguments passed by position.
- *keywords* holds a list of *keyword* objects representing arguments passed by keyword.

When creating a *Call* node, *args* and *keywords* are required, but they can be empty lists.

```

>>> print(ast.dump(ast.parse('func(a, b=c, *d, **e)', mode='eval'), indent=4))
Expression(
  body=Call(
    func=Name(id='func', ctx=Load()),
    args=[
      Name(id='a', ctx=Load()),
      Starred(
        value=Name(id='d', ctx=Load()),
        ctx=Load()),
    keywords=[
      keyword(
        arg='b',
        value=Name(id='c', ctx=Load())),
      keyword(
        value=Name(id='e', ctx=Load()))])])

```

```
class ast.keyword (arg, value)
```

A keyword argument to a function call or class definition. *arg* is a raw string of the parameter name, *value* is a node to pass in.

```
class ast.IfExp (test, body, or_else)
```

An expression such as *a if b else c*. Each field holds a single node, so in the following example, all three are *Name* nodes.

```

>>> print(ast.dump(ast.parse('a if b else c', mode='eval'), indent=4))
Expression(
  body=IfExp(
    test=Name(id='b', ctx=Load()),
    body=Name(id='a', ctx=Load()),
    or_else=Name(id='c', ctx=Load()))

```

```
class ast.Attribute (value, attr, ctx)
```

Attribute access, e.g. *d.keys*. *value* is a node, typically a *Name*. *attr* is a bare string giving the name of the attribute, and *ctx* is *Load*, *Store* or *Del* according to how the attribute is acted on.

```

>>> print(ast.dump(ast.parse('snake.colour', mode='eval'), indent=4))
Expression(
  body=Attribute(
    value=Name(id='snake', ctx=Load()),
    attr='colour',
    ctx=Load())

```

class `ast.NamedExpr` (*target, value*)

A named expression. This AST node is produced by the assignment expressions operator (also known as the walrus operator). As opposed to the *Assign* node in which the first argument can be multiple nodes, in this case both `target` and `value` must be single nodes.

```
>>> print(ast.dump(ast.parse('(x := 4)', mode='eval'), indent=4))
Expression(
  body=NamedExpr(
    target=Name(id='x', ctx=Store()),
    value=Constant(value=4))
```

Subscripting

class `ast.Subscript` (*value, slice, ctx*)

A subscript, such as `l[1]`. `value` is the subscripted object (usually sequence or mapping). `slice` is an index, slice or key. It can be a *Tuple* and contain a *Slice*. `ctx` is *Load*, *Store* or *Del* according to the action performed with the subscript.

```
>>> print(ast.dump(ast.parse('l[1:2, 3]', mode='eval'), indent=4))
Expression(
  body=Subscript(
    value=Name(id='l', ctx=Load()),
    slice=Tuple(
      elts=[
        Slice(
          lower=Constant(value=1),
          upper=Constant(value=2)),
        Constant(value=3)],
      ctx=Load()),
    ctx=Load())
```

class `ast.Slice` (*lower, upper, step*)

Regular slicing (on the form `lower:upper` or `lower:upper:step`). Can occur only inside the *slice* field of *Subscript*, either directly or as an element of *Tuple*.

```
>>> print(ast.dump(ast.parse('l[1:2]', mode='eval'), indent=4))
Expression(
  body=Subscript(
    value=Name(id='l', ctx=Load()),
    slice=Slice(
      lower=Constant(value=1),
      upper=Constant(value=2)),
    ctx=Load())
```

Comprehensions

class `ast.ListComp` (*elt, generators*)

class `ast.SetComp` (*elt, generators*)

class `ast.GeneratorExp` (*elt, generators*)

class `ast.DictComp` (*key, value, generators*)

List and set comprehensions, generator expressions, and dictionary comprehensions. `elt` (or `key` and `value`) is a single node representing the part that will be evaluated for each item.

`generators` is a list of *comprehension* nodes.


```

>>> print(ast.dump(ast.parse('[x for x in numbers]', mode='eval'), indent=4))
Expression(
  body=ListComp(
    elt=Name(id='x', ctx=Load()),
    generators=[
      comprehension(
        target=Name(id='x', ctx=Store()),
        iter=Name(id='numbers', ctx=Load()),
        ifs=[],
        is_async=0)))
>>> print(ast.dump(ast.parse('{x: x**2 for x in numbers}', mode='eval'),
↳ indent=4))
Expression(
  body=DictComp(
    key=Name(id='x', ctx=Load()),
    value=BinOp(
      left=Name(id='x', ctx=Load()),
      op=Pow(),
      right=Constant(value=2)),
    generators=[
      comprehension(
        target=Name(id='x', ctx=Store()),
        iter=Name(id='numbers', ctx=Load()),
        ifs=[],
        is_async=0)])
>>> print(ast.dump(ast.parse('{x for x in numbers}', mode='eval'), indent=4))
Expression(
  body=SetComp(
    elt=Name(id='x', ctx=Load()),
    generators=[
      comprehension(
        target=Name(id='x', ctx=Store()),
        iter=Name(id='numbers', ctx=Load()),
        ifs=[],
        is_async=0)])

```

class `ast.comprehension` (*target, iter, ifs, is_async*)

One for clause in a comprehension. *target* is the reference to use for each element - typically a [Name](#) or [Tuple](#) node. *iter* is the object to iterate over. *ifs* is a list of test expressions: each for clause can have multiple ifs.

is_async indicates a comprehension is asynchronous (using an `async for` instead of `for`). The value is an integer (0 or 1).

```

>>> print(ast.dump(ast.parse('[ord(c) for line in file for c in line]', mode=
↳ 'eval'),
...               indent=4)) # Multiple comprehensions in one.
Expression(
  body=ListComp(
    elt=Call(
      func=Name(id='ord', ctx=Load()),
      args=[
        Name(id='c', ctx=Load())],
      keywords=[]),
    generators=[
      comprehension(
        target=Name(id='line', ctx=Store()),
        iter=Name(id='file', ctx=Load()),
        ifs=[],
        is_async=0),
      comprehension(
        target=Name(id='c', ctx=Store()),

```

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```

        iter=Name(id='line', ctx=Load()),
        ifs=[],
        is_async=0)))

>>> print(ast.dump(ast.parse('(n**2 for n in it if n>5 if n<10)', mode='eval'),
...                        indent=4)) # generator comprehension
Expression(
  body=GeneratorExp(
    elt=BinOp(
      left=Name(id='n', ctx=Load()),
      op=Pow(),
      right=Constant(value=2)),
    generators=[
      comprehension(
        target=Name(id='n', ctx=Store()),
        iter=Name(id='it', ctx=Load()),
        ifs=[
          Compare(
            left=Name(id='n', ctx=Load()),
            ops=[
              Gt()],
            comparators=[
              Constant(value=5)]),
          Compare(
            left=Name(id='n', ctx=Load()),
            ops=[
              Lt()],
            comparators=[
              Constant(value=10)])),
        is_async=0)))]))

>>> print(ast.dump(ast.parse('[i async for i in soc]', mode='eval'),
...                        indent=4)) # Async comprehension
Expression(
  body=ListComp(
    elt=Name(id='i', ctx=Load()),
    generators=[
      comprehension(
        target=Name(id='i', ctx=Store()),
        iter=Name(id='soc', ctx=Load()),
        ifs=[],
        is_async=1)))]))

```

Statements

class `ast.Assign(targets, value, type_comment)`

An assignment. `targets` is a list of nodes, and `value` is a single node.

Multiple nodes in `targets` represents assigning the same value to each. Unpacking is represented by putting a *Tuple* or *List* within `targets`.

type_comment

`type_comment` is an optional string with the type annotation as a comment.

```

>>> print(ast.dump(ast.parse('a = b = 1', indent=4)) # Multiple assignment
Module(
  body=[
    Assign(
      targets=[
        Name(id='a', ctx=Store()),

```

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```

        Name(id='b', ctx=Store())]],
        value=Constant(value=1))],
        type_ignores=[])

>>> print(ast.dump(ast.parse('a,b = c'), indent=4)) # Unpacking
Module(
  body=[
    Assign(
      targets=[
        Tuple(
          elts=[
            Name(id='a', ctx=Store()),
            Name(id='b', ctx=Store())],
          ctx=Store())],
      value=Name(id='c', ctx=Load()))],
  type_ignores=[])

```

class `ast.AnnAssign` (*target, annotation, value, simple*)

An assignment with a type annotation. *target* is a single node and can be a *Name*, a *Attribute* or a *Subscript*. *annotation* is the annotation, such as a *Constant* or *Name* node. *value* is a single optional node. *simple* is a boolean integer set to True for a *Name* node in *target* that do not appear in between parenthesis and are hence pure names and not expressions.

```

>>> print(ast.dump(ast.parse('c: int'), indent=4))
Module(
  body=[
    AnnAssign(
      target=Name(id='c', ctx=Store()),
      annotation=Name(id='int', ctx=Load()),
      simple=1)],
  type_ignores=[])

>>> print(ast.dump(ast.parse('(a): int = 1'), indent=4)) # Annotation with
↳parenthesis
Module(
  body=[
    AnnAssign(
      target=Name(id='a', ctx=Store()),
      annotation=Name(id='int', ctx=Load()),
      value=Constant(value=1),
      simple=0)],
  type_ignores=[])

>>> print(ast.dump(ast.parse('a.b: int'), indent=4)) # Attribute annotation
Module(
  body=[
    AnnAssign(
      target=Attribute(
        value=Name(id='a', ctx=Load()),
        attr='b',
        ctx=Store()),
      annotation=Name(id='int', ctx=Load()),
      simple=0)],
  type_ignores=[])

>>> print(ast.dump(ast.parse('a[1]: int'), indent=4)) # Subscript annotation
Module(
  body=[
    AnnAssign(
      target=Subscript(
        value=Name(id='a', ctx=Load()),

```

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```

        slice=Constant(value=1),
        ctx=Store()),
        annotation=Name(id='int', ctx=Load()),
        simple=0)],
        type_ignores=[])

```

class `ast.AugAssign` (*target, op, value*)

Augmented assignment, such as `a += 1`. In the following example, *target* is a *Name* node for `x` (with the *Store* context), *op* is *Add*, and *value* is a *Constant* with value for 1.

The *target* attribute cannot be of class *Tuple* or *List*, unlike the targets of *Assign*.

```

>>> print(ast.dump(ast.parse('x += 2'), indent=4))
Module(
  body=[
    AugAssign(
      target=Name(id='x', ctx=Store()),
      op=Add(),
      value=Constant(value=2)),
    type_ignores=[])

```

class `ast.Raise` (*exc, cause*)

A raise statement. *exc* is the exception object to be raised, normally a *Call* or *Name*, or *None* for a standalone raise. *cause* is the optional part for `raise x from y`.

```

>>> print(ast.dump(ast.parse('raise x from y'), indent=4))
Module(
  body=[
    Raise(
      exc=Name(id='x', ctx=Load()),
      cause=Name(id='y', ctx=Load()))],
  type_ignores=[])

```

class `ast.Assert` (*test, msg*)

An assertion. *test* holds the condition, such as a *Compare* node. *msg* holds the failure message.

```

>>> print(ast.dump(ast.parse('assert x,y'), indent=4))
Module(
  body=[
    Assert(
      test=Name(id='x', ctx=Load()),
      msg=Name(id='y', ctx=Load()))],
  type_ignores=[])

```

class `ast.Delete` (*targets*)

Represents a `del` statement. *targets* is a list of nodes, such as *Name*, *Attribute* or *Subscript* nodes.

```

>>> print(ast.dump(ast.parse('del x,y,z'), indent=4))
Module(
  body=[
    Delete(
      targets=[
        Name(id='x', ctx=Del()),
        Name(id='y', ctx=Del()),
        Name(id='z', ctx=Del())
      ]
    ),
    type_ignores=[])

```

class `ast.Pass`

A pass statement.

```
>>> print(ast.dump(ast.parse('pass'), indent=4))
Module(
  body=[
    Pass(),
  ],
  type_ignores=[])
```

Other statements which are only applicable inside functions or loops are described in other sections.

Imports

class `ast.Import(names)`

An import statement. `names` is a list of *alias* nodes.

```
>>> print(ast.dump(ast.parse('import x,y,z'), indent=4))
Module(
  body=[
    Import(
      names=[
        alias(name='x'),
        alias(name='y'),
        alias(name='z')
      ]
    ),
  ],
  type_ignores=[])
```

class `ast.ImportFrom(module, names, level)`

Represents `from x import y`. `module` is a raw string of the 'from' name, without any leading dots, or `None` for statements such as `from . import foo`. `level` is an integer holding the level of the relative import (0 means absolute import).

```
>>> print(ast.dump(ast.parse('from y import x,y,z'), indent=4))
Module(
  body=[
    ImportFrom(
      module='y',
      names=[
        alias(name='x'),
        alias(name='y'),
        alias(name='z')
      ],
      level=0
    ),
  ],
  type_ignores=[])
```

class `ast.alias(name, asname)`

Both parameters are raw strings of the names. `asname` can be `None` if the regular name is to be used.

```
>>> print(ast.dump(ast.parse('from ..foo.bar import a as b, c'), indent=4))
Module(
  body=[
    ImportFrom(
      module='foo.bar',
      names=[
        alias(name='a', asname='b'),
        alias(name='c')
      ],
      level=2
    ),
  ],
  type_ignores=[])
```

Control flow

備 F: Optional clauses such as `else` are stored as an empty list if they're not present.

class `ast.If` (*test, body, orelse*)

An if statement. *test* holds a single node, such as a *Compare* node. *body* and *orelse* each hold a list of nodes.

`elif` clauses don't have a special representation in the AST, but rather appear as extra *If* nodes within the *orelse* section of the previous one.

```
>>> print(ast.dump(ast.parse("""
... if x:
...     ...
... elif y:
...     ...
... else:
...     ...
... """), indent=4))
Module(
  body=[
    If(
      test=Name(id='x', ctx=Load()),
      body=[
        Expr(
          value=Constant(value=Ellipsis))],
      orelse=[
        If(
          test=Name(id='y', ctx=Load()),
          body=[
            Expr(
              value=Constant(value=Ellipsis))],
            orelse=[
              Expr(
                value=Constant(value=Ellipsis)))])),
      type_ignores=[])
```

class `ast.For` (*target, iter, body, orelse, type_comment*)

A for loop. *target* holds the variable(s) the loop assigns to, as a single *Name*, *Tuple* or *List* node. *iter* holds the item to be looped over, again as a single node. *body* and *orelse* contain lists of nodes to execute. Those in *orelse* are executed if the loop finishes normally, rather than via a `break` statement.

type_comment

type_comment is an optional string with the type annotation as a comment.

```
>>> print(ast.dump(ast.parse("""
... for x in y:
...     ...
... else:
...     ...
... """), indent=4))
Module(
  body=[
    For(
      target=Name(id='x', ctx=Store()),
      iter=Name(id='y', ctx=Load()),
      body=[
        Expr(
          value=Constant(value=Ellipsis))],
      orelse=[
```

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```
Expr(
    value=Constant(value=Ellipsis))]],
type_ignores=[])
```

class `ast.While` (*test, body, or_else*)

A while loop. *test* holds the condition, such as a [Compare](#) node.

```
>> print(ast.dump(ast.parse("""
... while x:
...     ...
... else:
...     ...
... """), indent=4))
Module(
  body=[
    While(
      test=Name(id='x', ctx=Load()),
      body=[
        Expr(
          value=Constant(value=Ellipsis))],
      or_else=[
        Expr(
          value=Constant(value=Ellipsis))]],
      type_ignores=[])
```

class `ast.Break`

class `ast.Continue`

The break and continue statements.

```
>>> print(ast.dump(ast.parse("""\
... for a in b:
...     if a > 5:
...         break
...     else:
...         continue
... """), indent=4))
Module(
  body=[
    For(
      target=Name(id='a', ctx=Store()),
      iter=Name(id='b', ctx=Load()),
      body=[
        If(
          test=Compare(
            left=Name(id='a', ctx=Load()),
            ops=[
              Gt()],
            comparators=[
              Constant(value=5)]),
          body=[
            Break()],
          or_else=[
            Continue()])],
        or_else=[])],
      type_ignores=[])
```

class `ast.Try` (*body, handlers, or_else, finalbody*)

try blocks. All attributes are list of nodes to execute, except for *handlers*, which is a list of [ExceptHandler](#) nodes.

```

>>> print(ast.dump(ast.parse("""
... try:
...     ...
... except Exception:
...     ...
... except OtherException as e:
...     ...
... else:
...     ...
... finally:
...     ...
... """), indent=4))
Module(
  body=[
    Try(
      body=[
        Expr(
          value=Constant(value=Ellipsis))),
      handlers=[
        ExceptHandler(
          type=Name(id='Exception', ctx=Load()),
          body=[
            Expr(
              value=Constant(value=Ellipsis))]),
        ExceptHandler(
          type=Name(id='OtherException', ctx=Load()),
          name='e',
          body=[
            Expr(
              value=Constant(value=Ellipsis))])]),
      or_else=[
        Expr(
          value=Constant(value=Ellipsis))],
      finalbody=[
        Expr(
          value=Constant(value=Ellipsis))]),
      type_ignores=[])

```

class `ast.TryStar` (*body, handlers, or_else, finalbody*)

try blocks which are followed by `except*` clauses. The attributes are the same as for `Try` but the `ExceptHandler` nodes in `handlers` are interpreted as `except*` blocks rather than `except`.

```

>>> print(ast.dump(ast.parse("""
... try:
...     ...
... except* Exception:
...     ...
... """), indent=4))
Module(
  body=[
    TryStar(
      body=[
        Expr(
          value=Constant(value=Ellipsis))],
      handlers=[
        ExceptHandler(
          type=Name(id='Exception', ctx=Load()),
          body=[
            Expr(
              value=Constant(value=Ellipsis))])]),
      or_else=[],

```

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```

        finalbody=[])],
    type_ignores=[])

```

class `ast.ExceptHandler` (*type, name, body*)

A single except clause. *type* is the exception type it will match, typically a *Name* node (or `None` for a catch-all `except: clause`). *name* is a raw string for the name to hold the exception, or `None` if the clause doesn't have `as foo`. *body* is a list of nodes.

```

>>> print(ast.dump(ast.parse("""\
... try:
...     a + 1
... except TypeError:
...     pass
... """), indent=4))
Module(
  body=[
    Try(
      body=[
        Expr(
          value=BinOp(
            left=Name(id='a', ctx=Load()),
            op=Add(),
            right=Constant(value=1))),
        handlers=[
          ExceptHandler(
            type=Name(id='TypeError', ctx=Load()),
            body=[
              Pass()])],
        or_else=[],
        finalbody=[])],
    type_ignores=[])

```

class `ast.With` (*items, body, type_comment*)

A with block. *items* is a list of *withitem* nodes representing the context managers, and *body* is the indented block inside the context.

type_comment

type_comment is an optional string with the type annotation as a comment.

class `ast.withitem` (*context_expr, optional_vars*)

A single context manager in a with block. *context_expr* is the context manager, often a *Call* node. *optional_vars* is a *Name*, *Tuple* or *List* for the `as foo` part, or `None` if that isn't used.

```

>>> print(ast.dump(ast.parse("""\
... with a as b, c as d:
...     something(b, d)
... """), indent=4))
Module(
  body=[
    With(
      items=[
        withitem(
          context_expr=Name(id='a', ctx=Load()),
          optional_vars=Name(id='b', ctx=Store())),
        withitem(
          context_expr=Name(id='c', ctx=Load()),
          optional_vars=Name(id='d', ctx=Store()))],
      body=[
        Expr(
          value=Call(

```

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```

func=Name(id='something', ctx=Load()),
args=[
    Name(id='b', ctx=Load()),
    Name(id='d', ctx=Load())],
keywords=[])])],
type_ignores=[])

```

Pattern matching

class `ast.Match` (*subject, cases*)

A match statement. *subject* holds the subject of the match (the object that is being matched against the cases) and *cases* contains an iterable of *match_case* nodes with the different cases.

class `ast.match_case` (*pattern, guard, body*)

A single case pattern in a match statement. *pattern* contains the match pattern that the subject will be matched against. Note that the *AST* nodes produced for patterns differ from those produced for expressions, even when they share the same syntax.

The *guard* attribute contains an expression that will be evaluated if the pattern matches the subject.

body contains a list of nodes to execute if the pattern matches and the result of evaluating the guard expression is true.

```

>>> print(ast.dump(ast.parse("""
... match x:
...     case [x] if x>0:
...         ...
...     case tuple():
...         ...
... """), indent=4))
Module(
  body=[
    Match(
      subject=Name(id='x', ctx=Load()),
      cases=[
        match_case(
          pattern=MatchSequence(
            patterns=[
              MatchAs(name='x')]),
          guard=Compare(
            left=Name(id='x', ctx=Load()),
            ops=[
              Gt()],
            comparators=[
              Constant(value=0)]),
          body=[
            Expr(
              value=Constant(value=Ellipsis))]),
        match_case(
          pattern=MatchClass(
            cls=Name(id='tuple', ctx=Load()),
            patterns=[],
            kwd_attrs=[],
            kwd_patterns=[]),
          body=[
            Expr(
              value=Constant(value=Ellipsis))])])],
    type_ignores=[])

```

class `ast.MatchValue` (*value*)

A match literal or value pattern that compares by equality. *value* is an expression node. Permitted value nodes are restricted as described in the match statement documentation. This pattern succeeds if the match subject is equal to the evaluated value.

```
>>> print(ast.dump(ast.parse("""
... match x:
...     case "Relevant":
...         ...
... """), indent=4))
Module(
  body=[
    Match(
      subject=Name(id='x', ctx=Load()),
      cases=[
        match_case(
          pattern=MatchValue(
            value=Constant(value='Relevant')),
          body=[
            Expr(
              value=Constant(value=Ellipsis))]]),
      type_ignores=[])
```

class `ast.MatchSingleton` (*value*)

A match literal pattern that compares by identity. *value* is the singleton to be compared against: `None`, `True`, or `False`. This pattern succeeds if the match subject is the given constant.

```
>>> print(ast.dump(ast.parse("""
... match x:
...     case None:
...         ...
... """), indent=4))
Module(
  body=[
    Match(
      subject=Name(id='x', ctx=Load()),
      cases=[
        match_case(
          pattern=MatchSingleton(value=None),
          body=[
            Expr(
              value=Constant(value=Ellipsis))]]),
      type_ignores=[])
```

class `ast.MatchSequence` (*patterns*)

A match sequence pattern. *patterns* contains the patterns to be matched against the subject elements if the subject is a sequence. Matches a variable length sequence if one of the subpatterns is a `MatchStar` node, otherwise matches a fixed length sequence.

```
>>> print(ast.dump(ast.parse("""
... match x:
...     case [1, 2]:
...         ...
... """), indent=4))
Module(
  body=[
    Match(
      subject=Name(id='x', ctx=Load()),
      cases=[
        match_case(
          pattern=MatchSequence(
```

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```

        patterns=[
            MatchValue(
                value=Constant(value=1)),
            MatchValue(
                value=Constant(value=2))]),
        body=[
            Expr(
                value=Constant(value=Ellipsis)))]],
    type_ignores=[])

```

class `ast.MatchStar(name)`

Matches the rest of the sequence in a variable length match sequence pattern. If `name` is not `None`, a list containing the remaining sequence elements is bound to that name if the overall sequence pattern is successful.

```

>>> print(ast.dump(ast.parse("""
... match x:
...     case [1, 2, *rest]:
...         ...
...     case [*_]:
...         ...
... """), indent=4))
Module(
  body=[
    Match(
      subject=Name(id='x', ctx=Load()),
      cases=[
        match_case(
          pattern=MatchSequence(
            patterns=[
              MatchValue(
                value=Constant(value=1)),
              MatchValue(
                value=Constant(value=2)),
              MatchStar(name='rest')]),
          body=[
            Expr(
              value=Constant(value=Ellipsis))]),
        match_case(
          pattern=MatchSequence(
            patterns=[
              MatchStar())],
          body=[
            Expr(
              value=Constant(value=Ellipsis)))]])],
    type_ignores=[])

```

class `ast.MatchMapping(keys, patterns, rest)`

A match mapping pattern. `keys` is a sequence of expression nodes. `patterns` is a corresponding sequence of pattern nodes. `rest` is an optional name that can be specified to capture the remaining mapping elements. Permitted key expressions are restricted as described in the match statement documentation.

This pattern succeeds if the subject is a mapping, all evaluated key expressions are present in the mapping, and the value corresponding to each key matches the corresponding subpattern. If `rest` is not `None`, a dict containing the remaining mapping elements is bound to that name if the overall mapping pattern is successful.

```

>>> print(ast.dump(ast.parse("""
... match x:
...     case {1: _, 2: _}:
...         ...
...     case {**rest}:

```

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```

...     """), indent=4))
Module(
    body=[
        Match(
            subject=Name(id='x', ctx=Load()),
            cases=[
                match_case(
                    pattern=MatchMapping(
                        keys=[
                            Constant(value=1),
                            Constant(value=2)],
                        patterns=[
                            MatchAs(),
                            MatchAs()],
                    body=[
                        Expr(
                            value=Constant(value=Ellipsis))),
                match_case(
                    pattern=MatchMapping(keys=[], patterns=[], rest='rest'),
                    body=[
                        Expr(
                            value=Constant(value=Ellipsis)))]],
            type_ignores=[])

```

class `ast.MatchClass` (*cls, patterns, kwd_attrs, kwd_patterns*)

A match class pattern. `cls` is an expression giving the nominal class to be matched. `patterns` is a sequence of pattern nodes to be matched against the class defined sequence of pattern matching attributes. `kwd_attrs` is a sequence of additional attributes to be matched (specified as keyword arguments in the class pattern), `kwd_patterns` are the corresponding patterns (specified as keyword values in the class pattern).

This pattern succeeds if the subject is an instance of the nominated class, all positional patterns match the corresponding class-defined attributes, and any specified keyword attributes match their corresponding pattern.

Note: classes may define a property that returns self in order to match a pattern node against the instance being matched. Several builtin types are also matched that way, as described in the match statement documentation.

```

>>> print(ast.dump(ast.parse("""
... match x:
...     case Point2D(0, 0):
...         ...
...     case Point3D(x=0, y=0, z=0):
...         ...
... """), indent=4))
Module(
    body=[
        Match(
            subject=Name(id='x', ctx=Load()),
            cases=[
                match_case(
                    pattern=MatchClass(
                        cls=Name(id='Point2D', ctx=Load()),
                        patterns=[
                            MatchValue(
                                value=Constant(value=0)),
                            MatchValue(
                                value=Constant(value=0))],
                        kwd_attrs=[],
                        kwd_patterns=[]),
                    body=[
                        Expr(

```

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```

        value=Constant (value=Ellipsis))]),
    match_case (
        pattern=MatchClass (
            cls=Name (id='Point3D', ctx=Load()),
            patterns=[],
            kwd_attrs=[
                'x',
                'y',
                'z'],
            kwd_patterns=[
                MatchValue (
                    value=Constant (value=0)),
                MatchValue (
                    value=Constant (value=0)),
                MatchValue (
                    value=Constant (value=0))]),
            body=[
                Expr (
                    value=Constant (value=Ellipsis)))])),
    type_ignores=[])

```

class `ast.MatchAs (pattern, name)`

A match “as-pattern”, capture pattern or wildcard pattern. `pattern` contains the match pattern that the subject will be matched against. If the pattern is `None`, the node represents a capture pattern (i.e a bare name) and will always succeed.

The `name` attribute contains the name that will be bound if the pattern is successful. If `name` is `None`, `pattern` must also be `None` and the node represents the wildcard pattern.

```

>>> print (ast.dump (ast.parse ("""
... match x:
...     case [x] as y:
...         ...
...     case _:
...         ...
... """), indent=4))
Module (
    body=[
        Match (
            subject=Name (id='x', ctx=Load()),
            cases=[
                match_case (
                    pattern=MatchAs (
                        pattern=MatchSequence (
                            patterns=[
                                MatchAs (name='x')]),
                        name='y'),
                    body=[
                        Expr (
                            value=Constant (value=Ellipsis))]),
                match_case (
                    pattern=MatchAs (),
                    body=[
                        Expr (
                            value=Constant (value=Ellipsis)))])),
    type_ignores=[])

```

class `ast.MatchOr (patterns)`

A match “or-pattern”. An or-pattern matches each of its subpatterns in turn to the subject, until one succeeds. The or-pattern is then deemed to succeed. If none of the subpatterns succeed the or-pattern fails. The `patterns` attribute contains a list of match pattern nodes that will be matched against the subject.

```
>>> print(ast.dump(ast.parse("""
... match x:
...     case [x] | (y):
...         ...
... """), indent=4))
Module(
  body=[
    Match(
      subject=Name(id='x', ctx=Load()),
      cases=[
        match_case(
          pattern=MatchOr(
            patterns=[
              MatchSequence(
                patterns=[
                  MatchAs(name='x')]),
              MatchAs(name='y')]),
            body=[
              Expr(
                value=Constant(value=Ellipsis)))]],
          type_ignores=[])
```

Function and class definitions

class `ast.FunctionDef` (*name, args, body, decorator_list, returns, type_comment*)

A function definition.

- *name* is a raw string of the function name.
- *args* is an *arguments* node.
- *body* is the list of nodes inside the function.
- *decorator_list* is the list of decorators to be applied, stored outermost first (i.e. the first in the list will be applied last).
- *returns* is the return annotation.

type_comment

type_comment is an optional string with the type annotation as a comment.

class `ast.Lambda` (*args, body*)

lambda is a minimal function definition that can be used inside an expression. Unlike *FunctionDef*, *body* holds a single node.

```
>>> print(ast.dump(ast.parse('lambda x,y: ...'), indent=4))
Module(
  body=[
    Expr(
      value=Lambda(
        args=arguments(
          posonlyargs=[],
          args=[
            arg(arg='x'),
            arg(arg='y')],
          kwonlyargs=[],
          kw_defaults=[],
          defaults=[]),
        body=Constant(value=Ellipsis))),
    type_ignores=[])
```

class `ast.arguments` (*posonlyargs, args, vararg, kwonlyargs, kw_defaults, kwarg, defaults*)

The arguments for a function.

- `posonlyargs`, `args` and `kwonlyargs` are lists of *arg* nodes.
- `vararg` and `kwarg` are single *arg* nodes, referring to the `*args`, `**kwargs` parameters.
- `kw_defaults` is a list of default values for keyword-only arguments. If one is `None`, the corresponding argument is required.
- `defaults` is a list of default values for arguments that can be passed positionally. If there are fewer defaults, they correspond to the last `n` arguments.

class `ast.arg` (*arg, annotation, type_comment*)

A single argument in a list. `arg` is a raw string of the argument name; `annotation` is its annotation, such as a *Name* node.

type_comment

`type_comment` is an optional string with the type annotation as a comment

```
>>> print(ast.dump(ast.parse("""\
... @decorator1
... @decorator2
... def f(a: 'annotation', b=1, c=2, *d, e, f=3, **g) -> 'return annotation':
...     pass
... """), indent=4))
Module(
  body=[
    FunctionDef(
      name='f',
      args=arguments(
        posonlyargs=[],
        args=[
          arg(
            arg='a',
            annotation=Constant(value='annotation')),
          arg(arg='b'),
          arg(arg='c')],
        vararg=arg(arg='d'),
        kwonlyargs=[
          arg(arg='e'),
          arg(arg='f')],
        kw_defaults=[
          None,
          Constant(value=3)],
        kwarg=arg(arg='g'),
        defaults=[
          Constant(value=1),
          Constant(value=2)]),
      body=[
        Pass()],
      decorator_list=[
        Name(id='decorator1', ctx=Load()),
        Name(id='decorator2', ctx=Load())],
      returns=Constant(value='return annotation')),
    type_ignores=[])
```

class `ast.Return` (*value*)

A return statement.

```
>>> print(ast.dump(ast.parse('return 4'), indent=4))
Module(
  body=[
```

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```

    Return (
        value=Constant (value=4)) ],
    type_ignores=[])

```

class `ast.Yield (value)`

class `ast.YieldFrom (value)`

A `yield` or `yield from` expression. Because these are expressions, they must be wrapped in a [Expr](#) node if the value sent back is not used.

```

>>> print (ast.dump (ast.parse ('yield x'), indent=4))
Module (
  body=[
    Expr (
      value=Yield (
        value=Name (id='x', ctx=Load ())),
      type_ignores=[])

>>> print (ast.dump (ast.parse ('yield from x'), indent=4))
Module (
  body=[
    Expr (
      value=YieldFrom (
        value=Name (id='x', ctx=Load ())),
      type_ignores=[])

```

class `ast.Global (names)`

class `ast.Nonlocal (names)`

global and nonlocal statements. `names` is a list of raw strings.

```

>>> print (ast.dump (ast.parse ('global x,y,z'), indent=4))
Module (
  body=[
    Global (
      names=[
        'x',
        'y',
        'z' ]),
    type_ignores=[])

>>> print (ast.dump (ast.parse ('nonlocal x,y,z'), indent=4))
Module (
  body=[
    Nonlocal (
      names=[
        'x',
        'y',
        'z' ]),
    type_ignores=[])

```

class `ast.ClassDef (name, bases, keywords, body, decorator_list)`

A class definition.

- `name` is a raw string for the class name
- `bases` is a list of nodes for explicitly specified base classes.
- `keywords` is a list of [keyword](#) nodes, principally for 'metaclass'. Other keywords will be passed to the metaclass, as per [PEP-3115](#).
- `body` is a list of nodes representing the code within the class definition.
- `decorator_list` is a list of nodes, as in [FunctionDef](#).

```
>>> print(ast.dump(ast.parse("""\
... @decorator1
... @decorator2
... class Foo(base1, base2, metaclass=meta):
...     pass
... """), indent=4))
Module(
  body=[
    ClassDef(
      name='Foo',
      bases=[
        Name(id='base1', ctx=Load()),
        Name(id='base2', ctx=Load())],
      keywords=[
        keyword(
          arg='metaclass',
          value=Name(id='meta', ctx=Load()))],
      body=[
        Pass()],
      decorator_list=[
        Name(id='decorator1', ctx=Load()),
        Name(id='decorator2', ctx=Load())]),
    type_ignores=[])
```

Async and await

class `ast.AsyncFunctionDef` (*name, args, body, decorator_list, returns, type_comment*)

An `async def` function definition. Has the same fields as `FunctionDef`.

class `ast.Await` (*value*)

An `await` expression. *value* is what it waits for. Only valid in the body of an `AsyncFunctionDef`.

```
>>> print(ast.dump(ast.parse("""\
... async def f():
...     await other_func()
... """), indent=4))
Module(
  body=[
    AsyncFunctionDef(
      name='f',
      args=arguments(
        posonlyargs=[],
        args=[],
        kwonlyargs=[],
        kw_defaults=[],
        defaults=[]),
      body=[
        Expr(
          value=Await(
            value=Call(
              func=Name(id='other_func', ctx=Load()),
              args=[],
              keywords=[]))),
        decorator_list=[]]),
    type_ignores=[])
```

class `ast.AsyncFor` (*target, iter, body, or_else, type_comment*)

class `ast.AsyncWith` (*items, body, type_comment*)

`async for` loops and `async with` context managers. They have the same fields as `For` and `With`, respectively. Only valid in the body of an `AsyncFunctionDef`.

備 備: When a string is parsed by `ast.parse()`, operator nodes (subclasses of `ast.operator`, `ast.unaryop`, `ast.cmpop`, `ast.boolop` and `ast.expr_context`) on the returned tree will be singletons. Changes to one will be reflected in all other occurrences of the same value (e.g. `ast.Add`).

32.1.3 ast Helpers

Apart from the node classes, the `ast` module defines these utility functions and classes for traversing abstract syntax trees:

`ast.parse(source, filename='<unknown>', mode='exec', *, type_comments=False, feature_version=None)`

Parse the source into an AST node. Equivalent to `compile(source, filename, mode, ast.PyCF_ONLY_AST)`.

If `type_comments=True` is given, the parser is modified to check and return type comments as specified by [PEP 484](#) and [PEP 526](#). This is equivalent to adding `ast.PyCF_TYPE_COMMENTS` to the flags passed to `compile()`. This will report syntax errors for misplaced type comments. Without this flag, type comments will be ignored, and the `type_comment` field on selected AST nodes will always be `None`. In addition, the locations of `# type: ignore` comments will be returned as the `type_ignores` attribute of `Module` (otherwise it is always an empty list).

In addition, if `mode` is `'func_type'`, the input syntax is modified to correspond to [PEP 484](#) "signature type comments", e.g. `(str, int) -> List[str]`.

Setting `feature_version` to a tuple (major, minor) will result in a "best-effort" attempt to parse using that Python version's grammar. For example, setting `feature_version=(3, 9)` will attempt to disallow parsing of `match` statements. Currently `major` must equal to 3. The lowest supported version is (3, 4) (and this may increase in future Python versions); the highest is `sys.version_info[0:2]`. "Best-effort" attempt means there is no guarantee that the parse (or success of the parse) is the same as when run on the Python version corresponding to `feature_version`.

If `source` contains a null character (`\0`), `ValueError` is raised.

警告: Note that successfully parsing source code into an AST object doesn't guarantee that the source code provided is valid Python code that can be executed as the compilation step can raise further `SyntaxError` exceptions. For instance, the source `return 42` generates a valid AST node for a return statement, but it cannot be compiled alone (it needs to be inside a function node).

In particular, `ast.parse()` won't do any scoping checks, which the compilation step does.

警告: It is possible to crash the Python interpreter with a sufficiently large/complex string due to stack depth limitations in Python's AST compiler.

在 3.8 版的變更: 新增 `type_comments`、`mode='func_type'` 與 `feature_version`。

`ast.unparse(ast_obj)`

Unparse an `ast.AST` object and generate a string with code that would produce an equivalent `ast.AST` object if parsed back with `ast.parse()`.

警告: The produced code string will not necessarily be equal to the original code that generated the `ast.AST` object (without any compiler optimizations, such as constant tuples/frozensets).

警告: Trying to unparse a highly complex expression would result with `RecursionError`.

在 3.9 版新加入。

`ast.literal_eval (node_or_string)`

Evaluate an expression node or a string containing only a Python literal or container display. The string or node provided may only consist of the following Python literal structures: strings, bytes, numbers, tuples, lists, dicts, sets, booleans, `None` and `Ellipsis`.

This can be used for evaluating strings containing Python values without the need to parse the values oneself. It is not capable of evaluating arbitrarily complex expressions, for example involving operators or indexing.

This function had been documented as “safe” in the past without defining what that meant. That was misleading. This is specifically designed not to execute Python code, unlike the more general `eval()`. There is no namespace, no name lookups, or ability to call out. But it is not free from attack: A relatively small input can lead to memory exhaustion or to C stack exhaustion, crashing the process. There is also the possibility for excessive CPU consumption denial of service on some inputs. Calling it on untrusted data is thus not recommended.

警告: It is possible to crash the Python interpreter due to stack depth limitations in Python’s AST compiler. It can raise `ValueError`, `TypeError`, `SyntaxError`, `MemoryError` and `RecursionError` depending on the malformed input.

在 3.2 版的變更: Now allows bytes and set literals.

在 3.9 版的變更: Now supports creating empty sets with `'set()'`.

在 3.10 版的變更: For string inputs, leading spaces and tabs are now stripped.

`ast.get_docstring (node, clean=True)`

Return the docstring of the given *node* (which must be a `FunctionDef`, `AsyncFunctionDef`, `ClassDef`, or `Module` node), or `None` if it has no docstring. If *clean* is true, clean up the docstring’s indentation with `inspect.cleandoc()`.

在 3.5 版的變更: 目前已支援 `AsyncFunctionDef`.

`ast.get_source_segment (source, node, *, padded=False)`

Get source code segment of the *source* that generated *node*. If some location information (*lineno*, *end_lineno*, *col_offset*, or *end_col_offset*) is missing, return `None`.

If *padded* is `True`, the first line of a multi-line statement will be padded with spaces to match its original position.

在 3.8 版新加入。

`ast.fix_missing_locations (node)`

When you compile a node tree with `compile()`, the compiler expects *lineno* and *col_offset* attributes for every node that supports them. This is rather tedious to fill in for generated nodes, so this helper adds these attributes recursively where not already set, by setting them to the values of the parent node. It works recursively starting at *node*.

`ast.increment_lineno (node, n=1)`

Increment the line number and end line number of each node in the tree starting at *node* by *n*. This is useful to “move code” to a different location in a file.

`ast.copy_location (new_node, old_node)`

Copy source location (*lineno*, *col_offset*, *end_lineno*, and *end_col_offset*) from *old_node* to *new_node* if possible, and return *new_node*.

`ast.iter_fields (node)`

Yield a tuple of (fieldname, value) for each field in `node._fields` that is present on `node`.

`ast.iter_child_nodes (node)`

Yield all direct child nodes of `node`, that is, all fields that are nodes and all items of fields that are lists of nodes.

`ast.walk (node)`

Recursively yield all descendant nodes in the tree starting at `node` (including `node` itself), in no specified order. This is useful if you only want to modify nodes in place and don't care about the context.

class `ast.NodeVisitor`

A node visitor base class that walks the abstract syntax tree and calls a visitor function for every node found. This function may return a value which is forwarded by the `visit()` method.

This class is meant to be subclassed, with the subclass adding visitor methods.

visit (node)

Visit a node. The default implementation calls the method called `self.visit_classname` where `classname` is the name of the node class, or `generic_visit()` if that method doesn't exist.

generic_visit (node)

This visitor calls `visit()` on all children of the node.

Note that child nodes of nodes that have a custom visitor method won't be visited unless the visitor calls `generic_visit()` or visits them itself.

visit_Constant (node)

Handles all constant nodes.

Don't use the `NodeVisitor` if you want to apply changes to nodes during traversal. For this a special visitor exists (`NodeTransformer`) that allows modifications.

在 3.8 版之後被 用: Methods `visit_Num()`, `visit_Str()`, `visit_Bytes()`, `visit_NameConstant()` and `visit_Ellipsis()` are deprecated now and will not be called in future Python versions. Add the `visit_Constant()` method to handle all constant nodes.

class `ast.NodeTransformer`

A `NodeVisitor` subclass that walks the abstract syntax tree and allows modification of nodes.

The `NodeTransformer` will walk the AST and use the return value of the visitor methods to replace or remove the old node. If the return value of the visitor method is `None`, the node will be removed from its location, otherwise it is replaced with the return value. The return value may be the original node in which case no replacement takes place.

Here is an example transformer that rewrites all occurrences of name lookups (`foo`) to `data['foo']`:

```
class RewriteName(NodeTransformer):

    def visit_Name(self, node):
        return Subscript(
            value=Name(id='data', ctx=Load()),
            slice=Constant(value=node.id),
            ctx=node.ctx
        )
```

Keep in mind that if the node you're operating on has child nodes you must either transform the child nodes yourself or call the `generic_visit()` method for the node first.

For nodes that were part of a collection of statements (that applies to all statement nodes), the visitor may also return a list of nodes rather than just a single node.

If `NodeTransformer` introduces new nodes (that weren't part of original tree) without giving them location information (such as `lineno`), `fix_missing_locations()` should be called with the new sub-tree to recalculate the location information:

```
tree = ast.parse('foo', mode='eval')
new_tree = fix_missing_locations(RewriteName().visit(tree))
```

Usually you use the transformer like this:

```
node = YourTransformer().visit(node)
```

`ast.dump` (*node*, *annotate_fields*=*True*, *include_attributes*=*False*, *, *indent*=*None*)

Return a formatted dump of the tree in *node*. This is mainly useful for debugging purposes. If *annotate_fields* is true (by default), the returned string will show the names and the values for fields. If *annotate_fields* is false, the result string will be more compact by omitting unambiguous field names. Attributes such as line numbers and column offsets are not dumped by default. If this is wanted, *include_attributes* can be set to true.

If *indent* is a non-negative integer or string, then the tree will be pretty-printed with that indent level. An indent level of 0, negative, or "" will only insert newlines. None (the default) selects the single line representation. Using a positive integer *indent* indents that many spaces per level. If *indent* is a string (such as "\t"), that string is used to indent each level.

在 3.9 版的變更: 新增 *indent* 選項。

32.1.4 Compiler Flags

The following flags may be passed to `compile()` in order to change effects on the compilation of a program:

`ast.PyCF_ALLOW_TOP_LEVEL_AWAIT`

Enables support for top-level `await`, `async for`, `async with` and `async comprehensions`.

在 3.8 版新加入。

`ast.PyCF_ONLY_AST`

Generates and returns an abstract syntax tree instead of returning a compiled code object.

`ast.PyCF_TYPE_COMMENTS`

Enables support for [PEP 484](#) and [PEP 526](#) style type comments (`# type: <type>`, `# type: ignore <stuff>`).

在 3.8 版新加入。

32.1.5 Command-Line Usage

在 3.9 版新加入。

The `ast` module can be executed as a script from the command line. It is as simple as:

```
python -m ast [-m <mode>] [-a] [infile]
```

The following options are accepted:

-h, --help

Show the help message and exit.

-m <mode>

--mode <mode>

Specify what kind of code must be compiled, like the *mode* argument in `parse()`.

--no-type-comments

Don't parse type comments.

-a, --include-attributes

Include attributes such as line numbers and column offsets.

-i <indent>**--indent <indent>**

Indentation of nodes in AST (number of spaces).

If `infile` is specified its contents are parsed to AST and dumped to stdout. Otherwise, the content is read from stdin.

也參考:

[Green Tree Snakes](#), an external documentation resource, has good details on working with Python ASTs.

[ASTTokens](#) annotates Python ASTs with the positions of tokens and text in the source code that generated them. This is helpful for tools that make source code transformations.

[leoAst.py](#) unifies the token-based and parse-tree-based views of python programs by inserting two-way links between tokens and ast nodes.

[LibCST](#) parses code as a Concrete Syntax Tree that looks like an ast tree and keeps all formatting details. It's useful for building automated refactoring (codemod) applications and linters.

[Parso](#) is a Python parser that supports error recovery and round-trip parsing for different Python versions (in multiple Python versions). Parso is also able to list multiple syntax errors in your python file.

32.2 `symtable` --- Access to the compiler's symbol tables

原始碼: [Lib/symtable.py](#)

Symbol tables are generated by the compiler from AST just before bytecode is generated. The symbol table is responsible for calculating the scope of every identifier in the code. `symtable` provides an interface to examine these tables.

32.2.1 Generating Symbol Tables

`symtable.symtable (code, filename, compile_type)`

Return the toplevel [SymbolTable](#) for the Python source *code*. *filename* is the name of the file containing the code. *compile_type* is like the *mode* argument to `compile()`.

32.2.2 Examining Symbol Tables

class `symtable.SymbolTable`

A namespace table for a block. The constructor is not public.

get_type()

Return the type of the symbol table. Possible values are 'class', 'module', and 'function'.

get_id()

Return the table's identifier.

get_name()

Return the table's name. This is the name of the class if the table is for a class, the name of the function if the table is for a function, or 'top' if the table is global (`get_type()` returns 'module').

get_lineno()

Return the number of the first line in the block this table represents.

is_optimized()

Return True if the locals in this table can be optimized.

is_nested()

Return True if the block is a nested class or function.

has_children()

Return True if the block has nested namespaces within it. These can be obtained with [*get_children\(\)*](#).

get_identifiers()

Return a view object containing the names of symbols in the table. See the [*documentation of view objects*](#).

lookup(name)

Lookup *name* in the table and return a [*Symbol*](#) instance.

get_symbols()

Return a list of [*Symbol*](#) instances for names in the table.

get_children()

Return a list of the nested symbol tables.

class symtable.Function

A namespace for a function or method. This class inherits from [*SymbolTable*](#).

get_parameters()

Return a tuple containing names of parameters to this function.

get_locals()

Return a tuple containing names of locals in this function.

get_globals()

Return a tuple containing names of globals in this function.

get_nonlocals()

Return a tuple containing names of nonlocals in this function.

get_frees()

Return a tuple containing names of free variables in this function.

class symtable.Class

A namespace of a class. This class inherits from [*SymbolTable*](#).

get_methods()

Return a tuple containing the names of methods declared in the class.

class symtable.Symbol

An entry in a [*SymbolTable*](#) corresponding to an identifier in the source. The constructor is not public.

get_name()

Return the symbol's name.

is_referenced()

Return True if the symbol is used in its block.

is_imported()

Return True if the symbol is created from an import statement.

is_parameter()

Return True if the symbol is a parameter.

is_global()

Return True if the symbol is global.

is_nonlocal()

Return True if the symbol is nonlocal.

is_declared_global()

Return True if the symbol is declared global with a global statement.

is_local()

Return True if the symbol is local to its block.

is_annotated()

Return True if the symbol is annotated.

在 3.6 版新加入。

is_free()

Return True if the symbol is referenced in its block, but not assigned to.

is_assigned()

Return True if the symbol is assigned to in its block.

is_namespace()

Return True if name binding introduces new namespace.

If the name is used as the target of a function or class statement, this will be true.

舉例來：

```
>>> table = symtable.symtable("def some_func(): pass", "string", "exec")
>>> table.lookup("some_func").is_namespace()
True
```

Note that a single name can be bound to multiple objects. If the result is True, the name may also be bound to other objects, like an int or list, that does not introduce a new namespace.

get_namespaces()

Return a list of namespaces bound to this name.

get_namespace()

Return the namespace bound to this name. If more than one or no namespace is bound to this name, a *ValueError* is raised.

32.3 token --- Constants used with Python parse trees

原始碼: [Lib/token.py](#)

This module provides constants which represent the numeric values of leaf nodes of the parse tree (terminal tokens). Refer to the file `Grammar/Tokens` in the Python distribution for the definitions of the names in the context of the language grammar. The specific numeric values which the names map to may change between Python versions.

The module also provides a mapping from numeric codes to names and some functions. The functions mirror definitions in the Python C header files.

token.tok_name

Dictionary mapping the numeric values of the constants defined in this module back to name strings, allowing more human-readable representation of parse trees to be generated.

`token.ISTERMINAL` (*x*)

Return `True` for terminal token values.

`token.ISNONTERMINAL` (*x*)

Return `True` for non-terminal token values.

`token.ISEOF` (*x*)

Return `True` if *x* is the marker indicating the end of input.

The token constants are:

`token.ENDMARKER`

`token.NAME`

`token.NUMBER`

`token.STRING`

`token.NEWLINE`

`token.INDENT`

`token.DEDENT`

`token.LPAR`

Token value for " (".

`token.RPAR`

Token value for ") ".

`token.LSQB`

Token value for " [".

`token.RSQB`

Token value for "] ".

`token.COLON`

Token value for " : ".

`token.COMMA`

Token value for " , ".

`token.SEMI`

Token value for " ; ".

`token.PLUS`

Token value for " + ".

`token.MINUS`

Token value for " - ".

`token.STAR`

Token value for " * ".

`token.SLASH`

Token value for " / ".

`token.VBAR`

Token value for " | ".

`token.AMPER`

Token value for " & ".

`token.LESS`

Token value for "<".

`token.GREATER`

Token value for ">".

`token.EQUAL`

Token value for "=".

`token.DOT`

Token value for ".".

`token.PERCENT`

Token value for "%".

`token.LBRACE`

Token value for "{".

`token.RBRACE`

Token value for "}".

`token.EQEQUAL`

Token value for "==".

`token.NOTEQUAL`

Token value for "!=".

`token.LESSEQUAL`

Token value for "<=".

`token.GREATEREQUAL`

Token value for ">=".

`token.TILDE`

Token value for "~".

`token.CIRCUMFLEX`

Token value for "^".

`token.LEFTSHIFT`

Token value for "<<".

`token.RIGHTSHIFT`

Token value for ">>".

`token.DOUBLESTAR`

Token value for "**".

`token.PLUSEQUAL`

Token value for "+=".

`token.MINEQUAL`

Token value for "-=".

`token.STAREQUAL`

Token value for "*=".

`token.SLASHEQUAL`

Token value for "/=".

`token.PERCENTEQUAL`

Token value for "%=".

`token.AMPEREQUAL`

Token value for "&=".

`token.VBAREQUAL`

Token value for "|=".

`token.CIRCUMFLEXEQUAL`

Token value for "^=".

`token.LEFTSHIFTEQUAL`

Token value for "<=".

`token.RIGHTSHIFTEQUAL`

Token value for ">=".

`token.DOUBLESTAREQUAL`

Token value for "**=".

`token.DOUBLESLASH`

Token value for "/".

`token.DOUBLESLASHEQUAL`

Token value for "/=".

`token.AT`

Token value for "@".

`token.ATEQUAL`

Token value for "@=".

`token.RARROW`

Token value for "->".

`token.ELLIPSIS`

Token value for "...".

`token.COLONEQUAL`

Token value for "!=".

`token.OP`

`token.AWAIT`

`token.ASYNC`

`token.TYPE_IGNORE`

`token.TYPE_COMMENT`

`token.SOFT_KEYWORD`

`token.ERRORTOKEN`

`token.N_TOKENS`

`token.NT_OFFSET`

The following token type values aren't used by the C tokenizer but are needed for the *tokenize* module.

`token.COMMENT`

Token value used to indicate a comment.

`token.NL`

Token value used to indicate a non-terminating newline. The *NEWLINE* token indicates the end of a logical line of Python code; NL tokens are generated when a logical line of code is continued over multiple physical lines.

`token.ENCODING`

Token value that indicates the encoding used to decode the source bytes into text. The first token returned by `tokenize.tokenize()` will always be an ENCODING token.

`token.TYPE_COMMENT`

Token value indicating that a type comment was recognized. Such tokens are only produced when `ast.parse()` is invoked with `type_comments=True`.

在 3.5 版的變更: Added *AWAIT* and *ASYNC* tokens.

在 3.7 版的變更: Added *COMMENT*, *NL* and *ENCODING* tokens.

在 3.7 版的變更: Removed *AWAIT* and *ASYNC* tokens. "async" and "await" are now tokenized as *NAME* tokens.

在 3.8 版的變更: Added *TYPE_COMMENT*, *TYPE_IGNORE*, *COLONEQUAL*. Added *AWAIT* and *ASYNC* tokens back (they're needed to support parsing older Python versions for `ast.parse()` with `feature_version` set to 6 or lower).

32.4 keyword --- 檢驗 Python 關鍵字

原始碼: [Lib/keyword.py](#)

此模組允許 Python 程式確定某個字串是否 關鍵字或軟關鍵字 (soft keyword)。

`keyword.iskeyword(s)`

如果 *s* 是一個 Python 關鍵字則回傳 True。

`keyword.kwlist`

包含直譯器定義的所有 關鍵字的序列。如果所定義的任何關鍵字僅在特定 `__future__` 陳述式生效時被 用，它們也將被包含在 。

`keyword.issoftkeyword(s)`

如果 *s* 是一個 Python 軟關鍵字則回傳 True。

在 3.9 版新加入。

`keyword.softkwlist`

包含直譯器定義的所有 軟關鍵字的序列。如果所定義的任何軟關鍵字僅在特定 `__future__` 陳述式生效時被 用，它們也將被包含在 。

在 3.9 版新加入。

32.5 tokenize --- Tokenizer for Python source

原始碼: [Lib/tokenize.py](#)

The *tokenize* module provides a lexical scanner for Python source code, implemented in Python. The scanner in this module returns comments as tokens as well, making it useful for implementing "pretty-printers", including colorizers for on-screen displays.

To simplify token stream handling, all operator and delimiter tokens and *Ellipsis* are returned using the generic *OP* token type. The exact type can be determined by checking the `exact_type` property on the *named tuple* returned from `tokenize.tokenize()`.

警告: Note that the functions in this module are only designed to parse syntactically valid Python code (code that does not raise when parsed using `ast.parse()`). The behavior of the functions in this module is **undefined** when providing invalid Python code and it can change at any point.

32.5.1 Tokenizing Input

The primary entry point is a *generator*:

`tokenize.tokenize(readline)`

The `tokenize()` generator requires one argument, *readline*, which must be a callable object which provides the same interface as the `io.IOBase.readline()` method of file objects. Each call to the function should return one line of input as bytes.

The generator produces 5-tuples with these members: the token type; the token string; a 2-tuple (`srow`, `scol`) of ints specifying the row and column where the token begins in the source; a 2-tuple (`erow`, `ecol`) of ints specifying the row and column where the token ends in the source; and the line on which the token was found. The line passed (the last tuple item) is the *physical* line. The 5 tuple is returned as a *named tuple* with the field names: `type string start end line`.

The returned *named tuple* has an additional property named `exact_type` that contains the exact operator type for *OP* tokens. For all other token types `exact_type` equals the named tuple `type` field.

在 3.1 版的變更: Added support for named tuples.

在 3.3 版的變更: Added support for `exact_type`.

`tokenize()` determines the source encoding of the file by looking for a UTF-8 BOM or encoding cookie, according to [PEP 263](#).

`tokenize.generate_tokens(readline)`

Tokenize a source reading unicode strings instead of bytes.

Like `tokenize()`, the *readline* argument is a callable returning a single line of input. However, `generate_tokens()` expects *readline* to return a str object rather than bytes.

The result is an iterator yielding named tuples, exactly like `tokenize()`. It does not yield an *ENCODING* token.

All constants from the `token` module are also exported from `tokenize`.

Another function is provided to reverse the tokenization process. This is useful for creating tools that tokenize a script, modify the token stream, and write back the modified script.

`tokenize.untokenize(iterable)`

Converts tokens back into Python source code. The *iterable* must return sequences with at least two elements, the token type and the token string. Any additional sequence elements are ignored.

The reconstructed script is returned as a single string. The result is guaranteed to tokenize back to match the input so that the conversion is lossless and round-trips are assured. The guarantee applies only to the token type and token string as the spacing between tokens (column positions) may change.

It returns bytes, encoded using the *ENCODING* token, which is the first token sequence output by `tokenize()`. If there is no encoding token in the input, it returns a str instead.

`tokenize()` needs to detect the encoding of source files it tokenizes. The function it uses to do this is available:

`tokenize.detect_encoding(readline)`

The `detect_encoding()` function is used to detect the encoding that should be used to decode a Python source file. It requires one argument, `readline`, in the same way as the `tokenize()` generator.

It will call `readline` a maximum of twice, and return the encoding used (as a string) and a list of any lines (not decoded from bytes) it has read in.

It detects the encoding from the presence of a UTF-8 BOM or an encoding cookie as specified in [PEP 263](#). If both a BOM and a cookie are present, but disagree, a `SyntaxError` will be raised. Note that if the BOM is found, `'utf-8-sig'` will be returned as an encoding.

If no encoding is specified, then the default of `'utf-8'` will be returned.

Use `open()` to open Python source files: it uses `detect_encoding()` to detect the file encoding.

`tokenize.open(filename)`

Open a file in read only mode using the encoding detected by `detect_encoding()`.

在 3.2 版新加入.

exception `tokenize.TokenError`

Raised when either a docstring or expression that may be split over several lines is not completed anywhere in the file, for example:

```
"""Beginning of
docstring
```

或是:

```
[1,
2,
3
```

Note that unclosed single-quoted strings do not cause an error to be raised. They are tokenized as `ERRORTOKEN`, followed by the tokenization of their contents.

32.5.2 Command-Line Usage

在 3.3 版新加入.

The `tokenize` module can be executed as a script from the command line. It is as simple as:

```
python -m tokenize [-e] [filename.py]
```

The following options are accepted:

-h, --help

show this help message and exit

-e, --exact

display token names using the exact type

If `filename.py` is specified its contents are tokenized to stdout. Otherwise, tokenization is performed on stdin.

32.5.3 范例

Example of a script rewriter that transforms float literals into Decimal objects:

```
from tokenize import tokenize, untokenize, NUMBER, STRING, NAME, OP
from io import BytesIO

def decistmt(s):
    """Substitute Decimals for floats in a string of statements.

    >>> from decimal import Decimal
    >>> s = 'print(+21.3e-5*-.1234/81.7)'
    >>> decistmt(s)
    "print (+Decimal ('21.3e-5')*-Decimal ('.1234')/Decimal ('81.7'))"

    The format of the exponent is inherited from the platform C library.
    Known cases are "e-007" (Windows) and "e-07" (not Windows). Since
    we're only showing 12 digits, and the 13th isn't close to 5, the
    rest of the output should be platform-independent.

    >>> exec(s) #doctest: +ELLIPSIS
    -3.21716034272e-0...7

    Output from calculations with Decimal should be identical across all
    platforms.

    >>> exec(decistmt(s))
    -3.217160342717258261933904529E-7
    """
    result = []
    g = tokenize(BytesIO(s.encode('utf-8')).readline) # tokenize the string
    for toknum, tokval, _, _, _ in g:
        if toknum == NUMBER and '.' in tokval: # replace NUMBER tokens
            result.extend([
                (NAME, 'Decimal'),
                (OP, '('),
                (STRING, repr(tokval)),
                (OP, ')')
            ])
        else:
            result.append((toknum, tokval))
    return untokenize(result).decode('utf-8')
```

Example of tokenizing from the command line. The script:

```
def say_hello():
    print("Hello, World!")

say_hello()
```

will be tokenized to the following output where the first column is the range of the line/column coordinates where the token is found, the second column is the name of the token, and the final column is the value of the token (if any)

```
$ python -m tokenize hello.py
0,0-0,0:      ENCODING      'utf-8'
1,0-1,3:      NAME          'def'
1,4-1,13:     NAME          'say_hello'
1,13-1,14:    OP            '('
1,14-1,15:    OP            ')'
1,15-1,16:    OP            ':'
1,16-1,17:    NEWLINE      '\n'
2,0-2,4:      INDENT        '    '
```

(繼續下一頁)

(繼續上一頁)

```

2,4-2,9:      NAME      'print'
2,9-2,10:     OP        '('
2,10-2,25:    STRING    '"Hello, World!'"
2,25-2,26:    OP        ')'
2,26-2,27:    NEWLINE   '\n'
3,0-3,1:      NL        '\n'
4,0-4,0:      DEDENT    ''
4,0-4,9:      NAME      'say_hello'
4,9-4,10:     OP        '('
4,10-4,11:    OP        ')'
4,11-4,12:    NEWLINE   '\n'
5,0-5,0:      ENDMARKER ''

```

The exact token type names can be displayed using the `-e` option:

```

$ python -m tokenize -e hello.py
0,0-0,0:      ENCODING   'utf-8'
1,0-1,3:      NAME       'def'
1,4-1,13:     NAME       'say_hello'
1,13-1,14:    LPAR       '('
1,14-1,15:    RPAREN     ')'
1,15-1,16:    COLON      ':'
1,16-1,17:    NEWLINE    '\n'
2,0-2,4:      INDENT     '    '
2,4-2,9:      NAME       'print'
2,9-2,10:     LPAR       '('
2,10-2,25:    STRING     '"Hello, World!'"
2,25-2,26:    RPAREN     ')'
2,26-2,27:    NEWLINE    '\n'
3,0-3,1:      NL         '\n'
4,0-4,0:      DEDENT     ''
4,0-4,9:      NAME       'say_hello'
4,9-4,10:     LPAR       '('
4,10-4,11:    RPAREN     ')'
4,11-4,12:    NEWLINE    '\n'
5,0-5,0:      ENDMARKER  ''

```

Example of tokenizing a file programmatically, reading unicode strings instead of bytes with `generate_tokens()`:

```

import tokenize

with tokenize.open('hello.py') as f:
    tokens = tokenize.generate_tokens(f.readline)
    for token in tokens:
        print(token)

```

Or reading bytes directly with `tokenize()`:

```

import tokenize

with open('hello.py', 'rb') as f:
    tokens = tokenize.tokenize(f.readline)
    for token in tokens:
        print(token)

```

32.6 tabnanny --- 偵測不良縮排

原始碼: [Lib/tabnanny.py](#)

目前現 是此模組打算以 本方式被呼叫使用，但也可以將其引入於 IDE 中 使用下方 述的 `check()` 函式。

備 註：此模組所提供的 API 很有可能會在未來的發 版本中有所變更，且有可能不具有向後相容性。

`tabnanny.check(file_or_dir)`

如果 `file_or_dir` 是個目錄且 非符號鏈接 (symbolic link)，則會遞 地在名 的 `file_or_dir` 的目錄樹 (directory tree) 中不斷下行檢查所有 `.py` 檔案。如果 `file_or_dir` 是個一般 Python 原始檔案，則 其檢查空格相關問題。診斷訊息會以 `print()` 函式輸出至標準輸出 (standard output) 當中。

`tabnanny.verbose`

標示是否要印出詳細訊息 (verbose message) 的旗標，若是以 本方式呼叫的話則可以用 `-v` 選項來增加。

`tabnanny.filename_only`

標示是否要只印出那些有空白相關問題檔案之檔名的旗標，若是以 本方式呼叫的話則可以用 `-q` 選項來設 真值。

exception `tabnanny.NannyNag`

當偵測到不良縮排時，此例外會被 `process_tokens()` 引發，會在 `check()` 中捕獲與處理。

`tabnanny.process_tokens(tokens)`

此函式被 `check()` 用來處理由 `tokenize` 生的標記 (token)。

也參考：

`tokenize` 模組

Python 原始程式碼的詞 掃描器 (lexical scanner)。

32.7 pyc1br --- Python module browser support

原始碼: [Lib/pyc1br.py](#)

The `pyc1br` module provides limited information about the functions, classes, and methods defined in a Python-coded module. The information is sufficient to implement a module browser. The information is extracted from the Python source code rather than by importing the module, so this module is safe to use with untrusted code. This restriction makes it impossible to use this module with modules not implemented in Python, including all standard and optional extension modules.

`pyc1br.readmodule(module, path=None)`

Return a dictionary mapping module-level class names to class descriptors. If possible, descriptors for imported base classes are included. Parameter `module` is a string with the name of the module to read; it may be the name of a module within a package. If given, `path` is a sequence of directory paths prepended to `sys.path`, which is used to locate the module source code.

This function is the original interface and is only kept for back compatibility. It returns a filtered version of the following.

`pyclbr.readmodule_ex(module, path=None)`

Return a dictionary-based tree containing a function or class descriptors for each function and class defined in the module with a `def` or `class` statement. The returned dictionary maps module-level function and class names to their descriptors. Nested objects are entered into the children dictionary of their parent. As with `readmodule`, *module* names the module to be read and *path* is prepended to `sys.path`. If the module being read is a package, the returned dictionary has a key `'__path__'` whose value is a list containing the package search path.

在 3.7 版新加入: Descriptors for nested definitions. They are accessed through the new `children` attribute. Each has a new `parent` attribute.

The descriptors returned by these functions are instances of `Function` and `Class` classes. Users are not expected to create instances of these classes.

32.7.1 函式物件

class `pyclbr.Function`

Class `Function` instances describe functions defined by `def` statements. They have the following attributes:

file

Name of the file in which the function is defined.

module

The name of the module defining the function described.

name

The name of the function.

lineno

The line number in the file where the definition starts.

parent

For top-level functions, `None`. For nested functions, the parent.

在 3.7 版新加入.

children

A *dictionary* mapping names to descriptors for nested functions and classes.

在 3.7 版新加入.

is_async

True for functions that are defined with the `async` prefix, False otherwise.

在 3.10 版新加入.

32.7.2 Class Objects

class `pyclbr.Class`

Class `Class` instances describe classes defined by class statements. They have the same attributes as *Functions* and two more.

file

Name of the file in which the class is defined.

module

The name of the module defining the class described.

name

The name of the class.

lineno

The line number in the file where the definition starts.

parent

For top-level classes, `None`. For nested classes, the parent.

在 3.7 版新加入.

children

A dictionary mapping names to descriptors for nested functions and classes.

在 3.7 版新加入.

super

A list of `Class` objects which describe the immediate base classes of the class being described. Classes which are named as superclasses but which are not discoverable by `readmodule_ex()` are listed as a string with the class name instead of as `Class` objects.

methods

A *dictionary* mapping method names to line numbers. This can be derived from the newer *children* dictionary, but remains for back-compatibility.

32.8 py_compile --- Compile Python source files

原始碼: [Lib/py_compile.py](#)

The `py_compile` module provides a function to generate a byte-code file from a source file, and another function used when the module source file is invoked as a script.

Though not often needed, this function can be useful when installing modules for shared use, especially if some of the users may not have permission to write the byte-code cache files in the directory containing the source code.

exception `py_compile.PyCompileError`

Exception raised when an error occurs while attempting to compile the file.

`py_compile.compile(file, cfile=None, dfile=None, doraise=False, optimize=-1, invalidation_mode=PycInvalidationMode.TIMESTAMP, quiet=0)`

Compile a source file to byte-code and write out the byte-code cache file. The source code is loaded from the file named *file*. The byte-code is written to *cfile*, which defaults to the **PEP 3147/PEP 488** path, ending in `.pyc`. For example, if *file* is `/foo/bar/baz.py` *cfile* will default to `/foo/bar/__pycache__/baz.cpython-32.pyc` for Python 3.2. If *dfile* is specified, it is used instead of *file* as the name of the source file from which source lines are obtained for display in exception tracebacks. If *doraise* is true, a `PyCompileError` is raised when an error is encountered while compiling *file*. If *doraise* is false (the default), an error string is written to `sys.stderr`, but no exception is raised. This function returns the path to byte-compiled file, i.e. whatever *cfile* value was used.

The *doraise* and *quiet* arguments determine how errors are handled while compiling file. If *quiet* is 0 or 1, and *doraise* is false, the default behaviour is enabled: an error string is written to `sys.stderr`, and the function returns `None` instead of a path. If *doraise* is true, a `PyCompileError` is raised instead. However if *quiet* is 2, no message is written, and *doraise* has no effect.

If the path that *cfile* becomes (either explicitly specified or computed) is a symlink or non-regular file, `FileExistsError` will be raised. This is to act as a warning that import will turn those paths into regular files if it is allowed to write byte-compiled files to those paths. This is a side-effect of import using file renaming to place the final byte-compiled file into place to prevent concurrent file writing issues.

optimize controls the optimization level and is passed to the built-in `compile()` function. The default of `-1` selects the optimization level of the current interpreter.

invalidation_mode should be a member of the `PycInvalidationMode` enum and controls how the generated bytecode cache is invalidated at runtime. The default is `PycInvalidationMode.CHECKED_HASH` if the `SOURCE_DATE_EPOCH` environment variable is set, otherwise the default is `PycInvalidationMode.TIMESTAMP`.

在 3.2 版的變更: Changed default value of *cfile* to be **PEP 3147**-compliant. Previous default was `file + 'c'` ('o' if optimization was enabled). Also added the *optimize* parameter.

在 3.4 版的變更: Changed code to use `importlib` for the byte-code cache file writing. This means file creation/writing semantics now match what `importlib` does, e.g. permissions, write-and-move semantics, etc. Also added the caveat that `FileExistsError` is raised if *cfile* is a symlink or non-regular file.

在 3.7 版的變更: The *invalidation_mode* parameter was added as specified in **PEP 552**. If the `SOURCE_DATE_EPOCH` environment variable is set, *invalidation_mode* will be forced to `PycInvalidationMode.CHECKED_HASH`.

在 3.7.2 版的變更: The `SOURCE_DATE_EPOCH` environment variable no longer overrides the value of the *invalidation_mode* argument, and determines its default value instead.

在 3.8 版的變更: 新增 *quiet* 參數。

class `py_compile.PycInvalidationMode`

An enumeration of possible methods the interpreter can use to determine whether a bytecode file is up to date with a source file. The `.pyc` file indicates the desired invalidation mode in its header. See `pyc-invalidation` for more information on how Python invalidates `.pyc` files at runtime.

在 3.7 版新加入。

TIMESTAMP

The `.pyc` file includes the timestamp and size of the source file, which Python will compare against the metadata of the source file at runtime to determine if the `.pyc` file needs to be regenerated.

CHECKED_HASH

The `.pyc` file includes a hash of the source file content, which Python will compare against the source at runtime to determine if the `.pyc` file needs to be regenerated.

UNCHECKED_HASH

Like `CHECKED_HASH`, the `.pyc` file includes a hash of the source file content. However, Python will at runtime assume the `.pyc` file is up to date and not validate the `.pyc` against the source file at all.

This option is useful when the `.pycs` are kept up to date by some system external to Python like a build system.

32.8.1 Command-Line Interface

This module can be invoked as a script to compile several source files. The files named in *filenames* are compiled and the resulting bytecode is cached in the normal manner. This program does not search a directory structure to locate source files; it only compiles files named explicitly. The exit status is nonzero if one of the files could not be compiled.

<file> ... **<fileN>**

–

Positional arguments are files to compile. If – is the only parameter, the list of files is taken from standard input.

-q, --quiet

Suppress errors output.

在 3.2 版的變更: 新增對 – 的支援。

在 3.10 版的變更: 新增對 -q 的支援。

也參考:

compileall 模組

Utilities to compile all Python source files in a directory tree.

32.9 compileall --- Byte-compile Python libraries

原始碼: [Lib/compileall.py](#)

This module provides some utility functions to support installing Python libraries. These functions compile Python source files in a directory tree. This module can be used to create the cached byte-code files at library installation time, which makes them available for use even by users who don't have write permission to the library directories.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

32.9.1 Command-line use

This module can work as a script (using `python -m compileall`) to compile Python sources.

directory ...

file ...

Positional arguments are files to compile or directories that contain source files, traversed recursively. If no argument is given, behave as if the command line was `-l <directories from sys.path>`.

-l

Do not recurse into subdirectories, only compile source code files directly contained in the named or implied directories.

-f

Force rebuild even if timestamps are up-to-date.

-q

Do not print the list of files compiled. If passed once, error messages will still be printed. If passed twice (`-qq`), all output is suppressed.

-d *destdir*

Directory prepended to the path to each file being compiled. This will appear in compilation time tracebacks, and is also compiled in to the byte-code file, where it will be used in tracebacks and other messages in cases where the source file does not exist at the time the byte-code file is executed.

-s *strip_prefix*

-p *prepend_prefix*

Remove (`-s`) or append (`-p`) the given prefix of paths recorded in the `.pyc` files. Cannot be combined with `-d`.

-x *regex*

regex is used to search the full path to each file considered for compilation, and if the regex produces a match, the file is skipped.

-i *list*

Read the file *list* and add each line that it contains to the list of files and directories to compile. If *list* is `-`, read lines from `stdin`.

-b

Write the byte-code files to their legacy locations and names, which may overwrite byte-code files created by another version of Python. The default is to write files to their **PEP 3147** locations and names, which allows byte-code files from multiple versions of Python to coexist.

-r

Control the maximum recursion level for subdirectories. If this is given, then `-l` option will not be taken into account. `python -m compileall <directory> -r 0` is equivalent to `python -m compileall <directory> -l`.

-j N

Use *N* workers to compile the files within the given directory. If 0 is used, then the result of `os.cpu_count()` will be used.

--invalidation-mode [timestamp|checked-hash|unchecked-hash]

Control how the generated byte-code files are invalidated at runtime. The `timestamp` value, means that `.pyc` files with the source timestamp and size embedded will be generated. The `checked-hash` and `unchecked-hash` values cause hash-based pycs to be generated. Hash-based pycs embed a hash of the source file contents rather than a timestamp. See `pyc-invalidation` for more information on how Python validates bytecode cache files at runtime. The default is `timestamp` if the `SOURCE_DATE_EPOCH` environment variable is not set, and `checked-hash` if the `SOURCE_DATE_EPOCH` environment variable is set.

-o level

Compile with the given optimization level. May be used multiple times to compile for multiple levels at a time (for example, `compileall -o 1 -o 2`).

-e dir

Ignore symlinks pointing outside the given directory.

--hardlink-dupes

If two `.pyc` files with different optimization level have the same content, use hard links to consolidate duplicate files.

在 3.2 版的變更: 新增選項 `-i`、`-b` 與 `-h`。

在 3.5 版的變更: Added the `-j`, `-r`, and `-qq` options. `-q` option was changed to a multilevel value. `-b` will always produce a byte-code file ending in `.pyc`, never `.pyo`.

在 3.7 版的變更: 新增選項 `--invalidation-mode`。

在 3.9 版的變更: Added the `-s`, `-p`, `-e` and `--hardlink-dupes` options. Raised the default recursion limit from 10 to `sys.getrecursionlimit()`. Added the possibility to specify the `-o` option multiple times.

There is no command-line option to control the optimization level used by the `compile()` function, because the Python interpreter itself already provides the option: `python -O -m compileall`.

Similarly, the `compile()` function respects the `sys.pycache_prefix` setting. The generated bytecode cache will only be useful if `compile()` is run with the same `sys.pycache_prefix` (if any) that will be used at runtime.

32.9.2 Public functions

```
compileall.compile_dir(dir, maxlevels=sys.getrecursionlimit(), ddir=None, force=False, rx=None,
                        quiet=0, legacy=False, optimize=-1, workers=1, invalidation_mode=None, *,
                        stripdir=None, prependdir=None, limit_sl_dest=None, hardlink_dupes=False)
```

Recursively descend the directory tree named by *dir*, compiling all `.py` files along the way. Return a true value if all the files compiled successfully, and a false value otherwise.

The *maxlevels* parameter is used to limit the depth of the recursion; it defaults to `sys.getrecursionlimit()`.

If *ddir* is given, it is prepended to the path to each file being compiled for use in compilation time tracebacks, and is also compiled in to the byte-code file, where it will be used in tracebacks and other messages in cases where the source file does not exist at the time the byte-code file is executed.

If *force* is true, modules are re-compiled even if the timestamps are up to date.

If *rx* is given, its `search` method is called on the complete path to each file considered for compilation, and if it returns a true value, the file is skipped. This can be used to exclude files matching a regular expression, given as a *re.Pattern* object.

If *quiet* is `False` or 0 (the default), the filenames and other information are printed to standard out. Set to 1, only errors are printed. Set to 2, all output is suppressed.

If *legacy* is true, byte-code files are written to their legacy locations and names, which may overwrite byte-code files created by another version of Python. The default is to write files to their **PEP 3147** locations and names, which allows byte-code files from multiple versions of Python to coexist.

optimize specifies the optimization level for the compiler. It is passed to the built-in `compile()` function. Accepts also a sequence of optimization levels which lead to multiple compilations of one `.py` file in one call.

The argument *workers* specifies how many workers are used to compile files in parallel. The default is to not use multiple workers. If the platform can't use multiple workers and *workers* argument is given, then sequential compilation will be used as a fallback. If *workers* is 0, the number of cores in the system is used. If *workers* is lower than 0, a *ValueError* will be raised.

invalidation_mode should be a member of the `py_compile.PycInvalidationMode` enum and controls how the generated pycs are invalidated at runtime.

The *stripdir*, *prependdir* and *limit_sl_dest* arguments correspond to the `-s`, `-p` and `-e` options described above. They may be specified as `str` or *os.PathLike*.

If *hardlink_dupes* is true and two `.pyc` files with different optimization level have the same content, use hard links to consolidate duplicate files.

在 3.2 版的變更: 新增 *legacy* 與 *optimize* 參數。

在 3.5 版的變更: 新增 *workers* 參數。

在 3.5 版的變更: *quiet* parameter was changed to a multilevel value.

在 3.5 版的變更: The *legacy* parameter only writes out `.pyc` files, not `.pyo` files no matter what the value of *optimize* is.

在 3.6 版的變更: Accepts a *path-like object*.

在 3.7 版的變更: 新增 *invalidation_mode* 參數。

在 3.7.2 版的變更: The *invalidation_mode* parameter's default value is updated to `None`.

在 3.8 版的變更: Setting *workers* to 0 now chooses the optimal number of cores.

在 3.9 版的變更: Added *stripdir*, *prependdir*, *limit_sl_dest* and *hardlink_dupes* arguments. Default value of *maxlevels* was changed from 10 to `sys.getrecursionlimit()`

```
compileall.compile_file(fullname, ddir=None, force=False, rx=None, quiet=0, legacy=False,
                        optimize=-1, invalidation_mode=None, *, stripdir=None, prependdir=None,
                        limit_sl_dest=None, hardlink_dupes=False)
```

Compile the file with path *fullname*. Return a true value if the file compiled successfully, and a false value otherwise.

If *ddir* is given, it is prepended to the path to the file being compiled for use in compilation time tracebacks, and is also compiled in to the byte-code file, where it will be used in tracebacks and other messages in cases where the source file does not exist at the time the byte-code file is executed.

If *rx* is given, its `search` method is passed the full path name to the file being compiled, and if it returns a true value, the file is not compiled and `True` is returned. This can be used to exclude files matching a regular expression, given as a *re.Pattern* object.

If *quiet* is `False` or 0 (the default), the filenames and other information are printed to standard out. Set to 1, only errors are printed. Set to 2, all output is suppressed.

If *legacy* is true, byte-code files are written to their legacy locations and names, which may overwrite byte-code files created by another version of Python. The default is to write files to their [PEP 3147](#) locations and names, which allows byte-code files from multiple versions of Python to coexist.

optimize specifies the optimization level for the compiler. It is passed to the built-in `compile()` function. Accepts also a sequence of optimization levels which lead to multiple compilations of one `.py` file in one call.

invalidation_mode should be a member of the `py_compile.PycInvalidationMode` enum and controls how the generated pycs are invalidated at runtime.

The *stripdir*, *prependdir* and *limit_sl_dest* arguments correspond to the `-s`, `-p` and `-e` options described above. They may be specified as `str` or `os.PathLike`.

If *hardlink_dupes* is true and two `.pyc` files with different optimization level have the same content, use hard links to consolidate duplicate files.

在 3.2 版新加入。

在 3.5 版的變更: *quiet* parameter was changed to a multilevel value.

在 3.5 版的變更: The *legacy* parameter only writes out `.pyc` files, not `.pyo` files no matter what the value of *optimize* is.

在 3.7 版的變更: 新增 *invalidation_mode* 參數。

在 3.7.2 版的變更: The *invalidation_mode* parameter's default value is updated to `None`.

在 3.9 版的變更: Added *stripdir*, *prependdir*, *limit_sl_dest* and *hardlink_dupes* arguments.

```
compileall.compile_path(skip_curdir=True, maxlevels=0, force=False, quiet=0, legacy=False,
                        optimize=-1, invalidation_mode=None)
```

Byte-compile all the `.py` files found along `sys.path`. Return a true value if all the files compiled successfully, and a false value otherwise.

If *skip_curdir* is true (the default), the current directory is not included in the search. All other parameters are passed to the `compile_dir()` function. Note that unlike the other compile functions, *maxlevels* defaults to 0.

在 3.2 版的變更: 新增 *legacy* 與 *optimize* 參數。

在 3.5 版的變更: *quiet* parameter was changed to a multilevel value.

在 3.5 版的變更: The *legacy* parameter only writes out `.pyc` files, not `.pyo` files no matter what the value of *optimize* is.

在 3.7 版的變更: 新增 *invalidation_mode* 參數。

在 3.7.2 版的變更: The *invalidation_mode* parameter's default value is updated to `None`.

To force a recompile of all the `.py` files in the `Lib/` subdirectory and all its subdirectories:

```
import compileall

compileall.compile_dir('Lib/', force=True)

# Perform same compilation, excluding files in .svn directories.
import re
compileall.compile_dir('Lib/', rx=re.compile(r'[/\\][.]svn'), force=True)

# pathlib.Path objects can also be used.
import pathlib
compileall.compile_dir(pathlib.Path('Lib/'), force=True)
```

也參考:

`py_compile` 模組

Byte-compile a single source file.

32.10 `dis` --- Python bytecode 的反組譯器

原始碼: [Lib/dis.py](#)

`dis` 模組支援反組譯分析 CPython *bytecode*。CPython bytecode 作輸入的模組被定義於 `Include/opcode.h` 且被編譯器和直譯器所使用。

CPython 實作細節： Bytecode is an implementation detail of the CPython interpreter. No guarantees are made that bytecode will not be added, removed, or changed between versions of Python. Use of this module should not be considered to work across Python VMs or Python releases.

在 3.6 版的變更: Use 2 bytes for each instruction. Previously the number of bytes varied by instruction.

在 3.10 版的變更: The argument of jump, exception handling and loop instructions is now the instruction offset rather than the byte offset.

在 3.11 版的變更: Some instructions are accompanied by one or more inline cache entries, which take the form of *CACHE* instructions. These instructions are hidden by default, but can be shown by passing `show_caches=True` to any `dis` utility. Furthermore, the interpreter now adapts the bytecode to specialize it for different runtime conditions. The adaptive bytecode can be shown by passing `adaptive=True`.

Example: Given the function `myfunc()`:

```
def myfunc(alist):
    return len(alist)
```

the following command can be used to display the disassembly of `myfunc()`:

```
>>> dis.dis(myfunc)
2           0 RESUME                0

3           2 LOAD_GLOBAL            1 (NULL + len)
          14 LOAD_FAST                0 (alist)
          16 PRECALL                  1
          20 CALL                     1
          30 RETURN_VALUE
```

(The "2" is a line number).

32.10.1 Command-line interface

The `dis` module can be invoked as a script from the command line:

```
python -m dis [-h] [-C] [infile]
```

The following options are accepted:

-h, --help

Display usage and exit.

-C, --show-caches

Show inline caches.

If `infile` is specified, its disassembled code will be written to stdout. Otherwise, disassembly is performed on compiled source code recieved from stdin.

32.10.2 Bytecode analysis

在 3.4 版新加入。

The bytecode analysis API allows pieces of Python code to be wrapped in a *Bytecode* object that provides easy access to details of the compiled code.

class `dis.Bytecode` (*x*, *, *first_line=None*, *current_offset=None*, *show_caches=False*, *adaptive=False*)

Analyse the bytecode corresponding to a function, generator, asynchronous generator, coroutine, method, string of source code, or a code object (as returned by `compile()`).

This is a convenience wrapper around many of the functions listed below, most notably `get_instructions()`, as iterating over a *Bytecode* instance yields the bytecode operations as *Instruction* instances.

If *first_line* is not `None`, it indicates the line number that should be reported for the first source line in the disassembled code. Otherwise, the source line information (if any) is taken directly from the disassembled code object.

If *current_offset* is not `None`, it refers to an instruction offset in the disassembled code. Setting this means `dis()` will display a "current instruction" marker against the specified opcode.

If *show_caches* is `True`, `dis()` will display inline cache entries used by the interpreter to specialize the bytecode.

If *adaptive* is `True`, `dis()` will display specialized bytecode that may be different from the original bytecode.

classmethod `from_traceback` (*tb*, *, *show_caches=False*)

Construct a *Bytecode* instance from the given traceback, setting *current_offset* to the instruction responsible for the exception.

codeobj

The compiled code object.

first_line

The first source line of the code object (if available)

dis()

Return a formatted view of the bytecode operations (the same as printed by `dis.dis()`, but returned as a multi-line string).

info()

Return a formatted multi-line string with detailed information about the code object, like `code_info()`.

在 3.7 版的變更: This can now handle coroutine and asynchronous generator objects.

在 3.11 版的變更: 新增 *show_caches* 與 *adaptive* 參數。

範例:

```
>>> bytecode = dis.Bytecode(myfunc)
>>> for instr in bytecode:
...     print(instr.opname)
...
RESUME
LOAD_GLOBAL
LOAD_FAST
PRECALL
CALL
RETURN_VALUE
```

32.10.3 Analysis functions

The `dis` module also defines the following analysis functions that convert the input directly to the desired output. They can be useful if only a single operation is being performed, so the intermediate analysis object isn't useful:

`dis.code_info(x)`

Return a formatted multi-line string with detailed code object information for the supplied function, generator, asynchronous generator, coroutine, method, source code string or code object.

Note that the exact contents of code info strings are highly implementation dependent and they may change arbitrarily across Python VMs or Python releases.

在 3.2 版新加入。

在 3.7 版的變更: This can now handle coroutine and asynchronous generator objects.

`dis.show_code(x, *, file=None)`

Print detailed code object information for the supplied function, method, source code string or code object to `file` (or `sys.stdout` if `file` is not specified).

This is a convenient shorthand for `print(code_info(x), file=file)`, intended for interactive exploration at the interpreter prompt.

在 3.2 版新加入。

在 3.4 版的變更: 新增 `file` 參數。

`dis.dis(x=None, *, file=None, depth=None, show_caches=False, adaptive=False)`

Disassemble the `x` object. `x` can denote either a module, a class, a method, a function, a generator, an asynchronous generator, a coroutine, a code object, a string of source code or a byte sequence of raw bytecode. For a module, it disassembles all functions. For a class, it disassembles all methods (including class and static methods). For a code object or sequence of raw bytecode, it prints one line per bytecode instruction. It also recursively disassembles nested code objects (the code of comprehensions, generator expressions and nested functions, and the code used for building nested classes). Strings are first compiled to code objects with the `compile()` built-in function before being disassembled. If no object is provided, this function disassembles the last traceback.

The disassembly is written as text to the supplied `file` argument if provided and to `sys.stdout` otherwise.

The maximal depth of recursion is limited by `depth` unless it is `None`. `depth=0` means no recursion.

If `show_caches` is `True`, this function will display inline cache entries used by the interpreter to specialize the bytecode.

If `adaptive` is `True`, this function will display specialized bytecode that may be different from the original bytecode.

在 3.4 版的變更: 新增 `file` 參數。

在 3.7 版的變更: Implemented recursive disassembling and added `depth` parameter.

在 3.7 版的變更: This can now handle coroutine and asynchronous generator objects.

在 3.11 版的變更: 新增 `show_caches` 與 `adaptive` 參數。

`dis.distb(tb=None, *, file=None, show_caches=False, adaptive=False)`

Disassemble the top-of-stack function of a traceback, using the last traceback if none was passed. The instruction causing the exception is indicated.

The disassembly is written as text to the supplied `file` argument if provided and to `sys.stdout` otherwise.

在 3.4 版的變更: 新增 `file` 參數。

在 3.11 版的變更: 新增 `show_caches` 與 `adaptive` 參數。

`dis.disassemble(code, lasti=-1, *, file=None, show_caches=False, adaptive=False)`

`dis.disco` (*code*, *lasti*=-1, *, *file*=None, *show_caches*=False, *adaptive*=False)

Disassemble a code object, indicating the last instruction if *lasti* was provided. The output is divided in the following columns:

1. the line number, for the first instruction of each line
2. the current instruction, indicated as -->,
3. a labelled instruction, indicated with >>.,
4. the address of the instruction,
5. the operation code name,
6. operation parameters, and
7. interpretation of the parameters in parentheses.

The parameter interpretation recognizes local and global variable names, constant values, branch targets, and compare operators.

The disassembly is written as text to the supplied *file* argument if provided and to `sys.stdout` otherwise.

在 3.4 版的變更: 新增 *file* 參數。

在 3.11 版的變更: 新增 *show_caches* 與 *adaptive* 參數。

`dis.get_instructions` (*x*, *, *first_line*=None, *show_caches*=False, *adaptive*=False)

Return an iterator over the instructions in the supplied function, method, source code string or code object.

The iterator generates a series of *Instruction* named tuples giving the details of each operation in the supplied code.

If *first_line* is not None, it indicates the line number that should be reported for the first source line in the disassembled code. Otherwise, the source line information (if any) is taken directly from the disassembled code object.

The *show_caches* and *adaptive* parameters work as they do in `dis()`.

在 3.4 版新加入。

在 3.11 版的變更: 新增 *show_caches* 與 *adaptive* 參數。

`dis.findlinestarts` (*code*)

This generator function uses the `co_lines()` method of the code object *code* to find the offsets which are starts of lines in the source code. They are generated as (*offset*, *lineno*) pairs.

在 3.6 版的變更: Line numbers can be decreasing. Before, they were always increasing.

在 3.10 版的變更: The **PEP 626** `co_lines()` method is used instead of the `co_firstlineno` and `co_notab` attributes of the code object.

`dis.findlabels` (*code*)

Detect all offsets in the raw compiled bytecode string *code* which are jump targets, and return a list of these offsets.

`dis.stack_effect` (*opcode*, *oparg*=None, *, *jump*=None)

Compute the stack effect of *opcode* with argument *oparg*.

If the code has a jump target and *jump* is True, `stack_effect()` will return the stack effect of jumping. If *jump* is False, it will return the stack effect of not jumping. And if *jump* is None (default), it will return the maximal stack effect of both cases.

在 3.4 版新加入。

在 3.8 版的變更: 新增 *jump* 參數。

32.10.4 Python Bytecode Instructions

The `get_instructions()` function and `Bytecode` class provide details of bytecode instructions as `Instruction` instances:

class `dis.Instruction`

Details for a bytecode operation

opcode

numeric code for operation, corresponding to the opcode values listed below and the bytecode values in the *Opcode collections*.

opname

human readable name for operation

arg

numeric argument to operation (if any), otherwise `None`

argval

resolved arg value (if any), otherwise `None`

argrepr

human readable description of operation argument (if any), otherwise an empty string.

offset

start index of operation within bytecode sequence

starts_line

line started by this opcode (if any), otherwise `None`

is_jump_target

`True` if other code jumps to here, otherwise `False`

positions

`dis.Positions` object holding the start and end locations that are covered by this instruction.

在 3.4 版新加入.

在 3.11 版的變更: Field `positions` is added.

class `dis.Positions`

In case the information is not available, some fields might be `None`.

lineno

end_lineno

col_offset

end_col_offset

在 3.11 版新加入.

The Python compiler currently generates the following bytecode instructions.

General instructions

NOP

Do nothing code. Used as a placeholder by the bytecode optimizer, and to generate line tracing events.

POP_TOP

Removes the top-of-stack (TOS) item.

COPY (*i*)

Push the *i*-th item to the top of the stack. The item is not removed from its original location.

在 3.11 版新加入。

SWAP (*i*)

Swap TOS with the item at position *i*.

在 3.11 版新加入。

CACHE

Rather than being an actual instruction, this opcode is used to mark extra space for the interpreter to cache useful data directly in the bytecode itself. It is automatically hidden by all `dis` utilities, but can be viewed with `show_caches=True`.

Logically, this space is part of the preceding instruction. Many opcodes expect to be followed by an exact number of caches, and will instruct the interpreter to skip over them at runtime.

Populated caches can look like arbitrary instructions, so great care should be taken when reading or modifying raw, adaptive bytecode containing quickened data.

在 3.11 版新加入。

Unary operations

Unary operations take the top of the stack, apply the operation, and push the result back on the stack.

UNARY_POSITIVE

Implements `TOS = +TOS`.

UNARY_NEGATIVE

Implements `TOS = -TOS`.

UNARY_NOT

Implements `TOS = not TOS`.

UNARY_INVERT

Implements `TOS = ~TOS`.

GET_ITER

Implements `TOS = iter(TOS)`.

GET_YIELD_FROM_ITER

If TOS is a [generator iterator](#) or [coroutine](#) object it is left as is. Otherwise, implements `TOS = iter(TOS)`.

在 3.5 版新加入。

Binary and in-place operations

Binary operations remove the top of the stack (TOS) and the second top-most stack item (TOS1) from the stack. They perform the operation, and put the result back on the stack.

In-place operations are like binary operations, in that they remove TOS and TOS1, and push the result back on the stack, but the operation is done in-place when TOS1 supports it, and the resulting TOS may be (but does not have to be) the original TOS1.

BINARY_OP (*op*)

Implements the binary and in-place operators (depending on the value of *op*).

在 3.11 版新加入。

BINARY_SUBSCR

Implements `TOS = TOS1[TOS]`.

STORE_SUBSCR

Implements `TOS1[TOS] = TOS2`.

DELETE_SUBSCR

Implements `del TOS1[TOS]`.

Coroutine opcodes**GET_AWAITABLE** (*where*)

Implements `TOS = get_awaitable(TOS)`, where `get_awaitable(o)` returns `o` if `o` is a coroutine object or a generator object with the `CO_ITERABLE_COROUTINE` flag, or resolves `o.__await__`.

If the `where` operand is nonzero, it indicates where the instruction occurs:

- 1 After a call to `__aenter__`
- 2 After a call to `__aexit__`

在 3.5 版新加入.

在 3.11 版的變更: Previously, this instruction did not have an `oparg`.

GET_AITER

Implements `TOS = TOS.__aiter__()`.

在 3.5 版新加入.

在 3.7 版的變更: Returning awaitable objects from `__aiter__` is no longer supported.

GET_ANEXT

Pushes `get_awaitable(TOS.__anext__())` to the stack. See `GET_AWAITABLE` for details about `get_awaitable`.

在 3.5 版新加入.

END_ASYNC_FOR

Terminates an `async for` loop. Handles an exception raised when awaiting a next item. The stack contains the `async iterable` in `TOS1` and the raised exception in `TOS`. Both are popped. If the exception is not [StopAsyncIteration](#), it is re-raised.

在 3.8 版新加入.

在 3.11 版的變更: Exception representation on the stack now consist of one, not three, items.

BEFORE_ASYNC_WITH

Resolves `__aenter__` and `__aexit__` from the object on top of the stack. Pushes `__aexit__` and result of `__aenter__()` to the stack.

在 3.5 版新加入.

Miscellaneous opcodes**PRINT_EXPR**

Implements the expression statement for the interactive mode. `TOS` is removed from the stack and printed. In non-interactive mode, an expression statement is terminated with [POP_TOP](#).

SET_ADD (*i*)

Calls `set.add(TOS1[-i], TOS)`. Used to implement set comprehensions.

LIST_APPEND (*i*)

Calls `list.append(TOS1[-i], TOS)`. Used to implement list comprehensions.

MAP_ADD (*i*)

Calls `dict.__setitem__(TOS1[-i], TOS1, TOS)`. Used to implement dict comprehensions.

在 3.1 版新加入.

在 3.8 版的變更: Map value is `TOS` and map key is `TOS1`. Before, those were reversed.

For all of the [SET_ADD](#), [LIST_APPEND](#) and [MAP_ADD](#) instructions, while the added value or key/value pair is popped off, the container object remains on the stack so that it is available for further iterations of the loop.

RETURN_VALUE

Returns with TOS to the caller of the function.

YIELD_VALUE

Pops TOS and yields it from a *generator*.

SETUP_ANNOTATIONS

Checks whether `__annotations__` is defined in `locals()`, if not it is set up to an empty dict. This opcode is only emitted if a class or module body contains *variable annotations* statically.

在 3.6 版新加入。

IMPORT_STAR

Loads all symbols not starting with `'_'` directly from the module TOS to the local namespace. The module is popped after loading all names. This opcode implements `from module import *`.

POP_EXCEPT

Pops a value from the stack, which is used to restore the exception state.

在 3.11 版的變更: Exception representation on the stack now consist of one, not three, items.

RERAISE

Re-raises the exception currently on top of the stack. If `oparg` is non-zero, pops an additional value from the stack which is used to set `f_lasti` of the current frame.

在 3.9 版新加入。

在 3.11 版的變更: Exception representation on the stack now consist of one, not three, items.

PUSH_EXC_INFO

Pops a value from the stack. Pushes the current exception to the top of the stack. Pushes the value originally popped back to the stack. Used in exception handlers.

在 3.11 版新加入。

CHECK_EXC_MATCH

Performs exception matching for `except`. Tests whether the TOS1 is an exception matching TOS. Pops TOS and pushes the boolean result of the test.

在 3.11 版新加入。

CHECK_EG_MATCH

Performs exception matching for `except*`. Applies `split(TOS)` on the exception group representing TOS1.

In case of a match, pops two items from the stack and pushes the non-matching subgroup (`None` in case of full match) followed by the matching subgroup. When there is no match, pops one item (the match type) and pushes `None`.

在 3.11 版新加入。

PREP_RERAISE_STAR

Combines the raised and reraised exceptions list from TOS, into an exception group to propagate from a `try-except*` block. Uses the original exception group from TOS1 to reconstruct the structure of reraised exceptions. Pops two items from the stack and pushes the exception to reraise or `None` if there isn't one.

在 3.11 版新加入。

WITH_EXCEPT_START

Calls the function in position 4 on the stack with arguments (`type`, `val`, `tb`) representing the exception at the top of the stack. Used to implement the call `context_manager.__exit__(*exc_info())` when an exception has occurred in a `with` statement.

在 3.9 版新加入。

在 3.11 版的變更: The `__exit__` function is in position 4 of the stack rather than 7. Exception representation on the stack now consist of one, not three, items.

LOAD_ASSERTION_ERROR

Pushes `AssertionError` onto the stack. Used by the `assert` statement.

在 3.9 版新加入。

LOAD_BUILD_CLASS

Pushes `builtins.__build_class__()` onto the stack. It is later called to construct a class.

BEFORE_WITH (*delta*)

This opcode performs several operations before a `with` block starts. First, it loads `__exit__()` from the context manager and pushes it onto the stack for later use by `WITH_EXCEPT_START`. Then, `__enter__()` is called. Finally, the result of calling the `__enter__()` method is pushed onto the stack.

在 3.11 版新加入。

GET_LEN

Push `len(TOS)` onto the stack.

在 3.10 版新加入。

MATCH_MAPPING

If TOS is an instance of `collections.abc.Mapping` (or, more technically: if it has the `Py_TPFLAGS_MAPPING` flag set in its `tp_flags`), push `True` onto the stack. Otherwise, push `False`.

在 3.10 版新加入。

MATCH_SEQUENCE

If TOS is an instance of `collections.abc.Sequence` and is *not* an instance of `str/bytes/bytearray` (or, more technically: if it has the `Py_TPFLAGS_SEQUENCE` flag set in its `tp_flags`), push `True` onto the stack. Otherwise, push `False`.

在 3.10 版新加入。

MATCH_KEYS

TOS is a tuple of mapping keys, and TOS1 is the match subject. If TOS1 contains all of the keys in TOS, push a `tuple` containing the corresponding values. Otherwise, push `None`.

在 3.10 版新加入。

在 3.11 版的變更: Previously, this instruction also pushed a boolean value indicating success (`True`) or failure (`False`).

STORE_NAME (*namei*)

Implements `name = TOS`. *namei* is the index of *name* in the attribute `co_names` of the code object. The compiler tries to use `STORE_FAST` or `STORE_GLOBAL` if possible.

DELETE_NAME (*namei*)

Implements `del name`, where *namei* is the index into `co_names` attribute of the code object.

UNPACK_SEQUENCE (*count*)

Unpacks TOS into *count* individual values, which are put onto the stack right-to-left.

UNPACK_EX (*counts*)

Implements assignment with a starred target: Unpacks an iterable in TOS into individual values, where the total number of values can be smaller than the number of items in the iterable: one of the new values will be a list of all leftover items.

The low byte of *counts* is the number of values before the list value, the high byte of *counts* the number of values after it. The resulting values are put onto the stack right-to-left.

STORE_ATTR (*namei*)

Implements `TOS.name = TOS1`, where *namei* is the index of *name* in `co_names`.

DELETE_ATTR (*namei*)

Implements `del TOS.name`, using *namei* as index into `co_names` of the code object.

STORE_GLOBAL (*namei*)

Works as *STORE_NAME*, but stores the name as a global.

DELETE_GLOBAL (*namei*)

Works as *DELETE_NAME*, but deletes a global name.

LOAD_CONST (*consti*)

Pushes `co_consts[consti]` onto the stack.

LOAD_NAME (*namei*)

Pushes the value associated with `co_names[namei]` onto the stack.

BUILD_TUPLE (*count*)

Creates a tuple consuming *count* items from the stack, and pushes the resulting tuple onto the stack.

BUILD_LIST (*count*)

Works as *BUILD_TUPLE*, but creates a list.

BUILD_SET (*count*)

Works as *BUILD_TUPLE*, but creates a set.

BUILD_MAP (*count*)

Pushes a new dictionary object onto the stack. Pops $2 * \text{count}$ items so that the dictionary holds *count* entries: `{..., TOS3: TOS2, TOS1: TOS}`.

在 3.5 版的變更: The dictionary is created from stack items instead of creating an empty dictionary pre-sized to hold *count* items.

BUILD_CONST_KEY_MAP (*count*)

The version of *BUILD_MAP* specialized for constant keys. Pops the top element on the stack which contains a tuple of keys, then starting from `TOS1`, pops *count* values to form values in the built dictionary.

在 3.6 版新加入.

BUILD_STRING (*count*)

Concatenates *count* strings from the stack and pushes the resulting string onto the stack.

在 3.6 版新加入.

LIST_TO_TUPLE

Pops a list from the stack and pushes a tuple containing the same values.

在 3.9 版新加入.

LIST_EXTEND (*i*)

Calls `list.extend(TOS1[-i], TOS)`. Used to build lists.

在 3.9 版新加入.

SET_UPDATE (*i*)

Calls `set.update(TOS1[-i], TOS)`. Used to build sets.

在 3.9 版新加入.

DICT_UPDATE (*i*)

Calls `dict.update(TOS1[-i], TOS)`. Used to build dicts.

在 3.9 版新加入.

DICT_MERGE (*i*)

Like *DICT_UPDATE* but raises an exception for duplicate keys.

在 3.9 版新加入.

LOAD_ATTR (*namei*)

Replaces TOS with `getattr(TOS, co_names[namei])`.

COMPARE_OP (*opname*)

Performs a Boolean operation. The operation name can be found in `cmp_op[opname]`.

IS_OP (*invert*)

Performs `is` comparison, or `is not` if `invert` is 1.

在 3.9 版新加入.

CONTAINS_OP (*invert*)

Performs `in` comparison, or `not in` if `invert` is 1.

在 3.9 版新加入.

IMPORT_NAME (*namei*)

Imports the module `co_names[namei]`. TOS and TOS1 are popped and provide the *fromlist* and *level* arguments of `__import__()`. The module object is pushed onto the stack. The current namespace is not affected: for a proper `import` statement, a subsequent *STORE_FAST* instruction modifies the namespace.

IMPORT_FROM (*namei*)

Loads the attribute `co_names[namei]` from the module found in TOS. The resulting object is pushed onto the stack, to be subsequently stored by a *STORE_FAST* instruction.

JUMP_FORWARD (*delta*)

Increments bytecode counter by *delta*.

JUMP_BACKWARD (*delta*)

Decrements bytecode counter by *delta*. Checks for interrupts.

在 3.11 版新加入.

JUMP_BACKWARD_NO_INTERRUPT (*delta*)

Decrements bytecode counter by *delta*. Does not check for interrupts.

在 3.11 版新加入.

POP_JUMP_FORWARD_IF_TRUE (*delta*)

If TOS is true, increments the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入.

POP_JUMP_BACKWARD_IF_TRUE (*delta*)

If TOS is true, decrements the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入.

POP_JUMP_FORWARD_IF_FALSE (*delta*)

If TOS is false, increments the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入.

POP_JUMP_BACKWARD_IF_FALSE (*delta*)

If TOS is false, decrements the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入.

POP_JUMP_FORWARD_IF_NOT_NONE (*delta*)

If TOS is not `None`, increments the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入.

POP_JUMP_BACKWARD_IF_NOT_NONE (*delta*)

If TOS is not None, decrements the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入。

POP_JUMP_FORWARD_IF_NONE (*delta*)

If TOS is None, increments the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入。

POP_JUMP_BACKWARD_IF_NONE (*delta*)

If TOS is None, decrements the bytecode counter by *delta*. TOS is popped.

在 3.11 版新加入。

JUMP_IF_TRUE_OR_POP (*delta*)

If TOS is true, increments the bytecode counter by *delta* and leaves TOS on the stack. Otherwise (TOS is false), TOS is popped.

在 3.1 版新加入。

在 3.11 版的變更: The oparg is now a relative delta rather than an absolute target.

JUMP_IF_FALSE_OR_POP (*delta*)

If TOS is false, increments the bytecode counter by *delta* and leaves TOS on the stack. Otherwise (TOS is true), TOS is popped.

在 3.1 版新加入。

在 3.11 版的變更: The oparg is now a relative delta rather than an absolute target.

FOR_ITER (*delta*)

TOS is an *iterator*. Call its `__next__()` method. If this yields a new value, push it on the stack (leaving the iterator below it). If the iterator indicates it is exhausted, TOS is popped, and the byte code counter is incremented by *delta*.

LOAD_GLOBAL (*namei*)

Loads the global named `co_names[namei>>1]` onto the stack.

在 3.11 版的變更: If the low bit of *namei* is set, then a NULL is pushed to the stack before the global variable.

LOAD_FAST (*var_num*)

Pushes a reference to the local `co_varnames[var_num]` onto the stack.

STORE_FAST (*var_num*)

Stores TOS into the local `co_varnames[var_num]`.

DELETE_FAST (*var_num*)

Deletes local `co_varnames[var_num]`.

MAKE_CELL (*i*)

Creates a new cell in slot *i*. If that slot is nonempty then that value is stored into the new cell.

在 3.11 版新加入。

LOAD_CLOSURE (*i*)

Pushes a reference to the cell contained in slot *i* of the "fast locals" storage. The name of the variable is `co_fastlocalnames[i]`.

Note that `LOAD_CLOSURE` is effectively an alias for `LOAD_FAST`. It exists to keep bytecode a little more readable.

在 3.11 版的變更: *i* is no longer offset by the length of `co_varnames`.

LOAD_DEREF (*i*)

Loads the cell contained in slot *i* of the "fast locals" storage. Pushes a reference to the object the cell contains on the stack.

在 3.11 版的變更: *i* is no longer offset by the length of `co_varnames`.

LOAD_CLASSDEREF (*i*)

Much like [LOAD_DEREF](#) but first checks the locals dictionary before consulting the cell. This is used for loading free variables in class bodies.

在 3.4 版新加入.

在 3.11 版的變更: *i* is no longer offset by the length of `co_varnames`.

STORE_DEREF (*i*)

Stores TOS into the cell contained in slot *i* of the "fast locals" storage.

在 3.11 版的變更: *i* is no longer offset by the length of `co_varnames`.

DELETE_DEREF (*i*)

Empties the cell contained in slot *i* of the "fast locals" storage. Used by the `del` statement.

在 3.2 版新加入.

在 3.11 版的變更: *i* is no longer offset by the length of `co_varnames`.

COPY_FREE_VARS (*n*)

Copies the *n* free variables from the closure into the frame. Removes the need for special code on the caller's side when calling closures.

在 3.11 版新加入.

RAISE_VARARGS (*argc*)

Raises an exception using one of the 3 forms of the `raise` statement, depending on the value of *argc*:

- 0: `raise` (re-raise previous exception)
- 1: `raise TOS` (raise exception instance or type at TOS)
- 2: `raise TOS1 from TOS` (raise exception instance or type at TOS1 with `__cause__` set to TOS)

CALL (*argc*)

Calls a callable object with the number of arguments specified by *argc*, including the named arguments specified by the preceding [KW_NAMES](#), if any. On the stack are (in ascending order), either:

- NULL
- The callable
- The positional arguments
- The named arguments

or:

- The callable
- `self`
- The remaining positional arguments
- The named arguments

argc is the total of the positional and named arguments, excluding `self` when a NULL is not present.

CALL pops all arguments and the callable object off the stack, calls the callable object with those arguments, and pushes the return value returned by the callable object.

在 3.11 版新加入.

CALL_FUNCTION_EX (*flags*)

Calls a callable object with variable set of positional and keyword arguments. If the lowest bit of *flags* is set, the top of the stack contains a mapping object containing additional keyword arguments. Before the callable is called, the mapping object and iterable object are each “unpacked” and their contents passed in as keyword and positional arguments respectively. `CALL_FUNCTION_EX` pops all arguments and the callable object off the stack, calls the callable object with those arguments, and pushes the return value returned by the callable object.

在 3.6 版新加入。

LOAD_METHOD (*namei*)

Loads a method named `co_names[namei]` from the TOS object. TOS is popped. This bytecode distinguishes two cases: if TOS has a method with the correct name, the bytecode pushes the unbound method and TOS. TOS will be used as the first argument (`self`) by `CALL` when calling the unbound method. Otherwise, `NULL` and the object return by the attribute lookup are pushed.

在 3.7 版新加入。

PRECALL (*argc*)

Prefixes `CALL`. Logically this is a no op. It exists to enable effective specialization of calls. *argc* is the number of arguments as described in `CALL`.

在 3.11 版新加入。

PUSH_NULL

Pushes a `NULL` to the stack. Used in the call sequence to match the `NULL` pushed by `LOAD_METHOD` for non-method calls.

在 3.11 版新加入。

KW_NAMES (*i*)

Prefixes `PRECALL`. Stores a reference to `co_consts[consti]` into an internal variable for use by `CALL`. `co_consts[consti]` must be a tuple of strings.

在 3.11 版新加入。

MAKE_FUNCTION (*flags*)

Pushes a new function object on the stack. From bottom to top, the consumed stack must consist of values if the argument carries a specified flag value

- `0x01` a tuple of default values for positional-only and positional-or-keyword parameters in positional order
- `0x02` a dictionary of keyword-only parameters' default values
- `0x04` a tuple of strings containing parameters' annotations
- `0x08` a tuple containing cells for free variables, making a closure
- the code associated with the function (at TOS)

在 3.10 版的變更: Flag value `0x04` is a tuple of strings instead of dictionary

在 3.11 版的變更: Qualified name at TOS was removed.

BUILD_SLICE (*argc*)

Pushes a slice object on the stack. *argc* must be 2 or 3. If it is 2, `slice(TOS1, TOS)` is pushed; if it is 3, `slice(TOS2, TOS1, TOS)` is pushed. See the `slice()` built-in function for more information.

EXTENDED_ARG (*ext*)

Prefixes any opcode which has an argument too big to fit into the default one byte. *ext* holds an additional byte which act as higher bits in the argument. For each opcode, at most three prefixal `EXTENDED_ARG` are allowed, forming an argument from two-byte to four-byte.

FORMAT_VALUE (*flags*)

Used for implementing formatted literal strings (f-strings). Pops an optional *fmt_spec* from the stack, then a required *value*. *flags* is interpreted as follows:

- (flags & 0x03) == 0x00: *value* is formatted as-is.
- (flags & 0x03) == 0x01: call `str()` on *value* before formatting it.
- (flags & 0x03) == 0x02: call `repr()` on *value* before formatting it.
- (flags & 0x03) == 0x03: call `ascii()` on *value* before formatting it.
- (flags & 0x04) == 0x04: pop *fmt_spec* from the stack and use it, else use an empty *fmt_spec*.

Formatting is performed using `PyObject_Format()`. The result is pushed on the stack.

在 3.6 版新加入.

MATCH_CLASS (*count*)

TOS is a tuple of keyword attribute names, TOS1 is the class being matched against, and TOS2 is the match subject. *count* is the number of positional sub-patterns.

Pop TOS, TOS1, and TOS2. If TOS2 is an instance of TOS1 and has the positional and keyword attributes required by *count* and TOS, push a tuple of extracted attributes. Otherwise, push `None`.

在 3.10 版新加入.

在 3.11 版的變更: Previously, this instruction also pushed a boolean value indicating success (`True`) or failure (`False`).

RESUME (*where*)

A no-op. Performs internal tracing, debugging and optimization checks.

The *where* operand marks where the **RESUME** occurs:

- 0 The start of a function
- 1 After a `yield` expression
- 2 After a `yield from` expression
- 3 After an `await` expression

在 3.11 版新加入.

RETURN_GENERATOR

Create a generator, coroutine, or async generator from the current frame. Clear the current frame and return the newly created generator.

在 3.11 版新加入.

SEND

Sends `None` to the sub-generator of this generator. Used in `yield from` and `await` statements.

在 3.11 版新加入.

ASYNC_GEN_WRAP

Wraps the value on top of the stack in an `async_generator_wrapped_value`. Used to yield in async generators.

在 3.11 版新加入.

HAVE_ARGUMENT

This is not really an opcode. It identifies the dividing line between opcodes which don't use their argument and those that do (`< HAVE_ARGUMENT` and `>= HAVE_ARGUMENT`, respectively).

在 3.6 版的變更: Now every instruction has an argument, but opcodes `< HAVE_ARGUMENT` ignore it. Before, only opcodes `>= HAVE_ARGUMENT` had an argument.

32.10.5 Opcode collections

These collections are provided for automatic introspection of bytecode instructions:

`dis.opname`

Sequence of operation names, indexable using the bytecode.

`dis.opmap`

Dictionary mapping operation names to bytecodes.

`dis.cmp_op`

Sequence of all compare operation names.

`dis.hasconst`

Sequence of bytecodes that access a constant.

`dis.hasfree`

Sequence of bytecodes that access a free variable (note that 'free' in this context refers to names in the current scope that are referenced by inner scopes or names in outer scopes that are referenced from this scope. It does *not* include references to global or builtin scopes).

`dis.hasname`

Sequence of bytecodes that access an attribute by name.

`dis.hasjrel`

Sequence of bytecodes that have a relative jump target.

`dis.hasjabs`

Sequence of bytecodes that have an absolute jump target.

`dis.haslocal`

Sequence of bytecodes that access a local variable.

`dis.hascompare`

Sequence of bytecodes of Boolean operations.

32.11 pickletools --- Tools for pickle developers

原始碼: [Lib/pickletools.py](#)

This module contains various constants relating to the intimate details of the *pickle* module, some lengthy comments about the implementation, and a few useful functions for analyzing pickled data. The contents of this module are useful for Python core developers who are working on the *pickle*; ordinary users of the *pickle* module probably won't find the *pickletools* module relevant.

32.11.1 Command line usage

在 3.2 版新加入.

When invoked from the command line, `python -m pickletools` will disassemble the contents of one or more pickle files. Note that if you want to see the Python object stored in the pickle rather than the details of pickle format, you may want to use `-m pickle` instead. However, when the pickle file that you want to examine comes from an untrusted source, `-m pickletools` is a safer option because it does not execute pickle bytecode.

For example, with a tuple `(1, 2)` pickled in file `x.pickle`:

```
$ python -m pickle x.pickle
(1, 2)

$ python -m pickletools x.pickle
0: \x80 PROTO      3
2: K    BININT1    1
4: K    BININT1    2
6: \x86 TUPLE2
7: q    BINPUT     0
9: .    STOP
highest protocol among opcodes = 2
```

Command line options

-a, --annotate

Annotate each line with a short opcode description.

-o, --output=<file>

Name of a file where the output should be written.

-l, --indentlevel=<num>

The number of blanks by which to indent a new MARK level.

-m, --memo

When multiple objects are disassembled, preserve memo between disassemblies.

-p, --preamble=<preamble>

When more than one pickle file are specified, print given preamble before each disassembly.

32.11.2 Programmatic Interface

`pickletools.dis (pickle, out=None, memo=None, indentlevel=4, annotate=0)`

Outputs a symbolic disassembly of the pickle to the file-like object *out*, defaulting to `sys.stdout`. *pickle* can be a string or a file-like object. *memo* can be a Python dictionary that will be used as the pickle's memo; it can be used to perform disassemblies across multiple pickles created by the same pickler. Successive levels, indicated by MARK opcodes in the stream, are indented by *indentlevel* spaces. If a nonzero value is given to *annotate*, each opcode in the output is annotated with a short description. The value of *annotate* is used as a hint for the column where annotation should start.

在 3.2 版的變更: Added the *annotate* parameter.

`pickletools.genops (pickle)`

Provides an *iterator* over all of the opcodes in a pickle, returning a sequence of (opcode, arg, pos) triples. *opcode* is an instance of an `OpcodeInfo` class; *arg* is the decoded value, as a Python object, of the opcode's argument; *pos* is the position at which this opcode is located. *pickle* can be a string or a file-like object.

`pickletools.optimize (picklestring)`

Returns a new equivalent pickle string after eliminating unused PUT opcodes. The optimized pickle is shorter, takes less transmission time, requires less storage space, and unpickles more efficiently.

此章節描述僅在 MS Windows 系統上可用的模組 (module)。

33.1 msvcrt --- Useful routines from the MS VC++ runtime

These functions provide access to some useful capabilities on Windows platforms. Some higher-level modules use these functions to build the Windows implementations of their services. For example, the *getpass* module uses this in the implementation of the *getpass()* function.

Further documentation on these functions can be found in the Platform API documentation.

The module implements both the normal and wide char variants of the console I/O api. The normal API deals only with ASCII characters and is of limited use for internationalized applications. The wide char API should be used where ever possible.

在 3.3 版的變更: Operations in this module now raise *OSError* where *IOError* was raised.

33.1.1 File Operations

`msvcrt.locking(fd, mode, nbytes)`

Lock part of a file based on file descriptor *fd* from the C runtime. Raises *OSError* on failure. The locked region of the file extends from the current file position for *nbytes* bytes, and may continue beyond the end of the file. *mode* must be one of the `LK_*` constants listed below. Multiple regions in a file may be locked at the same time, but may not overlap. Adjacent regions are not merged; they must be unlocked individually.

引發一個附帶引數 *fd*、*mode*、*nbytes* 的稽核事件 `msvcrt.locking`。

`msvcrt.LK_LOCK`

`msvcrt.LK_RLCK`

Locks the specified bytes. If the bytes cannot be locked, the program immediately tries again after 1 second. If, after 10 attempts, the bytes cannot be locked, *OSError* is raised.

`msvcrt.LK_NBLCK`

`msvcrt.LK_NBRLCK`

Locks the specified bytes. If the bytes cannot be locked, `OSError` is raised.

`msvcrt.LK_UNLCK`

Unlocks the specified bytes, which must have been previously locked.

`msvcrt.setmode(fd, flags)`

Set the line-end translation mode for the file descriptor `fd`. To set it to text mode, `flags` should be `os.O_TEXT`; for binary, it should be `os.O_BINARY`.

`msvcrt.open_osfhandle(handle, flags)`

Create a C runtime file descriptor from the file handle `handle`. The `flags` parameter should be a bitwise OR of `os.O_APPEND`, `os.O_RDONLY`, and `os.O_TEXT`. The returned file descriptor may be used as a parameter to `os.fdopen()` to create a file object.

引發一個附帶引數 `arguments`、`handle`、`flags` 的稽核事件 `msvcrt.open_osfhandle`。

`msvcrt.get_osfhandle(fd)`

Return the file handle for the file descriptor `fd`. Raises `OSError` if `fd` is not recognized.

引發一個附帶引數 `fd` 的稽核事件 `msvcrt.get_osfhandle`。

33.1.2 Console I/O

`msvcrt.kbhit()`

Return `True` if a keypress is waiting to be read.

`msvcrt.getch()`

Read a keypress and return the resulting character as a byte string. Nothing is echoed to the console. This call will block if a keypress is not already available, but will not wait for `Enter` to be pressed. If the pressed key was a special function key, this will return `'\000'` or `'\xe0'`; the next call will return the keycode. The `Control-C` keypress cannot be read with this function.

`msvcrt.getwch()`

Wide char variant of `getch()`, returning a Unicode value.

`msvcrt.getche()`

Similar to `getch()`, but the keypress will be echoed if it represents a printable character.

`msvcrt.getwche()`

Wide char variant of `getche()`, returning a Unicode value.

`msvcrt.putch(char)`

Print the byte string `char` to the console without buffering.

`msvcrt.putwch(unicode_char)`

Wide char variant of `putch()`, accepting a Unicode value.

`msvcrt.ungetch(char)`

Cause the byte string `char` to be "pushed back" into the console buffer; it will be the next character read by `getch()` or `getche()`.

`msvcrt.ungetwch(unicode_char)`

Wide char variant of `ungetch()`, accepting a Unicode value.

33.1.3 Other Functions

`msvcrt.heapmin()`

Force the `malloc()` heap to clean itself up and return unused blocks to the operating system. On failure, this raises `OSError`.

`msvcrt.CRT_ASSEMBLY_VERSION`

The CRT Assembly version, from the `crtassem.h` header file.

`msvcrt.VC_ASSEMBLY_PUBLICKEYTOKEN`

The VC Assembly public key token, from the `crtassem.h` header file.

`msvcrt.LIBRARIES_ASSEMBLY_NAME_PREFIX`

The Libraries Assembly name prefix, from the `crtassem.h` header file.

33.2 winreg --- Windows registry access

These functions expose the Windows registry API to Python. Instead of using an integer as the registry handle, a *handle object* is used to ensure that the handles are closed correctly, even if the programmer neglects to explicitly close them.

在 3.3 版的變更: Several functions in this module used to raise a `WindowsError`, which is now an alias of `OSError`.

33.2.1 函式

This module offers the following functions:

`winreg.CloseKey(hkey)`

Closes a previously opened registry key. The *hkey* argument specifies a previously opened key.

備 F: If *hkey* is not closed using this method (or via `hkey.Close()`), it is closed when the *hkey* object is destroyed by Python.

`winreg.ConnectRegistry(computer_name, key)`

Establishes a connection to a predefined registry handle on another computer, and returns a *handle object*.

computer_name is the name of the remote computer, of the form `r"\\computername"`. If `None`, the local computer is used.

key is the predefined handle to connect to.

The return value is the handle of the opened key. If the function fails, an `OSError` exception is raised.

引發一個附帶引數 *computer_name*、*key* 的稽核事件 `winreg.ConnectRegistry`。

在 3.3 版的變更: See *above*.

`winreg.CreateKey(key, sub_key)`

Creates or opens the specified key, returning a *handle object*.

key is an already open key, or one of the predefined `HKEY_* constants`.

sub_key is a string that names the key this method opens or creates.

If *key* is one of the predefined keys, *sub_key* may be `None`. In that case, the handle returned is the same key handle passed in to the function.

If the key already exists, this function opens the existing key.

The return value is the handle of the opened key. If the function fails, an *OSError* exception is raised.

引發一個附帶引數 `key`、`sub_key`、`access` 的稽核事件 `winreg.CreateKey`。

引發一個附帶引數 `key` 的稽核事件 `winreg.OpenKey/result`。

在 3.3 版的變更: See *above*.

`winreg.CreateKeyEx` (*key*, *sub_key*, *reserved*=0, *access*=*KEY_WRITE*)

Creates or opens the specified key, returning a *handle object*.

key is an already open key, or one of the predefined *HKEY_* constants*.

sub_key is a string that names the key this method opens or creates.

reserved is a reserved integer, and must be zero. The default is zero.

access is an integer that specifies an access mask that describes the desired security access for the key. Default is *KEY_WRITE*. See *Access Rights* for other allowed values.

If *key* is one of the predefined keys, *sub_key* may be `None`. In that case, the handle returned is the same key handle passed in to the function.

If the key already exists, this function opens the existing key.

The return value is the handle of the opened key. If the function fails, an *OSError* exception is raised.

引發一個附帶引數 `key`、`sub_key`、`access` 的稽核事件 `winreg.CreateKey`。

引發一個附帶引數 `key` 的稽核事件 `winreg.OpenKey/result`。

在 3.2 版新加入。

在 3.3 版的變更: See *above*.

`winreg.DeleteKey` (*key*, *sub_key*)

Deletes the specified key.

key is an already open key, or one of the predefined *HKEY_* constants*.

sub_key is a string that must be a subkey of the key identified by the *key* parameter. This value must not be `None`, and the key may not have subkeys.

This method can not delete keys with subkeys.

If the method succeeds, the entire key, including all of its values, is removed. If the method fails, an *OSError* exception is raised.

引發一個附帶引數 `key`、`sub_key`、`access` 的稽核事件 `winreg.DeleteKey`。

在 3.3 版的變更: See *above*.

`winreg.DeleteKeyEx` (*key*, *sub_key*, *access*=*KEY_WOW64_64KEY*, *reserved*=0)

Deletes the specified key.

key is an already open key, or one of the predefined *HKEY_* constants*.

sub_key is a string that must be a subkey of the key identified by the *key* parameter. This value must not be `None`, and the key may not have subkeys.

reserved is a reserved integer, and must be zero. The default is zero.

access is an integer that specifies an access mask that describes the desired security access for the key. Default is *KEY_WOW64_64KEY*. On 32-bit Windows, the WOW64 constants are ignored. See *Access Rights* for other allowed values.

This method can not delete keys with subkeys.

If the method succeeds, the entire key, including all of its values, is removed. If the method fails, an *OSError* exception is raised.

On unsupported Windows versions, `NotImplementedError` is raised.

引發一個附帶引數 `key`、`sub_key`、`access` 的稽核事件 `winreg.DeleteKey`。

在 3.2 版新加入。

在 3.3 版的變更: See [above](#).

`winreg.DeleteValue (key, value)`

Removes a named value from a registry key.

`key` is an already open key, or one of the predefined `HKEY_* constants`.

`value` is a string that identifies the value to remove.

引發一個附帶引數 `key`、`value` 的稽核事件 `winreg.DeleteValue`。

`winreg.EnumKey (key, index)`

Enumerates subkeys of an open registry key, returning a string.

`key` is an already open key, or one of the predefined `HKEY_* constants`.

`index` is an integer that identifies the index of the key to retrieve.

The function retrieves the name of one subkey each time it is called. It is typically called repeatedly until an `OSError` exception is raised, indicating, no more values are available.

引發一個附帶引數 `key`、`index` 的稽核事件 `winreg.EnumKey`。

在 3.3 版的變更: See [above](#).

`winreg.EnumValue (key, index)`

Enumerates values of an open registry key, returning a tuple.

`key` is an already open key, or one of the predefined `HKEY_* constants`.

`index` is an integer that identifies the index of the value to retrieve.

The function retrieves the name of one subkey each time it is called. It is typically called repeatedly, until an `OSError` exception is raised, indicating no more values.

The result is a tuple of 3 items:

Index	Meaning
0	A string that identifies the value name
1	An object that holds the value data, and whose type depends on the underlying registry type
2	An integer that identifies the type of the value data (see table in docs for <code>SetValueEx()</code>)

引發一個附帶引數 `key`、`index` 的稽核事件 `winreg.EnumValue`。

在 3.3 版的變更: See [above](#).

`winreg.ExpandEnvironmentStrings (str)`

Expands environment variable placeholders `%NAME%` in strings like `REG_EXPAND_SZ`:

```
>>> ExpandEnvironmentStrings('%windir%')
'C:\\Windows'
```

引發一個附帶引數 `str` 的稽核事件 `winreg.ExpandEnvironmentStrings`。

`winreg.FlushKey (key)`

Writes all the attributes of a key to the registry.

`key` is an already open key, or one of the predefined `HKEY_* constants`.

It is not necessary to call `FlushKey()` to change a key. Registry changes are flushed to disk by the registry using its lazy flusher. Registry changes are also flushed to disk at system shutdown. Unlike `CloseKey()`, the

`FlushKey()` method returns only when all the data has been written to the registry. An application should only call `FlushKey()` if it requires absolute certainty that registry changes are on disk.

備 F: If you don't know whether a `FlushKey()` call is required, it probably isn't.

`winreg.LoadKey(key, sub_key, file_name)`

Creates a subkey under the specified key and stores registration information from a specified file into that subkey.

`key` is a handle returned by `ConnectRegistry()` or one of the constants `HKEY_USERS` or `HKEY_LOCAL_MACHINE`.

`sub_key` is a string that identifies the subkey to load.

`file_name` is the name of the file to load registry data from. This file must have been created with the `SaveKey()` function. Under the file allocation table (FAT) file system, the filename may not have an extension.

A call to `LoadKey()` fails if the calling process does not have the `SE_RESTORE_PRIVILEGE` privilege. Note that privileges are different from permissions -- see the [RegLoadKey documentation](#) for more details.

If `key` is a handle returned by `ConnectRegistry()`, then the path specified in `file_name` is relative to the remote computer.

引發一個附帶引數 `key`、`sub_key`、`file_name` 的稽核事件 `winreg.LoadKey`。

`winreg.OpenKey(key, sub_key, reserved=0, access=KEY_READ)`

`winreg.OpenKeyEx(key, sub_key, reserved=0, access=KEY_READ)`

Opens the specified key, returning a *handle object*.

`key` is an already open key, or one of the predefined `HKEY_* constants`.

`sub_key` is a string that identifies the sub_key to open.

`reserved` is a reserved integer, and must be zero. The default is zero.

`access` is an integer that specifies an access mask that describes the desired security access for the key. Default is `KEY_READ`. See [Access Rights](#) for other allowed values.

The result is a new handle to the specified key.

If the function fails, `OSError` is raised.

引發一個附帶引數 `key`、`sub_key`、`access` 的稽核事件 `winreg.OpenKey`。

引發一個附帶引數 `key` 的稽核事件 `winreg.OpenKey/result`。

在 3.2 版的變更: Allow the use of named arguments.

在 3.3 版的變更: See [above](#).

`winreg.QueryInfoKey(key)`

Returns information about a key, as a tuple.

`key` is an already open key, or one of the predefined `HKEY_* constants`.

The result is a tuple of 3 items:

In- dex	Meaning
0	An integer giving the number of sub keys this key has.
1	An integer giving the number of values this key has.
2	An integer giving when the key was last modified (if available) as 100's of nanoseconds since Jan 1, 1601.

引發一個附帶引數 `key` 的稽核事件 `winreg.QueryInfoKey`。

`winreg.QueryValue (key, sub_key)`

Retrieves the unnamed value for a key, as a string.

`key` is an already open key, or one of the predefined *HKEY_* constants*.

`sub_key` is a string that holds the name of the subkey with which the value is associated. If this parameter is `None` or empty, the function retrieves the value set by the `SetValue()` method for the key identified by `key`.

Values in the registry have name, type, and data components. This method retrieves the data for a key's first value that has a `NULL` name. But the underlying API call doesn't return the type, so always use `QueryValueEx()` if possible.

引發一個附帶引數 `key`、`sub_key`、`value_name` 的稽核事件 `winreg.QueryKey`。

`winreg.QueryValueEx (key, value_name)`

Retrieves the type and data for a specified value name associated with an open registry key.

`key` is an already open key, or one of the predefined *HKEY_* constants*.

`value_name` is a string indicating the value to query.

The result is a tuple of 2 items:

Index	Meaning
0	The value of the registry item.
1	An integer giving the registry type for this value (see table in docs for <code>SetValueEx()</code>)

引發一個附帶引數 `key`、`sub_key`、`value_name` 的稽核事件 `winreg.QueryKey`。

`winreg.SaveKey (key, file_name)`

Saves the specified key, and all its subkeys to the specified file.

`key` is an already open key, or one of the predefined *HKEY_* constants*.

`file_name` is the name of the file to save registry data to. This file cannot already exist. If this filename includes an extension, it cannot be used on file allocation table (FAT) file systems by the `LoadKey()` method.

If `key` represents a key on a remote computer, the path described by `file_name` is relative to the remote computer. The caller of this method must possess the **SeBackupPrivilege** security privilege. Note that privileges are different than permissions -- see the [Conflicts Between User Rights and Permissions](#) documentation for more details.

This function passes `NULL` for `security_attributes` to the API.

引發一個附帶引數 `key`、`file_name` 的稽核事件 `winreg.SaveKey`。

`winreg.SetValue (key, sub_key, type, value)`

Associates a value with a specified key.

`key` is an already open key, or one of the predefined *HKEY_* constants*.

`sub_key` is a string that names the subkey with which the value is associated.

`type` is an integer that specifies the type of the data. Currently this must be `REG_SZ`, meaning only strings are supported. Use the `SetValueEx()` function for support for other data types.

`value` is a string that specifies the new value.

If the key specified by the `sub_key` parameter does not exist, the `SetValue` function creates it.

Value lengths are limited by available memory. Long values (more than 2048 bytes) should be stored as files with the filenames stored in the configuration registry. This helps the registry perform efficiently.

The key identified by the `key` parameter must have been opened with `KEY_SET_VALUE` access.

引發一個附帶引數 `key`、`sub_key`、`type`、`value` 的稽核事件 `winreg.SetValue`。

`winreg.SetValueEx(key, value_name, reserved, type, value)`

Stores data in the value field of an open registry key.

key is an already open key, or one of the predefined *HKEY_* constants*.

value_name is a string that names the subkey with which the value is associated.

reserved can be anything -- zero is always passed to the API.

type is an integer that specifies the type of the data. See *Value Types* for the available types.

value is a string that specifies the new value.

This method can also set additional value and type information for the specified key. The key identified by the *key* parameter must have been opened with *KEY_SET_VALUE* access.

To open the key, use the *CreateKey()* or *OpenKey()* methods.

Value lengths are limited by available memory. Long values (more than 2048 bytes) should be stored as files with the filenames stored in the configuration registry. This helps the registry perform efficiently.

引發一個附帶引數 *key*、*sub_key*、*type*、*value* 的稽核事件 `winreg.SetValue`。

`winreg.DisableReflectionKey(key)`

Disables registry reflection for 32-bit processes running on a 64-bit operating system.

key is an already open key, or one of the predefined *HKEY_* constants*.

Will generally raise *NotImplementedError* if executed on a 32-bit operating system.

If the key is not on the reflection list, the function succeeds but has no effect. Disabling reflection for a key does not affect reflection of any subkeys.

引發一個附帶引數 *key* 的稽核事件 `winreg.DisableReflectionKey`。

`winreg.EnableReflectionKey(key)`

Restores registry reflection for the specified disabled key.

key is an already open key, or one of the predefined *HKEY_* constants*.

Will generally raise *NotImplementedError* if executed on a 32-bit operating system.

Restoring reflection for a key does not affect reflection of any subkeys.

引發一個附帶引數 *key* 的稽核事件 `winreg.EnableReflectionKey`。

`winreg.QueryReflectionKey(key)`

Determines the reflection state for the specified key.

key is an already open key, or one of the predefined *HKEY_* constants*.

Returns *True* if reflection is disabled.

Will generally raise *NotImplementedError* if executed on a 32-bit operating system.

引發一個附帶引數 *key* 的稽核事件 `winreg.QueryReflectionKey`。

33.2.2 常數

The following constants are defined for use in many *winreg* functions.

HKEY_* Constants

`winreg.HKEY_CLASSES_ROOT`

Registry entries subordinate to this key define types (or classes) of documents and the properties associated with those types. Shell and COM applications use the information stored under this key.

`winreg.HKEY_CURRENT_USER`

Registry entries subordinate to this key define the preferences of the current user. These preferences include the settings of environment variables, data about program groups, colors, printers, network connections, and application preferences.

`winreg.HKEY_LOCAL_MACHINE`

Registry entries subordinate to this key define the physical state of the computer, including data about the bus type, system memory, and installed hardware and software.

`winreg.HKEY_USERS`

Registry entries subordinate to this key define the default user configuration for new users on the local computer and the user configuration for the current user.

`winreg.HKEY_PERFORMANCE_DATA`

Registry entries subordinate to this key allow you to access performance data. The data is not actually stored in the registry; the registry functions cause the system to collect the data from its source.

`winreg.HKEY_CURRENT_CONFIG`

Contains information about the current hardware profile of the local computer system.

`winreg.HKEY_DYN_DATA`

This key is not used in versions of Windows after 98.

Access Rights

For more information, see [Registry Key Security and Access](#).

`winreg.KEY_ALL_ACCESS`

Combines the `STANDARD_RIGHTS_REQUIRED`, `KEY_QUERY_VALUE`, `KEY_SET_VALUE`, `KEY_CREATE_SUB_KEY`, `KEY_ENUMERATE_SUB_KEYS`, `KEY_NOTIFY`, and `KEY_CREATE_LINK` access rights.

`winreg.KEY_WRITE`

Combines the `STANDARD_RIGHTS_WRITE`, `KEY_SET_VALUE`, and `KEY_CREATE_SUB_KEY` access rights.

`winreg.KEY_READ`

Combines the `STANDARD_RIGHTS_READ`, `KEY_QUERY_VALUE`, `KEY_ENUMERATE_SUB_KEYS`, and `KEY_NOTIFY` values.

`winreg.KEY_EXECUTE`

Equivalent to `KEY_READ`.

`winreg.KEY_QUERY_VALUE`

Required to query the values of a registry key.

`winreg.KEY_SET_VALUE`

Required to create, delete, or set a registry value.

`winreg.KEY_CREATE_SUB_KEY`

Required to create a subkey of a registry key.

`winreg.KEY_ENUMERATE_SUB_KEYS`

Required to enumerate the subkeys of a registry key.

`winreg.KEY_NOTIFY`

Required to request change notifications for a registry key or for subkeys of a registry key.

`winreg.KEY_CREATE_LINK`

Reserved for system use.

64-bit Specific

For more information, see [Accessing an Alternate Registry View](#).

`winreg.KEY_WOW64_64KEY`

Indicates that an application on 64-bit Windows should operate on the 64-bit registry view. On 32-bit Windows, this constant is ignored.

`winreg.KEY_WOW64_32KEY`

Indicates that an application on 64-bit Windows should operate on the 32-bit registry view. On 32-bit Windows, this constant is ignored.

Value Types

For more information, see [Registry Value Types](#).

`winreg.REG_BINARY`

Binary data in any form.

`winreg.REG_DWORD`

32-bit number.

`winreg.REG_DWORD_LITTLE_ENDIAN`

A 32-bit number in little-endian format. Equivalent to [REG_DWORD](#).

`winreg.REG_DWORD_BIG_ENDIAN`

A 32-bit number in big-endian format.

`winreg.REG_EXPAND_SZ`

Null-terminated string containing references to environment variables (%PATH%).

`winreg.REG_LINK`

A Unicode symbolic link.

`winreg.REG_MULTI_SZ`

A sequence of null-terminated strings, terminated by two null characters. (Python handles this termination automatically.)

`winreg.REG_NONE`

No defined value type.

`winreg.REG_QWORD`

A 64-bit number.

在 3.6 版新加入.

`winreg.REG_QWORD_LITTLE_ENDIAN`

A 64-bit number in little-endian format. Equivalent to [REG_QWORD](#).

在 3.6 版新加入.

`winreg.REG_RESOURCE_LIST`

A device-driver resource list.

`winreg.REG_FULL_RESOURCE_DESCRIPTOR`

A hardware setting.

`winreg.REG_RESOURCE_REQUIREMENTS_LIST`

A hardware resource list.

`winreg.REG_SZ`

A null-terminated string.

33.2.3 Registry Handle Objects

This object wraps a Windows HKEY object, automatically closing it when the object is destroyed. To guarantee cleanup, you can call either the `Close()` method on the object, or the `CloseKey()` function.

All registry functions in this module return one of these objects.

All registry functions in this module which accept a handle object also accept an integer, however, use of the handle object is encouraged.

Handle objects provide semantics for `__bool__()` -- thus

```
if handle:
    print("Yes")
```

will print `Yes` if the handle is currently valid (has not been closed or detached).

The object also support comparison semantics, so handle objects will compare true if they both reference the same underlying Windows handle value.

Handle objects can be converted to an integer (e.g., using the built-in `int()` function), in which case the underlying Windows handle value is returned. You can also use the `Detach()` method to return the integer handle, and also disconnect the Windows handle from the handle object.

`PyHKEY.Close()`

Closes the underlying Windows handle.

If the handle is already closed, no error is raised.

`PyHKEY.Detach()`

Detaches the Windows handle from the handle object.

The result is an integer that holds the value of the handle before it is detached. If the handle is already detached or closed, this will return zero.

After calling this function, the handle is effectively invalidated, but the handle is not closed. You would call this function when you need the underlying Win32 handle to exist beyond the lifetime of the handle object.

引發一個附帶引數 `key` 的稽核事件 `winreg.PyHKEY.Detach`。

`PyHKEY.__enter__()`

`PyHKEY.__exit__(*exc_info)`

The HKEY object implements `__enter__()` and `__exit__()` and thus supports the context protocol for the `with` statement:

```
with OpenKey(HKEY_LOCAL_MACHINE, "foo") as key:
    ... # work with key
```

will automatically close `key` when control leaves the `with` block.

33.3 winsound --- Sound-playing interface for Windows

The `winsound` module provides access to the basic sound-playing machinery provided by Windows platforms. It includes functions and several constants.

`winsound.Beep` (*frequency*, *duration*)

Beep the PC's speaker. The *frequency* parameter specifies frequency, in hertz, of the sound, and must be in the range 37 through 32,767. The *duration* parameter specifies the number of milliseconds the sound should last. If the system is not able to beep the speaker, `RuntimeError` is raised.

`winsound.PlaySound` (*sound*, *flags*)

Call the underlying `PlaySound()` function from the Platform API. The *sound* parameter may be a filename, a system sound alias, audio data as a *bytes-like object*, or `None`. Its interpretation depends on the value of *flags*, which can be a bitwise ORed combination of the constants described below. If the *sound* parameter is `None`, any currently playing waveform sound is stopped. If the system indicates an error, `RuntimeError` is raised.

`winsound.MessageBeep` (*type*=`MB_OK`)

Call the underlying `MessageBeep()` function from the Platform API. This plays a sound as specified in the registry. The *type* argument specifies which sound to play; possible values are `-1`, `MB_ICONASTERISK`, `MB_ICONEXCLAMATION`, `MB_ICONHAND`, `MB_ICONQUESTION`, and `MB_OK`, all described below. The value `-1` produces a "simple beep"; this is the final fallback if a sound cannot be played otherwise. If the system indicates an error, `RuntimeError` is raised.

`winsound.SND_FILENAME`

The *sound* parameter is the name of a WAV file. Do not use with `SND_ALIAS`.

`winsound.SND_ALIAS`

The *sound* parameter is a sound association name from the registry. If the registry contains no such name, play the system default sound unless `SND_NODEFAULT` is also specified. If no default sound is registered, raise `RuntimeError`. Do not use with `SND_FILENAME`.

All Win32 systems support at least the following; most systems support many more:

<i>PlaySound()</i> name	Corresponding Control Panel Sound name
'SystemAsterisk'	Asterisk
'SystemExclamation'	Exclamation
'SystemExit'	Exit Windows
'SystemHand'	Critical Stop
'SystemQuestion'	Question

例如：

```
import winsound
# Play Windows exit sound.
winsound.PlaySound("SystemExit", winsound.SND_ALIAS)

# Probably play Windows default sound, if any is registered (because
# "" probably isn't the registered name of any sound).
winsound.PlaySound("", winsound.SND_ALIAS)
```

`winsound.SND_LOOP`

Play the sound repeatedly. The `SND_ASYNC` flag must also be used to avoid blocking. Cannot be used with `SND_MEMORY`.

`winsound.SND_MEMORY`

The *sound* parameter to `PlaySound()` is a memory image of a WAV file, as a *bytes-like object*.

備: This module does not support playing from a memory image asynchronously, so a combination of this flag and `SND_ASYNC` will raise `RuntimeError`.

`winsound.SND_PURGE`

Stop playing all instances of the specified sound.

備: This flag is not supported on modern Windows platforms.

`winsound.SND_ASYNC`

Return immediately, allowing sounds to play asynchronously.

`winsound.SND_NODEFAULT`

If the specified sound cannot be found, do not play the system default sound.

`winsound.SND_NOSTOP`

Do not interrupt sounds currently playing.

`winsound.SND_NOWAIT`

Return immediately if the sound driver is busy.

備: This flag is not supported on modern Windows platforms.

`winsound.MB_ICONASTERISK`

播放 SystemDefault 聲音。

`winsound.MB_ICONEXCLAMATION`

播放 SystemExclamation 聲音。

`winsound.MB_ICONHAND`

播放 SystemHand 聲音。

`winsound.MB_ICONQUESTION`

播放 SystemQuestion 聲音。

`winsound.MB_OK`

播放 SystemDefault 聲音。

此章節所描述的模組 (module) 提供了針對 Unix 作業系統獨有特性的介面，或在某些情況下可用於其他 Unix 變形版本。以下概述：

34.1 `posix` --- 最常見的 POSIX 系統呼叫

該模組提供對由 C 標準和 POSIX 標準（一種包裝的 Unix 介面）所標準化的作業系統功能的存取。

Availability: Unix.

不要直接引入此模組。請改用引入 `os` 模組，它提供了此介面的可移植 (*portable*) 版本。在 Unix 上，`os` 模組提供了 `posix` 介面的超集 (*superset*)。在非 Unix 作業系統上，`posix` 模組不可用，但始終可以通過 `os` 介面使用一個子集。一旦 `os` 有被引入，使用它代替 `posix` 不會有性能損失。此外，`os` 提供了一些額外的功能，例如當 `os.environ` 中的條目更改時自動呼叫 `putenv()`。

錯誤會以例外的形式被回報；常見的例外是因型錯誤而給出的，而系統呼叫回報的錯誤會引發 `OSError`。

34.1.1 對大檔案 (Large File) 的支援

一些作業系統（包括 AIX 和 Solaris）支援來自 C 程式模型且大於 2 GiB 的檔案，其中 `int` 和 `long` 是 32-bit (32 位元) 的值。這通常透過將相關大小和偏移量 (*offset*) 種類定義為 64-bit 值來實作。此類檔案有時被稱作「大檔案 (*large files*)」。

當 `off_t` 的大小大於 `long` 且 `long long` 的大小至少與 `off_t` 相同時，對大檔案的支援會被啟用。可能需要使用某些編譯器旗標來配置和編譯 Python 以啟用此模式。例如，對於 Solaris 2.6 和 2.7，你需要執行如下操作：

```
CFLAGS=`getconf LFS_CFLAGS` OPT="-g -O2 $CFLAGS" \  
./configure
```

在支援大檔案的 Linux 系統上，這可能有效：

```
CFLAGS='-D_LARGEFILE64_SOURCE -D_FILE_OFFSET_BITS=64' OPT="-g -O2 $CFLAGS" \  
./configure
```

34.1.2 值得注意的模組內容

除了 `os` 模組明文件中描述的許多函式外，`posix` 還定義了以下資料項目：

`posix.environ`

表示直譯器動時的字串環境的字典。鍵和值在 Unix 上是位元組，在 Windows 上是 `str`。例如，`environ[b'HOME']` (Windows 上 `environ['HOME']`) 是你的主目錄的路徑名，等同於 C 語言中的 `getenv("HOME")`。

修改這個字典不會影響由 `execv()`、`popen()` 或 `system()` 傳遞的字串環境；如果你需要更改環境，請將 `environ` 傳遞給 `execve()` 或將變數賦值和匯出陳述句新增到 `system()` 或 `popen()` 的指令字串中。

在 3.2 版的變更：在 Unix 上，鍵和值是位元組。

備註： `os` 模組提供了 `environ` 的替代實作，會在修改時更新環境。另請注意，更新 `os.environ` 將使該字典變成過時的。建議使用 `os` 模組版本，而不是直接存取 `posix` 模組。

34.2 pwd --- 密碼資料庫

此模組提供對 Unix 使用者帳和密碼資料庫的存取介面。它適用於所有 Unix 版本。

Availability: Unix, not Emscripten, not WASI.

密碼資料庫條目被報告類似元組的物件 (tuple-like object)，其屬性會對應於 `passwd` 結構的成員（屬性欄位請見下面的 `<pwd.h>`）：

索引	屬性	意義
0	<code>pw_name</code>	登入名
1	<code>pw_passwd</code>	可選的加密密碼
2	<code>pw_uid</code>	數值的使用者 ID
3	<code>pw_gid</code>	數值的群組 ID
4	<code>pw_gecos</code>	使用者名稱或解欄位
5	<code>pw_dir</code>	使用者主目錄 (home directory)
6	<code>pw_shell</code>	使用者命令直譯器

`uid` 和 `gid` 項目是整數，其他項目都是字串。如果找不到請求的條目，則會引發 `KeyError`。

備註： 在傳統的 Unix 中，`pw_passwd` 欄位通常包含一個使用 DES 衍生演算法加密的密碼（參見模組 `crypt`）。然而，大多數現代 Unix 是使用所謂的 *shadow password* 系統。在那些 Unix 上，`pw_passwd` 欄位僅包含一個星號 ('*') 或字母 'x'，其中加密密碼存儲在非全域可讀的 (not world readable) `/etc/shadow` 文件中。`pw_passwd` 欄位是否包含任何有用的內容取決於系統。如果可用，應該要在需要存取加密密碼的地方使用 `spwd` 模組。

它定義了以下項目：

`pwd.getpwuid(uid)`

回傳給定數值使用者 ID 的密碼資料庫條目。

`pwd.getpwnam(name)`

回傳給定使用者名稱的密碼資料庫條目。

`pwd.getpwall()`

以任意順序回傳所有可用密碼資料庫條目的 list。

也參考:

grp 模組

群組資料庫的介面，與此模組類似。

spwd 模組

Shadow 密碼資料庫的介面，與此模組類似。

34.3 grp --- The group database

This module provides access to the Unix group database. It is available on all Unix versions.

Availability: Unix, not Emscripten, not WASI.

Group database entries are reported as a tuple-like object, whose attributes correspond to the members of the `group` structure (Attribute field below, see `<grp.h>`):

Index	屬性	Meaning
0	<code>gr_name</code>	the name of the group
1	<code>gr_passwd</code>	the (encrypted) group password; often empty
2	<code>gr_gid</code>	the numerical group ID
3	<code>gr_mem</code>	all the group member's user names

The gid is an integer, name and password are strings, and the member list is a list of strings. (Note that most users are not explicitly listed as members of the group they are in according to the password database. Check both databases to get complete membership information. Also note that a `gr_name` that starts with a + or – is likely to be a YP/NIS reference and may not be accessible via `getgrnam()` or `getgrgid().`)

It defines the following items:

`grp.getgrgid(id)`

Return the group database entry for the given numeric group ID. `KeyError` is raised if the entry asked for cannot be found.

在 3.10 版的變更: `TypeError` is raised for non-integer arguments like floats or strings.

`grp.getgrnam(name)`

Return the group database entry for the given group name. `KeyError` is raised if the entry asked for cannot be found.

`grp.getgrall()`

Return a list of all available group entries, in arbitrary order.

也參考:

pwd 模組

An interface to the user database, similar to this.

spwd 模組

An interface to the shadow password database, similar to this.

34.4 `termios` --- POSIX style tty control

This module provides an interface to the POSIX calls for tty I/O control. For a complete description of these calls, see *termios(3)* Unix manual page. It is only available for those Unix versions that support POSIX *termios* style tty I/O control configured during installation.

Availability: Unix.

All functions in this module take a file descriptor *fd* as their first argument. This can be an integer file descriptor, such as returned by `sys.stdin.fileno()`, or a *file object*, such as `sys.stdin` itself.

This module also defines all the constants needed to work with the functions provided here; these have the same name as their counterparts in C. Please refer to your system documentation for more information on using these terminal control interfaces.

The module defines the following functions:

`termios.tcgetattr(fd)`

Return a list containing the tty attributes for file descriptor *fd*, as follows: [*iflag*, *oflag*, *cflag*, *lflag*, *ispeed*, *ospeed*, *cc*] where *cc* is a list of the tty special characters (each a string of length 1, except the items with indices *VMIN* and *VTIME*, which are integers when these fields are defined). The interpretation of the flags and the speeds as well as the indexing in the *cc* array must be done using the symbolic constants defined in the *termios* module.

`termios.tcsetattr(fd, when, attributes)`

Set the tty attributes for file descriptor *fd* from the *attributes*, which is a list like the one returned by *tcgetattr()*. The *when* argument determines when the attributes are changed:

`termios.TCSANOW`

Change attributes immediately.

`termios.TCSADRAIN`

Change attributes after transmitting all queued output.

`termios.TCSAFLUSH`

Change attributes after transmitting all queued output and discarding all queued input.

`termios.tcsendbreak(fd, duration)`

Send a break on file descriptor *fd*. A zero *duration* sends a break for 0.25--0.5 seconds; a nonzero *duration* has a system dependent meaning.

`termios.tcdrain(fd)`

Wait until all output written to file descriptor *fd* has been transmitted.

`termios.tcflush(fd, queue)`

Discard queued data on file descriptor *fd*. The *queue* selector specifies which queue: *TCIFLUSH* for the input queue, *TCOFLUSH* for the output queue, or *TCIOFLUSH* for both queues.

`termios.tcflow(fd, action)`

Suspend or resume input or output on file descriptor *fd*. The *action* argument can be *TCOOFF* to suspend output, *TCOON* to restart output, *TCIOFF* to suspend input, or *TCION* to restart input.

`termios.tcgetwinsize(fd)`

Return a tuple (*ws_row*, *ws_col*) containing the tty window size for file descriptor *fd*. Requires *termios.TIOCGWINSZ* or *termios.TIOCGSIZE*.

在 3.11 版新加入。

`termios.tcsetwinsize(fd, winsize)`

Set the tty window size for file descriptor *fd* from *winsize*, which is a two-item tuple (*ws_row*, *ws_col*) like the one returned by `tcgetwinsize()`. Requires at least one of the pairs (`termios.TIOCGWINSZ`, `termios.TIOCSWINSZ`); (`termios.TIOCGSIZE`, `termios.TIOCSSIZE`) to be defined.

在 3.11 版新加入。

也參考：

`tty` 模組

Convenience functions for common terminal control operations.

34.4.1 范例

Here's a function that prompts for a password with echoing turned off. Note the technique using a separate `tcgetattr()` call and a `try ... finally` statement to ensure that the old tty attributes are restored exactly no matter what happens:

```
def getpass(prompt="Password: "):
    import termios, sys
    fd = sys.stdin.fileno()
    old = termios.tcgetattr(fd)
    new = termios.tcgetattr(fd)
    new[3] = new[3] & ~termios.ECHO          # lflags
    try:
        termios.tcsetattr(fd, termios.TCSADRAIN, new)
        passwd = input(prompt)
    finally:
        termios.tcsetattr(fd, termios.TCSADRAIN, old)
    return passwd
```

34.5 tty --- 終端機控制函式

原始碼：Lib/tty.py

`tty` 模組定義了將 tty 放入 cbreak 和 raw 模式的函式。

Availability: Unix.

因它需要 `termios` 模組，所以只能在 Unix 上執行。

`tty` 模組定義了以下函式：

`tty.setraw(fd, when=termios.TCSAFLUSH)`

將檔案描述器 *fd* 的模式更改為 raw。如果 *when* 被省略，則預設為 `termios.TCSAFLUSH`，傳遞給 `termios.tcsetattr()`。

`tty.setcbreak(fd, when=termios.TCSAFLUSH)`

將檔案描述器 *fd* 的模式更改為 cbreak。如果 *when* 被省略，則預設為 `termios.TCSAFLUSH`，傳遞給 `termios.tcsetattr()`。

也參考：

`termios` 模組

低階終端機控制介面。

34.6 `pty` --- Pseudo-terminal utilities

原始碼: [Lib/pty.py](#)

The `pty` module defines operations for handling the pseudo-terminal concept: starting another process and being able to write to and read from its controlling terminal programmatically.

Availability: Unix.

Pseudo-terminal handling is highly platform dependent. This code is mainly tested on Linux, FreeBSD, and macOS (it is supposed to work on other POSIX platforms but it's not been thoroughly tested).

The `pty` module defines the following functions:

`pty.fork()`

Fork. Connect the child's controlling terminal to a pseudo-terminal. Return value is `(pid, fd)`. Note that the child gets `pid` 0, and the `fd` is *invalid*. The parent's return value is the `pid` of the child, and `fd` is a file descriptor connected to the child's controlling terminal (and also to the child's standard input and output).

警告: On macOS the use of this function is unsafe when mixed with using higher-level system APIs, and that includes using `urllib.request`.

`pty.openpty()`

Open a new pseudo-terminal pair, using `os.openpty()` if possible, or emulation code for generic Unix systems. Return a pair of file descriptors `(master, slave)`, for the master and the slave end, respectively.

`pty.spawn(argv[, master_read[, stdin_read]])`

Spawn a process, and connect its controlling terminal with the current process's standard io. This is often used to baffle programs which insist on reading from the controlling terminal. It is expected that the process spawned behind the `pty` will eventually terminate, and when it does `spawn` will return.

A loop copies STDIN of the current process to the child and data received from the child to STDOUT of the current process. It is not signaled to the child if STDIN of the current process closes down.

The functions `master_read` and `stdin_read` are passed a file descriptor which they should read from, and they should always return a byte string. In order to force `spawn` to return before the child process exits an empty byte array should be returned to signal end of file.

The default implementation for both functions will read and return up to 1024 bytes each time the function is called. The `master_read` callback is passed the pseudoterminal's master file descriptor to read output from the child process, and `stdin_read` is passed file descriptor 0, to read from the parent process's standard input.

Returning an empty byte string from either callback is interpreted as an end-of-file (EOF) condition, and that callback will not be called after that. If `stdin_read` signals EOF the controlling terminal can no longer communicate with the parent process OR the child process. Unless the child process will quit without any input, `spawn` will then loop forever. If `master_read` signals EOF the same behavior results (on linux at least).

Return the exit status value from `os.waitpid()` on the child process.

`os.waitstatus_to_exitcode()` can be used to convert the exit status into an exit code.

引發一個附帶引數 `argv` 的稽核事件 `pty.spawn`。

在 3.4 版的變更: `spawn()` now returns the status value from `os.waitpid()` on the child process.

34.6.1 范例

The following program acts like the Unix command *script* (1), using a pseudo-terminal to record all input and output of a terminal session in a “typescript”.

```
import argparse
import os
import pty
import sys
import time

parser = argparse.ArgumentParser()
parser.add_argument('-a', dest='append', action='store_true')
parser.add_argument('-p', dest='use_python', action='store_true')
parser.add_argument('filename', nargs='?', default='typescript')
options = parser.parse_args()

shell = sys.executable if options.use_python else os.environ.get('SHELL', 'sh')
filename = options.filename
mode = 'ab' if options.append else 'wb'

with open(filename, mode) as script:
    def read(fd):
        data = os.read(fd, 1024)
        script.write(data)
        return data

    print('Script started, file is', filename)
    script.write(('Script started on %s\n' % time.asctime()).encode())

    pty.spawn(shell, read)

    script.write(('Script done on %s\n' % time.asctime()).encode())
    print('Script done, file is', filename)
```

34.7 fcntl --- The fcntl and ioctl system calls

This module performs file and I/O control on file descriptors. It is an interface to the `fcntl()` and `ioctl()` Unix routines. See the *fcntl* (2) and *ioctl* (2) Unix manual pages for full details.

Availability: Unix, not Emscripten, not WASI.

All functions in this module take a file descriptor *fd* as their first argument. This can be an integer file descriptor, such as returned by `sys.stdin.fileno()`, or an `io.IOBase` object, such as `sys.stdin` itself, which provides a *fileno()* that returns a genuine file descriptor.

在 3.3 版的變更: Operations in this module used to raise an `IOError` where they now raise an `OSError`.

在 3.8 版的變更: The `fcntl` module now contains `F_ADD_SEALS`, `F_GET_SEALS`, and `F_SEAL_*` constants for sealing of `os.memfd_create()` file descriptors.

在 3.9 版的變更: On macOS, the `fcntl` module exposes the `F_GETPATH` constant, which obtains the path of a file from a file descriptor. On Linux(>=3.15), the `fcntl` module exposes the `F_OFD_GETLK`, `F_OFD_SETLK` and `F_OFD_SETLKW` constants, which are used when working with open file description locks.

在 3.10 版的變更: On Linux >= 2.6.11, the `fcntl` module exposes the `F_GETPIPE_SZ` and `F_SETPIPE_SZ` constants, which allow to check and modify a pipe’s size respectively.

在 3.11 版的變更: On FreeBSD, the `fcntl` module exposes the `F_DUP2FD` and `F_DUP2FD_CLOEXEC` constants, which allow to duplicate a file descriptor, the latter setting `FD_CLOEXEC` flag in addition.

The module defines the following functions:

`fcntl.fcntl(fd, cmd, arg=0)`

Perform the operation *cmd* on file descriptor *fd* (file objects providing a `fileno()` method are accepted as well). The values used for *cmd* are operating system dependent, and are available as constants in the `fcntl` module, using the same names as used in the relevant C header files. The argument *arg* can either be an integer value, or a `bytes` object. With an integer value, the return value of this function is the integer return value of the C `fcntl()` call. When the argument is bytes it represents a binary structure, e.g. created by `struct.pack()`. The binary data is copied to a buffer whose address is passed to the C `fcntl()` call. The return value after a successful call is the contents of the buffer, converted to a `bytes` object. The length of the returned object will be the same as the length of the *arg* argument. This is limited to 1024 bytes. If the information returned in the buffer by the operating system is larger than 1024 bytes, this is most likely to result in a segmentation violation or a more subtle data corruption.

If the `fcntl()` call fails, an `OSError` is raised.

引發一個附帶引數 *fd*、*cmd*、*arg* 的稽核事件 `fcntl.fcntl`。

`fcntl.ioctl(fd, request, arg=0, mutate_flag=True)`

This function is identical to the `fcntl()` function, except that the argument handling is even more complicated.

The *request* parameter is limited to values that can fit in 32-bits. Additional constants of interest for use as the *request* argument can be found in the `termios` module, under the same names as used in the relevant C header files.

The parameter *arg* can be one of an integer, an object supporting the read-only buffer interface (like `bytes`) or an object supporting the read-write buffer interface (like `bytearray`).

In all but the last case, behaviour is as for the `fcntl()` function.

If a mutable buffer is passed, then the behaviour is determined by the value of the *mutate_flag* parameter.

If it is false, the buffer's mutability is ignored and behaviour is as for a read-only buffer, except that the 1024 byte limit mentioned above is avoided -- so long as the buffer you pass is at least as long as what the operating system wants to put there, things should work.

If *mutate_flag* is true (the default), then the buffer is (in effect) passed to the underlying `ioctl()` system call, the latter's return code is passed back to the calling Python, and the buffer's new contents reflect the action of the `ioctl()`. This is a slight simplification, because if the supplied buffer is less than 1024 bytes long it is first copied into a static buffer 1024 bytes long which is then passed to `ioctl()` and copied back into the supplied buffer.

If the `ioctl()` call fails, an `OSError` exception is raised.

範例：

```
>>> import array, fcntl, struct, termios, os
>>> os.getpgrp()
13341
>>> struct.unpack('h', fcntl.ioctl(0, termios.TIOCGPGRP, " "))[0]
13341
>>> buf = array.array('h', [0])
>>> fcntl.ioctl(0, termios.TIOCGPGRP, buf, 1)
0
>>> buf
array('h', [13341])
```

引發一個附帶引數 *fd*、*request*、*arg* 的稽核事件 `fcntl.ioctl`。

`fcntl.flock(fd, operation)`

Perform the lock operation *operation* on file descriptor *fd* (file objects providing a `fileno()` method are accepted as well). See the Unix manual `flock(2)` for details. (On some systems, this function is emulated using `fcntl()`.)

If the `flock()` call fails, an `OSError` exception is raised.

引發一個附帶引數 `fd`、`operation` 的稽核事件 `fcntl.flock`。

`fcntl.lockf(fd, cmd, len=0, start=0, whence=0)`

This is essentially a wrapper around the `fcntl()` locking calls. `fd` is the file descriptor (file objects providing a `fileno()` method are accepted as well) of the file to lock or unlock, and `cmd` is one of the following values:

`fcntl.LOCK_UN`

Release an existing lock.

`fcntl.LOCK_SH`

Acquire a shared lock.

`fcntl.LOCK_EX`

Acquire an exclusive lock.

`fcntl.LOCK_NB`

Bitwise OR with any of the other three `LOCK_*` constants to make the request non-blocking.

If `LOCK_NB` is used and the lock cannot be acquired, an `OSError` will be raised and the exception will have an `errno` attribute set to `EACCES` or `EAGAIN` (depending on the operating system; for portability, check for both values). On at least some systems, `LOCK_EX` can only be used if the file descriptor refers to a file opened for writing.

`len` is the number of bytes to lock, `start` is the byte offset at which the lock starts, relative to `whence`, and `whence` is as with `io.IOBase.seek()`, specifically:

- 0 -- relative to the start of the file (`os.SEEK_SET`)
- 1 -- relative to the current buffer position (`os.SEEK_CUR`)
- 2 -- relative to the end of the file (`os.SEEK_END`)

The default for `start` is 0, which means to start at the beginning of the file. The default for `len` is 0 which means to lock to the end of the file. The default for `whence` is also 0.

引發一個附帶引數 `fd`、`cmd`、`len`、`start`、`whence` 的稽核事件 `fcntl.lockf`。

Examples (all on a SVR4 compliant system):

```
import struct, fcntl, os

f = open(...)
rv = fcntl.fcntl(f, fcntl.F_SETFL, os.O_NDELAY)

lockdata = struct.pack('hhllhh', fcntl.F_WRLCK, 0, 0, 0, 0, 0)
rv = fcntl.fcntl(f, fcntl.F_SETLKW, lockdata)
```

Note that in the first example the return value variable `rv` will hold an integer value; in the second example it will hold a `bytes` object. The structure lay-out for the `lockdata` variable is system dependent --- therefore using the `flock()` call may be better.

也參考:

os 模組

If the locking flags `O_SHLOCK` and `O_EXLOCK` are present in the `os` module (on BSD only), the `os.open()` function provides an alternative to the `lockf()` and `flock()` functions.

34.8 resource --- Resource usage information

This module provides basic mechanisms for measuring and controlling system resources utilized by a program.

Availability: Unix, not Emscripten, not WASI.

Symbolic constants are used to specify particular system resources and to request usage information about either the current process or its children.

An `OSError` is raised on syscall failure.

exception `resource.error`

A deprecated alias of `OSError`.

在 3.3 版的變更: Following [PEP 3151](#), this class was made an alias of `OSError`.

34.8.1 Resource Limits

Resources usage can be limited using the `setrlimit()` function described below. Each resource is controlled by a pair of limits: a soft limit and a hard limit. The soft limit is the current limit, and may be lowered or raised by a process over time. The soft limit can never exceed the hard limit. The hard limit can be lowered to any value greater than the soft limit, but not raised. (Only processes with the effective UID of the super-user can raise a hard limit.)

The specific resources that can be limited are system dependent. They are described in the `getrlimit(2)` man page. The resources listed below are supported when the underlying operating system supports them; resources which cannot be checked or controlled by the operating system are not defined in this module for those platforms.

`resource.RLIM_INFINITY`

Constant used to represent the limit for an unlimited resource.

`resource.getrlimit(resource)`

Returns a tuple (soft, hard) with the current soft and hard limits of *resource*. Raises `ValueError` if an invalid resource is specified, or `error` if the underlying system call fails unexpectedly.

`resource.setrlimit(resource, limits)`

Sets new limits of consumption of *resource*. The *limits* argument must be a tuple (soft, hard) of two integers describing the new limits. A value of `RLIM_INFINITY` can be used to request a limit that is unlimited.

Raises `ValueError` if an invalid resource is specified, if the new soft limit exceeds the hard limit, or if a process tries to raise its hard limit. Specifying a limit of `RLIM_INFINITY` when the hard or system limit for that resource is not unlimited will result in a `ValueError`. A process with the effective UID of super-user can request any valid limit value, including unlimited, but `ValueError` will still be raised if the requested limit exceeds the system imposed limit.

`setrlimit` may also raise `error` if the underlying system call fails.

VxWorks only supports setting `RLIMIT_NOFILE`.

引發一個附帶引數 `resource`、`limits` 的稽核事件 `resource.setrlimit`。

`resource.prlimit(pid, resource[, limits])`

Combines `setrlimit()` and `getrlimit()` in one function and supports to get and set the resources limits of an arbitrary process. If *pid* is 0, then the call applies to the current process. *resource* and *limits* have the same meaning as in `setrlimit()`, except that *limits* is optional.

When *limits* is not given the function returns the *resource* limit of the process *pid*. When *limits* is given the *resource* limit of the process is set and the former resource limit is returned.

Raises `ProcessLookupError` when *pid* can't be found and `PermissionError` when the user doesn't have `CAP_SYS_RESOURCE` for the process.

引發一個附帶引數 `pid`、`resource`、`limits` 的稽核事件 `resource.prlimit`。

適用：Linux 2.6.36 以上且具有 glibc 2.13 以上。

在 3.4 版新加入。

These symbols define resources whose consumption can be controlled using the `setrlimit()` and `getrlimit()` functions described below. The values of these symbols are exactly the constants used by C programs.

The Unix man page for `getrlimit(2)` lists the available resources. Note that not all systems use the same symbol or same value to denote the same resource. This module does not attempt to mask platform differences --- symbols not defined for a platform will not be available from this module on that platform.

`resource.RLIMIT_CORE`

The maximum size (in bytes) of a core file that the current process can create. This may result in the creation of a partial core file if a larger core would be required to contain the entire process image.

`resource.RLIMIT_CPU`

The maximum amount of processor time (in seconds) that a process can use. If this limit is exceeded, a `SIGXCPU` signal is sent to the process. (See the `signal` module documentation for information about how to catch this signal and do something useful, e.g. flush open files to disk.)

`resource.RLIMIT_FSIZE`

The maximum size of a file which the process may create.

`resource.RLIMIT_DATA`

The maximum size (in bytes) of the process's heap.

`resource.RLIMIT_STACK`

The maximum size (in bytes) of the call stack for the current process. This only affects the stack of the main thread in a multi-threaded process.

`resource.RLIMIT_RSS`

The maximum resident set size that should be made available to the process.

`resource.RLIMIT_NPROC`

The maximum number of processes the current process may create.

`resource.RLIMIT_NOFILE`

The maximum number of open file descriptors for the current process.

`resource.RLIMIT_OFILE`

The BSD name for `RLIMIT_NOFILE`.

`resource.RLIMIT_MEMLOCK`

The maximum address space which may be locked in memory.

`resource.RLIMIT_VMEM`

The largest area of mapped memory which the process may occupy.

適用：FreeBSD 11 以上。

`resource.RLIMIT_AS`

The maximum area (in bytes) of address space which may be taken by the process.

`resource.RLIMIT_MSGQUEUE`

The number of bytes that can be allocated for POSIX message queues.

適用：Linux 2.6.8 以上。

在 3.4 版新加入。

`resource.RLIMIT_NICE`

The ceiling for the process's nice level (calculated as 20 - rlim_cur).

適用：Linux 2.6.12 以上。

在 3.4 版新加入。

`resource.RLIMIT_RTPRIO`

The ceiling of the real-time priority.

適用：Linux 2.6.12 以上。

在 3.4 版新加入。

`resource.RLIMIT_RTTIME`

The time limit (in microseconds) on CPU time that a process can spend under real-time scheduling without making a blocking syscall.

適用：Linux 2.6.25 以上。

在 3.4 版新加入。

`resource.RLIMIT_SIGPENDING`

The number of signals which the process may queue.

適用：Linux 2.6.8 以上。

在 3.4 版新加入。

`resource.RLIMIT_SBSIZE`

The maximum size (in bytes) of socket buffer usage for this user. This limits the amount of network memory, and hence the amount of mbufs, that this user may hold at any time.

適用：FreeBSD。

在 3.4 版新加入。

`resource.RLIMIT_SWAP`

The maximum size (in bytes) of the swap space that may be reserved or used by all of this user id's processes. This limit is enforced only if bit 1 of the vm.overcommit sysctl is set. Please see [tuning\(7\)](#) for a complete description of this sysctl.

適用：FreeBSD。

在 3.4 版新加入。

`resource.RLIMIT_NPTS`

The maximum number of pseudo-terminals created by this user id.

適用：FreeBSD。

在 3.4 版新加入。

`resource.RLIMIT_KQUEUES`

The maximum number of kqueues this user id is allowed to create.

適用：FreeBSD 11 以上。

在 3.10 版新加入。

34.8.2 Resource Usage

These functions are used to retrieve resource usage information:

`resource.getrusage(who)`

This function returns an object that describes the resources consumed by either the current process or its children, as specified by the *who* parameter. The *who* parameter should be specified using one of the `RUSAGE_*` constants described below.

一個簡單範例：

```
from resource import *
import time

# a non CPU-bound task
time.sleep(3)
print(getrusage(RUSAGE_SELF))

# a CPU-bound task
for i in range(10 ** 8):
    _ = 1 + 1
print(getrusage(RUSAGE_SELF))
```

The fields of the return value each describe how a particular system resource has been used, e.g. amount of time spent running in user mode or number of times the process was swapped out of main memory. Some values are dependent on the clock tick interval, e.g. the amount of memory the process is using.

For backward compatibility, the return value is also accessible as a tuple of 16 elements.

The fields `ru_utime` and `ru_stime` of the return value are floating point values representing the amount of time spent executing in user mode and the amount of time spent executing in system mode, respectively. The remaining values are integers. Consult the *getrusage(2)* man page for detailed information about these values. A brief summary is presented here:

Index	Field	Resource
0	<code>ru_utime</code>	time in user mode (float seconds)
1	<code>ru_stime</code>	time in system mode (float seconds)
2	<code>ru_maxrss</code>	maximum resident set size
3	<code>ru_ixrss</code>	shared memory size
4	<code>ru_idrss</code>	unshared memory size
5	<code>ru_isrss</code>	unshared stack size
6	<code>ru_minflt</code>	page faults not requiring I/O
7	<code>ru_majflt</code>	page faults requiring I/O
8	<code>ru_nswap</code>	number of swap outs
9	<code>ru_inblock</code>	block input operations
10	<code>ru_oublock</code>	block output operations
11	<code>ru_msgsnd</code>	messages sent
12	<code>ru_msgrcv</code>	messages received
13	<code>ru_nsignals</code>	signals received
14	<code>ru_nvcsw</code>	voluntary context switches
15	<code>ru_nivcsw</code>	involuntary context switches

This function will raise a `ValueError` if an invalid *who* parameter is specified. It may also raise `error` exception in unusual circumstances.

`resource.getpagesize()`

Returns the number of bytes in a system page. (This need not be the same as the hardware page size.)

The following `RUSAGE_*` symbols are passed to the *getrusage()* function to specify which processes information should be provided for.

`resource.RUSAGE_SELF`

Pass to `getrusage()` to request resources consumed by the calling process, which is the sum of resources used by all threads in the process.

`resource.RUSAGE_CHILDREN`

Pass to `getrusage()` to request resources consumed by child processes of the calling process which have been terminated and waited for.

`resource.RUSAGE_BOTH`

Pass to `getrusage()` to request resources consumed by both the current process and child processes. May not be available on all systems.

`resource.RUSAGE_THREAD`

Pass to `getrusage()` to request resources consumed by the current thread. May not be available on all systems.

在 3.2 版新加入。

34.9 syslog --- Unix syslog library routines

This module provides an interface to the Unix `syslog` library routines. Refer to the Unix manual pages for a detailed description of the `syslog` facility.

Availability: Unix, not Emscripten, not WASI.

This module wraps the system `syslog` family of routines. A pure Python library that can speak to a syslog server is available in the `logging.handlers` module as `SysLogHandler`.

該模組定義了以下函式：

`syslog.syslog(message)`

`syslog.syslog(priority, message)`

Send the string *message* to the system logger. A trailing newline is added if necessary. Each message is tagged with a priority composed of a *facility* and a *level*. The optional *priority* argument, which defaults to `LOG_INFO`, determines the message priority. If the facility is not encoded in *priority* using logical-or (`LOG_INFO | LOG_USER`), the value given in the `openlog()` call is used.

If `openlog()` has not been called prior to the call to `syslog()`, `openlog()` will be called with no arguments.

引發一個附帶引數 `priority`、`message` 的稽核事件 `syslog.syslog`。

在 3.2 版的變更: In previous versions, `openlog()` would not be called automatically if it wasn't called prior to the call to `syslog()`, deferring to the syslog implementation to call `openlog()`.

`syslog.openlog([ident[, logoption[, facility]]])`

Logging options of subsequent `syslog()` calls can be set by calling `openlog()`. `syslog()` will call `openlog()` with no arguments if the log is not currently open.

The optional *ident* keyword argument is a string which is prepended to every message, and defaults to `sys.argv[0]` with leading path components stripped. The optional *logoption* keyword argument (default is 0) is a bit field -- see below for possible values to combine. The optional *facility* keyword argument (default is `LOG_USER`) sets the default facility for messages which do not have a facility explicitly encoded.

引發一個附帶引數 `ident`、`logoption`、`facility` 的稽核事件 `syslog.openlog`。

在 3.2 版的變更: In previous versions, keyword arguments were not allowed, and *ident* was required.

syslog.closelog()

Reset the syslog module values and call the system library `closelog()`.

This causes the module to behave as it does when initially imported. For example, `openlog()` will be called on the first `syslog()` call (if `openlog()` hasn't already been called), and `ident` and other `openlog()` parameters are reset to defaults.

引發一個不附帶引數的稽核事件 `syslog.closelog`。

syslog.setlogmask(maskpri)

Set the priority mask to `maskpri` and return the previous mask value. Calls to `syslog()` with a priority level not set in `maskpri` are ignored. The default is to log all priorities. The function `LOG_MASK(pri)` calculates the mask for the individual priority `pri`. The function `LOG_UPTO(pri)` calculates the mask for all priorities up to and including `pri`.

引發一個附帶引數 `maskpri` 的稽核事件 `syslog.setlogmask`。

The module defines the following constants:

Priority levels (high to low):

`LOG_EMERG`, `LOG_ALERT`, `LOG_CRIT`, `LOG_ERR`, `LOG_WARNING`, `LOG_NOTICE`, `LOG_INFO`, `LOG_DEBUG`.

Facilities:

`LOG_KERN`, `LOG_USER`, `LOG_MAIL`, `LOG_DAEMON`, `LOG_AUTH`, `LOG_LPR`, `LOG_NEWS`, `LOG_UUCP`, `LOG_CRON`, `LOG_SYSLOG`, `LOG_LOCAL0` to `LOG_LOCAL7`, and, if defined in `<syslog.h>`, `LOG_AUTHPRIV`.

Log options:

`LOG_PID`, `LOG_CONS`, `LOG_NDELAY`, and, if defined in `<syslog.h>`, `LOG_ODELAY`, `LOG_NOWAIT`, and `LOG_PERROR`.

34.9.1 范例

簡單范例

一組簡單範例：

```
import syslog

syslog.syslog('Processing started')
if error:
    syslog.syslog(syslog.LOG_ERR, 'Processing started')
```

An example of setting some log options, these would include the process ID in logged messages, and write the messages to the destination facility used for mail logging:

```
syslog.openlog(logoption=syslog.LOG_PID, facility=syslog.LOG_MAIL)
syslog.syslog('E-mail processing initiated...')
```

Modules command-line interface (CLI)

The following modules have a command-line interface.

- *ast*
- *asyncio*
- *base64*
- *calendar*
- *code*
- *compileall*
- *cProfile*: see *profile*
- *difflib*
- *dis*
- *doctest*
- `encodings.rot_13`
- *ensurepip*
- *filecmp*
- *fileinput*
- *ftplib*
- *gzip*
- *http.server*
- *idlelib*
- *inspect*
- *json.tool*
- *mimetypes*
- *pdb*
- *pickle*

- *pickletools*
- *platform*
- *poplib*
- *profile*
- *pstats*
- *py_compile*
- *pyclbr*
- *pydoc*
- *quopri*
- *runpy*
- *site*
- *sysconfig*
- *tabnanny*
- *tarfile*
- *this*
- *timeit*
- *tokenize*
- *trace*
- *turtledemo*
- *unittest*
- *venv*
- *webbrowser*
- *zipapp*
- *zipfile*

See also the Python command-line interface.

已被取代的模組

此章節所描述的模組 (modules) 均已被⌘用，僅⌘了向後相容性而被保留下來。它們已經被其他模組所取代。

36.1 `aifc` --- 讀寫 AIFF 與 AIFC 檔案

原始碼: [Lib/aifc.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `aifc` 模組 (module) 即將被⌘用 (詳見 [PEP 594](#))。

This module provides support for reading and writing AIFF and AIFF-C files. AIFF is Audio Interchange File Format, a format for storing digital audio samples in a file. AIFF-C is a newer version of the format that includes the ability to compress the audio data.

Audio files have a number of parameters that describe the audio data. The sampling rate or frame rate is the number of times per second the sound is sampled. The number of channels indicate if the audio is mono, stereo, or quadro. Each frame consists of one sample per channel. The sample size is the size in bytes of each sample. Thus a frame consists of `nchannels * samplesize` bytes, and a second's worth of audio consists of `nchannels * samplesize * framerate` bytes.

For example, CD quality audio has a sample size of two bytes (16 bits), uses two channels (stereo) and has a frame rate of 44,100 frames/second. This gives a frame size of 4 bytes ($2*2$), and a second's worth occupies $2*2*44100$ bytes (176,400 bytes).

`aifc` 模組定義了以下函式:

`aifc.open(file, mode=None)`

Open an AIFF or AIFF-C file and return an object instance with methods that are described below. The argument *file* is either a string naming a file or a *file object*. *mode* must be 'r' or 'rb' when the file must be opened for reading, or 'w' or 'wb' when the file must be opened for writing. If omitted, `file.mode` is used if it exists, otherwise 'rb' is used. When used for writing, the file object should be seekable, unless you know ahead of time how many samples you are going to write in total and use `writeframesraw()` and `setnframes()`. The `open()` function may be used in a `with` statement. When the `with` block completes, the `close()` method is called.

在 3.4 版的變更: Support for the `with` statement was added.

Objects returned by `open()` when a file is opened for reading have the following methods:

`aifc.getnchannels()`

Return the number of audio channels (1 for mono, 2 for stereo).

`aifc.getsampwidth()`

Return the size in bytes of individual samples.

`aifc.getframerate()`

Return the sampling rate (number of audio frames per second).

`aifc.getnframes()`

Return the number of audio frames in the file.

`aifc.getcomptype()`

Return a bytes array of length 4 describing the type of compression used in the audio file. For AIFF files, the returned value is `b'NONE'`.

`aifc.getcompname()`

Return a bytes array convertible to a human-readable description of the type of compression used in the audio file. For AIFF files, the returned value is `b'not compressed'`.

`aifc.getparams()`

Returns a `namedtuple()` (`nchannels`, `sampwidth`, `framerate`, `nframes`, `comptype`, `compname`), equivalent to output of the `get*()` methods.

`aifc.getmarkers()`

Return a list of markers in the audio file. A marker consists of a tuple of three elements. The first is the mark ID (an integer), the second is the mark position in frames from the beginning of the data (an integer), the third is the name of the mark (a string).

`aifc.getmark(id)`

Return the tuple as described in `getmarkers()` for the mark with the given `id`.

`aifc.readframes(nframes)`

Read and return the next `nframes` frames from the audio file. The returned data is a string containing for each frame the uncompressed samples of all channels.

`aifc.rewind()`

Rewind the read pointer. The next `readframes()` will start from the beginning.

`aifc.setpos(pos)`

Seek to the specified frame number.

`aifc.tell()`

Return the current frame number.

`aifc.close()`

Close the AIFF file. After calling this method, the object can no longer be used.

Objects returned by `open()` when a file is opened for writing have all the above methods, except for `readframes()` and `setpos()`. In addition the following methods exist. The `get*()` methods can only be called after the corresponding `set*()` methods have been called. Before the first `writeframes()` or `writeframesraw()`, all parameters except for the number of frames must be filled in.

`aifc.aiff()`

Create an AIFF file. The default is that an AIFF-C file is created, unless the name of the file ends in `'.aiff'` in which case the default is an AIFF file.

`aifc.aifc()`

Create an AIFF-C file. The default is that an AIFF-C file is created, unless the name of the file ends in `'.aiff'` in which case the default is an AIFF file.

`aifc.setnchannels(nchannels)`

Specify the number of channels in the audio file.

`aifc.setsampwidth(width)`

Specify the size in bytes of audio samples.

`aifc.setframerate(rate)`

Specify the sampling frequency in frames per second.

`aifc.setnframes(nframes)`

Specify the number of frames that are to be written to the audio file. If this parameter is not set, or not set correctly, the file needs to support seeking.

`aifc.setcomptype(type, name)`

Specify the compression type. If not specified, the audio data will not be compressed. In AIFF files, compression is not possible. The name parameter should be a human-readable description of the compression type as a bytes array, the type parameter should be a bytes array of length 4. Currently the following compression types are supported: `b'NONE'`, `b'ULAW'`, `b'ALAW'`, `b'G722'`.

`aifc.setparams(nchannels, sampwidth, framerate, comptype, compname)`

Set all the above parameters at once. The argument is a tuple consisting of the various parameters. This means that it is possible to use the result of a `getparams()` call as argument to `setparams()`.

`aifc.setmark(id, pos, name)`

Add a mark with the given id (larger than 0), and the given name at the given position. This method can be called at any time before `close()`.

`aifc.tell()`

Return the current write position in the output file. Useful in combination with `setmark()`.

`aifc.writeframes(data)`

Write data to the output file. This method can only be called after the audio file parameters have been set.

在 3.4 版的變更: Any *bytes-like object* is now accepted.

`aifc.writeframesraw(data)`

Like `writeframes()`, except that the header of the audio file is not updated.

在 3.4 版的變更: Any *bytes-like object* is now accepted.

`aifc.close()`

Close the AIFF file. The header of the file is updated to reflect the actual size of the audio data. After calling this method, the object can no longer be used.

36.2 asynchat --- 非同步 socket 指令/回應處理函式

原始碼: [Lib/asynchat.py](#)

自從版本 3.6 後不推薦使用，將會自版本 3.12 中移除。: `asynchat` 已被 用 (詳情請見: [pep:PEP 594 <594#asynchat>](#))。請改用 `asyncio`。

備: This module exists for backwards compatibility only. For new code we recommend using `asyncio`.

This module builds on the `asyncore` infrastructure, simplifying asynchronous clients and servers and making it easier to handle protocols whose elements are terminated by arbitrary strings, or are of variable length. `asynchat` defines the abstract class `async_chat` that you subclass, providing implementations of the `collect_incoming_data()` and `found_terminator()` methods. It uses the same asynchronous loop as `asyncore`, and the two types of channel, `asyncore.dispatcher` and `asynchat.async_chat`, can freely

be mixed in the channel map. Typically an `asyncore.dispatcher` server channel generates new `asyncchat.async_chat` channel objects as it receives incoming connection requests.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

class `asyncchat.async_chat`

This class is an abstract subclass of `asyncore.dispatcher`. To make practical use of the code you must subclass `async_chat`, providing meaningful `collect_incoming_data()` and `found_terminator()` methods. The `asyncore.dispatcher` methods can be used, although not all make sense in a message/response context.

Like `asyncore.dispatcher`, `async_chat` defines a set of events that are generated by an analysis of socket conditions after a `select()` call. Once the polling loop has been started the `async_chat` object's methods are called by the event-processing framework with no action on the part of the programmer.

Two class attributes can be modified, to improve performance, or possibly even to conserve memory.

`ac_in_buffer_size`

The asynchronous input buffer size (default 4096).

`ac_out_buffer_size`

The asynchronous output buffer size (default 4096).

Unlike `asyncore.dispatcher`, `async_chat` allows you to define a FIFO queue of *producers*. A producer need have only one method, `more()`, which should return data to be transmitted on the channel. The producer indicates exhaustion (*i.e.* that it contains no more data) by having its `more()` method return the empty bytes object. At this point the `async_chat` object removes the producer from the queue and starts using the next producer, if any. When the producer queue is empty the `handle_write()` method does nothing. You use the channel object's `set_terminator()` method to describe how to recognize the end of, or an important breakpoint in, an incoming transmission from the remote endpoint.

To build a functioning `async_chat` subclass your input methods `collect_incoming_data()` and `found_terminator()` must handle the data that the channel receives asynchronously. The methods are described below.

`async_chat.close_when_done()`

Pushes a `None` on to the producer queue. When this producer is popped off the queue it causes the channel to be closed.

`async_chat.collect_incoming_data(data)`

Called with `data` holding an arbitrary amount of received data. The default method, which must be overridden, raises a `NotImplementedError` exception.

`async_chat.discard_buffers()`

In emergencies this method will discard any data held in the input and/or output buffers and the producer queue.

`async_chat.found_terminator()`

Called when the incoming data stream matches the termination condition set by `set_terminator()`. The default method, which must be overridden, raises a `NotImplementedError` exception. The buffered input data should be available via an instance attribute.

`async_chat.get_terminator()`

Returns the current terminator for the channel.

`async_chat.push(data)`

Pushes data on to the channel's queue to ensure its transmission. This is all you need to do to have the channel write the data out to the network, although it is possible to use your own producers in more complex schemes to implement encryption and chunking, for example.

`async_chat.push_with_producer(producer)`

Takes a producer object and adds it to the producer queue associated with the channel. When all currently pushed producers have been exhausted the channel will consume this producer's data by calling its `more()` method and send the data to the remote endpoint.

`async_chat.set_terminator(term)`

Sets the terminating condition to be recognized on the channel. `term` may be any of three types of value, corresponding to three different ways to handle incoming protocol data.

term	描述
<i>string</i>	Will call <code>found_terminator()</code> when the string is found in the input stream
<i>integer</i>	Will call <code>found_terminator()</code> when the indicated number of characters have been received
<code>None</code>	The channel continues to collect data forever

Note that any data following the terminator will be available for reading by the channel after `found_terminator()` is called.

36.2.1 asyncchat Example

The following partial example shows how HTTP requests can be read with `async_chat`. A web server might create an `http_request_handler` object for each incoming client connection. Notice that initially the channel terminator is set to match the blank line at the end of the HTTP headers, and a flag indicates that the headers are being read.

Once the headers have been read, if the request is of type POST (indicating that further data are present in the input stream) then the `Content-Length:` header is used to set a numeric terminator to read the right amount of data from the channel.

The `handle_request()` method is called once all relevant input has been marshalled, after setting the channel terminator to `None` to ensure that any extraneous data sent by the web client are ignored.

```
import asyncchat

class http_request_handler(asyncchat.async_chat):

    def __init__(self, sock, addr, sessions, log):
        asyncchat.async_chat.__init__(self, sock=sock)
        self.addr = addr
        self.sessions = sessions
        self.ibuffer = []
        self.obuffer = b""
        self.set_terminator(b"\r\n\r\n")
        self.reading_headers = True
        self.handling = False
        self.cgi_data = None
        self.log = log

    def collect_incoming_data(self, data):
        """Buffer the data"""
        self.ibuffer.append(data)

    def found_terminator(self):
        if self.reading_headers:
            self.reading_headers = False
            self.parse_headers(b"".join(self.ibuffer))
            self.ibuffer = []
            if self.op.upper() == b"POST":
```

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(繼續上一頁)

```

        clen = self.headers.getheader("content-length")
        self.set_terminator(int(clen))
    else:
        self.handling = True
        self.set_terminator(None)
        self.handle_request()
    elif not self.handling:
        self.set_terminator(None) # browsers sometimes over-send
        self.cgi_data = parse(self.headers, b"".join(self.ibuffer))
        self.handling = True
        self.ibuffer = []
        self.handle_request()

```

36.3 `asyncore` --- 非同步 socket 處理函式

原始碼: `Lib/asyncore.py`

自從版本 3.6 後不推薦使用，將會自版本 3.12 中移除。: `asyncore` 已被 F 用（詳情請見: [pep:PEP 594 <594#asyncore>](#)）。請改用 `asyncio`。

備 F: This module exists for backwards compatibility only. For new code we recommend using `asyncio`.

This module provides the basic infrastructure for writing asynchronous socket service clients and servers.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscrip`ten and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

There are only two ways to have a program on a single processor do "more than one thing at a time." Multi-threaded programming is the simplest and most popular way to do it, but there is another very different technique, that lets you have nearly all the advantages of multi-threading, without actually using multiple threads. It's really only practical if your program is largely I/O bound. If your program is processor bound, then pre-emptive scheduled threads are probably what you really need. Network servers are rarely processor bound, however.

If your operating system supports the `select()` system call in its I/O library (and nearly all do), then you can use it to juggle multiple communication channels at once; doing other work while your I/O is taking place in the "background." Although this strategy can seem strange and complex, especially at first, it is in many ways easier to understand and control than multi-threaded programming. The `asyncore` module solves many of the difficult problems for you, making the task of building sophisticated high-performance network servers and clients a snap. For "conversational" applications and protocols the companion `asynchat` module is invaluable.

The basic idea behind both modules is to create one or more network *channels*, instances of class `asyncore.dispatcher` and `asynchat.async_chat`. Creating the channels adds them to a global map, used by the `loop()` function if you do not provide it with your own *map*.

Once the initial channel(s) is(are) created, calling the `loop()` function activates channel service, which continues until the last channel (including any that have been added to the map during asynchronous service) is closed.

`asyncore.loop([timeout[, use_poll[, map[, count]]]])`

Enter a polling loop that terminates after *count* passes or all open channels have been closed. All arguments are optional. The *count* parameter defaults to `None`, resulting in the loop terminating only when all channels have been closed. The *timeout* argument sets the timeout parameter for the appropriate `select()` or `poll()` call, measured in seconds; the default is 30 seconds. The *use_poll* parameter, if true, indicates that `poll()` should be used in preference to `select()` (the default is `False`).

The *map* parameter is a dictionary whose items are the channels to watch. As channels are closed they are deleted from their map. If *map* is omitted, a global map is used. Channels (instances of *asyncore.dispatcher*, *asyncchat.async_chat* and subclasses thereof) can freely be mixed in the map.

class `asyncore.dispatcher`

The *dispatcher* class is a thin wrapper around a low-level socket object. To make it more useful, it has a few methods for event-handling which are called from the asynchronous loop. Otherwise, it can be treated as a normal non-blocking socket object.

The firing of low-level events at certain times or in certain connection states tells the asynchronous loop that certain higher-level events have taken place. For example, if we have asked for a socket to connect to another host, we know that the connection has been made when the socket becomes writable for the first time (at this point you know that you may write to it with the expectation of success). The implied higher-level events are:

Event	描述
<code>handle_connect()</code>	Implied by the first read or write event
<code>handle_close()</code>	Implied by a read event with no data available
<code>handle_accepted()</code>	Implied by a read event on a listening socket

During asynchronous processing, each mapped channel's *readable()* and *writable()* methods are used to determine whether the channel's socket should be added to the list of channels *select()* ed or *poll()* ed for read and write events.

Thus, the set of channel events is larger than the basic socket events. The full set of methods that can be overridden in your subclass follows:

handle_read()

Called when the asynchronous loop detects that a *read()* call on the channel's socket will succeed.

handle_write()

Called when the asynchronous loop detects that a writable socket can be written. Often this method will implement the necessary buffering for performance. For example:

```
def handle_write(self):
    sent = self.send(self.buffer)
    self.buffer = self.buffer[sent:]
```

handle_expt()

Called when there is out of band (OOB) data for a socket connection. This will almost never happen, as OOB is tenuously supported and rarely used.

handle_connect()

Called when the active opener's socket actually makes a connection. Might send a "welcome" banner, or initiate a protocol negotiation with the remote endpoint, for example.

handle_close()

Called when the socket is closed.

handle_error()

Called when an exception is raised and not otherwise handled. The default version prints a condensed traceback.

handle_accept()

Called on listening channels (passive openers) when a connection can be established with a new remote endpoint that has issued a *connect()* call for the local endpoint. Deprecated in version 3.2; use *handle_accepted()* instead.

在 3.2 版之後被 `handle_accepted()` 用。

handle_accepted (*sock, addr*)

Called on listening channels (passive openers) when a connection has been established with a new remote endpoint that has issued a `connect()` call for the local endpoint. *sock* is a *new* socket object usable to send and receive data on the connection, and *addr* is the address bound to the socket on the other end of the connection.

在 3.2 版新加入。

readable ()

Called each time around the asynchronous loop to determine whether a channel's socket should be added to the list on which read events can occur. The default method simply returns `True`, indicating that by default, all channels will be interested in read events.

writable ()

Called each time around the asynchronous loop to determine whether a channel's socket should be added to the list on which write events can occur. The default method simply returns `True`, indicating that by default, all channels will be interested in write events.

In addition, each channel delegates or extends many of the socket methods. Most of these are nearly identical to their socket partners.

create_socket (*family=socket.AF_INET, type=socket.SOCK_STREAM*)

This is identical to the creation of a normal socket, and will use the same options for creation. Refer to the `socket` documentation for information on creating sockets.

在 3.3 版的變更: *family* and *type* arguments can be omitted.

connect (*address*)

As with the normal socket object, *address* is a tuple with the first element the host to connect to, and the second the port number.

send (*data*)

Send *data* to the remote end-point of the socket.

recv (*buffer_size*)

Read at most *buffer_size* bytes from the socket's remote end-point. An empty bytes object implies that the channel has been closed from the other end.

Note that `recv()` may raise `BlockingIOError`, even though `select.select()` or `select.poll()` has reported the socket ready for reading.

listen (*backlog*)

Listen for connections made to the socket. The *backlog* argument specifies the maximum number of queued connections and should be at least 1; the maximum value is system-dependent (usually 5).

bind (*address*)

Bind the socket to *address*. The socket must not already be bound. (The format of *address* depends on the address family --- refer to the `socket` documentation for more information.) To mark the socket as reusable (setting the `SO_REUSEADDR` option), call the `dispatcher` object's `set_reuse_addr()` method.

accept ()

Accept a connection. The socket must be bound to an address and listening for connections. The return value can be either `None` or a pair (*conn*, *address*) where *conn* is a *new* socket object usable to send and receive data on the connection, and *address* is the address bound to the socket on the other end of the connection. When `None` is returned it means the connection didn't take place, in which case the server should just ignore this event and keep listening for further incoming connections.

close ()

Close the socket. All future operations on the socket object will fail. The remote end-point will receive no more data (after queued data is flushed). Sockets are automatically closed when they are garbage-collected.

class `asyncore.dispatcher_with_send`

A *dispatcher* subclass which adds simple buffered output capability, useful for simple clients. For more sophisticated usage use *asynchat.async_chat*.

class `asyncore.file_dispatcher`

A *file_dispatcher* takes a file descriptor or *file object* along with an optional map argument and wraps it for use with the `poll()` or `loop()` functions. If provided a file object or anything with a `fileno()` method, that method will be called and passed to the *file_wrapper* constructor.

適用：Unix。

class `asyncore.file_wrapper`

A *file_wrapper* takes an integer file descriptor and calls *os.dup()* to duplicate the handle so that the original handle may be closed independently of the *file_wrapper*. This class implements sufficient methods to emulate a socket for use by the *file_dispatcher* class.

適用：Unix。

36.3.1 `asyncore` Example basic HTTP client

Here is a very basic HTTP client that uses the *dispatcher* class to implement its socket handling:

```
import asyncore

class HTTPClient(asyncore.dispatcher):

    def __init__(self, host, path):
        asyncore.dispatcher.__init__(self)
        self.create_socket()
        self.connect((host, 80))
        self.buffer = bytes('GET %s HTTP/1.0\r\nHost: %s\r\n\r\n' %
                             (path, host), 'ascii')

    def handle_connect(self):
        pass

    def handle_close(self):
        self.close()

    def handle_read(self):
        print(self.recv(8192))

    def writable(self):
        return (len(self.buffer) > 0)

    def handle_write(self):
        sent = self.send(self.buffer)
        self.buffer = self.buffer[sent:]

client = HTTPClient('www.python.org', '/')
asyncore.loop()
```

36.3.2 `asyncore` Example basic echo server

Here is a basic echo server that uses the `dispatcher` class to accept connections and dispatches the incoming connections to a handler:

```
import asyncore

class EchoHandler(asyncore.dispatcher_with_send):

    def handle_read(self):
        data = self.recv(8192)
        if data:
            self.send(data)

class EchoServer(asyncore.dispatcher):

    def __init__(self, host, port):
        asyncore.dispatcher.__init__(self)
        self.create_socket()
        self.set_reuse_addr()
        self.bind((host, port))
        self.listen(5)

    def handle_accepted(self, sock, addr):
        print('Incoming connection from %s' % repr(addr))
        handler = EchoHandler(sock)

server = EchoServer('localhost', 8080)
asyncore.loop()
```

36.4 `audioop` --- 操作原始聲音檔案

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `audioop` 模組 (module) 即將被 F 用（詳見 [PEP 594](#)）。

The `audioop` module contains some useful operations on sound fragments. It operates on sound fragments consisting of signed integer samples 8, 16, 24 or 32 bits wide, stored in *bytes-like objects*. All scalar items are integers, unless specified otherwise.

在 3.4 版的變更: Support for 24-bit samples was added. All functions now accept any *bytes-like object*. String input now results in an immediate error.

This module provides support for a-LAW, u-LAW and Intel/DVI ADPCM encodings.

A few of the more complicated operations only take 16-bit samples, otherwise the sample size (in bytes) is always a parameter of the operation.

The module defines the following variables and functions:

exception `audioop.error`

This exception is raised on all errors, such as unknown number of bytes per sample, etc.

`audioop.add(fragment1, fragment2, width)`

Return a fragment which is the addition of the two samples passed as parameters. *width* is the sample width in bytes, either 1, 2, 3 or 4. Both fragments should have the same length. Samples are truncated in case of overflow.

`audioop.adpcm2lin (adpcmfragment, width, state)`

Decode an Intel/DVI ADPCM coded fragment to a linear fragment. See the description of `lin2adpcm()` for details on ADPCM coding. Return a tuple (`sample`, `newstate`) where the sample has the width specified in `width`.

`audioop.alaw2lin (fragment, width)`

Convert sound fragments in a-LAW encoding to linearly encoded sound fragments. a-LAW encoding always uses 8 bits samples, so `width` refers only to the sample width of the output fragment here.

`audioop.avg (fragment, width)`

Return the average over all samples in the fragment.

`audioop.avgpp (fragment, width)`

Return the average peak-peak value over all samples in the fragment. No filtering is done, so the usefulness of this routine is questionable.

`audioop.bias (fragment, width, bias)`

Return a fragment that is the original fragment with a bias added to each sample. Samples wrap around in case of overflow.

`audioop.byteswap (fragment, width)`

"Byteswap" all samples in a fragment and returns the modified fragment. Converts big-endian samples to little-endian and vice versa.

在 3.4 版新加入。

`audioop.cross (fragment, width)`

Return the number of zero crossings in the fragment passed as an argument.

`audioop.findfactor (fragment, reference)`

Return a factor F such that `rms(add(fragment, mul(reference, -F)))` is minimal, i.e., return the factor with which you should multiply `reference` to make it match as well as possible to `fragment`. The fragments should both contain 2-byte samples.

The time taken by this routine is proportional to `len(fragment)`.

`audioop.findfit (fragment, reference)`

Try to match `reference` as well as possible to a portion of `fragment` (which should be the longer fragment). This is (conceptually) done by taking slices out of `fragment`, using `findfactor()` to compute the best match, and minimizing the result. The fragments should both contain 2-byte samples. Return a tuple (`offset`, `factor`) where `offset` is the (integer) offset into `fragment` where the optimal match started and `factor` is the (floating-point) factor as per `findfactor()`.

`audioop.findmax (fragment, length)`

Search `fragment` for a slice of length `length` samples (not bytes!) with maximum energy, i.e., return i for which `rms(fragment[i*2:(i+length)*2])` is maximal. The fragments should both contain 2-byte samples.

The routine takes time proportional to `len(fragment)`.

`audioop.getsample (fragment, width, index)`

Return the value of sample `index` from the fragment.

`audioop.lin2adpcm (fragment, width, state)`

Convert samples to 4 bit Intel/DVI ADPCM encoding. ADPCM coding is an adaptive coding scheme, whereby each 4 bit number is the difference between one sample and the next, divided by a (varying) step. The Intel/DVI ADPCM algorithm has been selected for use by the IMA, so it may well become a standard.

`state` is a tuple containing the state of the coder. The coder returns a tuple (`adpcmfrag`, `newstate`), and the `newstate` should be passed to the next call of `lin2adpcm()`. In the initial call, `None` can be passed as the state. `adpcmfrag` is the ADPCM coded fragment packed 2 4-bit values per byte.

`audioop.lin2alaw(fragment, width)`

Convert samples in the audio fragment to a-LAW encoding and return this as a bytes object. a-LAW is an audio encoding format whereby you get a dynamic range of about 13 bits using only 8 bit samples. It is used by the Sun audio hardware, among others.

`audioop.lin2lin(fragment, width, newwidth)`

Convert samples between 1-, 2-, 3- and 4-byte formats.

備 F: In some audio formats, such as .WAV files, 16, 24 and 32 bit samples are signed, but 8 bit samples are unsigned. So when converting to 8 bit wide samples for these formats, you need to also add 128 to the result:

```
new_frames = audioop.lin2lin(frames, old_width, 1)
new_frames = audioop.bias(new_frames, 1, 128)
```

The same, in reverse, has to be applied when converting from 8 to 16, 24 or 32 bit width samples.

`audioop.lin2ulaw(fragment, width)`

Convert samples in the audio fragment to u-LAW encoding and return this as a bytes object. u-LAW is an audio encoding format whereby you get a dynamic range of about 14 bits using only 8 bit samples. It is used by the Sun audio hardware, among others.

`audioop.max(fragment, width)`

Return the maximum of the *absolute value* of all samples in a fragment.

`audioop.maxpp(fragment, width)`

Return the maximum peak-peak value in the sound fragment.

`audioop.minmax(fragment, width)`

Return a tuple consisting of the minimum and maximum values of all samples in the sound fragment.

`audioop.mul(fragment, width, factor)`

Return a fragment that has all samples in the original fragment multiplied by the floating-point value *factor*. Samples are truncated in case of overflow.

`audioop.ratecv(fragment, width, nchannels, inrate, outrate, state[, weightA[, weightB]])`

Convert the frame rate of the input fragment.

state is a tuple containing the state of the converter. The converter returns a tuple (*newfragment*, *newstate*), and *newstate* should be passed to the next call of `ratecv()`. The initial call should pass *None* as the state.

The *weightA* and *weightB* arguments are parameters for a simple digital filter and default to 1 and 0 respectively.

`audioop.reverse(fragment, width)`

Reverse the samples in a fragment and returns the modified fragment.

`audioop.rms(fragment, width)`

Return the root-mean-square of the fragment, i.e. $\sqrt{\text{sum}(S_i^2)/n}$.

This is a measure of the power in an audio signal.

`audioop.tomono(fragment, width, lfactor, rfactor)`

Convert a stereo fragment to a mono fragment. The left channel is multiplied by *lfactor* and the right channel by *rfactor* before adding the two channels to give a mono signal.

`audioop.tostereo(fragment, width, lfactor, rfactor)`

Generate a stereo fragment from a mono fragment. Each pair of samples in the stereo fragment are computed from the mono sample, whereby left channel samples are multiplied by *lfactor* and right channel samples by *rfactor*.

`audioop.ulaw2lin(fragment, width)`

Convert sound fragments in u-LAW encoding to linearly encoded sound fragments. u-LAW encoding always uses 8 bits samples, so *width* refers only to the sample width of the output fragment here.

Note that operations such as `mul()` or `max()` make no distinction between mono and stereo fragments, i.e. all samples are treated equal. If this is a problem the stereo fragment should be split into two mono fragments first and recombined later. Here is an example of how to do that:

```
def mul_stereo(sample, width, lfactor, rfactor):
    lsample = audioop.tomono(sample, width, 1, 0)
    rsample = audioop.tomono(sample, width, 0, 1)
    lsample = audioop.mul(lsample, width, lfactor)
    rsample = audioop.mul(rsample, width, rfactor)
    lsample = audioop.tostereo(lsample, width, 1, 0)
    rsample = audioop.tostereo(rsample, width, 0, 1)
    return audioop.add(lsample, rsample, width)
```

If you use the ADPCM coder to build network packets and you want your protocol to be stateless (i.e. to be able to tolerate packet loss) you should not only transmit the data but also the state. Note that you should send the *initial* state (the one you passed to `lin2adpcm()`) along to the decoder, not the final state (as returned by the coder). If you want to use `struct.Struct` to store the state in binary you can code the first element (the predicted value) in 16 bits and the second (the delta index) in 8.

The ADPCM coders have never been tried against other ADPCM coders, only against themselves. It could well be that I misinterpreted the standards in which case they will not be interoperable with the respective standards.

The `find*()` routines might look a bit funny at first sight. They are primarily meant to do echo cancellation. A reasonably fast way to do this is to pick the most energetic piece of the output sample, locate that in the input sample and subtract the whole output sample from the input sample:

```
def echocancel(outputdata, inputdata):
    pos = audioop.findmax(outputdata, 800)    # one tenth second
    out_test = outputdata[pos*2:]
    in_test = inputdata[pos*2:]
    ipos, factor = audioop.findfit(in_test, out_test)
    # Optional (for better cancellation):
    # factor = audioop.findfactor(in_test[ipos*2:ipos*2+len(out_test)],
    #                             out_test)
    prefill = '\0'*(pos+ipos)*2
    postfill = '\0'*(len(inputdata)-len(prefill)-len(outputdata))
    outputdata = prefill + audioop.mul(outputdata, 2, -factor) + postfill
    return audioop.add(inputdata, outputdata, 2)
```

36.5 cgi --- 通用閘道器介面支援

原始碼: `Lib/cgi.py`

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `cgi` 模組 (module) 即將被 `urllib` 取代 (詳情與替代方案請見 [PEP 594](#))。

The `FieldStorage` class can typically be replaced with `urllib.parse.parse_qs()` for GET and HEAD requests, and the `email.message` module or `multipart` for POST and PUT. Most *utility functions* have replacements.

Support module for Common Gateway Interface (CGI) scripts.

This module defines a number of utilities for use by CGI scripts written in Python.

The global variable `maxlen` can be set to an integer indicating the maximum size of a POST request. POST requests larger than this size will result in a `ValueError` being raised during parsing. The default value of this variable is 0, meaning the request size is unlimited.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

36.5.1 簡介

A CGI script is invoked by an HTTP server, usually to process user input submitted through an HTML `<FORM>` or `<ISINDEX>` element.

Most often, CGI scripts live in the server's special `cgi-bin` directory. The HTTP server places all sorts of information about the request (such as the client's hostname, the requested URL, the query string, and lots of other goodies) in the script's shell environment, executes the script, and sends the script's output back to the client.

The script's input is connected to the client too, and sometimes the form data is read this way; at other times the form data is passed via the "query string" part of the URL. This module is intended to take care of the different cases and provide a simpler interface to the Python script. It also provides a number of utilities that help in debugging scripts, and the latest addition is support for file uploads from a form (if your browser supports it).

The output of a CGI script should consist of two sections, separated by a blank line. The first section contains a number of headers, telling the client what kind of data is following. Python code to generate a minimal header section looks like this:

```
print("Content-Type: text/html")    # HTML is following
print()                           # blank line, end of headers
```

The second section is usually HTML, which allows the client software to display nicely formatted text with header, in-line images, etc. Here's Python code that prints a simple piece of HTML:

```
print("<TITLE>CGI script output</TITLE>")
print("<H1>This is my first CGI script</H1>")
print("Hello, world!")
```

36.5.2 Using the `cgi` module

Begin by writing `import cgi`.

When you write a new script, consider adding these lines:

```
import cgitb
cgitb.enable()
```

This activates a special exception handler that will display detailed reports in the web browser if any errors occur. If you'd rather not show the guts of your program to users of your script, you can have the reports saved to files instead, with code like this:

```
import cgitb
cgitb.enable(display=0, logdir="/path/to/logdir")
```

It's very helpful to use this feature during script development. The reports produced by `cgitb` provide information that can save you a lot of time in tracking down bugs. You can always remove the `cgitb` line later when you have tested your script and are confident that it works correctly.

To get at submitted form data, use the `FieldStorage` class. If the form contains non-ASCII characters, use the `encoding` keyword parameter set to the value of the encoding defined for the document. It is usually contained in the META tag in the HEAD section of the HTML document or by the `Content-Type` header. This reads the form contents from the standard input or the environment (depending on the value of various environment variables set according to the CGI standard). Since it may consume standard input, it should be instantiated only once.

The `FieldStorage` instance can be indexed like a Python dictionary. It allows membership testing with the `in` operator, and also supports the standard dictionary method `keys()` and the built-in function `len()`. Form fields

containing empty strings are ignored and do not appear in the dictionary; to keep such values, provide a true value for the optional `keep_blank_values` keyword parameter when creating the `FieldStorage` instance.

For instance, the following code (which assumes that the *Content-Type* header and blank line have already been printed) checks that the fields `name` and `addr` are both set to a non-empty string:

```
form = cgi.FieldStorage()
if "name" not in form or "addr" not in form:
    print("<H1>Error</H1>")
    print("Please fill in the name and addr fields.")
    return
print("<p>name:", form["name"].value)
print("<p>addr:", form["addr"].value)
...further form processing here...
```

Here the fields, accessed through `form[key]`, are themselves instances of `FieldStorage` (or `MiniFieldStorage`, depending on the form encoding). The `value` attribute of the instance yields the string value of the field. The `getvalue()` method returns this string value directly; it also accepts an optional second argument as a default to return if the requested key is not present.

If the submitted form data contains more than one field with the same name, the object retrieved by `form[key]` is not a `FieldStorage` or `MiniFieldStorage` instance but a list of such instances. Similarly, in this situation, `form.getvalue(key)` would return a list of strings. If you expect this possibility (when your HTML form contains multiple fields with the same name), use the `getlist()` method, which always returns a list of values (so that you do not need to special-case the single item case). For example, this code concatenates any number of `username` fields, separated by commas:

```
value = form.getlist("username")
usernames = ",".join(value)
```

If a field represents an uploaded file, accessing the value via the `value` attribute or the `getvalue()` method reads the entire file in memory as bytes. This may not be what you want. You can test for an uploaded file by testing either the `filename` attribute or the `file` attribute. You can then read the data from the `file` attribute before it is automatically closed as part of the garbage collection of the `FieldStorage` instance (the `read()` and `readline()` methods will return bytes):

```
fileitem = form["userfile"]
if fileitem.file:
    # It's an uploaded file; count lines
    linecount = 0
    while True:
        line = fileitem.file.readline()
        if not line: break
        linecount = linecount + 1
```

`FieldStorage` objects also support being used in a `with` statement, which will automatically close them when done.

If an error is encountered when obtaining the contents of an uploaded file (for example, when the user interrupts the form submission by clicking on a Back or Cancel button) the `done` attribute of the object for the field will be set to the value `-1`.

The file upload draft standard entertains the possibility of uploading multiple files from one field (using a recursive *multipart/** encoding). When this occurs, the item will be a dictionary-like `FieldStorage` item. This can be determined by testing its `type` attribute, which should be *multipart/form-data* (or perhaps another MIME type matching *multipart/**). In this case, it can be iterated over recursively just like the top-level form object.

When a form is submitted in the "old" format (as the query string or as a single data part of type *application/x-www-form-urlencoded*), the items will actually be instances of the class `MiniFieldStorage`. In this case, the `list`, `file`, and `filename` attributes are always `None`.

A form submitted via POST that also has a query string will contain both `FieldStorage` and `MiniFieldStorage` items.

在 3.4 版的變更: The `file` attribute is automatically closed upon the garbage collection of the creating `FieldStorage` instance.

在 3.5 版的變更: Added support for the context management protocol to the `FieldStorage` class.

36.5.3 Higher Level Interface

The previous section explains how to read CGI form data using the `FieldStorage` class. This section describes a higher level interface which was added to this class to allow one to do it in a more readable and intuitive way. The interface doesn't make the techniques described in previous sections obsolete --- they are still useful to process file uploads efficiently, for example.

The interface consists of two simple methods. Using the methods you can process form data in a generic way, without the need to worry whether only one or more values were posted under one name.

In the previous section, you learned to write following code anytime you expected a user to post more than one value under one name:

```
item = form.getvalue("item")
if isinstance(item, list):
    # The user is requesting more than one item.
else:
    # The user is requesting only one item.
```

This situation is common for example when a form contains a group of multiple checkboxes with the same name:

```
<input type="checkbox" name="item" value="1" />
<input type="checkbox" name="item" value="2" />
```

In most situations, however, there's only one form control with a particular name in a form and then you expect and need only one value associated with this name. So you write a script containing for example this code:

```
user = form.getvalue("user").upper()
```

The problem with the code is that you should never expect that a client will provide valid input to your scripts. For example, if a curious user appends another `user=foo` pair to the query string, then the script would crash, because in this situation the `getvalue("user")` method call returns a list instead of a string. Calling the `upper()` method on a list is not valid (since lists do not have a method of this name) and results in an `AttributeError` exception.

Therefore, the appropriate way to read form data values was to always use the code which checks whether the obtained value is a single value or a list of values. That's annoying and leads to less readable scripts.

A more convenient approach is to use the methods `getfirst()` and `getlist()` provided by this higher level interface.

`FieldStorage.getfirst(name, default=None)`

This method always returns only one value associated with form field *name*. The method returns only the first value in case that more values were posted under such name. Please note that the order in which the values are received may vary from browser to browser and should not be counted on.¹ If no such form field or value exists then the method returns the value specified by the optional parameter *default*. This parameter defaults to `None` if not specified.

`FieldStorage.getlist(name)`

This method always returns a list of values associated with form field *name*. The method returns an empty list if no such form field or value exists for *name*. It returns a list consisting of one item if only one such value exists.

Using these methods you can write nice compact code:

¹ Note that some recent versions of the HTML specification do state what order the field values should be supplied in, but knowing whether a request was received from a conforming browser, or even from a browser at all, is tedious and error-prone.

```
import cgi
form = cgi.FieldStorage()
user = form.getfirst("user", "").upper()      # This way it's safe.
for item in form.getlist("item"):
    do_something(item)
```

36.5.4 函式

These are useful if you want more control, or if you want to employ some of the algorithms implemented in this module in other circumstances.

`cgi.parse` (*fp=None, environ=os.environ, keep_blank_values=False, strict_parsing=False, separator='&'*)

Parse a query in the environment or from a file (the file defaults to `sys.stdin`). The `keep_blank_values`, `strict_parsing` and `separator` parameters are passed to `urllib.parse.parse_qs()` unchanged.

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: This function, like the rest of the `cgi` module, is deprecated. It can be replaced by calling `urllib.parse.parse_qs()` directly on the desired query string (except for multipart/form-data input, which can be handled as described for `parse_multipart()`).

`cgi.parse_multipart` (*fp, pdict, encoding='utf-8', errors='replace', separator='&'*)

Parse input of type *multipart/form-data* (for file uploads). Arguments are *fp* for the input file, *pdict* for a dictionary containing other parameters in the *Content-Type* header, and *encoding*, the request encoding.

Returns a dictionary just like `urllib.parse.parse_qs()`: keys are the field names, each value is a list of values for that field. For non-file fields, the value is a list of strings.

This is easy to use but not much good if you are expecting megabytes to be uploaded --- in that case, use the `FieldStorage` class instead which is much more flexible.

在 3.7 版的變更: Added the *encoding* and *errors* parameters. For non-file fields, the value is now a list of strings, not bytes.

在 3.10 版的變更: 新增 *separator* 參數。

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: This function, like the rest of the `cgi` module, is deprecated. It can be replaced with the functionality in the `email` package (e.g. `email.message.EmailMessage/email.message.Message`) which implements the same MIME RFCs, or with the `multipart` PyPI project.

`cgi.parse_header` (*string*)

Parse a MIME header (such as *Content-Type*) into a main value and a dictionary of parameters.

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: This function, like the rest of the `cgi` module, is deprecated. It can be replaced with the functionality in the `email` package, which implements the same MIME RFCs.

For example, with `email.message.EmailMessage`:

```
from email.message import EmailMessage
msg = EmailMessage()
msg['content-type'] = 'application/json; charset="utf8"'
main, params = msg.get_content_type(), msg['content-type'].params
```

`cgi.test` ()

Robust test CGI script, usable as main program. Writes minimal HTTP headers and formats all information provided to the script in HTML format.

`cgi.print_environ` ()

Format the shell environment in HTML.

```
cgi.print_form(form)
```

Format a form in HTML.

```
cgi.print_directory()
```

Format the current directory in HTML.

```
cgi.print_environ_usage()
```

Print a list of useful (used by CGI) environment variables in HTML.

36.5.5 Caring about security

There's one important rule: if you invoke an external program (via `os.system()`, `os.popen()` or other functions with similar functionality), make very sure you don't pass arbitrary strings received from the client to the shell. This is a well-known security hole whereby clever hackers anywhere on the web can exploit a gullible CGI script to invoke arbitrary shell commands. Even parts of the URL or field names cannot be trusted, since the request doesn't have to come from your form!

To be on the safe side, if you must pass a string gotten from a form to a shell command, you should make sure the string contains only alphanumeric characters, dashes, underscores, and periods.

36.5.6 Installing your CGI script on a Unix system

Read the documentation for your HTTP server and check with your local system administrator to find the directory where CGI scripts should be installed; usually this is in a directory `cgi-bin` in the server tree.

Make sure that your script is readable and executable by "others"; the Unix file mode should be `00755` octal (use `chmod 0755 filename`). Make sure that the first line of the script contains `#!` starting in column 1 followed by the pathname of the Python interpreter, for instance:

```
#!/usr/local/bin/python
```

Make sure the Python interpreter exists and is executable by "others".

Make sure that any files your script needs to read or write are readable or writable, respectively, by "others" --- their mode should be `00644` for readable and `00666` for writable. This is because, for security reasons, the HTTP server executes your script as user "nobody", without any special privileges. It can only read (write, execute) files that everybody can read (write, execute). The current directory at execution time is also different (it is usually the server's `cgi-bin` directory) and the set of environment variables is also different from what you get when you log in. In particular, don't count on the shell's search path for executables (`PATH`) or the Python module search path (`PYTHONPATH`) to be set to anything interesting.

If you need to load modules from a directory which is not on Python's default module search path, you can change the path in your script, before importing other modules. For example:

```
import sys
sys.path.insert(0, "/usr/home/joe/lib/python")
sys.path.insert(0, "/usr/local/lib/python")
```

(This way, the directory inserted last will be searched first!)

Instructions for non-Unix systems will vary; check your HTTP server's documentation (it will usually have a section on CGI scripts).

36.5.7 Testing your CGI script

Unfortunately, a CGI script will generally not run when you try it from the command line, and a script that works perfectly from the command line may fail mysteriously when run from the server. There's one reason why you should still test your script from the command line: if it contains a syntax error, the Python interpreter won't execute it at all, and the HTTP server will most likely send a cryptic error to the client.

Assuming your script has no syntax errors, yet it does not work, you have no choice but to read the next section.

36.5.8 Debugging CGI scripts

First of all, check for trivial installation errors --- reading the section above on installing your CGI script carefully can save you a lot of time. If you wonder whether you have understood the installation procedure correctly, try installing a copy of this module file (`cgi.py`) as a CGI script. When invoked as a script, the file will dump its environment and the contents of the form in HTML format. Give it the right mode etc., and send it a request. If it's installed in the standard `cgi-bin` directory, it should be possible to send it a request by entering a URL into your browser of the form:

```
http://yourhostname/cgi-bin/cgi.py?name=Joe+Blow&addr=At+Home
```

If this gives an error of type 404, the server cannot find the script -- perhaps you need to install it in a different directory. If it gives another error, there's an installation problem that you should fix before trying to go any further. If you get a nicely formatted listing of the environment and form content (in this example, the fields should be listed as "addr" with value "At Home" and "name" with value "Joe Blow"), the `cgi.py` script has been installed correctly. If you follow the same procedure for your own script, you should now be able to debug it.

The next step could be to call the `cgi` module's `test()` function from your script: replace its main code with the single statement

```
cgi.test()
```

This should produce the same results as those gotten from installing the `cgi.py` file itself.

When an ordinary Python script raises an unhandled exception (for whatever reason: of a typo in a module name, a file that can't be opened, etc.), the Python interpreter prints a nice traceback and exits. While the Python interpreter will still do this when your CGI script raises an exception, most likely the traceback will end up in one of the HTTP server's log files, or be discarded altogether.

Fortunately, once you have managed to get your script to execute *some* code, you can easily send tracebacks to the web browser using the `cgitb` module. If you haven't done so already, just add the lines:

```
import cgitb
cgitb.enable()
```

to the top of your script. Then try running it again; when a problem occurs, you should see a detailed report that will likely make apparent the cause of the crash.

If you suspect that there may be a problem in importing the `cgitb` module, you can use an even more robust approach (which only uses built-in modules):

```
import sys
sys.stderr = sys.stdout
print("Content-Type: text/plain")
print()
...your code here...
```

This relies on the Python interpreter to print the traceback. The content type of the output is set to plain text, which disables all HTML processing. If your script works, the raw HTML will be displayed by your client. If it raises an exception, most likely after the first two lines have been printed, a traceback will be displayed. Because no HTML interpretation is going on, the traceback will be readable.

36.5.9 Common problems and solutions

- Most HTTP servers buffer the output from CGI scripts until the script is completed. This means that it is not possible to display a progress report on the client's display while the script is running.
- Check the installation instructions above.
- Check the HTTP server's log files. (`tail -f logfile` in a separate window may be useful!)
- Always check a script for syntax errors first, by doing something like `python script.py`.
- If your script does not have any syntax errors, try adding `import cgi; cgi.enable()` to the top of the script.
- When invoking external programs, make sure they can be found. Usually, this means using absolute path names --- `PATH` is usually not set to a very useful value in a CGI script.
- When reading or writing external files, make sure they can be read or written by the userid under which your CGI script will be running: this is typically the userid under which the web server is running, or some explicitly specified userid for a web server's `suexec` feature.
- Don't try to give a CGI script a set-uid mode. This doesn't work on most systems, and is a security liability as well.

解

36.6 `cgitb` --- CGI 本的回溯 (traceback) 管理程式

原始碼: [Lib/cgitb.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `cgitb` 模組 (module) 即將被 F 用 (詳見 [PEP 594](#))。

The `cgitb` module provides a special exception handler for Python scripts. (Its name is a bit misleading. It was originally designed to display extensive traceback information in HTML for CGI scripts. It was later generalized to also display this information in plain text.) After this module is activated, if an uncaught exception occurs, a detailed, formatted report will be displayed. The report includes a traceback showing excerpts of the source code for each level, as well as the values of the arguments and local variables to currently running functions, to help you debug the problem. Optionally, you can save this information to a file instead of sending it to the browser.

To enable this feature, simply add this to the top of your CGI script:

```
import cgi
cgi.enable()
```

The options to the `enable()` function control whether the report is displayed in the browser and whether the report is logged to a file for later analysis.

`cgitb.enable(display=1, logdir=None, context=5, format='html')`

This function causes the `cgitb` module to take over the interpreter's default handling for exceptions by setting the value of `sys.excepthook`.

The optional argument `display` defaults to 1 and can be set to 0 to suppress sending the traceback to the browser. If the argument `logdir` is present, the traceback reports are written to files. The value of `logdir` should be a directory where these files will be placed. The optional argument `context` is the number of lines of context to display around the current line of source code in the traceback; this defaults to 5. If the optional argument `format` is "html", the output is formatted as HTML. Any other value forces plain text output. The default value is "html".

`cgitb.text (info, context=5)`

This function handles the exception described by *info* (a 3-tuple containing the result of `sys.exc_info()`), formatting its traceback as text and returning the result as a string. The optional argument *context* is the number of lines of context to display around the current line of source code in the traceback; this defaults to 5.

`cgitb.html (info, context=5)`

This function handles the exception described by *info* (a 3-tuple containing the result of `sys.exc_info()`), formatting its traceback as HTML and returning the result as a string. The optional argument *context* is the number of lines of context to display around the current line of source code in the traceback; this defaults to 5.

`cgitb.handler (info=None)`

This function handles an exception using the default settings (that is, show a report in the browser, but don't log to a file). This can be used when you've caught an exception and want to report it using `cgitb`. The optional *info* argument should be a 3-tuple containing an exception type, exception value, and traceback object, exactly like the tuple returned by `sys.exc_info()`. If the *info* argument is not supplied, the current exception is obtained from `sys.exc_info()`.

36.7 chunk --- 讀取 IFF 分塊資料

原始碼: [Lib/chunk.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `chunk` 模組 (module) 即將被 用 (詳見 [PEP 594](#))。

This module provides an interface for reading files that use EA IFF 85 chunks.¹ This format is used in at least the Audio Interchange File Format (AIFF/AIFF-C) and the Real Media File Format (RMFF). The WAVE audio file format is closely related and can also be read using this module.

A chunk has the following structure:

Offset	長度	容
0	4	Chunk ID
4	4	Size of chunk in big-endian byte order, not including the header
8	<i>n</i>	Data bytes, where <i>n</i> is the size given in the preceding field
8 + <i>n</i>	0 或 1	Pad byte needed if <i>n</i> is odd and chunk alignment is used

The ID is a 4-byte string which identifies the type of chunk.

The size field (a 32-bit value, encoded using big-endian byte order) gives the size of the chunk data, not including the 8-byte header.

Usually an IFF-type file consists of one or more chunks. The proposed usage of the `Chunk` class defined here is to instantiate an instance at the start of each chunk and read from the instance until it reaches the end, after which a new instance can be instantiated. At the end of the file, creating a new instance will fail with an `EOFError` exception.

class `chunk.Chunk (file, align=True, bigendian=True, inclheader=False)`

Class which represents a chunk. The *file* argument is expected to be a file-like object. An instance of this class is specifically allowed. The only method that is needed is `read()`. If the methods `seek()` and `tell()` are present and don't raise an exception, they are also used. If these methods are present and raise an exception, they are expected to not have altered the object. If the optional argument *align* is true, chunks are assumed to be aligned on 2-byte boundaries. If *align* is false, no alignment is assumed. The default value is true. If the optional argument *bigendian* is false, the chunk size is assumed to be in little-endian order. This is needed for WAVE audio files. The default value is true. If the optional argument *inclheader* is true, the size given in the chunk header includes the size of the header. The default value is false.

¹ "EA IFF 85" Standard for Interchange Format Files, Jerry Morrison, Electronic Arts, January 1985.

A *Chunk* object supports the following methods:

getname ()

Returns the name (ID) of the chunk. This is the first 4 bytes of the chunk.

getsize ()

Returns the size of the chunk.

close ()

Close and skip to the end of the chunk. This does not close the underlying file.

The remaining methods will raise *OSError* if called after the *close* () method has been called. Before Python 3.3, they used to raise *IOError*, now an alias of *OSError*.

isatty ()

Returns *False*.

seek (*pos*, *whence*=0)

Set the chunk's current position. The *whence* argument is optional and defaults to 0 (absolute file positioning); other values are 1 (seek relative to the current position) and 2 (seek relative to the file's end). There is no return value. If the underlying file does not allow seek, only forward seeks are allowed.

tell ()

Return the current position into the chunk.

read (*size*=-1)

Read at most *size* bytes from the chunk (less if the read hits the end of the chunk before obtaining *size* bytes). If the *size* argument is negative or omitted, read all data until the end of the chunk. An empty bytes object is returned when the end of the chunk is encountered immediately.

skip ()

Skip to the end of the chunk. All further calls to *read* () for the chunk will return b''. If you are not interested in the contents of the chunk, this method should be called so that the file points to the start of the next chunk.

解

36.8 crypt --- 用於檢查 Unix 密碼的函式

原始碼: [Lib/crypt.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: The *crypt* module is deprecated (see [PEP 594](#) for details and alternatives). The *hashlib* module is a potential replacement for certain use cases. The *passlib* package can replace all use cases of this module.

This module implements an interface to the *crypt* (3) routine, which is a one-way hash function based upon a modified DES algorithm; see the Unix man page for further details. Possible uses include storing hashed passwords so you can check passwords without storing the actual password, or attempting to crack Unix passwords with a dictionary.

Notice that the behavior of this module depends on the actual implementation of the *crypt* (3) routine in the running system. Therefore, any extensions available on the current implementation will also be available on this module.

適用: Unix, 非 VxWorks。

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms *wasm32-emscripten* and *wasm32-wasi*. See [WebAssembly 平台](#) for more information.

36.8.1 Hashing Methods

在 3.3 版新加入。

The `crypt` module defines the list of hashing methods (not all methods are available on all platforms):

`crypt.METHOD_SHA512`

A Modular Crypt Format method with 16 character salt and 86 character hash based on the SHA-512 hash function. This is the strongest method.

`crypt.METHOD_SHA256`

Another Modular Crypt Format method with 16 character salt and 43 character hash based on the SHA-256 hash function.

`crypt.METHOD_BLOWFISH`

Another Modular Crypt Format method with 22 character salt and 31 character hash based on the Blowfish cipher.

在 3.7 版新加入。

`crypt.METHOD_MD5`

Another Modular Crypt Format method with 8 character salt and 22 character hash based on the MD5 hash function.

`crypt.METHOD_CRYPT`

The traditional method with a 2 character salt and 13 characters of hash. This is the weakest method.

36.8.2 模組屬性

在 3.3 版新加入。

`crypt.methods`

A list of available password hashing algorithms, as `crypt.METHOD_*` objects. This list is sorted from strongest to weakest.

36.8.3 模組函式

`crypt` 模組定義了以下函式：

`crypt.crypt(word, salt=None)`

`word` will usually be a user's password as typed at a prompt or in a graphical interface. The optional `salt` is either a string as returned from `mk salt()`, one of the `crypt.METHOD_*` values (though not all may be available on all platforms), or a full encrypted password including salt, as returned by this function. If `salt` is not provided, the strongest method available in `methods` will be used.

Checking a password is usually done by passing the plain-text password as `word` and the full results of a previous `crypt()` call, which should be the same as the results of this call.

`salt` (either a random 2 or 16 character string, possibly prefixed with `$digit$` to indicate the method) which will be used to perturb the encryption algorithm. The characters in `salt` must be in the set `[./a-zA-Z0-9]`, with the exception of Modular Crypt Format which prefixes a `$digit$`.

Returns the hashed password as a string, which will be composed of characters from the same alphabet as the salt.

Since a few `crypt(3)` extensions allow different values, with different sizes in the `salt`, it is recommended to use the full crypt password as salt when checking for a password.

在 3.3 版的變更: Accept `crypt.METHOD_*` values in addition to strings for `salt`.

`crypt.mksalt` (*method=None*, *, *rounds=None*)

Return a randomly generated salt of the specified method. If no *method* is given, the strongest method available in *methods* is used.

The return value is a string suitable for passing as the *salt* argument to `crypt()`.

rounds specifies the number of rounds for `METHOD_SHA256`, `METHOD_SHA512` and `METHOD_BLOWFISH`. For `METHOD_SHA256` and `METHOD_SHA512` it must be an integer between 1000 and 999_999_999, the default is 5000. For `METHOD_BLOWFISH` it must be a power of two between 16 (2^4) and 2_147_483_648 (2^{31}), the default is 4096 (2^{12}).

在 3.3 版新加入。

在 3.7 版的變更: 新增 *rounds* 參數。

36.8.4 范例

A simple example illustrating typical use (a constant-time comparison operation is needed to limit exposure to timing attacks. `hmac.compare_digest()` is suitable for this purpose):

```
import pwd
import crypt
import getpass
from hmac import compare_digest as compare_hash

def login():
    username = input('Python login: ')
    cryptpasswd = pwd.getpwnam(username)[1]
    if cryptpasswd:
        if cryptpasswd == 'x' or cryptpasswd == '*':
            raise ValueError('no support for shadow passwords')
        cleartext = getpass.getpass()
        return compare_hash(crypt.crypt(cleartext, cryptpasswd), cryptpasswd)
    else:
        return True
```

To generate a hash of a password using the strongest available method and check it against the original:

```
import crypt
from hmac import compare_digest as compare_hash

hashed = crypt.crypt(plaintext)
if not compare_hash(hashed, crypt.crypt(plaintext, hashed)):
    raise ValueError("hashed version doesn't validate against original")
```

36.9 imghdr --- 推測圖片種類

原始碼: `Lib/imghdr.py`

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `imghdr` 模組 (module) 即將被 `image` 取代 (詳情與替代方案見 [PEP 594](#))。

The `imghdr` module determines the type of image contained in a file or byte stream.

The `imghdr` module defines the following function:

`imghdr.what (file, h=None)`

Tests the image data contained in the file named by *file*, and returns a string describing the image type. If optional *h* is provided, the *file* argument is ignored and *h* is assumed to contain the byte stream to test.

在 3.6 版的變更: Accepts a *path-like object*.

The following image types are recognized, as listed below with the return value from `what()`:

Value	Image format
'rgb'	SGI ImgLib Files
'gif'	GIF 87a and 89a Files
'pbm'	Portable Bitmap Files
'pgm'	Portable Graymap Files
'ppm'	Portable Pixmap Files
'tiff'	TIFF 檔案
'rast'	Sun Raster Files
'xbm'	X Bitmap Files
'jpeg'	JPEG data in JFIF or Exif formats
'bmp'	BMP 檔案
'png'	Portable Network Graphics
'webp'	WebP 檔案
'exr'	OpenEXR 檔案

在 3.5 版新加入: 新增 *exr* 與 *webp* 格式。

You can extend the list of file types `imghdr` can recognize by appending to this variable:

`imghdr.tests`

A list of functions performing the individual tests. Each function takes two arguments: the byte-stream and an open file-like object. When `what()` is called with a byte-stream, the file-like object will be `None`.

The test function should return a string describing the image type if the test succeeded, or `None` if it failed.

範例:

```
>>> import imghdr
>>> imghdr.what('bass.gif')
'gif'
```

36.10 imp --- Access the import internals

原始碼: `Lib/imp.py`

自從版本 3.4 後不推薦使用, 將會自版本 3.12 中移除。: The `imp` module is deprecated in favor of `importlib`.

This module provides an interface to the mechanisms used to implement the `import` statement. It defines the following constants and functions:

`imp.get_magic()`

Return the magic string value used to recognize byte-compiled code files (`.pyc` files). (This value may be different for each Python version.)

在 3.4 版之後被用: Use `importlib.util.MAGIC_NUMBER` instead.

`imp.get_suffixes()`

Return a list of 3-element tuples, each describing a particular type of module. Each triple has the form `(suffix, mode, type)`, where *suffix* is a string to be appended to the module name to form the file-name to search for, *mode* is the mode string to pass to the built-in `open()` function to open the file (this can be `'r'` for text files or `'rb'` for binary files), and *type* is the file type, which has one of the values `PY_SOURCE`, `PY_COMPILED`, or `C_EXTENSION`, described below.

在 3.3 版之後被 用: Use the constants defined on `importlib.machinery` instead.

`imp.find_module(name[, path])`

Try to find the module *name*. If *path* is omitted or `None`, the list of directory names given by `sys.path` is searched, but first a few special places are searched: the function tries to find a built-in module with the given name (`C_BUILTIN`), then a frozen module (`PY_FROZEN`), and on some systems some other places are looked in as well (on Windows, it looks in the registry which may point to a specific file).

Otherwise, *path* must be a list of directory names; each directory is searched for files with any of the suffixes returned by `get_suffixes()` above. Invalid names in the list are silently ignored (but all list items must be strings).

If search is successful, the return value is a 3-element tuple `(file, pathname, description)`:

file is an open *file object* positioned at the beginning, *pathname* is the pathname of the file found, and *description* is a 3-element tuple as contained in the list returned by `get_suffixes()` describing the kind of module found.

If the module is built-in or frozen then *file* and *pathname* are both `None` and the *description* tuple contains empty strings for its suffix and mode; the module type is indicated as given in parentheses above. If the search is unsuccessful, `ImportError` is raised. Other exceptions indicate problems with the arguments or environment.

If the module is a package, *file* is `None`, *pathname* is the package path and the last item in the *description* tuple is `PKG_DIRECTORY`.

This function does not handle hierarchical module names (names containing dots). In order to find *P.M*, that is, submodule *M* of package *P*, use `find_module()` and `load_module()` to find and load package *P*, and then use `find_module()` with the *path* argument set to `P.__path__`. When *P* itself has a dotted name, apply this recipe recursively.

在 3.3 版之後被 用: Use `importlib.util.find_spec()` instead unless Python 3.3 compatibility is required, in which case use `importlib.find_loader()`. For example usage of the former case, see the 範例 section of the `importlib` documentation.

`imp.load_module(name, file, pathname, description)`

Load a module that was previously found by `find_module()` (or by an otherwise conducted search yielding compatible results). This function does more than importing the module: if the module was already imported, it will reload the module! The *name* argument indicates the full module name (including the package name, if this is a submodule of a package). The *file* argument is an open file, and *pathname* is the corresponding file name; these can be `None` and `' '`, respectively, when the module is a package or not being loaded from a file. The *description* argument is a tuple, as would be returned by `get_suffixes()`, describing what kind of module must be loaded.

If the load is successful, the return value is the module object; otherwise, an exception (usually `ImportError`) is raised.

Important: the caller is responsible for closing the *file* argument, if it was not `None`, even when an exception is raised. This is best done using a `try ... finally` statement.

在 3.3 版之後被 用: If previously used in conjunction with `imp.find_module()` then consider using `importlib.import_module()`, otherwise use the loader returned by the replacement you chose for `imp.find_module()`. If you called `imp.load_module()` and related functions directly with file path arguments then use a combination of `importlib.util.spec_from_file_location()` and `importlib.util.module_from_spec()`. See the 範例 section of the `importlib` documentation for details of the various approaches.

`imp.new_module(name)`

Return a new empty module object called *name*. This object is *not* inserted in `sys.modules`.

在 3.4 版之後被 F 用: Use `importlib.util.module_from_spec()` instead.

`imp.reload(module)`

Reload a previously imported *module*. The argument must be a module object, so it must have been successfully imported before. This is useful if you have edited the module source file using an external editor and want to try out the new version without leaving the Python interpreter. The return value is the module object (the same as the *module* argument).

When `reload(module)` is executed:

- Python modules' code is recompiled and the module-level code reexecuted, defining a new set of objects which are bound to names in the module's dictionary. The `init` function of extension modules is not called a second time.
- As with all other objects in Python the old objects are only reclaimed after their reference counts drop to zero.
- The names in the module namespace are updated to point to any new or changed objects.
- Other references to the old objects (such as names external to the module) are not rebound to refer to the new objects and must be updated in each namespace where they occur if that is desired.

There are a number of other caveats:

When a module is reloaded, its dictionary (containing the module's global variables) is retained. Redefinitions of names will override the old definitions, so this is generally not a problem. If the new version of a module does not define a name that was defined by the old version, the old definition remains. This feature can be used to the module's advantage if it maintains a global table or cache of objects --- with a `try` statement it can test for the table's presence and skip its initialization if desired:

```
try:
    cache
except NameError:
    cache = {}
```

It is legal though generally not very useful to reload built-in or dynamically loaded modules, except for `sys`, `__main__` and `builtins`. In many cases, however, extension modules are not designed to be initialized more than once, and may fail in arbitrary ways when reloaded.

If a module imports objects from another module using `from ... import ...`, calling `reload()` for the other module does not redefine the objects imported from it --- one way around this is to re-execute the `from` statement, another is to use `import` and qualified names (`module.*name*`) instead.

If a module instantiates instances of a class, reloading the module that defines the class does not affect the method definitions of the instances --- they continue to use the old class definition. The same is true for derived classes.

在 3.3 版的變更: Relies on both `__name__` and `__loader__` being defined on the module being reloaded instead of just `__name__`.

在 3.4 版之後被 F 用: Use `importlib.reload()` instead.

The following functions are conveniences for handling **PEP 3147** byte-compiled file paths.

在 3.2 版新加入.

`imp.cache_from_source(path, debug_override=None)`

Return the **PEP 3147** path to the byte-compiled file associated with the source *path*. For example, if *path* is `/foo/bar/baz.py` the return value would be `/foo/bar/__pycache__/baz.cpython-32.pyc` for Python 3.2. The `cpython-32` string comes from the current magic tag (see `get_tag()`; if `sys.implementation.cache_tag` is not defined then `NotImplementedError` will be raised). By passing in `True` or `False` for *debug_override* you can override the system's value for `__debug__`, leading to optimized bytecode.

path need not exist.

在 3.3 版的變更: If `sys.implementation.cache_tag` is `None`, then `NotImplementedError` is raised.

在 3.4 版之後被用: Use `importlib.util.cache_from_source()` instead.

在 3.5 版的變更: The `debug_override` parameter no longer creates a `.pyo` file.

`imp.source_from_cache(path)`

Given the *path* to a **PEP 3147** file name, return the associated source code file path. For example, if *path* is `/foo/bar/__pycache__/baz.cpython-32.pyc` the returned path would be `/foo/bar/baz.py`. *path* need not exist, however if it does not conform to **PEP 3147** format, a `ValueError` is raised. If `sys.implementation.cache_tag` is not defined, `NotImplementedError` is raised.

在 3.3 版的變更: Raise `NotImplementedError` when `sys.implementation.cache_tag` is not defined.

在 3.4 版之後被用: Use `importlib.util.source_from_cache()` instead.

`imp.get_tag()`

Return the **PEP 3147** magic tag string matching this version of Python's magic number, as returned by `get_magic()`.

在 3.4 版之後被用: Use `sys.implementation.cache_tag` directly starting in Python 3.3.

The following functions help interact with the import system's internal locking mechanism. Locking semantics of imports are an implementation detail which may vary from release to release. However, Python ensures that circular imports work without any deadlocks.

`imp.lock_held()`

Return `True` if the global import lock is currently held, else `False`. On platforms without threads, always return `False`.

On platforms with threads, a thread executing an import first holds a global import lock, then sets up a per-module lock for the rest of the import. This blocks other threads from importing the same module until the original import completes, preventing other threads from seeing incomplete module objects constructed by the original thread. An exception is made for circular imports, which by construction have to expose an incomplete module object at some point.

在 3.3 版的變更: The locking scheme has changed to per-module locks for the most part. A global import lock is kept for some critical tasks, such as initializing the per-module locks.

在 3.4 版之後被用.

`imp.acquire_lock()`

Acquire the interpreter's global import lock for the current thread. This lock should be used by import hooks to ensure thread-safety when importing modules.

Once a thread has acquired the import lock, the same thread may acquire it again without blocking; the thread must release it once for each time it has acquired it.

On platforms without threads, this function does nothing.

在 3.3 版的變更: The locking scheme has changed to per-module locks for the most part. A global import lock is kept for some critical tasks, such as initializing the per-module locks.

在 3.4 版之後被用.

`imp.release_lock()`

Release the interpreter's global import lock. On platforms without threads, this function does nothing.

在 3.3 版的變更: The locking scheme has changed to per-module locks for the most part. A global import lock is kept for some critical tasks, such as initializing the per-module locks.

在 3.4 版之後被用.

The following constants with integer values, defined in this module, are used to indicate the search result of `find_module()`.

`imp.PY_SOURCE`

The module was found as a source file.

在 3.3 版之後被用。

`imp.PY_COMPILED`

The module was found as a compiled code object file.

在 3.3 版之後被用。

`imp.C_EXTENSION`

The module was found as dynamically loadable shared library.

在 3.3 版之後被用。

`imp.PKG_DIRECTORY`

The module was found as a package directory.

在 3.3 版之後被用。

`imp.C_BUILTIN`

The module was found as a built-in module.

在 3.3 版之後被用。

`imp.PY_FROZEN`

The module was found as a frozen module.

在 3.3 版之後被用。

class `imp.NullImporter` (*path_string*)

The `NullImporter` type is a [PEP 302](#) import hook that handles non-directory path strings by failing to find any modules. Calling this type with an existing directory or empty string raises `ImportError`. Otherwise, a `NullImporter` instance is returned.

Instances have only one method:

find_module (*fullname* [, *path*])

This method always returns `None`, indicating that the requested module could not be found.

在 3.3 版的變更: `None` is inserted into `sys.path_importer_cache` instead of an instance of `NullImporter`.

在 3.4 版之後被用: Insert `None` into `sys.path_importer_cache` instead.

36.10.1 范例

The following function emulates what was the standard import statement up to Python 1.4 (no hierarchical module names). (This *implementation* wouldn't work in that version, since `find_module()` has been extended and `load_module()` has been added in 1.4.)

```
import imp
import sys

def __import__(name, globals=None, locals=None, fromlist=None):
    # Fast path: see if the module has already been imported.
    try:
        return sys.modules[name]
    except KeyError:
        pass
```

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```

# If any of the following calls raises an exception,
# there's a problem we can't handle -- let the caller handle it.

fp, pathname, description = imp.find_module(name)

try:
    return imp.load_module(name, fp, pathname, description)
finally:
    # Since we may exit via an exception, close fp explicitly.
    if fp:
        fp.close()

```

36.11 mailcap --- Mailcap file handling

原始碼: `Lib/mailcap.py`

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: The *mailcap* module is deprecated (see [PEP 594](#) for details). The *mimetypes* module provides an alternative.

Mailcap files are used to configure how MIME-aware applications such as mail readers and web browsers react to files with different MIME types. (The name "mailcap" is derived from the phrase "mail capability".) For example, a mailcap file might contain a line like `video/mpeg; xmpeg %s`. Then, if the user encounters an email message or web document with the MIME type `video/mpeg`, `%s` will be replaced by a filename (usually one belonging to a temporary file) and the `xmpeg` program can be automatically started to view the file.

The mailcap format is documented in [RFC 1524](#), "A User Agent Configuration Mechanism For Multimedia Mail Format Information", but is not an internet standard. However, mailcap files are supported on most Unix systems.

`mailcap.findmatch(caps, MIMEtype, key='view', filename='/dev/null', plist=[])`

Return a 2-tuple; the first element is a string containing the command line to be executed (which can be passed to `os.system()`), and the second element is the mailcap entry for a given MIME type. If no matching MIME type can be found, `(None, None)` is returned.

key is the name of the field desired, which represents the type of activity to be performed; the default value is 'view', since in the most common case you simply want to view the body of the MIME-typed data. Other possible values might be 'compose' and 'edit', if you wanted to create a new body of the given MIME type or alter the existing body data. See [RFC 1524](#) for a complete list of these fields.

filename is the filename to be substituted for `%s` in the command line; the default value is `'/dev/null'` which is almost certainly not what you want, so usually you'll override it by specifying a filename.

plist can be a list containing named parameters; the default value is simply an empty list. Each entry in the list must be a string containing the parameter name, an equals sign (`'='`), and the parameter's value. Mailcap entries can contain named parameters like `%{foo}`, which will be replaced by the value of the parameter named 'foo'. For example, if the command line `showpartial %{id} %{number} %{total}` was in a mailcap file, and *plist* was set to `['id=1', 'number=2', 'total=3']`, the resulting command line would be `'showpartial 1 2 3'`.

In a mailcap file, the "test" field can optionally be specified to test some external condition (such as the machine architecture, or the window system in use) to determine whether or not the mailcap line applies. `findmatch()` will automatically check such conditions and skip the entry if the check fails.

在 3.11 版的變更: To prevent security issues with shell metacharacters (symbols that have special effects in a shell command line), `findmatch` will refuse to inject ASCII characters other than alphanumerics and `@+=: , . / - _` into the returned command line.

If a disallowed character appears in *filename*, `findmatch` will always return `(None, None)` as if no entry was found. If such a character appears elsewhere (a value in *plist* or in *MIMEtype*), `findmatch` will ignore all mailcap entries which use that value. A *warning* will be raised in either case.

`mailcap.getcaps()`

Returns a dictionary mapping MIME types to a list of mailcap file entries. This dictionary must be passed to the `findmatch()` function. An entry is stored as a list of dictionaries, but it shouldn't be necessary to know the details of this representation.

The information is derived from all of the mailcap files found on the system. Settings in the user's mailcap file `$HOME/.mailcap` will override settings in the system mailcap files `/etc/mailcap`, `/usr/etc/mailcap`, and `/usr/local/etc/mailcap`.

An example usage:

```
>>> import mailcap
>>> d = mailcap.getcaps()
>>> mailcap.findmatch(d, 'video/mpeg', filename='tmp1223')
('xmpeg tmp1223', {'view': 'xmpeg %s'})
```

36.12 msilib --- 讀寫 Microsoft Installer 檔案

原始碼: `Lib/msilib/__init__.py`

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `msilib` 模組 (module) 即將被 廢用 (詳見 [PEP 594](#))。

The `msilib` supports the creation of Microsoft Installer (`.msi`) files. Because these files often contain an embedded "cabinet" file (`.cab`), it also exposes an API to create CAB files. Support for reading `.cab` files is currently not implemented; read support for the `.msi` database is possible.

This package aims to provide complete access to all tables in an `.msi` file, therefore, it is a fairly low-level API. One primary application of this package is the creation of Python installer package itself (although that currently uses a different version of `msilib`).

The package contents can be roughly split into four parts: low-level CAB routines, low-level MSI routines, higher-level MSI routines, and standard table structures.

`msilib.FCICreate(cabname, files)`

Create a new CAB file named *cabname*. *files* must be a list of tuples, each containing the name of the file on disk, and the name of the file inside the CAB file.

The files are added to the CAB file in the order they appear in the list. All files are added into a single CAB file, using the MSZIP compression algorithm.

Callbacks to Python for the various steps of MSI creation are currently not exposed.

`msilib.UuidCreate()`

Return the string representation of a new unique identifier. This wraps the Windows API functions `UuidCreate()` and `UuidToString()`.

`msilib.OpenDatabase(path, persist)`

Return a new database object by calling `MsiOpenDatabase`. *path* is the file name of the MSI file; *persist* can be one of the constants `MSIDBOPEN_CREATEDIRECT`, `MSIDBOPEN_CREATE`, `MSIDBOPEN_DIRECT`, `MSIDBOPEN_READONLY`, or `MSIDBOPEN_TRANSACT`, and may include the flag `MSIDBOPEN_PATCHFILE`. See the Microsoft documentation for the meaning of these flags; depending on the flags, an existing database is opened, or a new one created.

`msilib.CreateRecord(count)`

Return a new record object by calling `MSICreateRecord()`. *count* is the number of fields of the record.

`msilib.init_database` (*name*, *schema*, *ProductName*, *ProductCode*, *ProductVersion*, *Manufacturer*)

Create and return a new database *name*, initialize it with *schema*, and set the properties *ProductName*, *ProductCode*, *ProductVersion*, and *Manufacturer*.

schema must be a module object containing `tables` and `_Validation_records` attributes; typically, `msilib.schema` should be used.

The database will contain just the schema and the validation records when this function returns.

`msilib.add_data` (*database*, *table*, *records*)

Add all *records* to the table named *table* in *database*.

The *table* argument must be one of the predefined tables in the MSI schema, e.g. 'Feature', 'File', 'Component', 'Dialog', 'Control', etc.

records should be a list of tuples, each one containing all fields of a record according to the schema of the table. For optional fields, `None` can be passed.

Field values can be ints, strings, or instances of the `Binary` class.

class `msilib.Binary` (*filename*)

Represents entries in the `Binary` table; inserting such an object using `add_data()` reads the file named *filename* into the table.

`msilib.add_tables` (*database*, *module*)

Add all table content from *module* to *database*. *module* must contain an attribute `tables` listing all tables for which content should be added, and one attribute per table that has the actual content.

This is typically used to install the sequence tables.

`msilib.add_stream` (*database*, *name*, *path*)

Add the file *path* into the `_Stream` table of *database*, with the stream name *name*.

`msilib.gen_uuid` ()

Return a new UUID, in the format that MSI typically requires (i.e. in curly braces, and with all hexdigits in uppercase).

也参考:

[FCICreate](#) [UuidCreate](#) [UuidToString](#)

36.12.1 Database Objects

`Database.OpenView` (*sql*)

Return a view object, by calling `MSIDatabaseOpenView()`. *sql* is the SQL statement to execute.

`Database.Commit` ()

Commit the changes pending in the current transaction, by calling `MSIDatabaseCommit()`.

`Database.GetSummaryInformation` (*count*)

Return a new summary information object, by calling `MsiGetSummaryInformation()`. *count* is the maximum number of updated values.

`Database.Close` ()

Close the database object, through `MsiCloseHandle()`.

在 3.7 版新加入.

也参考:

[MSIDatabaseOpenView](#) [MSIDatabaseCommit](#) [MSIGetSummaryInformation](#) [MsiCloseHandle](#)

36.12.2 View Objects

`View.Execute(params)`

Execute the SQL query of the view, through `MsiViewExecute()`. If *params* is not `None`, it is a record describing actual values of the parameter tokens in the query.

`View.GetColumnInfo(kind)`

Return a record describing the columns of the view, through calling `MsiViewGetColumnInfo()`. *kind* can be either `MSICOLINFO_NAMES` or `MSICOLINFO_TYPES`.

`View.Fetch()`

Return a result record of the query, through calling `MsiViewFetch()`.

`View.Modify(kind, data)`

Modify the view, by calling `MsiViewModify()`. *kind* can be one of `MSIMODIFY_SEEK`, `MSIMODIFY_REFRESH`, `MSIMODIFY_INSERT`, `MSIMODIFY_UPDATE`, `MSIMODIFY_ASSIGN`, `MSIMODIFY_REPLACE`, `MSIMODIFY_MERGE`, `MSIMODIFY_DELETE`, `MSIMODIFY_INSERT_TEMPORARY`, `MSIMODIFY_VALIDATE`, `MSIMODIFY_VALIDATE_NEW`, `MSIMODIFY_VALIDATE_FIELD`, or `MSIMODIFY_VALIDATE_DELETE`.

data must be a record describing the new data.

`View.Close()`

Close the view, through `MsiViewClose()`.

也參考:

[MsiViewExecute](#) [MsiViewGetColumnInfo](#) [MsiViewFetch](#) [MsiViewModify](#) [MsiViewClose](#)

36.12.3 Summary Information Objects

`SummaryInformation.GetProperty(field)`

Return a property of the summary, through `MsiSummaryInfoGetProperty()`. *field* is the name of the property, and can be one of the constants `PID_CODEPAGE`, `PID_TITLE`, `PID_SUBJECT`, `PID_AUTHOR`, `PID_KEYWORDS`, `PID_COMMENTS`, `PID_TEMPLATE`, `PID_LASTAUTHOR`, `PID_REVNUMBER`, `PID_LASTPRINTED`, `PID_CREATE_DTM`, `PID_LASTSAVE_DTM`, `PID_PAGECOUNT`, `PID_WORDCOUNT`, `PID_CHARCOUNT`, `PID_APPNAME`, or `PID_SECURITY`.

`SummaryInformation.GetPropertyCount()`

Return the number of summary properties, through `MsiSummaryInfoGetPropertyCount()`.

`SummaryInformation.SetProperty(field, value)`

Set a property through `MsiSummaryInfoSetProperty()`. *field* can have the same values as in [GetProperty\(\)](#), *value* is the new value of the property. Possible value types are integer and string.

`SummaryInformation.Persist()`

Write the modified properties to the summary information stream, using `MsiSummaryInfoPersist()`.

也參考:

[MsiSummaryInfoGetProperty](#) [MsiSummaryInfoGetPropertyCount](#) [MsiSummaryInfoSetProperty](#) [MsiSummaryInfoPersist](#)

36.12.4 Record Objects

`Record.GetFieldCount()`

Return the number of fields of the record, through `MsiRecordGetFieldCount()`.

`Record.GetInteger(field)`

Return the value of *field* as an integer where possible. *field* must be an integer.

`Record.GetString(field)`

Return the value of *field* as a string where possible. *field* must be an integer.

`Record.SetString(field, value)`

Set *field* to *value* through `MsiRecordSetString()`. *field* must be an integer; *value* a string.

`Record.SetStream(field, value)`

Set *field* to the contents of the file named *value*, through `MsiRecordSetStream()`. *field* must be an integer; *value* a string.

`Record.SetInteger(field, value)`

Set *field* to *value* through `MsiRecordSetInteger()`. Both *field* and *value* must be an integer.

`Record.ClearData()`

Set all fields of the record to 0, through `MsiRecordClearData()`.

也参考:

[MsiRecordGetFieldCount](#) [MsiRecordSetString](#) [MsiRecordSetStream](#) [MsiRecordSetInteger](#) [MsiRecordClearData](#)

36.12.5 Errors

All wrappers around MSI functions raise `MSIError`; the string inside the exception will contain more detail.

36.12.6 CAB 物件

class `msilib.CAB(name)`

The class `CAB` represents a CAB file. During MSI construction, files will be added simultaneously to the `Files` table, and to a CAB file. Then, when all files have been added, the CAB file can be written, then added to the MSI file.

name is the name of the CAB file in the MSI file.

append (*full, file, logical*)

Add the file with the pathname *full* to the CAB file, under the name *logical*. If there is already a file named *logical*, a new file name is created.

Return the index of the file in the CAB file, and the new name of the file inside the CAB file.

commit (*database*)

Generate a CAB file, add it as a stream to the MSI file, put it into the `Media` table, and remove the generated file from the disk.

36.12.7 Directory Objects

class `msilib.Directory` (*database, cab, basedir, physical, logical, default[, componentflags]*)

Create a new directory in the Directory table. There is a current component at each point in time for the directory, which is either explicitly created through `start_component()`, or implicitly when files are added for the first time. Files are added into the current component, and into the cab file. To create a directory, a base directory object needs to be specified (can be `None`), the path to the physical directory, and a logical directory name. *default* specifies the DefaultDir slot in the directory table. *componentflags* specifies the default flags that new components get.

start_component (*component=None, feature=None, flags=None, keyfile=None, uuid=None*)

Add an entry to the Component table, and make this component the current component for this directory. If no component name is given, the directory name is used. If no *feature* is given, the current feature is used. If no *flags* are given, the directory's default flags are used. If no *keyfile* is given, the KeyPath is left null in the Component table.

add_file (*file, src=None, version=None, language=None*)

Add a file to the current component of the directory, starting a new one if there is no current component. By default, the file name in the source and the file table will be identical. If the *src* file is specified, it is interpreted relative to the current directory. Optionally, a *version* and a *language* can be specified for the entry in the File table.

glob (*pattern, exclude=None*)

Add a list of files to the current component as specified in the glob pattern. Individual files can be excluded in the *exclude* list.

remove_pyc ()

Remove .pyc files on uninstall.

也参考:

[Directory Table](#) [File Table](#) [Component Table](#) [FeatureComponents Table](#)

36.12.8 Features

class `msilib.Feature` (*db, id, title, desc, display, level=1, parent=None, directory=None, attributes=0*)

Add a new record to the Feature table, using the values *id*, *parent.id*, *title*, *desc*, *display*, *level*, *directory*, and *attributes*. The resulting feature object can be passed to the `start_component()` method of `Directory`.

set_current ()

Make this feature the current feature of `msilib`. New components are automatically added to the default feature, unless a feature is explicitly specified.

也参考:

[Feature Table](#)

36.12.9 GUI classes

`msilib` provides several classes that wrap the GUI tables in an MSI database. However, no standard user interface is provided.

class `msilib.Control` (*dlg, name*)

Base class of the dialog controls. *dlg* is the dialog object the control belongs to, and *name* is the control's name.

event (*event, argument, condition=1, ordering=None*)

Make an entry into the ControlEvent table for this control.

mapping (*event, attribute*)

Make an entry into the `EventMapping` table for this control.

condition (*action, condition*)

Make an entry into the `ControlCondition` table for this control.

class `msilib.RadioButtonGroup` (*dlg, name, property*)

Create a radio button control named *name*. *property* is the installer property that gets set when a radio button is selected.

add (*name, x, y, width, height, text, value=None*)

Add a radio button named *name* to the group, at the coordinates *x, y, width, height*, and with the label *text*. If *value* is `None`, it defaults to *name*.

class `msilib.Dialog` (*db, name, x, y, w, h, attr, title, first, default, cancel*)

Return a new `Dialog` object. An entry in the `Dialog` table is made, with the specified coordinates, dialog attributes, title, name of the first, default, and cancel controls.

control (*name, type, x, y, width, height, attributes, property, text, control_next, help*)

Return a new `Control` object. An entry in the `Control` table is made with the specified parameters.

This is a generic method; for specific types, specialized methods are provided.

text (*name, x, y, width, height, attributes, text*)

Add and return a `Text` control.

bitmap (*name, x, y, width, height, text*)

Add and return a `Bitmap` control.

line (*name, x, y, width, height*)

Add and return a `Line` control.

pushbutton (*name, x, y, width, height, attributes, text, next_control*)

Add and return a `PushButton` control.

radiogroup (*name, x, y, width, height, attributes, property, text, next_control*)

Add and return a `RadioButtonGroup` control.

checkbox (*name, x, y, width, height, attributes, property, text, next_control*)

Add and return a `CheckBox` control.

也参考:

[Dialog Table](#) [Control Table](#) [Control Types](#) [ControlCondition Table](#) [ControlEvents Table](#) [EventMapping Table](#) [RadioButton Table](#)

36.12.10 Precomputed tables

`msilib` provides a few subpackages that contain only schema and table definitions. Currently, these definitions are based on MSI version 2.0.

`msilib.schema`

This is the standard MSI schema for MSI 2.0, with the *tables* variable providing a list of table definitions, and *_Validation_records* providing the data for MSI validation.

`msilib.sequence`

This module contains table contents for the standard sequence tables: *AdminExecuteSequence*, *AdminUISequence*, *AdvtExecuteSequence*, *InstallExecuteSequence*, and *InstallUISequence*.

`msilib.text`

This module contains definitions for the *UIText* and *ActionText* tables, for the standard installer actions.

36.13 nis --- Sun NIS (Yellow Pages) 介面

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `nis` 模組 (module) 即將被廢用 (詳見 [PEP 594](#))。

The `nis` module gives a thin wrapper around the NIS library, useful for central administration of several hosts.

Because NIS exists only on Unix systems, this module is only available for Unix.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

The `nis` module defines the following functions:

`nis.match(key, mapname, domain=default_domain)`

Return the match for `key` in map `mapname`, or raise an error (`nis.error`) if there is none. Both should be strings, `key` is 8-bit clean. Return value is an arbitrary array of bytes (may contain NULL and other joys).

Note that `mapname` is first checked if it is an alias to another name.

The `domain` argument allows overriding the NIS domain used for the lookup. If unspecified, lookup is in the default NIS domain.

`nis.cat(mapname, domain=default_domain)`

Return a dictionary mapping `key` to `value` such that `match(key, mapname) == value`. Note that both keys and values of the dictionary are arbitrary arrays of bytes.

Note that `mapname` is first checked if it is an alias to another name.

The `domain` argument allows overriding the NIS domain used for the lookup. If unspecified, lookup is in the default NIS domain.

`nis.maps(domain=default_domain)`

Return a list of all valid maps.

The `domain` argument allows overriding the NIS domain used for the lookup. If unspecified, lookup is in the default NIS domain.

`nis.get_default_domain()`

Return the system default NIS domain.

The `nis` module defines the following exception:

exception `nis.error`

An error raised when a NIS function returns an error code.

36.14 nntplib --- NNTP 協定客戶端

原始碼: [Lib/nntplib.py](#)

在 3.11 版之後被廢用: `nntplib` 模組 (module) 即將被廢用 (詳見 [PEP 594](#))。

This module defines the class `NNTP` which implements the client side of the Network News Transfer Protocol. It can be used to implement a news reader or poster, or automated news processors. It is compatible with [RFC 3977](#) as well as the older [RFC 977](#) and [RFC 2980](#).

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

Here are two small examples of how it can be used. To list some statistics about a newsgroup and print the subjects of the last 10 articles:

```
>>> s = nntplib.NNTP('news.gmane.io')
>>> resp, count, first, last, name = s.group('gmane.comp.python.committers')
>>> print('Group', name, 'has', count, 'articles, range', first, 'to', last)
Group gmane.comp.python.committers has 1096 articles, range 1 to 1096
>>> resp, overviews = s.over((last - 9, last))
>>> for id, over in overviews:
...     print(id, nntplib.decode_header(over['subject']))
...
1087 Re: Commit privileges for Łukasz Langa
1088 Re: 3.2 alpha 2 freeze
1089 Re: 3.2 alpha 2 freeze
1090 Re: Commit privileges for Łukasz Langa
1091 Re: Commit privileges for Łukasz Langa
1092 Updated ssh key
1093 Re: Updated ssh key
1094 Re: Updated ssh key
1095 Hello fellow committers!
1096 Re: Hello fellow committers!
>>> s.quit()
'205 Bye!'
```

To post an article from a binary file (this assumes that the article has valid headers, and that you have right to post on the particular newsgroup):

```
>>> s = nntplib.NNTP('news.gmane.io')
>>> f = open('article.txt', 'rb')
>>> s.post(f)
'240 Article posted successfully.'
>>> s.quit()
'205 Bye!'
```

The module itself defines the following classes:

```
class nntplib.NNTP (host, port=119, user=None, password=None, readermode=None, usenetrc=False[,
                    timeout])
```

Return a new *NNTP* object, representing a connection to the NNTP server running on host *host*, listening at port *port*. An optional *timeout* can be specified for the socket connection. If the optional *user* and *password* are provided, or if suitable credentials are present in `/.netrc` and the optional flag *usenetrc* is true, the `AUTHINFO USER` and `AUTHINFO PASS` commands are used to identify and authenticate the user to the server. If the optional flag *readermode* is true, then a mode `reader` command is sent before authentication is performed. Reader mode is sometimes necessary if you are connecting to an NNTP server on the local machine and intend to call reader-specific commands, such as `group`. If you get unexpected *NNTPPermanentErrors*, you might need to set *readermode*. The *NNTP* class supports the `with` statement to unconditionally consume *OSError* exceptions and to close the NNTP connection when done, e.g.:

```
>>> from nntplib import NNTP
>>> with NNTP('news.gmane.io') as n:
...     n.group('gmane.comp.python.committers')
...
('211 1755 1 1755 gmane.comp.python.committers', 1755, 1, 1755, 'gmane.comp.
python.committers')
>>>
```

引發一個附帶引數 `self`、`host`、`port` 的稽核事件 `nntplib.connect`。

引發一個附帶引數 `self`、`line` 的稽核事件 `nntplib.putline`。

在 3.2 版的變更: *usenetrc* is now False by default.

在 3.3 版的變更: Support for the `with` statement was added.

在 3.9 版的變更: If the *timeout* parameter is set to be zero, it will raise a *ValueError* to prevent the creation of a non-blocking socket.

```
class nntplib.NNTP_SSL(host, port=563, user=None, password=None, ssl_context=None,
                      readmode=None, usenetr=False[, timeout ])
```

Return a new *NNTP_SSL* object, representing an encrypted connection to the NNTP server running on host *host*, listening at port *port*. *NNTP_SSL* objects have the same methods as *NNTP* objects. If *port* is omitted, port 563 (NNTPS) is used. *ssl_context* is also optional, and is a *SSLContext* object. Please read *Security considerations* for best practices. All other parameters behave the same as for *NNTP*.

Note that SSL-on-563 is discouraged per **RFC 4642**, in favor of STARTTLS as described below. However, some servers only support the former.

引發一個附帶引數 *self*、*host*、*port* 的稽核事件 `nntplib.connect`。

引發一個附帶引數 *self*、*line* 的稽核事件 `nntplib.putline`。

在 3.2 版新加入。

在 3.4 版的變更: The class now supports hostname check with *ssl.SSLContext.check_hostname* and *Server Name Indication* (see *ssl.HAS_SNI*).

在 3.9 版的變更: If the *timeout* parameter is set to be zero, it will raise a *ValueError* to prevent the creation of a non-blocking socket.

```
exception nntplib.NNTPError
```

Derived from the standard exception *Exception*, this is the base class for all exceptions raised by the *nntplib* module. Instances of this class have the following attribute:

response

The response of the server if available, as a *str* object.

```
exception nntplib.NNTPReplyError
```

Exception raised when an unexpected reply is received from the server.

```
exception nntplib.NNTPTemporaryError
```

Exception raised when a response code in the range 400--499 is received.

```
exception nntplib.NNTPPermanentError
```

Exception raised when a response code in the range 500--599 is received.

```
exception nntplib.NNTPProtocolError
```

Exception raised when a reply is received from the server that does not begin with a digit in the range 1--5.

```
exception nntplib.NNTPDataError
```

Exception raised when there is some error in the response data.

36.14.1 NNTP 物件

When connected, *NNTP* and *NNTP_SSL* objects support the following methods and attributes.

屬性

```
NNTP.nntp_version
```

An integer representing the version of the NNTP protocol supported by the server. In practice, this should be 2 for servers advertising **RFC 3977** compliance and 1 for others.

在 3.2 版新加入。

```
NNTP.nntp_implementation
```

A string describing the software name and version of the NNTP server, or *None* if not advertised by the server.

在 3.2 版新加入。

Methods

The *response* that is returned as the first item in the return tuple of almost all methods is the server's response: a string beginning with a three-digit code. If the server's response indicates an error, the method raises one of the above exceptions.

Many of the following methods take an optional keyword-only argument *file*. When the *file* argument is supplied, it must be either a *file object* opened for binary writing, or the name of an on-disk file to be written to. The method will then write any data returned by the server (except for the response line and the terminating dot) to the file; any list of lines, tuples or objects that the method normally returns will be empty.

在 3.2 版的變更: Many of the following methods have been reworked and fixed, which makes them incompatible with their 3.1 counterparts.

`NNTP.quit()`

Send a QUIT command and close the connection. Once this method has been called, no other methods of the NNTP object should be called.

`NNTP.getwelcome()`

Return the welcome message sent by the server in reply to the initial connection. (This message sometimes contains disclaimers or help information that may be relevant to the user.)

`NNTP.getcapabilities()`

Return the [RFC 3977](#) capabilities advertised by the server, as a *dict* instance mapping capability names to (possibly empty) lists of values. On legacy servers which don't understand the CAPABILITIES command, an empty dictionary is returned instead.

```
>>> s = NNTP('news.gmane.io')
>>> 'POST' in s.getcapabilities()
True
```

在 3.2 版新加入.

`NNTP.login(user=None, password=None, usenetrc=True)`

Send AUTHINFO commands with the user name and password. If *user* and *password* are *None* and *usenetrc* is true, credentials from `~/.netrc` will be used if possible.

Unless intentionally delayed, login is normally performed during the *NNTP* object initialization and separately calling this function is unnecessary. To force authentication to be delayed, you must not set *user* or *password* when creating the object, and must set *usenetrc* to False.

在 3.2 版新加入.

`NNTP.starttls(context=None)`

Send a STARTTLS command. This will enable encryption on the NNTP connection. The *context* argument is optional and should be a *ssl.SSLContext* object. Please read [Security considerations](#) for best practices.

Note that this may not be done after authentication information has been transmitted, and authentication occurs by default if possible during a *NNTP* object initialization. See *NNTP.login()* for information on suppressing this behavior.

在 3.2 版新加入.

在 3.4 版的變更: The method now supports hostname check with *ssl.SSLContext.check_hostname* and Server Name Indication (see *ssl.HAS_SNI*).

`NNTP.newgroups(date, *, file=None)`

Send a NEWGROUPS command. The *date* argument should be a *datetime.date* or *datetime.datetime* object. Return a pair (*response*, *groups*) where *groups* is a list representing the groups that are new since the given *date*. If *file* is supplied, though, then *groups* will be empty.

```
>>> from datetime import date, timedelta
>>> resp, groups = s.newgroups(date.today() - timedelta(days=3))
>>> len(groups)
85
>>> groups[0]
GroupInfo(group='gmane.network.tor.devel', last='4', first='1', flag='m')
```

NNTP.**newnews** (*group*, *date*, *, *file*=None)

Send a NEWNEWS command. Here, *group* is a group name or '*', and *date* has the same meaning as for *newgroups*(). Return a pair (response, articles) where *articles* is a list of message ids.

This command is frequently disabled by NNTP server administrators.

NNTP.**list** (*group_pattern*=None, *, *file*=None)

Send a LIST or LIST ACTIVE command. Return a pair (response, list) where *list* is a list of tuples representing all the groups available from this NNTP server, optionally matching the pattern string *group_pattern*. Each tuple has the form (group, last, first, flag), where *group* is a group name, *last* and *first* are the last and first article numbers, and *flag* usually takes one of these values:

- y: Local postings and articles from peers are allowed.
- m: The group is moderated and all postings must be approved.
- n: No local postings are allowed, only articles from peers.
- j: Articles from peers are filed in the junk group instead.
- x: No local postings, and articles from peers are ignored.
- =foo.bar: Articles are filed in the foo.bar group instead.

If *flag* has another value, then the status of the newsgroup should be considered unknown.

This command can return very large results, especially if *group_pattern* is not specified. It is best to cache the results offline unless you really need to refresh them.

在 3.2 版的變更: 新增 *group_pattern*。

NNTP.**descriptions** (*grouppattern*)

Send a LIST NEWSGROUPS command, where *grouppattern* is a wildmat string as specified in [RFC 3977](#) (it's essentially the same as DOS or UNIX shell wildcard strings). Return a pair (response, descriptions), where *descriptions* is a dictionary mapping group names to textual descriptions.

```
>>> resp, descs = s.descriptions('gmane.comp.python.*')
>>> len(descs)
295
>>> descs.popitem()
('gmane.comp.python.bio.general', 'BioPython discussion list (Moderated)')
```

NNTP.**description** (*group*)

Get a description for a single group *group*. If more than one group matches (if 'group' is a real wildmat string), return the first match. If no group matches, return an empty string.

This elides the response code from the server. If the response code is needed, use *descriptions*().

NNTP.**group** (*name*)

Send a GROUP command, where *name* is the group name. The group is selected as the current group, if it exists. Return a tuple (response, count, first, last, name) where *count* is the (estimated) number of articles in the group, *first* is the first article number in the group, *last* is the last article number in the group, and *name* is the group name.

NNTP.**over** (*message_spec*, *, *file*=None)

Send an OVER command, or an XOVER command on legacy servers. *message_spec* can be either a string representing a message id, or a (first, last) tuple of numbers indicating a range of articles in the

current group, or a `(first, None)` tuple indicating a range of articles starting from *first* to the last article in the current group, or `None` to select the current article in the current group.

Return a pair `(response, overviews)`. *overviews* is a list of `(article_number, overview)` tuples, one for each article selected by *message_spec*. Each *overview* is a dictionary with the same number of items, but this number depends on the server. These items are either message headers (the key is then the lower-cased header name) or metadata items (the key is then the metadata name prepended with `" : "`). The following items are guaranteed to be present by the NNTP specification:

- the `subject`, `from`, `date`, `message-id` and `references` headers
- the `:bytes` metadata: the number of bytes in the entire raw article (including headers and body)
- the `:lines` metadata: the number of lines in the article body

The value of each item is either a string, or `None` if not present.

It is advisable to use the `decode_header()` function on header values when they may contain non-ASCII characters:

```
>>> _, _, first, last, _ = s.group('gmane.comp.python.devel')
>>> resp, overviews = s.over((last, last))
>>> art_num, over = overviews[0]
>>> art_num
117216
>>> list(over.keys())
['xref', 'from', ':lines', ':bytes', 'references', 'date', 'message-id',
↪ 'subject']
>>> over['from']
'=?UTF-8?B?Ik1hcnRpbIB2LiBMw7Z3aXMi?= <martin@v.loewis.de>'
>>> nntplib.decode_header(over['from'])
'"Martin v. Löwis" <martin@v.loewis.de>'
```

在 3.2 版新加入。

NNTP.help (*, file=None)

Send a HELP command. Return a pair `(response, list)` where *list* is a list of help strings.

NNTP.stat (message_spec=None)

Send a STAT command, where *message_spec* is either a message id (enclosed in `'<'` and `'>'`) or an article number in the current group. If *message_spec* is omitted or `None`, the current article in the current group is considered. Return a triple `(response, number, id)` where *number* is the article number and *id* is the message id.

```
>>> _, _, first, last, _ = s.group('gmane.comp.python.devel')
>>> resp, number, message_id = s.stat(first)
>>> number, message_id
(9099, '<20030112190404.GE29873@epoch.metaslash.com>')
```

NNTP.next ()

Send a NEXT command. Return as for `stat()`.

NNTP.last ()

Send a LAST command. Return as for `stat()`.

NNTP.article (message_spec=None, *, file=None)

Send an ARTICLE command, where *message_spec* has the same meaning as for `stat()`. Return a tuple `(response, info)` where *info* is a *namedtuple* with three attributes *number*, *message_id* and *lines* (in that order). *number* is the article number in the group (or 0 if the information is not available), *message_id* the message id as a string, and *lines* a list of lines (without terminating newlines) comprising the raw message including headers and body.

```

>>> resp, info = s.article('<20030112190404.GE29873@epoch.metaslash.com>')
>>> info.number
0
>>> info.message_id
'<20030112190404.GE29873@epoch.metaslash.com>'
>>> len(info.lines)
65
>>> info.lines[0]
b'Path: main.gmane.org!not-for-mail'
>>> info.lines[1]
b'From: Neal Norwitz <neal@metaslash.com>'
>>> info.lines[-3:]
[b'There is a patch for 2.3 as well as 2.2.', b'', b'Neal']

```

NNTP.**head** (*message_spec=None*, *, *file=None*)

Same as [article\(\)](#), but sends a HEAD command. The *lines* returned (or written to *file*) will only contain the message headers, not the body.

NNTP.**body** (*message_spec=None*, *, *file=None*)

Same as [article\(\)](#), but sends a BODY command. The *lines* returned (or written to *file*) will only contain the message body, not the headers.

NNTP.**post** (*data*)

Post an article using the POST command. The *data* argument is either a *file object* opened for binary reading, or any iterable of bytes objects (representing raw lines of the article to be posted). It should represent a well-formed news article, including the required headers. The [post\(\)](#) method automatically escapes lines beginning with . and appends the termination line.

If the method succeeds, the server's response is returned. If the server refuses posting, a [NNTPReplyError](#) is raised.

NNTP.**ihave** (*message_id*, *data*)

Send an IHAVE command. *message_id* is the id of the message to send to the server (enclosed in '<' and '>'). The *data* parameter and the return value are the same as for [post\(\)](#).

NNTP.**date** ()

Return a pair (*response*, *date*). *date* is a [datetime](#) object containing the current date and time of the server.

NNTP.**slave** ()

Send a SLAVE command. Return the server's *response*.

NNTP.**set_debuglevel** (*level*)

Set the instance's debugging level. This controls the amount of debugging output printed. The default, 0, produces no debugging output. A value of 1 produces a moderate amount of debugging output, generally a single line per request or response. A value of 2 or higher produces the maximum amount of debugging output, logging each line sent and received on the connection (including message text).

The following are optional NNTP extensions defined in [RFC 2980](#). Some of them have been superseded by newer commands in [RFC 3977](#).

NNTP.**xhdr** (*hdr*, *str*, *, *file=None*)

Send an XHDR command. The *hdr* argument is a header keyword, e.g. 'subject'. The *str* argument should have the form 'first-last' where *first* and *last* are the first and last article numbers to search. Return a pair (*response*, *list*), where *list* is a list of pairs (*id*, *text*), where *id* is an article number (as a string) and *text* is the text of the requested header for that article. If the *file* parameter is supplied, then the output of the XHDR command is stored in a file. If *file* is a string, then the method will open a file with that name, write to it then close it. If *file* is a *file object*, then it will start calling [write\(\)](#) on it to store the lines of the command output. If *file* is supplied, then the returned *list* is an empty list.

NNTP **.xover** (*start*, *end*, *, *file*=None)

Send an XOVER command. *start* and *end* are article numbers delimiting the range of articles to select. The return value is the same of for `over()`. It is recommended to use `over()` instead, since it will automatically use the newer OVER command if available.

36.14.2 Utility functions

The module also defines the following utility function:

`nntplib.decode_header(header_str)`

Decode a header value, un-escaping any escaped non-ASCII characters. *header_str* must be a `str` object. The unescaped value is returned. Using this function is recommended to display some headers in a human readable form:

```
>>> decode_header("Some subject")
'Some subject'
>>> decode_header("=?ISO-8859-15?Q?D=E9buter_en_Python?=")
'Débuter en Python'
>>> decode_header("Re: =?UTF-8?B?cHJvYmZDqG1lIGRlIG1hdHJpY2U=?=")
'Re: problème de matrice'
```

36.15 optparse --- Parser for command line options

原始碼: [Lib/optparse.py](#)

在 3.2 版之後被用: The `optparse` module is deprecated and will not be developed further; development will continue with the `argparse` module.

`optparse` is a more convenient, flexible, and powerful library for parsing command-line options than the old `getopt` module. `optparse` uses a more declarative style of command-line parsing: you create an instance of `OptionParser`, populate it with options, and parse the command line. `optparse` allows users to specify options in the conventional GNU/POSIX syntax, and additionally generates usage and help messages for you.

Here's an example of using `optparse` in a simple script:

```
from optparse import OptionParser
...
parser = OptionParser()
parser.add_option("-f", "--file", dest="filename",
                  help="write report to FILE", metavar="FILE")
parser.add_option("-q", "--quiet",
                  action="store_false", dest="verbose", default=True,
                  help="don't print status messages to stdout")

(options, args) = parser.parse_args()
```

With these few lines of code, users of your script can now do the "usual thing" on the command-line, for example:

```
<yourscript> --file=outfile -q
```

As it parses the command line, `optparse` sets attributes of the options object returned by `parse_args()` based on user-supplied command-line values. When `parse_args()` returns from parsing this command line, `options.filename` will be "outfile" and `options.verbose` will be False. `optparse` supports both long and short options, allows short options to be merged together, and allows options to be associated with their arguments in a variety of ways. Thus, the following command lines are all equivalent to the above example:

```
<yourscript> -f outfile --quiet
<yourscript> --quiet --file outfile
<yourscript> -q -foutfile
<yourscript> -qfoutfile
```

Additionally, users can run one of the following

```
<yourscript> -h
<yourscript> --help
```

and `optparse` will print out a brief summary of your script's options:

```
Usage: <yourscript> [options]

Options:
  -h, --help            show this help message and exit
  -f FILE, --file=FILE  write report to FILE
  -q, --quiet           don't print status messages to stdout
```

where the value of `yourscript` is determined at runtime (normally from `sys.argv[0]`).

36.15.1 Background

`optparse` was explicitly designed to encourage the creation of programs with straightforward, conventional command-line interfaces. To that end, it supports only the most common command-line syntax and semantics conventionally used under Unix. If you are unfamiliar with these conventions, read this section to acquaint yourself with them.

Terminology

argument

a string entered on the command-line, and passed by the shell to `exec1()` or `execv()`. In Python, arguments are elements of `sys.argv[1:]` (`sys.argv[0]` is the name of the program being executed). Unix shells also use the term "word".

It is occasionally desirable to substitute an argument list other than `sys.argv[1:]`, so you should read "argument" as "an element of `sys.argv[1:]`", or of some other list provided as a substitute for `sys.argv[1:]`".

option

an argument used to supply extra information to guide or customize the execution of a program. There are many different syntaxes for options; the traditional Unix syntax is a hyphen ("-") followed by a single letter, e.g. `-x` or `-F`. Also, traditional Unix syntax allows multiple options to be merged into a single argument, e.g. `-x -F` is equivalent to `-xF`. The GNU project introduced `--` followed by a series of hyphen-separated words, e.g. `--file` or `--dry-run`. These are the only two option syntaxes provided by `optparse`.

Some other option syntaxes that the world has seen include:

- a hyphen followed by a few letters, e.g. `-pf` (this is *not* the same as multiple options merged into a single argument)
- a hyphen followed by a whole word, e.g. `-file` (this is technically equivalent to the previous syntax, but they aren't usually seen in the same program)
- a plus sign followed by a single letter, or a few letters, or a word, e.g. `+f`, `+rgb`
- a slash followed by a letter, or a few letters, or a word, e.g. `/f`, `/file`

These option syntaxes are not supported by `optparse`, and they never will be. This is deliberate: the first three are non-standard on any environment, and the last only makes sense if you're exclusively targeting Windows or certain legacy platforms (e.g. VMS, MS-DOS).

option argument

an argument that follows an option, is closely associated with that option, and is consumed from the argument list when that option is. With *optparse*, option arguments may either be in a separate argument from their option:

```
-f foo
--file foo
```

or included in the same argument:

```
-ffoo
--file=foo
```

Typically, a given option either takes an argument or it doesn't. Lots of people want an "optional option arguments" feature, meaning that some options will take an argument if they see it, and won't if they don't. This is somewhat controversial, because it makes parsing ambiguous: if `-a` takes an optional argument and `-b` is another option entirely, how do we interpret `-ab`? Because of this ambiguity, *optparse* does not support this feature.

positional argument

something leftover in the argument list after options have been parsed, i.e. after options and their arguments have been parsed and removed from the argument list.

required option

an option that must be supplied on the command-line; note that the phrase "required option" is self-contradictory in English. *optparse* doesn't prevent you from implementing required options, but doesn't give you much help at it either.

For example, consider this hypothetical command-line:

```
prog -v --report report.txt foo bar
```

`-v` and `--report` are both options. Assuming that `--report` takes one argument, `report.txt` is an option argument. `foo` and `bar` are positional arguments.

What are options for?

Options are used to provide extra information to tune or customize the execution of a program. In case it wasn't clear, options are usually *optional*. A program should be able to run just fine with no options whatsoever. (Pick a random program from the Unix or GNU toolsets. Can it run without any options at all and still make sense? The main exceptions are `find`, `tar`, and `dd`—all of which are mutant oddballs that have been rightly criticized for their non-standard syntax and confusing interfaces.)

Lots of people want their programs to have "required options". Think about it. If it's required, then it's *not optional*! If there is a piece of information that your program absolutely requires in order to run successfully, that's what positional arguments are for.

As an example of good command-line interface design, consider the humble `cp` utility, for copying files. It doesn't make much sense to try to copy files without supplying a destination and at least one source. Hence, `cp` fails if you run it with no arguments. However, it has a flexible, useful syntax that does not require any options at all:

```
cp SOURCE DEST
cp SOURCE ... DEST-DIR
```

You can get pretty far with just that. Most `cp` implementations provide a bunch of options to tweak exactly how the files are copied: you can preserve mode and modification time, avoid following symlinks, ask before clobbering existing files, etc. But none of this distracts from the core mission of `cp`, which is to copy either one file to another, or several files to another directory.

What are positional arguments for?

Positional arguments are for those pieces of information that your program absolutely, positively requires to run.

A good user interface should have as few absolute requirements as possible. If your program requires 17 distinct pieces of information in order to run successfully, it doesn't much matter *how* you get that information from the user---most people will give up and walk away before they successfully run the program. This applies whether the user interface is a command-line, a configuration file, or a GUI: if you make that many demands on your users, most of them will simply give up.

In short, try to minimize the amount of information that users are absolutely required to supply---use sensible defaults whenever possible. Of course, you also want to make your programs reasonably flexible. That's what options are for. Again, it doesn't matter if they are entries in a config file, widgets in the "Preferences" dialog of a GUI, or command-line options---the more options you implement, the more flexible your program is, and the more complicated its implementation becomes. Too much flexibility has drawbacks as well, of course; too many options can overwhelm users and make your code much harder to maintain.

36.15.2 Tutorial

While *optparse* is quite flexible and powerful, it's also straightforward to use in most cases. This section covers the code patterns that are common to any *optparse*-based program.

First, you need to import the `OptionParser` class; then, early in the main program, create an `OptionParser` instance:

```
from optparse import OptionParser
...
parser = OptionParser()
```

Then you can start defining options. The basic syntax is:

```
parser.add_option(opt_str, ...,
                  attr=value, ...)
```

Each option has one or more option strings, such as `-f` or `--file`, and several option attributes that tell *optparse* what to expect and what to do when it encounters that option on the command line.

Typically, each option will have one short option string and one long option string, e.g.:

```
parser.add_option("-f", "--file", ...)
```

You're free to define as many short option strings and as many long option strings as you like (including zero), as long as there is at least one option string overall.

The option strings passed to `OptionParser.add_option()` are effectively labels for the option defined by that call. For brevity, we will frequently refer to *encountering an option* on the command line; in reality, *optparse* encounters *option strings* and looks up options from them.

Once all of your options are defined, instruct *optparse* to parse your program's command line:

```
(options, args) = parser.parse_args()
```

(If you like, you can pass a custom argument list to `parse_args()`, but that's rarely necessary: by default it uses `sys.argv[1:]`.)

`parse_args()` 回傳兩個值:

- `options`, an object containing values for all of your options---e.g. if `--file` takes a single string argument, then `options.file` will be the filename supplied by the user, or `None` if the user did not supply that option
- `args`, the list of positional arguments leftover after parsing options

This tutorial section only covers the four most important option attributes: *action*, *type*, *dest* (destination), and *help*. Of these, *action* is the most fundamental.

Understanding option actions

Actions tell *optparse* what to do when it encounters an option on the command line. There is a fixed set of actions hard-coded into *optparse*; adding new actions is an advanced topic covered in section *Extending optparse*. Most actions tell *optparse* to store a value in some variable—for example, take a string from the command line and store it in an attribute of *options*.

If you don't specify an option action, *optparse* defaults to *store*.

The store action

The most common option action is *store*, which tells *optparse* to take the next argument (or the remainder of the current argument), ensure that it is of the correct type, and store it to your chosen destination.

舉例來：

```
parser.add_option("-f", "--file",
                  action="store", type="string", dest="filename")
```

Now let's make up a fake command line and ask *optparse* to parse it:

```
args = ["-f", "foo.txt"]
(options, args) = parser.parse_args(args)
```

When *optparse* sees the option string *-f*, it consumes the next argument, *foo.txt*, and stores it in *options.filename*. So, after this call to *parse_args()*, *options.filename* is *"foo.txt"*.

Some other option types supported by *optparse* are *int* and *float*. Here's an option that expects an integer argument:

```
parser.add_option("-n", type="int", dest="num")
```

Note that this option has no long option string, which is perfectly acceptable. Also, there's no explicit action, since the default is *store*.

Let's parse another fake command-line. This time, we'll jam the option argument right up against the option: since *-n42* (one argument) is equivalent to *-n 42* (two arguments), the code

```
(options, args) = parser.parse_args(["-n42"])
print(options.num)
```

will print 42.

If you don't specify a type, *optparse* assumes *string*. Combined with the fact that the default action is *store*, that means our first example can be a lot shorter:

```
parser.add_option("-f", "--file", dest="filename")
```

If you don't supply a destination, *optparse* figures out a sensible default from the option strings: if the first long option string is *--foo-bar*, then the default destination is *foo_bar*. If there are no long option strings, *optparse* looks at the first short option string: the default destination for *-f* is *f*.

optparse also includes the built-in *complex* type. Adding types is covered in section *Extending optparse*.

Handling boolean (flag) options

Flag options---set a variable to true or false when a particular option is seen---are quite common. *optparse* supports them with two separate actions, `store_true` and `store_false`. For example, you might have a `verbose` flag that is turned on with `-v` and off with `-q`:

```
parser.add_option("-v", action="store_true", dest="verbose")
parser.add_option("-q", action="store_false", dest="verbose")
```

Here we have two different options with the same destination, which is perfectly OK. (It just means you have to be a bit careful when setting default values---see below.)

When *optparse* encounters `-v` on the command line, it sets `options.verbose` to `True`; when it encounters `-q`, `options.verbose` is set to `False`.

Other actions

Some other actions supported by *optparse* are:

- "store_const"**
store a constant value, pre-set via *Option.const*
- "append"**
append this option's argument to a list
- "count"**
increment a counter by one
- "callback"**
call a specified function

These are covered in section *Reference Guide*, and section *Option Callbacks*.

Default values

All of the above examples involve setting some variable (the "destination") when certain command-line options are seen. What happens if those options are never seen? Since we didn't supply any defaults, they are all set to `None`. This is usually fine, but sometimes you want more control. *optparse* lets you supply a default value for each destination, which is assigned before the command line is parsed.

First, consider the verbose/quiet example. If we want *optparse* to set `verbose` to `True` unless `-q` is seen, then we can do this:

```
parser.add_option("-v", action="store_true", dest="verbose", default=True)
parser.add_option("-q", action="store_false", dest="verbose")
```

Since default values apply to the *destination* rather than to any particular option, and these two options happen to have the same destination, this is exactly equivalent:

```
parser.add_option("-v", action="store_true", dest="verbose")
parser.add_option("-q", action="store_false", dest="verbose", default=True)
```

Consider this:

```
parser.add_option("-v", action="store_true", dest="verbose", default=False)
parser.add_option("-q", action="store_false", dest="verbose", default=True)
```

Again, the default value for `verbose` will be `True`: the last default value supplied for any particular destination is the one that counts.

A clearer way to specify default values is the `set_defaults()` method of *OptionParser*, which you can call at any time before calling *parse_args()*:

```
parser.set_defaults(verbose=True)
parser.add_option(...)
(options, args) = parser.parse_args()
```

As before, the last value specified for a given option destination is the one that counts. For clarity, try to use one method or the other of setting default values, not both.

Generating help

optparse's ability to generate help and usage text automatically is useful for creating user-friendly command-line interfaces. All you have to do is supply a *help* value for each option, and optionally a short usage message for your whole program. Here's an *OptionParser* populated with user-friendly (documented) options:

```
usage = "usage: %prog [options] arg1 arg2"
parser = OptionParser(usage=usage)
parser.add_option("-v", "--verbose",
                  action="store_true", dest="verbose", default=True,
                  help="make lots of noise [default]")
parser.add_option("-q", "--quiet",
                  action="store_false", dest="verbose",
                  help="be vewwy quiet (I'm hunting wabbits)")
parser.add_option("-f", "--filename",
                  metavar="FILE", help="write output to FILE")
parser.add_option("-m", "--mode",
                  default="intermediate",
                  help="interaction mode: novice, intermediate, "
                        "or expert [default: %default]")
```

If *optparse* encounters either `-h` or `--help` on the command-line, or if you just call `parser.print_help()`, it prints the following to standard output:

```
Usage: <yourscript> [options] arg1 arg2

Options:
  -h, --help            show this help message and exit
  -v, --verbose          make lots of noise [default]
  -q, --quiet           be vewwy quiet (I'm hunting wabbits)
  -f FILE, --filename=FILE
                        write output to FILE
  -m MODE, --mode=MODE  interaction mode: novice, intermediate, or
                        expert [default: intermediate]
```

(If the help output is triggered by a help option, *optparse* exits after printing the help text.)

There's a lot going on here to help *optparse* generate the best possible help message:

- the script defines its own usage message:

```
usage = "usage: %prog [options] arg1 arg2"
```

optparse expands `%prog` in the usage string to the name of the current program, i.e. `os.path.basename(sys.argv[0])`. The expanded string is then printed before the detailed option help.

If you don't supply a usage string, *optparse* uses a bland but sensible default: `"Usage: %prog [options]"`, which is fine if your script doesn't take any positional arguments.

- every option defines a help string, and doesn't worry about line-wrapping---*optparse* takes care of wrapping lines and making the help output look good.
- options that take a value indicate this fact in their automatically generated help message, e.g. for the "mode" option:

```
-m MODE, --mode=MODE
```

Here, "MODE" is called the meta-variable: it stands for the argument that the user is expected to supply to `-m/--mode`. By default, `optparse` converts the destination variable name to uppercase and uses that for the meta-variable. Sometimes, that's not what you want—for example, the `--filename` option explicitly sets `metavar="FILE"`, resulting in this automatically generated option description:

```
-f FILE, --filename=FILE
```

This is important for more than just saving space, though: the manually written help text uses the meta-variable `FILE` to clue the user in that there's a connection between the semi-formal syntax `-f FILE` and the informal semantic description "write output to `FILE`". This is a simple but effective way to make your help text a lot clearer and more useful for end users.

- options that have a default value can include `%default` in the help string—`optparse` will replace it with `str()` of the option's default value. If an option has no default value (or the default value is `None`), `%default` expands to `none`.

Grouping Options

When dealing with many options, it is convenient to group these options for better help output. An `OptionParser` can contain several option groups, each of which can contain several options.

An option group is obtained using the class `OptionGroup`:

```
class optparse.OptionGroup (parser, title, description=None)
```

where

- `parser` is the `OptionParser` instance the group will be inserted in to
- `title` is the group title
- `description`, optional, is a long description of the group

`OptionGroup` inherits from `OptionContainer` (like `OptionParser`) and so the `add_option()` method can be used to add an option to the group.

Once all the options are declared, using the `OptionParser` method `add_option_group()` the group is added to the previously defined parser.

Continuing with the parser defined in the previous section, adding an `OptionGroup` to a parser is easy:

```
group = OptionGroup(parser, "Dangerous Options",
                    "Caution: use these options at your own risk. "
                    "It is believed that some of them bite.")
group.add_option("-g", action="store_true", help="Group option.")
parser.add_option_group(group)
```

This would result in the following help output:

```
Usage: <yourscript> [options] arg1 arg2

Options:
  -h, --help            show this help message and exit
  -v, --verbose          make lots of noise [default]
  -q, --quiet            be vewwy quiet (I'm hunting wabbits)
  -f FILE, --filename=FILE
                        write output to FILE
  -m MODE, --mode=MODE  interaction mode: novice, intermediate, or
                        expert [default: intermediate]

Dangerous Options:
```

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Caution: use these options at your own risk. It is believed that some of them bite.

-g Group option.

A bit more complete example might involve using more than one group: still extending the previous example:

```
group = OptionGroup(parser, "Dangerous Options",
                    "Caution: use these options at your own risk. "
                    "It is believed that some of them bite.")
group.add_option("-g", action="store_true", help="Group option.")
parser.add_option_group(group)

group = OptionGroup(parser, "Debug Options")
group.add_option("-d", "--debug", action="store_true",
                help="Print debug information")
group.add_option("-s", "--sql", action="store_true",
                help="Print all SQL statements executed")
group.add_option("-e", action="store_true", help="Print every action done")
parser.add_option_group(group)
```

that results in the following output:

```
Usage: <yourscrip> [options] arg1 arg2

Options:
  -h, --help            show this help message and exit
  -v, --verbose          make lots of noise [default]
  -q, --quiet            be vewwy quiet (I'm hunting wabbits)
  -f FILE, --filename=FILE
                        write output to FILE
  -m MODE, --mode=MODE  interaction mode: novice, intermediate, or expert
                        [default: intermediate]

Dangerous Options:
  Caution: use these options at your own risk.  It is believed that some
  of them bite.

  -g                    Group option.

Debug Options:
  -d, --debug          Print debug information
  -s, --sql            Print all SQL statements executed
  -e                  Print every action done
```

Another interesting method, in particular when working programmatically with option groups is:

`OptionParser.get_option_group(opt_str)`

Return the *OptionGroup* to which the short or long option string *opt_str* (e.g. `'-o'` or `'--option'`) belongs. If there's no such *OptionGroup*, return `None`.

Printing a version string

Similar to the brief usage string, `optparse` can also print a version string for your program. You have to supply the string as the `version` argument to `OptionParser`:

```
parser = OptionParser(usage="%prog [-f] [-q]", version="%prog 1.0")
```

`%prog` is expanded just like it is in `usage`. Apart from that, `version` can contain anything you like. When you supply it, `optparse` automatically adds a `--version` option to your parser. If it encounters this option on the command line, it expands your version string (by replacing `%prog`), prints it to `stdout`, and exits.

For example, if your script is called `/usr/bin/foo`:

```
$ /usr/bin/foo --version
foo 1.0
```

The following two methods can be used to print and get the `version` string:

`OptionParser.print_version(file=None)`

Print the version message for the current program (`self.version`) to *file* (default `stdout`). As with `print_usage()`, any occurrence of `%prog` in `self.version` is replaced with the name of the current program. Does nothing if `self.version` is empty or undefined.

`OptionParser.get_version()`

Same as `print_version()` but returns the version string instead of printing it.

How `optparse` handles errors

There are two broad classes of errors that `optparse` has to worry about: programmer errors and user errors. Programmer errors are usually erroneous calls to `OptionParser.add_option()`, e.g. invalid option strings, unknown option attributes, missing option attributes, etc. These are dealt with in the usual way: raise an exception (either `optparse.OptionError` or `TypeError`) and let the program crash.

Handling user errors is much more important, since they are guaranteed to happen no matter how stable your code is. `optparse` can automatically detect some user errors, such as bad option arguments (passing `-n 4x` where `-n` takes an integer argument), missing arguments (`-n` at the end of the command line, where `-n` takes an argument of any type). Also, you can call `OptionParser.error()` to signal an application-defined error condition:

```
(options, args) = parser.parse_args()
...
if options.a and options.b:
    parser.error("options -a and -b are mutually exclusive")
```

In either case, `optparse` handles the error the same way: it prints the program's usage message and an error message to standard error and exits with error status 2.

Consider the first example above, where the user passes `4x` to an option that takes an integer:

```
$ /usr/bin/foo -n 4x
Usage: foo [options]

foo: error: option -n: invalid integer value: '4x'
```

Or, where the user fails to pass a value at all:

```
$ /usr/bin/foo -n
Usage: foo [options]

foo: error: -n option requires an argument
```

optparse-generated error messages take care always to mention the option involved in the error; be sure to do the same when calling `OptionParser.error()` from your application code.

If *optparse*'s default error-handling behaviour does not suit your needs, you'll need to subclass `OptionParser` and override its `exit()` and/or `error()` methods.

Putting it all together

Here's what *optparse*-based scripts usually look like:

```
from optparse import OptionParser
...
def main():
    usage = "%prog [options] arg"
    parser = OptionParser(usage)
    parser.add_option("-f", "--file", dest="filename",
                      help="read data from FILENAME")
    parser.add_option("-v", "--verbose",
                      action="store_true", dest="verbose")
    parser.add_option("-q", "--quiet",
                      action="store_false", dest="verbose")
    ...
    (options, args) = parser.parse_args()
    if len(args) != 1:
        parser.error("incorrect number of arguments")
    if options.verbose:
        print("reading %s..." % options.filename)
    ...

if __name__ == "__main__":
    main()
```

36.15.3 Reference Guide

Creating the parser

The first step in using *optparse* is to create an `OptionParser` instance.

class `optparse.OptionParser(...)`

The `OptionParser` constructor has no required arguments, but a number of optional keyword arguments. You should always pass them as keyword arguments, i.e. do not rely on the order in which the arguments are declared.

usage (default: "%prog [options]")

The usage summary to print when your program is run incorrectly or with a help option. When *optparse* prints the usage string, it expands `%prog` to `os.path.basename(sys.argv[0])` (or to `prog` if you passed that keyword argument). To suppress a usage message, pass the special value `optparse.SUPPRESS_USAGE`.

option_list (default: [])

A list of `Option` objects to populate the parser with. The options in `option_list` are added after any options in `standard_option_list` (a class attribute that may be set by `OptionParser` subclasses), but before any version or help options. Deprecated; use `add_option()` after creating the parser instead.

option_class (default: `optparse.Option`)

Class to use when adding options to the parser in `add_option()`.

version (default: `None`)

A version string to print when the user supplies a version option. If you supply a true value for `version`,

`optparse` automatically adds a version option with the single option string `--version`. The substring `%prog` is expanded the same as for `usage`.

conflict_handler (default: "error")

Specifies what to do when options with conflicting option strings are added to the parser; see section *Conflicts between options*.

description (default: None)

A paragraph of text giving a brief overview of your program. `optparse` reformats this paragraph to fit the current terminal width and prints it when the user requests help (after `usage`, but before the list of options).

formatter (default: a new `IndentedHelpFormatter`)

An instance of `optparse.HelpFormatter` that will be used for printing help text. `optparse` provides two concrete classes for this purpose: `IndentedHelpFormatter` and `TitledHelpFormatter`.

add_help_option (default: True)

If true, `optparse` will add a help option (with option strings `-h` and `--help`) to the parser.

prog

The string to use when expanding `%prog` in `usage` and `version` instead of `os.path.basename(sys.argv[0])`.

epilog (default: None)

A paragraph of help text to print after the option help.

Populating the parser

There are several ways to populate the parser with options. The preferred way is by using `OptionParser.add_option()`, as shown in section *Tutorial*. `add_option()` can be called in one of two ways:

- pass it an `Option` instance (as returned by `make_option()`)
- pass it any combination of positional and keyword arguments that are acceptable to `make_option()` (i.e., to the `Option` constructor), and it will create the `Option` instance for you

The other alternative is to pass a list of pre-constructed `Option` instances to the `OptionParser` constructor, as in:

```
option_list = [
    make_option("-f", "--filename",
                action="store", type="string", dest="filename"),
    make_option("-q", "--quiet",
                action="store_false", dest="verbose"),
]
parser = OptionParser(option_list=option_list)
```

(`make_option()` is a factory function for creating `Option` instances; currently it is an alias for the `Option` constructor. A future version of `optparse` may split `Option` into several classes, and `make_option()` will pick the right class to instantiate. Do not instantiate `Option` directly.)

Defining options

Each `Option` instance represents a set of synonymous command-line option strings, e.g. `-f` and `--file`. You can specify any number of short or long option strings, but you must specify at least one overall option string.

The canonical way to create an `Option` instance is with the `add_option()` method of `OptionParser`.

`OptionParser.add_option(option)`

`OptionParser.add_option(*opt_str, attr=value, ...)`

To define an option with only a short option string:

```
parser.add_option("-f", attr=value, ...)
```

And to define an option with only a long option string:

```
parser.add_option("--foo", attr=value, ...)
```

The keyword arguments define attributes of the new `Option` object. The most important option attribute is *action*, and it largely determines which other attributes are relevant or required. If you pass irrelevant option attributes, or fail to pass required ones, *optparse* raises an *OptionError* exception explaining your mistake.

An option's *action* determines what *optparse* does when it encounters this option on the command-line. The standard option actions hard-coded into *optparse* are:

- "store"**
store this option's argument (default)
- "store_const"**
store a constant value, pre-set via *Option.const*
- "store_true"**
store True
- "store_false"**
store False
- "append"**
append this option's argument to a list
- "append_const"**
append a constant value to a list, pre-set via *Option.const*
- "count"**
increment a counter by one
- "callback"**
call a specified function
- "help"**
print a usage message including all options and the documentation for them

(If you don't supply an action, the default is "store". For this action, you may also supply *type* and *dest* option attributes; see *Standard option actions*.)

As you can see, most actions involve storing or updating a value somewhere. *optparse* always creates a special object for this, conventionally called *options*, which is an instance of *optparse.Values*.

class *optparse.Values*

An object holding parsed argument names and values as attributes. Normally created by calling when calling *OptionParser.parse_args()*, and can be overridden by a custom subclass passed to the *values* argument of *OptionParser.parse_args()* (as described in *Parsing arguments*).

Option arguments (and various other values) are stored as attributes of this object, according to the *dest* (destination) option attribute.

例如F，當你呼叫：

```
parser.parse_args()
```

one of the first things *optparse* does is create the *options* object:

```
options = Values()
```

If one of the options in this parser is defined with

```
parser.add_option("-f", "--file", action="store", type="string", dest="filename")
```

and the command-line being parsed includes any of the following:

```
-ffoo
-f foo
--file=foo
--file foo
```

then *optparse*, on seeing this option, will do the equivalent of

```
options.filename = "foo"
```

The *type* and *dest* option attributes are almost as important as *action*, but *action* is the only one that makes sense for *all* options.

Option attributes

class *optparse.Option*

A single command line argument, with various attributes passed by keyword to the constructor. Normally created with *OptionParser.add_option()* rather than directly, and can be overridden by a custom class via the *option_class* argument to *OptionParser*.

The following option attributes may be passed as keyword arguments to *OptionParser.add_option()*. If you pass an option attribute that is not relevant to a particular option, or fail to pass a required option attribute, *optparse* raises *OptionError*.

Option.action

(default: "store")

Determines *optparse*'s behaviour when this option is seen on the command line; the available options are documented [here](#).

Option.type

(default: "string")

The argument type expected by this option (e.g., "string" or "int"); the available option types are documented [here](#).

Option.dest

(default: derived from option strings)

If the option's action implies writing or modifying a value somewhere, this tells *optparse* where to write it: *dest* names an attribute of the *options* object that *optparse* builds as it parses the command line.

Option.default

The value to use for this option's destination if the option is not seen on the command line. See also *OptionParser.set_defaults()*.

Option.nargs

(default: 1)

How many arguments of type *type* should be consumed when this option is seen. If > 1, *optparse* will store a tuple of values to *dest*.

Option.const

For actions that store a constant value, the constant value to store.

Option.choices

For options of type "choice", the list of strings the user may choose from.

Option.callback

For options with action "callback", the callable to call when this option is seen. See section [Option Callbacks](#) for detail on the arguments passed to the callable.

Option.callback_args**Option.callback_kwargs**

Additional positional and keyword arguments to pass to `callback` after the four standard callback arguments.

Option.help

Help text to print for this option when listing all available options after the user supplies a `help` option (such as `--help`). If no help text is supplied, the option will be listed without help text. To hide this option, use the special value `optparse.SUPPRESS_HELP`.

Option.metavar

(default: derived from option strings)

Stand-in for the option argument(s) to use when printing help text. See section [Tutorial](#) for an example.

Standard option actions

The various option actions all have slightly different requirements and effects. Most actions have several relevant option attributes which you may specify to guide `optparse`'s behaviour; a few have required attributes, which you must specify for any option using that action.

- "store" [relevant: `type`, `dest`, `nargs`, `choices`]

The option must be followed by an argument, which is converted to a value according to `type` and stored in `dest`. If `nargs > 1`, multiple arguments will be consumed from the command line; all will be converted according to `type` and stored to `dest` as a tuple. See the [Standard option types](#) section.

If `choices` is supplied (a list or tuple of strings), the type defaults to "choice".

If `type` is not supplied, it defaults to "string".

If `dest` is not supplied, `optparse` derives a destination from the first long option string (e.g., `--foo-bar` implies `foo_bar`). If there are no long option strings, `optparse` derives a destination from the first short option string (e.g., `-f` implies `f`).

範例：

```
parser.add_option("-f")
parser.add_option("-p", type="float", nargs=3, dest="point")
```

As it parses the command line

```
-f foo.txt -p 1 -3.5 4 -fbar.txt
```

`optparse` will set

```
options.f = "foo.txt"
options.point = (1.0, -3.5, 4.0)
options.f = "bar.txt"
```

- "store_const" [required: `const`; relevant: `dest`]

The value `const` is stored in `dest`.

範例：

```
parser.add_option("-q", "--quiet",
                  action="store_const", const=0, dest="verbose")
parser.add_option("-v", "--verbose",
                  action="store_const", const=1, dest="verbose")
```

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```
parser.add_option("--noisy",
                  action="store_const", const=2, dest="verbose")
```

If `--noisy` is seen, `optparse` will set

```
options.verbose = 2
```

- "store_true" [relevant: `dest`]

A special case of "store_const" that stores True to `dest`.

- "store_false" [relevant: `dest`]

Like "store_true", but stores False.

範例：

```
parser.add_option("--clobber", action="store_true", dest="clobber")
parser.add_option("--no-clobber", action="store_false", dest="clobber")
```

- "append" [relevant: `type`, `dest`, `nargs`, `choices`]

The option must be followed by an argument, which is appended to the list in `dest`. If no default value for `dest` is supplied, an empty list is automatically created when `optparse` first encounters this option on the command-line. If `nargs > 1`, multiple arguments are consumed, and a tuple of length `nargs` is appended to `dest`.

The defaults for `type` and `dest` are the same as for the "store" action.

範例：

```
parser.add_option("-t", "--tracks", action="append", type="int")
```

If `-t3` is seen on the command-line, `optparse` does the equivalent of:

```
options.tracks = []
options.tracks.append(int("3"))
```

If, a little later on, `--tracks=4` is seen, it does:

```
options.tracks.append(int("4"))
```

The append action calls the append method on the current value of the option. This means that any default value specified must have an append method. It also means that if the default value is non-empty, the default elements will be present in the parsed value for the option, with any values from the command line appended after those default values:

```
>>> parser.add_option("--files", action="append", default=['~/mypkg/defaults',
↳'])
>>> opts, args = parser.parse_args(['--files', 'overrides.mypkg'])
>>> opts.files
['~/mypkg/defaults', 'overrides.mypkg']
```

- "append_const" [required: `const`; relevant: `dest`]

Like "store_const", but the value `const` is appended to `dest`; as with "append", `dest` defaults to None, and an empty list is automatically created the first time the option is encountered.

- "count" [relevant: `dest`]

Increment the integer stored at `dest`. If no default value is supplied, `dest` is set to zero before being incremented the first time.

範例：

```
parser.add_option("-v", action="count", dest="verbosity")
```

The first time `-v` is seen on the command line, `optparse` does the equivalent of:

```
options.verbosity = 0
options.verbosity += 1
```

Every subsequent occurrence of `-v` results in

```
options.verbosity += 1
```

- "callback" [required: `callback`; relevant: `type`, `nargs`, `callback_args`, `callback_kwargs`]

Call the function specified by `callback`, which is called as

```
func(option, opt_str, value, parser, *args, **kwargs)
```

更多細節請見 [Option Callbacks](#)。

- "help"

Prints a complete help message for all the options in the current option parser. The help message is constructed from the usage string passed to `OptionParser`'s constructor and the `help` string passed to every option.

If no `help` string is supplied for an option, it will still be listed in the help message. To omit an option entirely, use the special value `optparse.SUPPRESS_HELP`.

`optparse` automatically adds a `help` option to all `OptionParsers`, so you do not normally need to create one.

範例：

```
from optparse import OptionParser, SUPPRESS_HELP

# usually, a help option is added automatically, but that can
# be suppressed using the add_help_option argument
parser = OptionParser(add_help_option=False)

parser.add_option("-h", "--help", action="help")
parser.add_option("-v", action="store_true", dest="verbose",
                  help="Be moderately verbose")
parser.add_option("--file", dest="filename",
                  help="Input file to read data from")
parser.add_option("--secret", help=SUPPRESS_HELP)
```

If `optparse` sees either `-h` or `--help` on the command line, it will print something like the following help message to stdout (assuming `sys.argv[0]` is `"foo.py"`):

```
Usage: foo.py [options]

Options:
  -h, --help            Show this help message and exit
  -v                    Be moderately verbose
  --file=FILENAME       Input file to read data from
```

After printing the help message, `optparse` terminates your process with `sys.exit(0)`.

- "version"

Prints the version number supplied to the `OptionParser` to stdout and exits. The version number is actually formatted and printed by the `print_version()` method of `OptionParser`. Generally only relevant if the `version` argument is supplied to the `OptionParser` constructor. As with `help` options, you will rarely create version options, since `optparse` automatically adds them when needed.

Standard option types

`optparse` has five built-in option types: "string", "int", "choice", "float" and "complex". If you need to add new option types, see section [Extending optparse](#).

Arguments to string options are not checked or converted in any way: the text on the command line is stored in the destination (or passed to the callback) as-is.

Integer arguments (type "int") are parsed as follows:

- if the number starts with 0x, it is parsed as a hexadecimal number
- if the number starts with 0, it is parsed as an octal number
- if the number starts with 0b, it is parsed as a binary number
- otherwise, the number is parsed as a decimal number

The conversion is done by calling `int()` with the appropriate base (2, 8, 10, or 16). If this fails, so will `optparse`, although with a more useful error message.

"float" and "complex" option arguments are converted directly with `float()` and `complex()`, with similar error-handling.

"choice" options are a subtype of "string" options. The `choices` option attribute (a sequence of strings) defines the set of allowed option arguments. `optparse.check_choice()` compares user-supplied option arguments against this master list and raises `OptionValueError` if an invalid string is given.

Parsing arguments

The whole point of creating and populating an `OptionParser` is to call its `parse_args()` method.

`OptionParser.parse_args(args=None, values=None)`

Parse the command-line options found in *args*.

The input parameters are

args

the list of arguments to process (default: `sys.argv[1:]`)

values

an `Values` object to store option arguments in (default: a new instance of `Values`) -- if you give an existing object, the option defaults will not be initialized on it

and the return value is a pair (`options`, `args`) where

options

the same object that was passed in as *values*, or the `optparse.Values` instance created by `optparse`

args

the leftover positional arguments after all options have been processed

The most common usage is to supply neither keyword argument. If you supply *values*, it will be modified with repeated `setattr()` calls (roughly one for every option argument stored to an option destination) and returned by `parse_args()`.

If `parse_args()` encounters any errors in the argument list, it calls the `OptionParser.error()` method with an appropriate end-user error message. This ultimately terminates your process with an exit status of 2 (the traditional Unix exit status for command-line errors).

Querying and manipulating your option parser

The default behavior of the option parser can be customized slightly, and you can also poke around your option parser and see what's there. `OptionParser` provides several methods to help you out:

`OptionParser.disable_interspersed_args()`

Set parsing to stop on the first non-option. For example, if `-a` and `-b` are both simple options that take no arguments, `optparse` normally accepts this syntax:

```
prog -a arg1 -b arg2
```

and treats it as equivalent to

```
prog -a -b arg1 arg2
```

To disable this feature, call `disable_interspersed_args()`. This restores traditional Unix syntax, where option parsing stops with the first non-option argument.

Use this if you have a command processor which runs another command which has options of its own and you want to make sure these options don't get confused. For example, each command might have a different set of options.

`OptionParser.enable_interspersed_args()`

Set parsing to not stop on the first non-option, allowing interspersing switches with command arguments. This is the default behavior.

`OptionParser.get_option(opt_str)`

Returns the `Option` instance with the option string `opt_str`, or `None` if no options have that option string.

`OptionParser.has_option(opt_str)`

Return `True` if the `OptionParser` has an option with option string `opt_str` (e.g., `-q` or `--verbose`).

`OptionParser.remove_option(opt_str)`

If the `OptionParser` has an option corresponding to `opt_str`, that option is removed. If that option provided any other option strings, all of those option strings become invalid. If `opt_str` does not occur in any option belonging to this `OptionParser`, raises `ValueError`.

Conflicts between options

If you're not careful, it's easy to define options with conflicting option strings:

```
parser.add_option("-n", "--dry-run", ...)
...
parser.add_option("-n", "--noisy", ...)
```

(This is particularly true if you've defined your own `OptionParser` subclass with some standard options.)

Every time you add an option, `optparse` checks for conflicts with existing options. If it finds any, it invokes the current conflict-handling mechanism. You can set the conflict-handling mechanism either in the constructor:

```
parser = OptionParser(..., conflict_handler=handler)
```

or with a separate call:

```
parser.set_conflict_handler(handler)
```

The available conflict handlers are:

"error" (default)

assume option conflicts are a programming error and raise `OptionConflictError`

"resolve"

resolve option conflicts intelligently (see below)

As an example, let's define an `OptionParser` that resolves conflicts intelligently and add conflicting options to it:

```
parser = OptionParser(conflict_handler="resolve")
parser.add_option("-n", "--dry-run", ..., help="do no harm")
parser.add_option("-n", "--noisy", ..., help="be noisy")
```

At this point, `optparse` detects that a previously added option is already using the `-n` option string. Since `conflict_handler` is "resolve", it resolves the situation by removing `-n` from the earlier option's list of option strings. Now `--dry-run` is the only way for the user to activate that option. If the user asks for help, the help message will reflect that:

```
Options:
  --dry-run      do no harm
  ...
  -n, --noisy    be noisy
```

It's possible to whittle away the option strings for a previously added option until there are none left, and the user has no way of invoking that option from the command-line. In that case, `optparse` removes that option completely, so it doesn't show up in help text or anywhere else. Carrying on with our existing `OptionParser`:

```
parser.add_option("--dry-run", ..., help="new dry-run option")
```

At this point, the original `-n/--dry-run` option is no longer accessible, so `optparse` removes it, leaving this help text:

```
Options:
  ...
  -n, --noisy    be noisy
  --dry-run      new dry-run option
```

Cleanup

`OptionParser` instances have several cyclic references. This should not be a problem for Python's garbage collector, but you may wish to break the cyclic references explicitly by calling `destroy()` on your `OptionParser` once you are done with it. This is particularly useful in long-running applications where large object graphs are reachable from your `OptionParser`.

Other methods

`OptionParser` supports several other public methods:

`OptionParser.set_usage(usage)`

Set the usage string according to the rules described above for the `usage` constructor keyword argument. Passing `None` sets the default usage string; use `optparse.SUPPRESS_USAGE` to suppress a usage message.

`OptionParser.print_usage(file=None)`

Print the usage message for the current program (`self.usage`) to `file` (default `stdout`). Any occurrence of the string `%prog` in `self.usage` is replaced with the name of the current program. Does nothing if `self.usage` is empty or not defined.

`OptionParser.get_usage()`

Same as `print_usage()` but returns the usage string instead of printing it.

`OptionParser.set_defaults(dest=value, ...)`

Set default values for several option destinations at once. Using `set_defaults()` is the preferred way to set default values for options, since multiple options can share the same destination. For example, if several "mode" options all set the same destination, any one of them can set the default, and the last one wins:

```
parser.add_option("--advanced", action="store_const",
                  dest="mode", const="advanced",
                  default="novice")      # overridden below
parser.add_option("--novice", action="store_const",
                  dest="mode", const="novice",
                  default="advanced")    # overrides above setting
```

To avoid this confusion, use `set_defaults()`:

```
parser.set_defaults(mode="advanced")
parser.add_option("--advanced", action="store_const",
                  dest="mode", const="advanced")
parser.add_option("--novice", action="store_const",
                  dest="mode", const="novice")
```

36.15.4 Option Callbacks

When `optparse`'s built-in actions and types aren't quite enough for your needs, you have two choices: extend `optparse` or define a callback option. Extending `optparse` is more general, but overkill for a lot of simple cases. Quite often a simple callback is all you need.

There are two steps to defining a callback option:

- define the option itself using the "callback" action
- write the callback; this is a function (or method) that takes at least four arguments, as described below

Defining a callback option

As always, the easiest way to define a callback option is by using the `OptionParser.add_option()` method. Apart from `action`, the only option attribute you must specify is `callback`, the function to call:

```
parser.add_option("-c", action="callback", callback=my_callback)
```

`callback` is a function (or other callable object), so you must have already defined `my_callback()` when you create this callback option. In this simple case, `optparse` doesn't even know if `-c` takes any arguments, which usually means that the option takes no arguments---the mere presence of `-c` on the command-line is all it needs to know. In some circumstances, though, you might want your callback to consume an arbitrary number of command-line arguments. This is where writing callbacks gets tricky; it's covered later in this section.

`optparse` always passes four particular arguments to your callback, and it will only pass additional arguments if you specify them via `callback_args` and `callback_kwargs`. Thus, the minimal callback function signature is:

```
def my_callback(option, opt, value, parser):
```

The four arguments to a callback are described below.

There are several other option attributes that you can supply when you define a callback option:

`type`

has its usual meaning: as with the "store" or "append" actions, it instructs `optparse` to consume one argument and convert it to `type`. Rather than storing the converted value(s) anywhere, though, `optparse` passes it to your callback function.

nargs

also has its usual meaning: if it is supplied and > 1 , `optparse` will consume `nargs` arguments, each of which must be convertible to `type`. It then passes a tuple of converted values to your callback.

callback_args

a tuple of extra positional arguments to pass to the callback

callback_kwargs

a dictionary of extra keyword arguments to pass to the callback

How callbacks are called

All callbacks are called as follows:

```
func(option, opt_str, value, parser, *args, **kwargs)
```

where

option

is the `Option` instance that's calling the callback

opt_str

is the option string seen on the command-line that's triggering the callback. (If an abbreviated long option was used, `opt_str` will be the full, canonical option string--e.g. if the user puts `--foo` on the command-line as an abbreviation for `--foobar`, then `opt_str` will be `"--foobar"`.)

value

is the argument to this option seen on the command-line. `optparse` will only expect an argument if `type` is set; the type of `value` will be the type implied by the option's type. If `type` for this option is `None` (no argument expected), then `value` will be `None`. If `nargs` > 1 , `value` will be a tuple of values of the appropriate type.

parser

is the `OptionParser` instance driving the whole thing, mainly useful because you can access some other interesting data through its instance attributes:

parser.largs

the current list of leftover arguments, ie. arguments that have been consumed but are neither options nor option arguments. Feel free to modify `parser.largs`, e.g. by adding more arguments to it. (This list will become `args`, the second return value of `parse_args()`.)

parser.rargs

the current list of remaining arguments, ie. with `opt_str` and `value` (if applicable) removed, and only the arguments following them still there. Feel free to modify `parser.rargs`, e.g. by consuming more arguments.

parser.values

the object where option values are by default stored (an instance of `optparse.OptionValues`). This lets callbacks use the same mechanism as the rest of `optparse` for storing option values; you don't need to mess around with globals or closures. You can also access or modify the value(s) of any options already encountered on the command-line.

args

is a tuple of arbitrary positional arguments supplied via the `callback_args` option attribute.

kwargs

is a dictionary of arbitrary keyword arguments supplied via `callback_kwargs`.

Raising errors in a callback

The callback function should raise `OptionValueError` if there are any problems with the option or its argument(s). `optparse` catches this and terminates the program, printing the error message you supply to stderr. Your message should be clear, concise, accurate, and mention the option at fault. Otherwise, the user will have a hard time figuring out what they did wrong.

Callback example 1: trivial callback

Here's an example of a callback option that takes no arguments, and simply records that the option was seen:

```
def record_foo_seen(option, opt_str, value, parser):
    parser.values.saw_foo = True

parser.add_option("--foo", action="callback", callback=record_foo_seen)
```

Of course, you could do that with the "store_true" action.

Callback example 2: check option order

Here's a slightly more interesting example: record the fact that `-a` is seen, but blow up if it comes after `-b` in the command-line.

```
def check_order(option, opt_str, value, parser):
    if parser.values.b:
        raise OptionValueError("can't use -a after -b")
    parser.values.a = 1
...
parser.add_option("-a", action="callback", callback=check_order)
parser.add_option("-b", action="store_true", dest="b")
```

Callback example 3: check option order (generalized)

If you want to re-use this callback for several similar options (set a flag, but blow up if `-b` has already been seen), it needs a bit of work: the error message and the flag that it sets must be generalized.

```
def check_order(option, opt_str, value, parser):
    if parser.values.b:
        raise OptionValueError("can't use %s after -b" % opt_str)
    setattr(parser.values, option.dest, 1)
...
parser.add_option("-a", action="callback", callback=check_order, dest='a')
parser.add_option("-b", action="store_true", dest="b")
parser.add_option("-c", action="callback", callback=check_order, dest='c')
```

Callback example 4: check arbitrary condition

Of course, you could put any condition in there---you're not limited to checking the values of already-defined options. For example, if you have options that should not be called when the moon is full, all you have to do is this:

```
def check_moon(option, opt_str, value, parser):
    if is_moon_full():
        raise OptionValueError("%s option invalid when moon is full"
                                % opt_str)
    setattr(parser.values, option.dest, 1)
...
```

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```
parser.add_option("--foo",
                  action="callback", callback=check_moon, dest="foo")
```

(The definition of `is_moon_full()` is left as an exercise for the reader.)

Callback example 5: fixed arguments

Things get slightly more interesting when you define callback options that take a fixed number of arguments. Specifying that a callback option takes arguments is similar to defining a "store" or "append" option: if you define `type`, then the option takes one argument that must be convertible to that type; if you further define `nargs`, then the option takes `nargs` arguments.

Here's an example that just emulates the standard "store" action:

```
def store_value(option, opt_str, value, parser):
    setattr(parser.values, option.dest, value)
...
parser.add_option("--foo",
                  action="callback", callback=store_value,
                  type="int", nargs=3, dest="foo")
```

Note that `optparse` takes care of consuming 3 arguments and converting them to integers for you; all you have to do is store them. (Or whatever; obviously you don't need a callback for this example.)

Callback example 6: variable arguments

Things get hairy when you want an option to take a variable number of arguments. For this case, you must write a callback, as `optparse` doesn't provide any built-in capabilities for it. And you have to deal with certain intricacies of conventional Unix command-line parsing that `optparse` normally handles for you. In particular, callbacks should implement the conventional rules for bare `--` and `-` arguments:

- either `--` or `-` can be option arguments
- bare `--` (if not the argument to some option): halt command-line processing and discard the `--`
- bare `-` (if not the argument to some option): halt command-line processing but keep the `-` (append it to `parser.largs`)

If you want an option that takes a variable number of arguments, there are several subtle, tricky issues to worry about. The exact implementation you choose will be based on which trade-offs you're willing to make for your application (which is why `optparse` doesn't support this sort of thing directly).

Nevertheless, here's a stab at a callback for an option with variable arguments:

```
def vararg_callback(option, opt_str, value, parser):
    assert value is None
    value = []

    def floatable(str):
        try:
            float(str)
            return True
        except ValueError:
            return False

    for arg in parser.rargs:
        # stop on --foo like options
        if arg[:2] == "--" and len(arg) > 2:
            break
        # stop on -a, but not on -3 or -3.0
```

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```

    if arg[:1] == "-" and len(arg) > 1 and not floatable(arg):
        break
    value.append(arg)

    del parser.rargs[:len(value)]
    setattr(parser.values, option.dest, value)

...
parser.add_option("-c", "--callback", dest="vararg_attr",
                  action="callback", callback=vararg_callback)

```

36.15.5 Extending `optparse`

Since the two major controlling factors in how `optparse` interprets command-line options are the action and type of each option, the most likely direction of extension is to add new actions and new types.

Adding new types

To add new types, you need to define your own subclass of `optparse`'s `Option` class. This class has a couple of attributes that define `optparse`'s types: `TYPES` and `TYPE_CHECKER`.

`Option.TYPES`

A tuple of type names; in your subclass, simply define a new tuple `TYPES` that builds on the standard one.

`Option.TYPE_CHECKER`

A dictionary mapping type names to type-checking functions. A type-checking function has the following signature:

```
def check_mytype(option, opt, value)
```

where `option` is an `Option` instance, `opt` is an option string (e.g., `-f`), and `value` is the string from the command line that must be checked and converted to your desired type. `check_mytype()` should return an object of the hypothetical type `mytype`. The value returned by a type-checking function will wind up in the `OptionValues` instance returned by `OptionParser.parse_args()`, or be passed to a callback as the `value` parameter.

Your type-checking function should raise `OptionValueError` if it encounters any problems. `OptionValueError` takes a single string argument, which is passed as-is to `OptionParser.error()` method, which in turn prepends the program name and the string `"error: "` and prints everything to `stderr` before terminating the process.

Here's a silly example that demonstrates adding a `"complex"` option type to parse Python-style complex numbers on the command line. (This is even sillier than it used to be, because `optparse` 1.3 added built-in support for complex numbers, but never mind.)

First, the necessary imports:

```

from copy import copy
from optparse import Option, OptionValueError

```

You need to define your type-checker first, since it's referred to later (in the `TYPE_CHECKER` class attribute of your `Option` subclass):

```

def check_complex(option, opt, value):
    try:
        return complex(value)
    except ValueError:
        raise OptionValueError(
            "option %s: invalid complex value: %r" % (opt, value))

```

Finally, the Option subclass:

```
class MyOption (Option):
    TYPES = Option.TYPES + ("complex",)
    TYPE_CHECKER = copy(Option.TYPE_CHECKER)
    TYPE_CHECKER["complex"] = check_complex
```

(If we didn't make a `copy()` of `Option.TYPE_CHECKER`, we would end up modifying the `TYPE_CHECKER` attribute of `optparse`'s Option class. This being Python, nothing stops you from doing that except good manners and common sense.)

That's it! Now you can write a script that uses the new option type just like any other `optparse`-based script, except you have to instruct your OptionParser to use MyOption instead of Option:

```
parser = OptionParser(option_class=MyOption)
parser.add_option("-c", type="complex")
```

Alternately, you can build your own option list and pass it to OptionParser; if you don't use `add_option()` in the above way, you don't need to tell OptionParser which option class to use:

```
option_list = [MyOption("-c", action="store", type="complex", dest="c")]
parser = OptionParser(option_list=option_list)
```

Adding new actions

Adding new actions is a bit trickier, because you have to understand that `optparse` has a couple of classifications for actions:

"store" actions

actions that result in `optparse` storing a value to an attribute of the current OptionValues instance; these options require a `dest` attribute to be supplied to the Option constructor.

"typed" actions

actions that take a value from the command line and expect it to be of a certain type; or rather, a string that can be converted to a certain type. These options require a `type` attribute to the Option constructor.

These are overlapping sets: some default "store" actions are "store", "store_const", "append", and "count", while the default "typed" actions are "store", "append", and "callback".

When you add an action, you need to categorize it by listing it in at least one of the following class attributes of Option (all are lists of strings):

Option.ACTIONS

All actions must be listed in ACTIONS.

Option.STORE_ACTIONS

"store" actions are additionally listed here.

Option.TYPED_ACTIONS

"typed" actions are additionally listed here.

Option.ALWAYS_TYPED_ACTIONS

Actions that always take a type (i.e. whose options always take a value) are additionally listed here. The only effect of this is that `optparse` assigns the default type, "string", to options with no explicit type whose action is listed in `ALWAYS_TYPED_ACTIONS`.

In order to actually implement your new action, you must override Option's `take_action()` method and add a case that recognizes your action.

For example, let's add an "extend" action. This is similar to the standard "append" action, but instead of taking a single value from the command-line and appending it to an existing list, "extend" will take multiple values in a single comma-delimited string, and extend an existing list with them. That is, if `--names` is an "extend" option of type "string", the command line

```
--names=foo,bar --names blah --names ding,dong
```

would result in a list

```
["foo", "bar", "blah", "ding", "dong"]
```

Again we define a subclass of `Option`:

```
class MyOption(Option):

    ACTIONS = Option.ACTIONS + ("extend",)
    STORE_ACTIONS = Option.STORE_ACTIONS + ("extend",)
    TYPED_ACTIONS = Option.TYPED_ACTIONS + ("extend",)
    ALWAYS_TYPED_ACTIONS = Option.ALWAYS_TYPED_ACTIONS + ("extend",)

    def take_action(self, action, dest, opt, value, values, parser):
        if action == "extend":
            lvalue = value.split(",")
            values.ensure_value(dest, []).extend(lvalue)
        else:
            Option.take_action(
                self, action, dest, opt, value, values, parser)
```

Features of note:

- "extend" both expects a value on the command-line and stores that value somewhere, so it goes in both `STORE_ACTIONS` and `TYPED_ACTIONS`.
- to ensure that `optparse` assigns the default type of "string" to "extend" actions, we put the "extend" action in `ALWAYS_TYPED_ACTIONS` as well.
- `MyOption.take_action()` implements just this one new action, and passes control back to `Option.take_action()` for the standard `optparse` actions.
- `values` is an instance of the `optparse_parser.Values` class, which provides the very useful `ensure_value()` method. `ensure_value()` is essentially `getattr()` with a safety valve; it is called as

```
values.ensure_value(attr, value)
```

If the `attr` attribute of `values` doesn't exist or is `None`, then `ensure_value()` first sets it to `value`, and then returns `value`. This is very handy for actions like "extend", "append", and "count", all of which accumulate data in a variable and expect that variable to be of a certain type (a list for the first two, an integer for the latter). Using `ensure_value()` means that scripts using your action don't have to worry about setting a default value for the option destinations in question; they can just leave the default as `None` and `ensure_value()` will take care of getting it right when it's needed.

36.15.6 Exceptions

exception `optparse.OptionError`

Raised if an `Option` instance is created with invalid or inconsistent arguments.

exception `optparse.OptionConflictError`

Raised if conflicting options are added to an `OptionParser`.

exception `optparse.OptionValueError`

Raised if an invalid option value is encountered on the command line.

exception `optparse.BadOptionError`

Raised if an invalid option is passed on the command line.

exception `optparse.AmbiguousOptionError`

Raised if an ambiguous option is passed on the command line.

36.16 ossaudiodev --- 對 OSS 相容聲音裝置的存取

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `ossaudiodev` 模組 (module) 即將被 用 (詳見 [PEP 594](#))。

This module allows you to access the OSS (Open Sound System) audio interface. OSS is available for a wide range of open-source and commercial Unices, and is the standard audio interface for Linux and recent versions of FreeBSD.

在 3.3 版的變更: Operations in this module now raise `OSError` where `IOError` was raised.

也參考:

Open Sound System Programmer's Guide

the official documentation for the OSS C API

The module defines a large number of constants supplied by the OSS device driver; see `<sys/soundcard.h>` on either Linux or FreeBSD for a listing.

`ossaudiodev` defines the following variables and functions:

exception `ossaudiodev.OSSAudioError`

This exception is raised on certain errors. The argument is a string describing what went wrong.

(If `ossaudiodev` receives an error from a system call such as `open()`, `write()`, or `ioctl()`, it raises `OSError`. Errors detected directly by `ossaudiodev` result in `OSSAudioError`.)

(For backwards compatibility, the exception class is also available as `ossaudiodev.error`.)

`ossaudiodev.open(mode)`

`ossaudiodev.open(device, mode)`

Open an audio device and return an OSS audio device object. This object supports many file-like methods, such as `read()`, `write()`, and `fileno()` (although there are subtle differences between conventional Unix read/write semantics and those of OSS audio devices). It also supports a number of audio-specific methods; see below for the complete list of methods.

device is the audio device filename to use. If it is not specified, this module first looks in the environment variable `AUDIODEV` for a device to use. If not found, it falls back to `/dev/dsp`.

mode is one of `'r'` for read-only (record) access, `'w'` for write-only (playback) access and `'rw'` for both. Since many sound cards only allow one process to have the recorder or player open at a time, it is a good idea to open the device only for the activity needed. Further, some sound cards are half-duplex: they can be opened for reading or writing, but not both at once.

Note the unusual calling syntax: the *first* argument is optional, and the second is required. This is a historical artifact for compatibility with the older `linuxaudiodev` module which `ossaudiodev` supersedes.

`ossaudiodev.openmixer([device])`

Open a mixer device and return an OSS mixer device object. *device* is the mixer device filename to use. If it is not specified, this module first looks in the environment variable `MIXERDEV` for a device to use. If not found, it falls back to `/dev/mixer`.

36.16.1 Audio Device Objects

Before you can write to or read from an audio device, you must call three methods in the correct order:

1. `setfmt()` to set the output format
2. `channels()` to set the number of channels
3. `speed()` to set the sample rate

Alternately, you can use the `setparameters()` method to set all three audio parameters at once. This is more convenient, but may not be as flexible in all cases.

The audio device objects returned by `open()` define the following methods and (read-only) attributes:

`oss_audio_device.close()`

Explicitly close the audio device. When you are done writing to or reading from an audio device, you should explicitly close it. A closed device cannot be used again.

`oss_audio_device.fileno()`

Return the file descriptor associated with the device.

`oss_audio_device.read(size)`

Read *size* bytes from the audio input and return them as a Python string. Unlike most Unix device drivers, OSS audio devices in blocking mode (the default) will block `read()` until the entire requested amount of data is available.

`oss_audio_device.write(data)`

Write a *bytes-like object* *data* to the audio device and return the number of bytes written. If the audio device is in blocking mode (the default), the entire data is always written (again, this is different from usual Unix device semantics). If the device is in non-blocking mode, some data may not be written--see `writeall()`.

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

`oss_audio_device.writeall(data)`

Write a *bytes-like object* *data* to the audio device: waits until the audio device is able to accept data, writes as much data as it will accept, and repeats until *data* has been completely written. If the device is in blocking mode (the default), this has the same effect as `write()`; `writeall()` is only useful in non-blocking mode. Has no return value, since the amount of data written is always equal to the amount of data supplied.

在 3.5 版的變更: Writable *bytes-like object* is now accepted.

在 3.2 版的變更: Audio device objects also support the context management protocol, i.e. they can be used in a `with` statement.

The following methods each map to exactly one `ioctl()` system call. The correspondence is obvious: for example, `setfmt()` corresponds to the `SNDCTL_DSP_SETFMT` `ioctl`, and `sync()` to `SNDCTL_DSP_SYNC` (this can be useful when consulting the OSS documentation). If the underlying `ioctl()` fails, they all raise `OSError`.

`oss_audio_device.nonblock()`

Put the device into non-blocking mode. Once in non-blocking mode, there is no way to return it to blocking mode.

`oss_audio_device.getfmts()`

Return a bitmask of the audio output formats supported by the soundcard. Some of the formats supported by OSS are:

格式	描述
AFMT_MU_LAW	a logarithmic encoding (used by Sun .au files and /dev/audio)
AFMT_A_LAW	a logarithmic encoding
AFMT_IMA_ADPCM	a 4:1 compressed format defined by the Interactive Multimedia Association
AFMT_U8	Unsigned, 8-bit audio
AFMT_S16_LE	Signed, 16-bit audio, little-endian byte order (as used by Intel processors)
AFMT_S16_BE	Signed, 16-bit audio, big-endian byte order (as used by 68k, PowerPC, Sparc)
AFMT_S8	Signed, 8 bit audio
AFMT_U16_LE	Unsigned, 16-bit little-endian audio
AFMT_U16_BE	Unsigned, 16-bit big-endian audio

Consult the OSS documentation for a full list of audio formats, and note that most devices support only a subset of these formats. Some older devices only support AFMT_U8; the most common format used today is AFMT_S16_LE.

`oss_audio_device.setfmt(format)`

Try to set the current audio format to *format*---see `getfmts()` for a list. Returns the audio format that the device was set to, which may not be the requested format. May also be used to return the current audio format---do this by passing an "audio format" of AFMT_QUERY.

`oss_audio_device.channels(nchannels)`

Set the number of output channels to *nchannels*. A value of 1 indicates monophonic sound, 2 stereophonic. Some devices may have more than 2 channels, and some high-end devices may not support mono. Returns the number of channels the device was set to.

`oss_audio_device.speed(samplerate)`

Try to set the audio sampling rate to *samplerate* samples per second. Returns the rate actually set. Most sound devices don't support arbitrary sampling rates. Common rates are:

Rate	描述
8000	default rate for /dev/audio
11025	speech recording
22050	
44100	CD quality audio (at 16 bits/sample and 2 channels)
96000	DVD quality audio (at 24 bits/sample)

`oss_audio_device.sync()`

Wait until the sound device has played every byte in its buffer. (This happens implicitly when the device is closed.) The OSS documentation recommends closing and re-opening the device rather than using `sync()`.

`oss_audio_device.reset()`

Immediately stop playing or recording and return the device to a state where it can accept commands. The OSS documentation recommends closing and re-opening the device after calling `reset()`.

`oss_audio_device.post()`

Tell the driver that there is likely to be a pause in the output, making it possible for the device to handle the pause more intelligently. You might use this after playing a spot sound effect, before waiting for user input, or before doing disk I/O.

The following convenience methods combine several ioctls, or one ioctl and some simple calculations.

`oss_audio_device.setparameters(format, nchannels, samplerate[, strict=False])`

Set the key audio sampling parameters---sample format, number of channels, and sampling rate---in one method call. *format*, *nchannels*, and *samplerate* should be as specified in the `setfmt()`, `channels()`, and `speed()` methods. If *strict* is true, `setparameters()` checks to see if each parameter was actually

set to the requested value, and raises `OSSAudioError` if not. Returns a tuple (*format*, *nchannels*, *samplerate*) indicating the parameter values that were actually set by the device driver (i.e., the same as the return values of `setfmt()`, `channels()`, and `speed()`).

舉例來：

```
(fmt, channels, rate) = dsp.setparameters(fmt, channels, rate)
```

等價於：

```
fmt = dsp.setfmt(fmt)
channels = dsp.channels(channels)
rate = dsp.rate(rate)
```

`oss_audio_device.bufsize()`

Returns the size of the hardware buffer, in samples.

`oss_audio_device.obufcount()`

Returns the number of samples that are in the hardware buffer yet to be played.

`oss_audio_device.obuffree()`

Returns the number of samples that could be queued into the hardware buffer to be played without blocking.

Audio device objects also support several read-only attributes:

`oss_audio_device.closed`

Boolean indicating whether the device has been closed.

`oss_audio_device.name`

String containing the name of the device file.

`oss_audio_device.mode`

The I/O mode for the file, either "r", "rw", or "w".

36.16.2 Mixer Device Objects

The mixer object provides two file-like methods:

`oss_mixer_device.close()`

This method closes the open mixer device file. Any further attempts to use the mixer after this file is closed will raise an `OSError`.

`oss_mixer_device.fileno()`

Returns the file handle number of the open mixer device file.

在 3.2 版的變更: Mixer objects also support the context management protocol.

The remaining methods are specific to audio mixing:

`oss_mixer_device.controls()`

This method returns a bitmask specifying the available mixer controls ("Control" being a specific mixable "channel", such as `SOUND_MIXER_PCM` or `SOUND_MIXER_SYNTH`). This bitmask indicates a subset of all available mixer controls---the `SOUND_MIXER_*` constants defined at module level. To determine if, for example, the current mixer object supports a PCM mixer, use the following Python code:

```
mixer=ossaudiodev.openmixer()
if mixer.controls() & (1 << ossaudiodev.SOUND_MIXER_PCM):
    # PCM is supported
    ... code ...
```

For most purposes, the `SOUND_MIXER_VOLUME` (master volume) and `SOUND_MIXER_PCM` controls should suffice---but code that uses the mixer should be flexible when it comes to choosing mixer controls. On the Gravis Ultrasound, for example, `SOUND_MIXER_VOLUME` does not exist.

```
oss_mixer_device.stereocontrols()
```

Returns a bitmask indicating stereo mixer controls. If a bit is set, the corresponding control is stereo; if it is unset, the control is either monophonic or not supported by the mixer (use in combination with `controls()` to determine which).

See the code example for the `controls()` function for an example of getting data from a bitmask.

```
oss_mixer_device.recontrols()
```

Returns a bitmask specifying the mixer controls that may be used to record. See the code example for `controls()` for an example of reading from a bitmask.

```
oss_mixer_device.get(control)
```

Returns the volume of a given mixer control. The returned volume is a 2-tuple (`left_volume`, `right_volume`). Volumes are specified as numbers from 0 (silent) to 100 (full volume). If the control is monophonic, a 2-tuple is still returned, but both volumes are the same.

Raises `OSSAudioError` if an invalid control is specified, or `OSError` if an unsupported control is specified.

```
oss_mixer_device.set(control, (left, right))
```

Sets the volume for a given mixer control to (`left`, `right`). `left` and `right` must be ints and between 0 (silent) and 100 (full volume). On success, the new volume is returned as a 2-tuple. Note that this may not be exactly the same as the volume specified, because of the limited resolution of some soundcard's mixers.

Raises `OSSAudioError` if an invalid mixer control was specified, or if the specified volumes were out-of-range.

```
oss_mixer_device.get_recsrc()
```

This method returns a bitmask indicating which control(s) are currently being used as a recording source.

```
oss_mixer_device.set_recsrc(bitmask)
```

Call this function to specify a recording source. Returns a bitmask indicating the new recording source (or sources) if successful; raises `OSError` if an invalid source was specified. To set the current recording source to the microphone input:

```
mixer.setrecsrc (1 << ossaudiodev.SOUND_MIXER_MIC)
```

36.17 pipes --- shell pipelines 介面

原始碼: [Lib/pipes.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `pipes` 模組 (module) 即將被廢用 (詳見 [PEP 594](#))。請改用 `subprocess`。

The `pipes` module defines a class to abstract the concept of a *pipeline* --- a sequence of converters from one file to another.

Because the module uses `/bin/sh` command lines, a POSIX or compatible shell for `os.system()` and `os.popen()` is required.

適用: Unix, 非 VxWorks。

The `pipes` module defines the following class:

```
class pipes.Template
```

An abstraction of a pipeline.

範例:

```
>>> import pipes
>>> t = pipes.Template()
>>> t.append('tr a-z A-Z', '--')
>>> f = t.open('pipefile', 'w')
>>> f.write('hello world')
>>> f.close()
>>> open('pipefile').read()
'HELLO WORLD'
```

36.17.1 Template Objects

Template objects following methods:

`Template.reset()`

Restore a pipeline template to its initial state.

`Template.clone()`

Return a new, equivalent, pipeline template.

`Template.debug(flag)`

If *flag* is true, turn debugging on. Otherwise, turn debugging off. When debugging is on, commands to be executed are printed, and the shell is given `set -x` command to be more verbose.

`Template.append(cmd, kind)`

Append a new action at the end. The *cmd* variable must be a valid bourne shell command. The *kind* variable consists of two letters.

The first letter can be either of '-' (which means the command reads its standard input), 'f' (which means the commands reads a given file on the command line) or '.' (which means the commands reads no input, and hence must be first.)

Similarly, the second letter can be either of '-' (which means the command writes to standard output), 'f' (which means the command writes a file on the command line) or '.' (which means the command does not write anything, and hence must be last.)

`Template.prepend(cmd, kind)`

Add a new action at the beginning. See [append\(\)](#) for explanations of the arguments.

`Template.open(file, mode)`

Return a file-like object, open to *file*, but read from or written to by the pipeline. Note that only one of 'r', 'w' may be given.

`Template.copy(infile, outfile)`

Copy *infile* to *outfile* through the pipe.

36.18 smtpd --- SMTP 伺服器

原始碼: [Lib/smtpd.py](#)

This module offers several classes to implement SMTP (email) servers.

自從版本 3.6 後不推薦使用，將會自版本 3.12 中移除。: `smtpd` 已被 用 (詳見 [PEP 594](#))。基於 `asyncio` 且提供了更簡單易用 API 的 `aioSMTP` 套件是個推薦的替代模組 (module)。

Several server implementations are present; one is a generic do-nothing implementation, which can be overridden, while the other two offer specific mail-sending strategies.

Additionally the SMTPChannel may be extended to implement very specific interaction behaviour with SMTP clients.

The code supports [RFC 5321](#), plus the [RFC 1870](#) SIZE and [RFC 6531](#) SMTPUTF8 extensions.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

36.18.1 SMTPServer 物件

```
class smtpd.SMTPServer(localaddr, remoteaddr, data_size_limit=33554432, map=None,  
                      enable_SMTPUTF8=False, decode_data=False)
```

Create a new `SMTPServer` object, which binds to local address `localaddr`. It will treat `remoteaddr` as an upstream SMTP relayer. Both `localaddr` and `remoteaddr` should be a *(host, port)* tuple. The object inherits from `asyncore.dispatcher`, and so will insert itself into `asyncore`'s event loop on instantiation.

`data_size_limit` specifies the maximum number of bytes that will be accepted in a DATA command. A value of None or 0 means no limit.

`map` is the socket map to use for connections (an initially empty dictionary is a suitable value). If not specified the `asyncore` global socket map is used.

`enable_SMTPUTF8` determines whether the SMTPUTF8 extension (as defined in [RFC 6531](#)) should be enabled. The default is False. When True, SMTPUTF8 is accepted as a parameter to the MAIL command and when present is passed to `process_message()` in the `kwargs['mail_options']` list. `decode_data` and `enable_SMTPUTF8` cannot be set to True at the same time.

`decode_data` specifies whether the data portion of the SMTP transaction should be decoded using UTF-8. When `decode_data` is False (the default), the server advertises the 8BITMIME extension ([RFC 6152](#)), accepts the BODY=8BITMIME parameter to the MAIL command, and when present passes it to `process_message()` in the `kwargs['mail_options']` list. `decode_data` and `enable_SMTPUTF8` cannot be set to True at the same time.

```
process_message(peer, mailfrom, rcpttos, data, **kwargs)
```

Raise a `NotImplementedError` exception. Override this in subclasses to do something useful with this message. Whatever was passed in the constructor as `remoteaddr` will be available as the `_remoteaddr` attribute. `peer` is the remote host's address, `mailfrom` is the envelope originator, `rcpttos` are the envelope recipients and `data` is a string containing the contents of the e-mail (which should be in [RFC 5321](#) format).

If the `decode_data` constructor keyword is set to True, the `data` argument will be a unicode string. If it is set to False, it will be a bytes object.

`kwargs` is a dictionary containing additional information. It is empty if `decode_data=True` was given as an init argument, otherwise it contains the following keys:

mail_options:

a list of all received parameters to the MAIL command (the elements are uppercase strings; example: `['BODY=8BITMIME', 'SMTPUTF8']`).

rcpt_options:

same as `mail_options` but for the RCPT command. Currently no RCPT TO options are supported, so for now this will always be an empty list.

Implementations of `process_message` should use the `**kwargs` signature to accept arbitrary keyword arguments, since future feature enhancements may add keys to the `kwargs` dictionary.

Return None to request a normal 250 Ok response; otherwise return the desired response string in [RFC 5321](#) format.

channel_class

Override this in subclasses to use a custom `SMTPChannel` for managing SMTP clients.

在 3.4 版新加入: The *map* constructor argument.

在 3.5 版的變更: *localaddr* and *remoteaddr* may now contain IPv6 addresses.

在 3.5 版新加入: The *decode_data* and *enable_SMTPUTF8* constructor parameters, and the *kwargs* parameter to *process_message()* when *decode_data* is *False*.

在 3.6 版的變更: *decode_data* is now *False* by default.

36.18.2 DebuggingServer 物件

class smtpd.DebuggingServer(*localaddr*, *remoteaddr*)

Create a new debugging server. Arguments are as per *SMTPServer*. Messages will be discarded, and printed on stdout.

36.18.3 PureProxy 物件

class smtpd.PureProxy(*localaddr*, *remoteaddr*)

Create a new pure proxy server. Arguments are as per *SMTPServer*. Everything will be relayed to *remoteaddr*. Note that running this has a good chance to make you into an open relay, so please be careful.

36.18.4 SMTPChannel 物件

class smtpd.SMTPChannel(*server*, *conn*, *addr*, *data_size_limit*=33554432, *map*=None, *enable_SMTPUTF8*=False, *decode_data*=False)

Create a new *SMTPChannel* object which manages the communication between the server and a single SMTP client.

conn and *addr* are as per the instance variables described below.

data_size_limit specifies the maximum number of bytes that will be accepted in a DATA command. A value of None or 0 means no limit.

enable_SMTPUTF8 determines whether the SMTPUTF8 extension (as defined in [RFC 6531](#)) should be enabled. The default is *False*. *decode_data* and *enable_SMTPUTF8* cannot be set to *True* at the same time.

A dictionary can be specified in *map* to avoid using a global socket map.

decode_data specifies whether the data portion of the SMTP transaction should be decoded using UTF-8. The default is *False*. *decode_data* and *enable_SMTPUTF8* cannot be set to *True* at the same time.

To use a custom SMTPChannel implementation you need to override the *SMTPServer.channel_class* of your *SMTPServer*.

在 3.5 版的變更: 新增 *decode_data* 與 *enable_SMTPUTF8* 參數。

在 3.6 版的變更: *decode_data* is now *False* by default.

The *SMTPChannel* has the following instance variables:

smtp_server

Holds the *SMTPServer* that spawned this channel.

conn

Holds the socket object connecting to the client.

addr

Holds the address of the client, the second value returned by *socket.accept*

received_lines

Holds a list of the line strings (decoded using UTF-8) received from the client. The lines have their `"\r\n"` line ending translated to `"\n"`.

smtp_state

Holds the current state of the channel. This will be either `COMMAND` initially and then `DATA` after the client sends a "DATA" line.

seen_greeting

Holds a string containing the greeting sent by the client in its "HELO".

mailfrom

Holds a string containing the address identified in the "MAIL FROM:" line from the client.

rcpttos

Holds a list of strings containing the addresses identified in the "RCPT TO:" lines from the client.

received_data

Holds a string containing all of the data sent by the client during the `DATA` state, up to but not including the terminating `"\r\n.\r\n"`.

fqdn

Holds the fully qualified domain name of the server as returned by `socket.getfqdn()`.

peer

Holds the name of the client peer as returned by `conn.getpeername()` where `conn` is `conn`.

The `SMTPChannel` operates by invoking methods named `smtp_<command>` upon reception of a command line from the client. Built into the base `SMTPChannel` class are methods for handling the following commands (and responding to them appropriately):

指令	Action taken
HELO	Accepts the greeting from the client and stores it in <code>seen_greeting</code> . Sets server to base command mode.
EHLO	Accepts the greeting from the client and stores it in <code>seen_greeting</code> . Sets server to extended command mode.
NOOP	Takes no action.
QUIT	Closes the connection cleanly.
MAIL	Accepts the "MAIL FROM:" syntax and stores the supplied address as <code>mailfrom</code> . In extended command mode, accepts the RFC 1870 SIZE attribute and responds appropriately based on the value of <code>data_size_limit</code> .
RCP	Accepts the "RCPT TO:" syntax and stores the supplied addresses in the <code>rcpttos</code> list.
RSET	Resets the <code>mailfrom</code> , <code>rcpttos</code> , and <code>received_data</code> , but not the greeting.
DAT	Sets the internal state to <code>DATA</code> and stores remaining lines from the client in <code>received_data</code> until the terminator <code>"\r\n.\r\n"</code> is received.
HELO	Returns minimal information on command syntax
VRF	Returns code 252 (the server doesn't know if the address is valid)
EXP	Reports that the command is not implemented.

36.19 sndhdr --- 判定聲音檔案的型

原始碼: [Lib/sndhdr.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `sndhdr` 模組 (module) 即將被用 (詳情與替代方案請見 [PEP 594](#))。

`sndhdr` 提供了企圖猜測檔案中聲音資料型的工具函式。當這些函式可以推測出儲存在檔案中聲音資料的型，它們分回傳一個 `collections.namedtuple()`，包含了五種屬性: (`filetype`、`framerate`、`nchannels`、`nframes`、`sampwidth`)。這些 `type` 的值表示資料的型，會是以下字串之一: `'aifc'`、`'aiff'`、`'au'`、`'hcom'`、`'sndr'`、`'sndt'`、`'voc'`、`'wav'`、`'8svx'`、`'sb'`、`'ub'` 或 `'ul'`。`sampling_rate` (取樣頻率) 可能是實際值、或者當未知或者難以解碼時 0。同樣的，`channels` (影像通道數) 也會回傳實際值或者在無法推測或難以解碼時回傳 0。`frames` (幀數) 則是實際值或 -1。`tuple` 的最後一項，`bits_per_sample` 位元表示的取樣大小，或者在 A-LAW 時 'A'，u-LAW 時 'U'。

`sndhdr.what(filename)`

使用 `whathdr()` 推測儲存在 `filename` 檔案中聲音資料的型。如果成功，回傳上述的 `namedtuple` (附名元組)，否則回傳 `None`。

在 3.5 版的變更: 結果從 `tuple` 改 `namedtuple`。

`sndhdr.whathdr(filename)`

根據檔案標頭 (header) 推測儲存在檔案中的聲音資料型。檔名由 `filename` 給定。這個函式在成功時回傳上述 `namedtuple`，或在失敗時回傳 `None`。

在 3.5 版的變更: 結果從 `tuple` 改 `namedtuple`。

The following sound header types are recognized, as listed below with the return value from `whathdr()`: and `what()`:

Value	Sound header format
'aifc'	Compressed Audio Interchange Files
'aiff'	Audio Interchange Files
'au'	Au 檔案
'hcom'	HCOM 檔案
'sndt'	Sndtool Sound Files
'voc'	Creative Labs Audio Files
'wav'	Waveform Audio File Format Files
'8svx'	8-Bit Sampled Voice Files
'sb'	Signed Byte Audio Data Files
'ub'	UB 檔案
'ul'	uLAW 音檔

`sndhdr.tests`

A list of functions performing the individual tests. Each function takes two arguments: the byte-stream and an open file-like object. When `what()` is called with a byte-stream, the file-like object will be `None`.

The test function should return a string describing the image type if the test succeeded, or `None` if it failed.

範例:

```
>>> import sndhdr
>>> imghdr.what('bass.wav')
'wav'
>>> imghdr.whathdr('bass.wav')
'wav'
```

36.20 spwd --- shadow 密碼資料庫

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `spwd` 模組 (module) 即將被廢用（詳情與替代方案請見 [PEP 594](#)）。

This module provides access to the Unix shadow password database. It is available on various Unix versions.

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

You must have enough privileges to access the shadow password database (this usually means you have to be root).

Shadow password database entries are reported as a tuple-like object, whose attributes correspond to the members of the `spwd` structure (Attribute field below, see `<shadow.h>`):

Index	屬性	Meaning
0	<code>sp_namp</code>	Login name
1	<code>sp_pwdp</code>	Encrypted password
2	<code>sp_lstchg</code>	Date of last change
3	<code>sp_min</code>	Minimal number of days between changes
4	<code>sp_max</code>	Maximum number of days between changes
5	<code>sp_warn</code>	Number of days before password expires to warn user about it
6	<code>sp_inact</code>	Number of days after password expires until account is disabled
7	<code>sp_expire</code>	Number of days since 1970-01-01 when account expires
8	<code>sp_flag</code>	Reserved

The `sp_namp` and `sp_pwdp` items are strings, all others are integers. `KeyError` is raised if the entry asked for cannot be found.

The following functions are defined:

`spwd.getspnam(name)`

Return the shadow password database entry for the given user name.

在 3.6 版的變更: Raises a `PermissionError` instead of `KeyError` if the user doesn't have privileges.

`spwd.getspall()`

Return a list of all available shadow password database entries, in arbitrary order.

也參考:

[grp](#) 模組

An interface to the group database, similar to this.

[pwd](#) 模組

An interface to the normal password database, similar to this.

36.21 sunau --- 讀寫 Sun AU 檔案

原始碼: [Lib/sunau.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `sunau` 模組 (module) 即將被 用 (詳見 [PEP 594](#))。

`sunau` 模組 (module) 提供了一個處理 Sun AU 聲音格式的便利介面。請注意此模組與 `aifc` 和 `wave` 的介面是相容的。

音訊檔案由標頭 (header) 和資料組成。標頭包含以下欄位：

欄位	容
magic word	四個位元組 <code>.snd</code> 。
header size	標頭的大小，包括資訊，以位元組 單位。
data size	資料的物理大小，以位元組 單位。
encoding	表示音訊取樣的編碼方式。
sample rate	取樣頻率。
# of channels	取樣中的聲道數。
info	音訊檔案描述的 ASCII 字串（會以空位元組填補 (pad)）。

除了 `info` 欄位以外，所有其他標頭中欄位的大小都是 4 位元組，他們都是以 `big-endian` 位元組順序所編碼的 32-bit (位元) unsigned integers (無符號整數)

`sunau` 模組定義了以下函式：

`sunau.open(file, mode)`

如 `file` 是一個字串，則以此名開 檔案，否則把它當作一個可以被搜尋的 file-like object (類檔案物件)。`mode` 可以是以下任一

`'r'`

唯讀模式。

`'w'`

唯寫模式。

請注意這 不允許讀/寫檔案。

`mode` 若設 `'r'` 則會回傳一個 `AU_read` 物件，若設 `'w'` 或 `'wb'` 則回傳 `AU_write` 物件。

`sunau` 模組定義了以下例外：

exception `sunau.Error`

在不符合 Sun AU 規格或實作上有所不足而無法達成某些目的時會引發的錯誤。

`sunau` 模組定義了以下資料條目：

`sunau.AUDIO_FILE_MAGIC`

每個 Sun AU 檔案都會作 開頭的一個整數，以 `big-endian` 形式儲存。這也是 `.snd` 所直接轉譯成一個整數的字串。

`sunau.AUDIO_FILE_ENCODING_MULAW_8`

`sunau.AUDIO_FILE_ENCODING_LINEAR_8`

`sunau.AUDIO_FILE_ENCODING_LINEAR_16`

`sunau.AUDIO_FILE_ENCODING_LINEAR_24`

`sunau.AUDIO_FILE_ENCODING_LINEAR_32`

`sunau.AUDIO_FILE_ENCODING_ALAW_8`

此模組有支援的 AU 標頭中 encoding 欄位值。

`sunau.AUDIO_FILE_ENCODING_FLOAT`

`sunau.AUDIO_FILE_ENCODING_DOUBLE`

`sunau.AUDIO_FILE_ENCODING_ADPCM_G721`

`sunau.AUDIO_FILE_ENCODING_ADPCM_G722`

`sunau.AUDIO_FILE_ENCODING_ADPCM_G723_3`

`sunau.AUDIO_FILE_ENCODING_ADPCM_G723_5`

額外已知的 AU 標頭中 encoding 欄位值，但不被此模組支援。

36.21.1 AU_read 物件

如上述 `open()` 所回傳的 `AU_read` 物件擁有以下 method (方法)：

`AU_read.close()`

關閉串流 (stream)，使該實例無法被使用。(這會自動在除時呼叫。)

`AU_read.getnchannels()`

回傳音訊聲道數量 (單聲道 1，雙聲道 2)。

`AU_read.getsampwidth()`

回傳取樣位元組長度。

`AU_read.getframerate()`

回傳取樣頻率。

`AU_read.getnframes()`

回傳音訊總幀數。

`AU_read.getcomptype()`

回傳壓縮種類。支援的壓縮種類有 'ULAW'、'ALAW' 和 'NONE'。

`AU_read.getcompname()`

可被人類讀懂 (human-readable) 的 `getcomptype()`。有被支援的種類分有這些名稱 'CCITT G.711 u-law'、'CCITT G.711 A-law' 和 'not compressed'。

`AU_read.getparams()`

回傳一個 `namedtuple()` (`nchannels`, `sampwidth`, `framerate`, `nframes`, `comptype`, `compname`)，與 `get*()` methods 的輸出相同。

`AU_read.readframes(n)`

讀取以 `bytes` 物件形式回傳音檔中至多 `n` 幀，資料會以 `linear format` 回傳，如果原始資料是 `u-LAW` 格式，則它會被轉。

`AU_read.rewind()`

重置檔案指標 (file pointer) 至音訊開頭。

以下兩個 methods 都定義了在它們之間相容的 "position"，否則會與實作相依。

`AU_read.setpos(pos)`

設定檔案指標至指定的位置，只有 `tell()` 的回傳值應被做 `pos` 使用。

`AU_read.tell()`

回傳當前檔案指標位置，要注意回傳值和真實檔案中的位置無關。

以下兩個函式單純是了和 `aifc` 相容而定義，有做什麼特別的。

`AU_read.getmarkers()`

回傳 `None`。

`AU_read.getmark(id)`
引發錯誤。

36.21.2 AU_write 物件

如上述 `open()` 所回傳的 `AU_write` 物件擁有以下 methods:

`AU_write.setnchannels(n)`
設定聲道數。

`AU_write.setsampwidth(n)`
設定取樣寬度 (以位元組單位)。

在 3.4 版的變更: 新增對於 24-bit 取樣的支援。

`AU_write.setframerate(n)`
設定影格率 (frame rate)。

`AU_write.setnframes(n)`
設定幀數, 該值可以在寫入更多幀後修改。

`AU_write.setcomptype(type, name)`
設定壓縮種類和描述, 輸出只支援 'NONE' 和 'ULAW'。

`AU_write.setparams(tuple)`
tuple 應 (nchannels, sampwidth, framerate, nframes, comptype, compname) 形式, 各個值應該要是 `set*()` methods 能有效接受的值。該函數會一次設定所有參數。

`AU_write.tell()`
回傳當前檔案中的位置, 帶有和 `AU_read.tell()` 與 `AU_read.setpos()` 方法相同的免責聲明 (disclaimer)。

`AU_write.writeframesraw(data)`
寫入音訊資料但不更新 *nframes*。
在 3.4 版的變更: 現在可接受任意 *bytes-like object*。

`AU_write.writeframes(data)`
寫入音訊資料更新 *nframes* 以確保其正確性。
在 3.4 版的變更: 現在可接受任意 *bytes-like object*。

`AU_write.close()`
確保 *nframes* 是正確的, 關閉檔案。
此 method 會在除時呼叫。

請注意, 在呼叫 `writeframes()` 或 `writeframesraw()` 後設定任何參數都是無效的。

36.22 telnetlib --- Telnet 客戶端

原始碼: [Lib/telnetlib.py](#)

自從版本 3.11 後不推薦使用, 將會自版本 3.13 中移除。: `telnetlib` 模組 (module) 即將被 (詳情與替代方案請見 [PEP 594](#))。

The `telnetlib` module provides a `Telnet` class that implements the Telnet protocol. See [RFC 854](#) for details about the protocol. In addition, it provides symbolic constants for the protocol characters (see below), and for the telnet options. The symbolic names of the telnet options follow the definitions in `arpa/telnet.h`, with the leading

TELOPT_ removed. For symbolic names of options which are traditionally not included in `arpa/telnet.h`, see the module source itself.

The symbolic constants for the telnet commands are: IAC, DONT, DO, WONT, WILL, SE (Subnegotiation End), NOP (No Operation), DM (Data Mark), BRK (Break), IP (Interrupt process), AO (Abort output), AYT (Are You There), EC (Erase Character), EL (Erase Line), GA (Go Ahead), SB (Subnegotiation Begin).

Availability: not Emscripten, not WASI.

This module does not work or is not available on WebAssembly platforms `wasm32-emscripten` and `wasm32-wasi`. See [WebAssembly 平台](#) for more information.

class `telnetlib.Telnet` (*host=None, port=0[, timeout]*)

`Telnet` represents a connection to a Telnet server. The instance is initially not connected by default; the `open()` method must be used to establish a connection. Alternatively, the host name and optional port number can be passed to the constructor too, in which case the connection to the server will be established before the constructor returns. The optional `timeout` parameter specifies a timeout in seconds for blocking operations like the connection attempt (if not specified, the global default timeout setting will be used).

Do not reopen an already connected instance.

This class has many `read_*()` methods. Note that some of them raise `EOFError` when the end of the connection is read, because they can return an empty string for other reasons. See the individual descriptions below.

A `Telnet` object is a context manager and can be used in a `with` statement. When the `with` block ends, the `close()` method is called:

```
>>> from telnetlib import Telnet
>>> with Telnet('localhost', 23) as tn:
...     tn.interact()
... 
```

在 3.6 版的變更: Context manager support added

也參考:

RFC 854 - Telnet Protocol Specification

Definition of the Telnet protocol.

36.22.1 Telnet Objects

`Telnet` instances have the following methods:

`Telnet.read_until` (*expected, timeout=None*)

Read until a given byte string, *expected*, is encountered or until *timeout* seconds have passed.

When no match is found, return whatever is available instead, possibly empty bytes. Raise `EOFError` if the connection is closed and no cooked data is available.

`Telnet.read_all` ()

Read all data until EOF as bytes; block until connection closed.

`Telnet.read_some` ()

Read at least one byte of cooked data unless EOF is hit. Return `b''` if EOF is hit. Block if no data is immediately available.

`Telnet.read_very_eager` ()

Read everything that can be without blocking in I/O (eager).

Raise `EOFError` if connection closed and no cooked data available. Return `b''` if no cooked data available otherwise. Do not block unless in the midst of an IAC sequence.

`Telnet.read_eager()`

Read readily available data.

Raise `EOFError` if connection closed and no cooked data available. Return `b''` if no cooked data available otherwise. Do not block unless in the midst of an IAC sequence.

`Telnet.read_lazy()`

Process and return data already in the queues (lazy).

Raise `EOFError` if connection closed and no data available. Return `b''` if no cooked data available otherwise. Do not block unless in the midst of an IAC sequence.

`Telnet.read_very_lazy()`

Return any data available in the cooked queue (very lazy).

Raise `EOFError` if connection closed and no data available. Return `b''` if no cooked data available otherwise. This method never blocks.

`Telnet.read_sb_data()`

Return the data collected between a SB/SE pair (suboption begin/end). The callback should access these data when it was invoked with a SE command. This method never blocks.

`Telnet.open(host, port=0[, timeout])`

Connect to a host. The optional second argument is the port number, which defaults to the standard Telnet port (23). The optional *timeout* parameter specifies a timeout in seconds for blocking operations like the connection attempt (if not specified, the global default timeout setting will be used).

Do not try to reopen an already connected instance.

引發一個附帶引數 `self`、`host`、`port` 的稽核事件 `telnetlib.Telnet.open`。

`Telnet.msg(msg, *args)`

Print a debug message when the debug level is > 0 . If extra arguments are present, they are substituted in the message using the standard string formatting operator.

`Telnet.set_debuglevel(debuglevel)`

Set the debug level. The higher the value of *debuglevel*, the more debug output you get (on `sys.stdout`).

`Telnet.close()`

Close the connection.

`Telnet.get_socket()`

Return the socket object used internally.

`Telnet.fileno()`

Return the file descriptor of the socket object used internally.

`Telnet.write(buffer)`

Write a byte string to the socket, doubling any IAC characters. This can block if the connection is blocked. May raise `OSError` if the connection is closed.

引發一個附帶引數 `self`、`buffer` 的稽核事件 `telnetlib.Telnet.write`。

在 3.3 版的變更: This method used to raise `socket.error`, which is now an alias of `OSError`.

`Telnet.interact()`

Interaction function, emulates a very dumb Telnet client.

`Telnet.mt_interact()`

Multithreaded version of `interact()`.

`Telnet.expect` (*list*, *timeout=None*)

Read until one from a list of a regular expressions matches.

The first argument is a list of regular expressions, either compiled (*regex objects*) or uncompiled (byte strings). The optional second argument is a timeout, in seconds; the default is to block indefinitely.

Return a tuple of three items: the index in the list of the first regular expression that matches; the match object returned; and the bytes read up till and including the match.

If end of file is found and no bytes were read, raise `EOFError`. Otherwise, when nothing matches, return `(-1, None, data)` where *data* is the bytes received so far (may be empty bytes if a timeout happened).

If a regular expression ends with a greedy match (such as `.*`) or if more than one expression can match the same input, the results are non-deterministic, and may depend on the I/O timing.

`Telnet.set_option_negotiation_callback` (*callback*)

Each time a telnet option is read on the input flow, this *callback* (if set) is called with the following parameters: `callback(telnet socket, command (DO/DONT/WILL/WONT), option)`. No other action is done afterwards by `telnetlib`.

36.22.2 Telnet 范例

A simple example illustrating typical use:

```
import getpass
import telnetlib

HOST = "localhost"
user = input("Enter your remote account: ")
password = getpass.getpass()

tn = telnetlib.Telnet(HOST)

tn.read_until(b"login: ")
tn.write(user.encode('ascii') + b"\n")
if password:
    tn.read_until(b"Password: ")
    tn.write(password.encode('ascii') + b"\n")

tn.write(b"ls\n")
tn.write(b"exit\n")

print(tn.read_all().decode('ascii'))
```

36.23 xdrlib --- uuencode 檔案的編碼與解碼

原始碼: `Lib/uu.py`

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `uu` 模組 (module) 即將被 `base64` 取代 (詳見 [PEP 594](#))。 `base64` 是個現時常用的替代方案。

This module encodes and decodes files in uuencode format, allowing arbitrary binary data to be transferred over ASCII-only connections. Wherever a file argument is expected, the methods accept a file-like object. For backwards compatibility, a string containing a pathname is also accepted, and the corresponding file will be opened for reading and writing; the pathname `'-'` is understood to mean the standard input or output. However, this interface is deprecated; it's better for the caller to open the file itself, and be sure that, when required, the mode is `'rb'` or `'wb'` on Windows.

This code was contributed by Lance Ellinghouse, and modified by Jack Jansen.

The `uu` module defines the following functions:

`uu.encode(in_file, out_file, name=None, mode=None, *, backtick=False)`

Uuencode file `in_file` into file `out_file`. The uuencoded file will have the header specifying `name` and `mode` as the defaults for the results of decoding the file. The default defaults are taken from `in_file`, or `'-'` and `0o666` respectively. If `backtick` is true, zeros are represented by `'\`'` instead of spaces.

在 3.7 版的變更: 新增 `backtick` 參數。

`uu.decode(in_file, out_file=None, mode=None, quiet=False)`

This call decodes uuencoded file `in_file` placing the result on file `out_file`. If `out_file` is a pathname, `mode` is used to set the permission bits if the file must be created. Defaults for `out_file` and `mode` are taken from the uuencode header. However, if the file specified in the header already exists, a `uu.Error` is raised.

`decode()` may print a warning to standard error if the input was produced by an incorrect uuencoder and Python could recover from that error. Setting `quiet` to a true value silences this warning.

exception `uu.Error`

Subclass of `Exception`, this can be raised by `uu.decode()` under various situations, such as described above, but also including a badly formatted header, or truncated input file.

也參考:

`binascii` 模組

Support module containing ASCII-to-binary and binary-to-ASCII conversions.

36.24 `xdrlib` --- XDR 資料的編碼與解碼

原始碼: [Lib/xdrlib.py](#)

自從版本 3.11 後不推薦使用，將會自版本 3.13 中移除。: `xdrlib` 模組 (module) 即將被廢用 (詳見 [PEP 594](#))。

The `xdrlib` module supports the External Data Representation Standard as described in [RFC 1014](#), written by Sun Microsystems, Inc. June 1987. It supports most of the data types described in the RFC.

The `xdrlib` module defines two classes, one for packing variables into XDR representation, and another for unpacking from XDR representation. There are also two exception classes.

class `xdrlib.Packer`

`Packer` is the class for packing data into XDR representation. The `Packer` class is instantiated with no arguments.

class `xdrlib.Unpacker` (`data`)

`Unpacker` is the complementary class which unpacks XDR data values from a string buffer. The input buffer is given as `data`.

也參考:

RFC 1014 - XDR: External Data Representation Standard

This RFC defined the encoding of data which was XDR at the time this module was originally written. It has apparently been obsoleted by [RFC 1832](#).

RFC 1832 - XDR: External Data Representation Standard

Newer RFC that provides a revised definition of XDR.

36.24.1 Packer Objects

Packer instances have the following methods:

`Packer.get_buffer()`

Returns the current pack buffer as a string.

`Packer.reset()`

Resets the pack buffer to the empty string.

In general, you can pack any of the most common XDR data types by calling the appropriate `pack_type()` method. Each method takes a single argument, the value to pack. The following simple data type packing methods are supported: `pack_uint()`, `pack_int()`, `pack_enum()`, `pack_bool()`, `pack_uhyper()`, and `pack_hyper()`.

`Packer.pack_float(value)`

Packs the single-precision floating point number *value*.

`Packer.pack_double(value)`

Packs the double-precision floating point number *value*.

The following methods support packing strings, bytes, and opaque data:

`Packer.pack_fstring(n, s)`

Packs a fixed length string, *s*. *n* is the length of the string but it is *not* packed into the data buffer. The string is padded with null bytes if necessary to guaranteed 4 byte alignment.

`Packer.pack_fopaque(n, data)`

Packs a fixed length opaque data stream, similarly to `pack_fstring()`.

`Packer.pack_string(s)`

Packs a variable length string, *s*. The length of the string is first packed as an unsigned integer, then the string data is packed with `pack_fstring()`.

`Packer.pack_opaque(data)`

Packs a variable length opaque data string, similarly to `pack_string()`.

`Packer.pack_bytes(bytes)`

Packs a variable length byte stream, similarly to `pack_string()`.

The following methods support packing arrays and lists:

`Packer.pack_list(list, pack_item)`

Packs a *list* of homogeneous items. This method is useful for lists with an indeterminate size; i.e. the size is not available until the entire list has been walked. For each item in the list, an unsigned integer 1 is packed first, followed by the data value from the list. *pack_item* is the function that is called to pack the individual item. At the end of the list, an unsigned integer 0 is packed.

For example, to pack a list of integers, the code might appear like this:

```
import xdrlib
p = xdrlib.Packer()
p.pack_list([1, 2, 3], p.pack_int)
```

`Packer.pack_farray(n, array, pack_item)`

Packs a fixed length list (*array*) of homogeneous items. *n* is the length of the list; it is *not* packed into the buffer, but a `ValueError` exception is raised if `len(array)` is not equal to *n*. As above, *pack_item* is the function used to pack each element.

`Packer.pack_array(list, pack_item)`

Packs a variable length *list* of homogeneous items. First, the length of the list is packed as an unsigned integer, then each element is packed as in `pack_farray()` above.

36.24.2 Unpacker Objects

The *Unpacker* class offers the following methods:

`Unpacker.reset(data)`

Resets the string buffer with the given *data*.

`Unpacker.get_position()`

Returns the current unpack position in the data buffer.

`Unpacker.set_position(position)`

Sets the data buffer unpack position to *position*. You should be careful about using *get_position()* and *set_position()*.

`Unpacker.get_buffer()`

Returns the current unpack data buffer as a string.

`Unpacker.done()`

Indicates unpack completion. Raises an *Error* exception if all of the data has not been unpacked.

In addition, every data type that can be packed with a *Packer*, can be unpacked with an *Unpacker*. Unpacking methods are of the form *unpack_type()*, and take no arguments. They return the unpacked object.

`Unpacker.unpack_float()`

Unpacks a single-precision floating point number.

`Unpacker.unpack_double()`

Unpacks a double-precision floating point number, similarly to *unpack_float()*.

In addition, the following methods unpack strings, bytes, and opaque data:

`Unpacker.unpack_fstring(n)`

Unpacks and returns a fixed length string. *n* is the number of characters expected. Padding with null bytes to guaranteed 4 byte alignment is assumed.

`Unpacker.unpack_fopaque(n)`

Unpacks and returns a fixed length opaque data stream, similarly to *unpack_fstring()*.

`Unpacker.unpack_string()`

Unpacks and returns a variable length string. The length of the string is first unpacked as an unsigned integer, then the string data is unpacked with *unpack_fstring()*.

`Unpacker.unpack_opaque()`

Unpacks and returns a variable length opaque data string, similarly to *unpack_string()*.

`Unpacker.unpack_bytes()`

Unpacks and returns a variable length byte stream, similarly to *unpack_string()*.

The following methods support unpacking arrays and lists:

`Unpacker.unpack_list(unpack_item)`

Unpacks and returns a list of homogeneous items. The list is unpacked one element at a time by first unpacking an unsigned integer flag. If the flag is 1, then the item is unpacked and appended to the list. A flag of 0 indicates the end of the list. *unpack_item* is the function that is called to unpack the items.

`Unpacker.unpack_farray(n, unpack_item)`

Unpacks and returns (as a list) a fixed length array of homogeneous items. *n* is number of list elements to expect in the buffer. As above, *unpack_item* is the function used to unpack each element.

`Unpacker.unpack_array(unpack_item)`

Unpacks and returns a variable length *list* of homogeneous items. First, the length of the list is unpacked as an unsigned integer, then each element is unpacked as in *unpack_farray()* above.

36.24.3 例外

Exceptions in this module are coded as class instances:

exception `xdrlib.Error`

The base exception class. *Error* has a single public attribute `msg` containing the description of the error.

exception `xdrlib.ConversionError`

Class derived from *Error*. Contains no additional instance variables.

Here is an example of how you would catch one of these exceptions:

```
import xdrlib
p = xdrlib.Packer()
try:
    p.pack_double(8.01)
except xdrlib.ConversionError as instance:
    print('packing the double failed:', instance.msg)
```

Security Considerations

The following modules have specific security considerations:

- *base64*: *base64 security considerations in RFC 4648*
- *cgi*: *CGI security considerations*
- *hashlib*: *all constructors take a "usedforsecurity" keyword-only argument disabling known insecure and blocked algorithms*
- *http.server* is not suitable for production use, only implementing basic security checks. See the *security considerations*.
- *logging*: *Logging configuration uses eval()*
- *multiprocessing*: *Connection.recv() uses pickle*
- *pickle*: *Restricting globals in pickle*
- *random* shouldn't be used for security purposes, use *secrets* instead
- *shelve*: *shelve is based on pickle and thus unsuitable for dealing with untrusted sources*
- *ssl*: *SSL/TLS security considerations*
- *subprocess*: *Subprocess security considerations*
- *tempfile*: *mktemp is deprecated due to vulnerability to race conditions*
- *xml*: *XML vulnerabilities*
- *zipfile*: *maliciously prepared .zip files can cause disk volume exhaustion*

The `-I` command line option can be used to run Python in isolated mode. When it cannot be used, the `-P` option or the `PYTHONSAFEPATH` environment variable can be used to not prepend a potentially unsafe path to `sys.path` such as the current directory, the script's directory or an empty string.

術語表

>>>

互動式 shell 的預設 Python 提示字元。常見於能在直譯器中以互動方式被執行的程式碼範例。

...

可以表示：

- 在一個被縮排的程式碼區塊、在一對匹配的左右定界符 (delimiter, 例如括號、方括號、花括號或三引號) 內部, 或是在指定一個裝飾器 (decorator) 之後, 要輸入程式碼時, 互動式 shell 顯示的預設 Python 提示字元。
- 創建常數 *Ellipsis*。

2to3

一個試著將 Python 2.x 程式碼轉成 Python 3.x 程式碼的工具, 它是透過處理大部分的不相容性來達成此目的, 而這些不相容性能透過剖析原始碼和遍歷剖析樹而被檢測出來。

2to3 在標準函式庫中以 `lib2to3` 被使用; 它提供了一個獨立的入口點, 在 `Tools/scripts/2to3`。請參閱 `2to3` --- 自動將 *Python 2* 的程式碼轉成 *Python 3*。

abstract base class (抽象基底類)

抽象基底類 (又稱 ABC) 提供了一種定義介面的方法, 作 *duck-typing* (鴨子型) 的補充。其他類似的技術, 像是 `hasattr()`, 則顯得笨拙或是帶有細微的錯誤 (例如使用魔術方法 (magic method))。ABC 用擬的 subclass (子類), 它們不繼承自另一個 class (類), 但仍可被 `isinstance()` 及 `issubclass()` 辨識; 請參閱 `abc` 模組的說明文件。Python 有許多建的 ABC, 用於資料結構 (在 `collections.abc` 模組)、數字 (在 `numbers` 模組)、串流 (在 `io` 模組) 及 import 尋檢器和載入器 (在 `importlib.abc` 模組)。你可以使用 `abc` 模組建立自己的 ABC。

annotation (註釋)

一個與變數、class 屬性、函式的參數或回傳值相關聯的標記。照慣例, 它被用來作 *type hint* (型提示)。

在執行環境 (runtime), 區域變數的註釋無法被存取, 但全域變數、class 屬性和函式的註釋, 會分被儲存在模組、class 和函式的 `__annotations__` 特殊屬性中。

請參閱 *variable annotation*、*function annotation*、**PEP 484** 和 **PEP 526**, 這些章節皆有此功能的說明。關於註釋的最佳實踐方法也請參閱 `annotations-howto`。

argument (引數)

呼叫函式時被傳遞給 *function* (或 *method*) 的值。引數有兩種：

- 關鍵字引數 (*keyword argument*): 在函式呼叫中, 以識字 (identifier, 例如 `name=`) 開頭的引數, 或是以 `**` 後面 dictionary (字典) 的值被傳遞的引數。例如, 3 和 5 都是以下 `complex()` 呼叫中的關鍵字引數:

```
complex(real=3, imag=5)
complex(**{'real': 3, 'imag': 5})
```

- 位置引數 (*positional argument*): 不是關鍵字引數的引數。位置引數可在一個引數列表的起始處出現, 和 (或) 作 `*` 之後的 *iterable* (可代物件) 中的元素被傳遞。例如, 3 和 5 都是以下呼叫中的位置引數:

```
complex(3, 5)
complex(*(3, 5))
```

引數會被指定給函式主體中的附名區域變數。關於支配這個指定過程的規則, 請參 [calls](#) 章節。在語法上, 任何運算式都可以被用來表示一個引數; 其評估值會被指定給區域變數。

另請參 [術語表](#) 的 *parameter* (參數) 條目、常見問題中的引數和參數之間的差, 以及 [PEP 362](#)。

asynchronous context manager (非同步情境管理器)

一個可以控制 `async with` 陳述式中所見環境的物件, 而它是透過定義 `__aenter__()` 和 `__aexit__()` method (方法) 來控制的。由 [PEP 492](#) 引入。

asynchronous generator (非同步生器)

一個會回傳 *asynchronous generator iterator* (非同步生器代器) 的函式。它看起來像一個以 `async def` 定義的協程函式 (coroutine function), 但不同的是它包含了 `yield` 運算式, 能生成一系列可用於 `async for` 圈的值。

這個術語通常用來表示一個非同步生器函式, 但在某些情境中, 也可能是表示非同步生器代器 (*asynchronous generator iterator*)。萬一想表達的意思不清楚, 那就使用完整的術語, 以避免歧義。

一個非同步生器函式可能包含 `await` 運算式, 以及 `async for` 和 `async with` 陳述式。

asynchronous generator iterator (非同步生器代器)

一個由 *asynchronous generator* (非同步生器) 函式所建立的物件。

這是一個 *asynchronous iterator* (非同步代器), 當它以 `__anext__()` method 被呼叫時, 會回傳一個可等待物件 (awaitable object), 該物件將執行非同步生器的函式主體, 直到遇到下一個 `yield` 運算式。

每個 `yield` 會暫停處理程序, 記住位置執行狀態 (包括區域變數及擱置中的 `try` 陳述式)。當非同步生器代器以另一個被 `__anext__()` 回傳的可等待物件有效地回復時, 它會從停止的地方繼續執行。請參 [PEP 492](#) 和 [PEP 525](#)。

asynchronous iterable (非同步可代物件)

一個物件, 它可以在 `async for` 陳述式中被使用。必須從它的 `__aiter__()` method 回傳一個 *asynchronous iterator* (非同步代器)。由 [PEP 492](#) 引入。

asynchronous iterator (非同步代器)

一個實作 `__aiter__()` 和 `__anext__()` method 的物件。`__anext__()` 必須回傳一個 *awaitable* (可等待物件)。 `async for` 會解析非同步代器的 `__anext__()` method 所回傳的可等待物件, 直到它引發 `StopAsyncIteration` 例外。由 [PEP 492](#) 引入。

attribute (屬性)

一個與某物件相關聯的值, 該值大多能透過使用點分隔運算式 (dotted expression) 的名稱被參照。例如, 如果物件 `o` 有一個屬性 `a`, 則該屬性能以 `o.a` 被參照。

如果一個物件允許, 給予該物件一個名稱不是由 `identifiers` 所定義之識符 (identifier) 的屬性是有可能的, 例如使用 `setattr()`。像這樣的屬性將無法使用點分隔運算式來存取, 而是需要使用 `getattr()` 來取得它。

awaitable (可等待物件)

一個可以在 `await` 運算式中被使用的物件。它可以是一個 *coroutine* (協程), 或是一個有 `__await__()` method 的物件。另請參 [PEP 492](#)。

BDFL

Benevolent Dictator For Life (終身仁慈獨裁者), 又名 Guido van Rossum, Python 的創造者。

binary file (二進制檔案)

A *file object* able to read and write *bytes-like objects*. Examples of binary files are files opened in binary mode ('rb', 'wb' or 'rb+'), `sys.stdin.buffer`, `sys.stdout.buffer`, and instances of `io.BytesIO` and `gzip.GzipFile`.

另請參閱 *text file* (文字檔案), 它是一個能讀取和寫入 *str* 物件的檔案物件。

borrowed reference (借用參照)

In Python's C API, a borrowed reference is a reference to an object, where the code using the object does not own the reference. It becomes a dangling pointer if the object is destroyed. For example, a garbage collection can remove the last *strong reference* to the object and so destroy it.

對 *borrowed reference* 呼叫 `Py_INCREF()` 以將它原地 (in-place) 轉為 *strong reference* 是被建議的做法, 除非該物件不能在最後一次使用借用參照之前被銷毀。 `Py_NewRef()` 函式可用於建立一個新的 *strong reference*。

bytes-like object (類位元組串物件)

一個支援 *buffer objects* 且能匯出 C-contiguous 緩衝區的物件。這包括所有的 *bytes*、*bytearray* 和 *array.array* 物件, 以及許多常見的 *memoryview* 物件。類位元組串物件可用於處理二進制資料的各種運算; 這些運算包括壓縮、儲存至二進制檔案和透過 *socket* (插座) 發送。

有些運算需要二進制資料是可變的。明文文件通常會將這些物件稱為「可讀寫的類位元組串物件」。可變緩衝區的物件包括 *bytearray*, 以及 *bytearray* 的 *memoryview*。其他的運算需要讓二進制資料被儲存在不可變物件 (「唯讀的類位元組串物件」) 中; 這些物件包括 *bytes*, 以及 *bytes* 物件的 *memoryview*。

bytecode (位元組碼)

Python 的原始碼會被編譯成位元組碼, 它是 Python 程式在 CPython 直譯器中的內部表示法。該位元組碼也會被暫存在 `.pyc` 檔案中, 以便第二次執行同一個檔案時能更快 (可以不用從原始碼重新編譯位元組碼)。這種「中間語言 (intermediate language)」據說是運行在一個 *virtual machine* (虛擬機器) 上, 該虛擬機器會執行與每個位元組碼對應的機器碼 (machine code)。要注意的是, 位元組碼理論上是無法在不同的 Python 虛擬機器之間運作的, 也不能在不同版本的 Python 之間保持穩定。

位元組碼的指令列表可以在 *dis* 模組的明文文件中找到。

callable (可呼叫物件)

一個 callable 是可以被呼叫的物件, 呼叫時可能以下列形式帶有一組引數 (請見 *argument*):

```
callable(argument1, argument2, argumentN)
```

一個 *function* 與其延伸的 *method* 都是 callable。一個有實作 `__call__()` 方法的 *class* 之實例也是個 callable。

callback (回呼)

作引數被傳遞的一個副程式 (subroutine) 函式, 會在未來的某個時間點被執行。

class (類)

一個用於建立使用者定義物件的模板。Class 的定義通常會包含 *method* 的定義, 這些 *method* 可以在 *class* 的實例上進行操作。

class variable (類變數)

一個在 *class* 中被定義, 且應該只能在 *class* 層次 (意即不是在 *class* 的實例中) 被修改的變數。

complex number (複數)

一個我們熟悉的實數系統的擴充, 在此所有數字都會被表示為一個實部和一個虛部之和。複數就是虛數單位 (-1 的平方根) 的實數倍, 此單位通常在數學中被寫為 i , 在工程學中被寫為 j 。Python 建了對複數的支援, 它是用後者的記法來表示複數; 虛部會帶著一個後綴的 j 被編寫, 例如 $3+1j$ 。若要将 *math* 模組的工具等效地用於複數, 請使用 *cmath* 模組。複數的使用是一個相當進階的數學功能。如果你有察覺到對它們的需求, 那麼幾乎能確定你可以安全地忽略它們。

context manager (情境管理器)

An object which controls the environment seen in a `with` statement by defining `__enter__()` and `__exit__()` methods. See [PEP 343](#).

context variable (情境變數)

一個變數，其值可以根據上下文的情境而有所不同。這類似執行緒區域儲存區 (Thread-Local Storage)，在其中，一個變數在每個執行緒可能具有不同的值。然而，關於情境變數，在一個執行緒中可能會有多個情境，而情境變數的主要用途，是在行的非同步任務 (concurrent asynchronous task) 中，對於變數狀態的追蹤。請參閱 [contextvars](#)。

contiguous (連續的)

如果一個緩衝區是 *C-contiguous* 或是 *Fortran contiguous*，則它會確切地被視為是連續的。零維 (zero-dimensional) 的緩衝區都是 C 及 Fortran contiguous。在一維 (one-dimensional) 陣列中，各項目必須在記憶體中彼此相鄰地排列，而其索引順序是從零開始遞增。在多維的 (multidimensional) C-contiguous 陣列中，按記憶體位址的順序訪問各個項目時，最後一個索引的變化最快。然而，在 Fortran contiguous 陣列中，第一個索引的變化最快。

coroutine (協程)

協程是副程式 (subroutine) 的一種更廣義的形式。副程式是在某個時間點被進入在另一個時間點被退出。協程可以在許多不同的時間點被進入、退出和回復。它們能以 `async def` 陳述式被實作。另請參閱 [PEP 492](#)。

coroutine function (協程函式)

一個回傳 [coroutine](#) (協程) 物件的函式。一個協程函式能以 `async def` 陳述式被定義，可能包含 `await`、`async for` 和 `async with` 關鍵字。這些關鍵字由 [PEP 492](#) 引入。

CPython

Python 程式語言的標準實作 (canonical implementation)，被發布在 [python.org](#) 上。「CPython」這個術語在必要時被使用，以區分此實作與其它語言的實作，例如 Jython 或 IronPython。

decorator (裝飾器)

一個函式，它會回傳另一個函式，通常它會使用 `@wrapper` 語法，被應用一種函式的變換 (function transformation)。裝飾器的常見範例是 `classmethod()` 和 `staticmethod()`。

裝飾器語法只是語法糖。以下兩個函式定義在語義上是等效的：

```
def f(arg):
    ...
f = staticmethod(f)

@staticmethod
def f(arg):
    ...
```

Class 也存在相同的概念，但在那比較不常用。關於裝飾器的更多內容，請參閱函式定義和 class 定義的說明文件。

descriptor (描述器)

Any object which defines the methods `__get__()`, `__set__()`, or `__delete__()`. When a class attribute is a descriptor, its special binding behavior is triggered upon attribute lookup. Normally, using `a.b` to get, set or delete an attribute looks up the object named `b` in the class dictionary for `a`, but if `b` is a descriptor, the respective descriptor method gets called. Understanding descriptors is a key to a deep understanding of Python because they are the basis for many features including functions, methods, properties, class methods, static methods, and reference to super classes.

關於描述器 method 的更多資訊，請參閱 [descriptors](#) 或描述器使用指南。

dictionary (字典)

An associative array, where arbitrary keys are mapped to values. The keys can be any object with `__hash__()` and `__eq__()` methods. Called a hash in Perl.

dictionary comprehension (字典綜合運算)

一種緊密的方法，用來處理一個可迭代物件中的全部或部分元素，將處理結果以一個字典回傳。

`results = {n: n ** 2 for n in range(10)}` 會生一個字典，它包含了鍵 `n` 映射到值 `n ** 2`。請參 [comprehensions](#)。

dictionary view (字典檢視)

從 `dict.keys()`、`dict.values()` 及 `dict.items()` 回傳的物件被稱字典檢視。它們提供了字典中項目的動態檢視，這表示當字典有變動時，該檢視會反映這些變動。若要制將字典檢視轉完整的 list (串列)，須使用 `list(dictview)`。請參 [字典視圖物件](#)。

docstring (明字串)

A string literal which appears as the first expression in a class, function or module. While ignored when the suite is executed, it is recognized by the compiler and put into the `__doc__` attribute of the enclosing class, function or module. Since it is available via introspection, it is the canonical place for documentation of the object.

duck-typing (鴨子型)

一種程式設計風格，它不是藉由檢查一個物件的型來確定它是否具有正確的介面；取而代之的是，method 或屬性會單純地被呼叫或使用。（「如果它看起來像一鴨子而且叫起來像一鴨子，那它一定是一鴨子。」）因調介面而非特定型，精心設計的程式碼能讓多形替代 (polymorphic substitution) 來增進它的靈活性。鴨子型要避免使用 `type()` 或 `isinstance()` 進行測試。（但是請注意，鴨子型可以用抽象基底類 ([abstract base class](#)) 來補充。）然而，它通常會用 `hasattr()` 測試，或是 [EAFP](#) 程式設計風格。

EAFP

Easier to ask for forgiveness than permission. (請求寬恕比請求許可更容易。) 這種常見的 Python 編碼風格會先假設有效的鍵或屬性的存在，在該假設被推翻時再捕獲例外。這種乾且快速的風格，其特色是存在許多的 `try` 和 `except` 陳述式。該技術與許多其他語言 (例如 C) 常見的 [LBYL](#) 風格形成了對比。

expression (運算式)

一段可以被評估求值的語法。句話，一個運算式就是文字、名稱、屬性存取、運算子或函式呼叫等運算式元件的累積，而這些元件都能回傳一個值。與許多其他語言不同的是，非所有的 Python 語言構造都是運算式。另外有一些 [statement](#) (陳述式) 不能被用作運算式，例如 `while`。賦值 (assignment) 也是陳述式，而不是運算式。

extension module (擴充模組)

一個以 C 或 C++ 編寫的模組，它使用 Python 的 C API 來與核心及使用者程式碼進行互動。

f-string (f 字串)

以 `'f'` 或 `'F'` 前綴的字串文本通常被稱「f 字串」，它是格式化的字串文本的縮寫。另請參 [PEP 498](#)。

file object (檔案物件)

An object exposing a file-oriented API (with methods such as `read()` or `write()`) to an underlying resource. Depending on the way it was created, a file object can mediate access to a real on-disk file or to another type of storage or communication device (for example standard input/output, in-memory buffers, sockets, pipes, etc.). File objects are also called *file-like objects* or *streams*.

實際上，有三種檔案物件：原始的二進制檔案、緩衝的二進制檔案和文字檔案。它們的介面在 `io` 模組中被定義。建立檔案物件的標準方法是使用 `open()` 函式。

file-like object (類檔案物件)

[file object](#) (檔案物件) 的同義字。

filesystem encoding and error handler (檔案系統編碼和錯誤處理函式)

Python 所使用的一種編碼和錯誤處理函式，用來解碼來自作業系統的位元組，以及將 Unicode 編碼到作業系統。

檔案系統編碼必須保證能成功解碼所有小於 128 的位元組。如果檔案系統編碼無法提供此保證，則 API 函式會引發 `UnicodeError`。

`sys.getfilesystemencoding()` 和 `sys.getfilesystemcodeerrors()` 函式可用於取得檔案系統編碼和錯誤處理函式。

[filesystem encoding and error handler](#) (檔案系統編碼和錯誤處理函式) 會在 Python 動時由 `PyConfig_Read()` 函式來配置：請參 [filesystem_encoding](#)，以及 `PyConfig` 的成員

`filesystem_errors`。

另請參 [locale encoding](#)（區域編碼）。

finder（尋檢器）

一個物件，它會嘗試正在被 `import` 的模組尋找 *loader*（載入器）。

從 Python 3.3 開始，有兩種類型的尋檢器：元路徑尋檢器 (*meta path finder*) 會使用 `sys.meta_path`，而路徑項目尋檢器 (*path entry finder*) 會使用 `sys.path_hooks`。

請參 [PEP 302](#)、[PEP 420](#) 和 [PEP 451](#) 以了解更多細節。

floor division（向下取整除法）

向下無條件舍去到最接近整數的數學除法。向下取整除法的運算子是 `//`。例如，運算式 `11 // 4` 的計算結果是 `2`，與 `float`（浮點數）真除法所回傳的 `2.75` 不同。請注意，`(-11) // 4` 的結果是 `-3`，因是 `-2.75` 被向下無條件舍去。請參 [PEP 238](#)。

function（函式）

一連串的陳述式，它能向呼叫者回傳一些值。它也可以被傳遞零個或多個引數，這些引數可被使用於函式本體的執行。另請參 [parameter](#)（參數）、[method](#)（方法），以及 [function](#) 章節。

function annotation（函式釋）

函式參數或回傳值的一個 *annotation*（釋）。

函式釋通常被使用於 [型提示](#)：例如，這個函式預期會得到兩個 `int` 引數，會有一個 `int` 回傳值：

```
def sum_two_numbers(a: int, b: int) -> int:
    return a + b
```

函式釋的語法在 [function](#) 章節有詳細解釋。

請參 [variable annotation](#) 和 [PEP 484](#)，皆有此功能的描述。關於釋的最佳實踐方法，另請參 [annotations-howto](#)。

`__future__`

`future` 陳述式：`from __future__ import <feature>`，會指示編譯器使用那些在 Python 未來的發布版本中將成標準的語法或語義，來編譯當前的模組。而 `__future__` 模組則記了 *feature*（功能）可能的值。透過 `import` 此模組對其變數求值，你可以看見一個新的功能是何時首次被新增到此語言中，以及它何時將會（或已經）成預設的功能：

```
>>> import __future__
>>> __future__.division
_Feature((2, 2, 0, 'alpha', 2), (3, 0, 0, 'alpha', 0), 8192)
```

garbage collection（垃圾回收）

當記憶體不再被使用時，將其釋放的過程。Python 執行垃圾回收，是透過參照計數 (*reference counting*)，以及一個能檢測和中斷參照循環 (*reference cycle*) 的循環垃圾回收器 (*cyclic garbage collector*) 來完成。垃圾回收器可以使用 `gc` 模組對其進行控制。

generator（生成器）

一個會回傳 *generator iterator*（生成器代器）的函式。它看起來像一個正常的函式，但不同的是它包含了 `yield` 運算式，能生一系列的値，這些値可用於 `for` 圈，或是以 `next()` 函式，每次檢索其中的一個値。

這個術語通常用來表示一個生成器函式，但在某些情境中，也可能是表示生成器代器。萬一想表達的意思不清楚，那就使用完整的術語，以避免歧義。

generator iterator（生成器代器）

一個由 *generator*（生成器）函式所建立的物件。

每個 `yield` 會暫停處理程序，記住位置執行狀態（包括區域變數及擱置中的 `try` 陳述式）。當生成器代器回復時，它會從停止的地方繼續執行（與那些每次調用時都要重新開始的函式有所不同）。

generator expression (生成器運算式)

一個會回傳代器的運算式。它看起來像一個正常的運算式，後面接著一個 `for` 子句，該子句定義了圈變數、範圍以及一個選擇性的 `if` 子句。該組合運算式會外層函式生多個值：

```
>>> sum(i*i for i in range(10))      # sum of squares 0, 1, 4, ... 81
285
```

generic function (泛型函式)

一個由多個函式組成的函式，該函式會對不同的型實作相同的運算。呼叫期間應該使用哪種實作，是由調度演算法 (dispatch algorithm) 來定。

另請參 [single dispatch](#) (單一調度) 術語表條目、`functools.singledispatch()` 裝飾器和 [PEP 443](#)。

generic type (泛型型)

一個能被參數化 (parameterized) 的 *type* (型)；通常是一個容器型，像是 `list` 和 `dict`。它被用於型提示和釋。

詳情請參 [泛型名](#)、[PEP 483](#)、[PEP 484](#)、[PEP 585](#) 和 `typing` 模組。

GIL

請參 [global interpreter lock](#) (全域直譯器鎖)。

global interpreter lock (全域直譯器鎖)

CPython 直譯器所使用的機制，用以確保每次都只有一個執行緒能執行 Python 的 *bytecode* (位元組碼)。透過使物件模型 (包括關鍵的建型，如 `dict`) 自動地避免行存取 (concurrent access) 的危險，此機制可以簡化 *CPython* 的實作。鎖定整個直譯器，會使直譯器更容易成多執行緒 (multi-threaded)，但代價是會犧牲掉多處理器的機器能提供的一大部分平行性 (parallelism)。

然而，有些擴充模組，無論是標準的或是第三方的，它們被設計成在執行壓縮或雜等計算密集 (computationally intensive) 的任務時，可以解除 GIL。另外，在執行 I/O 時，GIL 總是會被解除。

過去對於建立「無限制執行緒」直譯器 (以更高的精細度鎖定共享資料的直譯器) 的努力未成功，因在一般的單一處理器情下，效能會有所損失。一般認為，若要克服這個效能問題，會使實作變得雜許多，進而付出更高的維護成本。

hash-based pyc (雜架構的 pyc)

一個位元組碼 (bytecode) 暫存檔，它使用雜值而不是對應原始檔案的最後修改時間，來確定其有效性。請參 [pyc-invalidation](#)。

hashable (可雜的)

An object is *hashable* if it has a hash value which never changes during its lifetime (it needs a `__hash__()` method), and can be compared to other objects (it needs an `__eq__()` method). Hashable objects which compare equal must have the same hash value.

可雜性 (hashability) 使一個物件可用作 `dictionary` (字典) 的鍵和 `set` (集合) 的成員，因這些資料結構都在其部使用了雜值。

大多數的 Python 不可變建物件都是可雜的；可變的容器 (例如 `list` 或 `dictionary`) 不是；而不可變的容器 (例如 `tuple` (元組) 和 `frozenset`)，只有當它們的元素是可雜的，它們本身才是可雜的。若物件是使用者自定 `class` 的實例，則這些物件會被預設可雜的。它們在互相比較時都是不相等的 (除非它們與自己比較)，而它們的雜值則是衍生自它們的 `id()`。

IDLE

Python 的 Integrated Development and Learning Environment (整合開發與學習環境)。*IDLE* 是一個基本的編輯器和直譯器環境，它和 Python 的標準發行版本一起被提供。

immutable (不可變物件)

一個具有固定值的物件。不可變物件包括數字、字串和 `tuple` (元組)。這類物件是不能被改變的。如果一個不同的值必須被儲存，則必須建立一個新的物件。它們在需要定雜值的地方，扮演重要的角色，例如 `dictionary` (字典) 中的一個鍵。

import path (引入路徑)

一個位置 (或路徑項目) 的列表，而那些位置就是在 `import` 模組時，會被 *path based finder* (基於路

徑的尋檢器) 搜尋模組的位置。在 `import` 期間, 此位置列表通常是來自 `sys.path`, 但對於子套件 (subpackage) 而言, 它也可能是來自父套件的 `__path__` 屬性。

importing (引入)

一個過程。一個模組中的 Python 程式碼可以透過此過程, 被另一個模組中的 Python 程式碼使用。

importer (引入器)

一個能尋找及載入模組的物件; 它既是 *finder* (尋檢器) 也是 *loader* (載入器) 物件。

interactive (互動的)

Python 有一個互動式直譯器, 這表示你可以在直譯器的提示字元輸入陳述式和運算式, 立即執行它們且看到它們的結果。只要啟動 python, 不需要任何引數 (可能藉由從你的電腦的主選單選擇它)。這是測試新想法或檢查模塊和包的非常大的方法 (請記住 `help(x)`)。

interpreted (直譯的)

Python 是一種直譯語言, 而不是編譯語言, 不過這個區分可能有些模糊, 因為有位元組碼 (bytecode) 編譯器的存在。這表示原始檔案可以直接被運行, 而不需明確地建立另一個執行檔, 然後再執行它。直譯語言通常比編譯語言有更短的開發 / 除錯期, 不過它們的程式通常也運行得較慢。另請參 *interactive* (互動的)。

interpreter shutdown (直譯器關閉)

當 Python 直譯器被要求關閉時, 它會進入一個特殊階段, 在此它逐漸釋放所有被配置的資源, 例如模組和各種關鍵部結構。它也會多次呼叫 *垃圾回收器* (*garbage collector*)。這能觸發使用者自定的解構函式 (destructor) 或弱引用的回呼 (*weakref callback*), 執行其中的程式碼。在關閉階段被執行的程式碼會遇到各種例外, 因為它所依賴的資源可能不再有作用了 (常見的例子是函式庫模組或是警告機制)。

直譯器關閉的主要原因, 是 `__main__` 模組或正被運行的本已經執行完成。

iterable (可迭代物件)

An object capable of returning its members one at a time. Examples of iterables include all sequence types (such as *list*, *str*, and *tuple*) and some non-sequence types like *dict*, *file objects*, and objects of any classes you define with an `__iter__()` method or with a `__getitem__()` method that implements *sequence* semantics.

Iterables can be used in a `for` loop and in many other places where a sequence is needed (*zip()*, *map()*, ...). When an iterable object is passed as an argument to the built-in function *iter()*, it returns an iterator for the object. This iterator is good for one pass over the set of values. When using iterables, it is usually not necessary to call *iter()* or deal with iterator objects yourself. The `for` statement does that automatically for you, creating a temporary unnamed variable to hold the iterator for the duration of the loop. See also *iterator*, *sequence*, and *generator*.

iterator (迭代器)

An object representing a stream of data. Repeated calls to the iterator's `__next__()` method (or passing it to the built-in function *next()*) return successive items in the stream. When no more data are available a *StopIteration* exception is raised instead. At this point, the iterator object is exhausted and any further calls to its `__next__()` method just raise *StopIteration* again. Iterators are required to have an `__iter__()` method that returns the iterator object itself so every iterator is also iterable and may be used in most places where other iterables are accepted. One notable exception is code which attempts multiple iteration passes. A container object (such as a *list*) produces a fresh new iterator each time you pass it to the *iter()* function or use it in a `for` loop. Attempting this with an iterator will just return the same exhausted iterator object used in the previous iteration pass, making it appear like an empty container.

在 *Iterator Types* 文中可以找到更多資訊。

CPython 實作細節: CPython does not consistently apply the requirement that an iterator define `__iter__()`.

key function (鍵函式)

鍵函式或理序函式 (collation function) 是一個可呼叫 (callable) 函式, 它會回傳一個用於排序 (sorting) 或定序 (ordering) 的值。例如, *locale.strxfrm()* 被用來生一個了解區域特定排序慣例的排序鍵。

Python 中的許多工具, 都接受以鍵函式來控制元素被定序或分組的方式。它們包括 *min()*、*max()*、*sorted()*、*list.sort()*、*heapq.merge()*、*heapq.nsmallest()*、*heapq.nlargest()*

和 `itertools.groupby()`。

有幾種方法可以建立一個鍵函式。例如，`str.lower()` method 可以作一個不分大小寫排序的鍵函式。或者，一個鍵函式也可以從 `lambda` 運算式被建造，例如 `lambda r: (r[0], r[2])`。另外，`operator.attrgetter()`、`operator.itemgetter()` 和 `operator.methodcaller()` 三個鍵函式的建構函式 (constructor)。關於如何建立和使用鍵函式的範例，請參閱如何排序。

keyword argument (關鍵字引數)

請參閱 `argument` (引數)。

lambda

由單一 *expression* (運算式) 所組成的一個匿名行內函式 (inline function)，於該函式被呼叫時求值。建立 `lambda` 函式的語法是 `lambda [parameters]: expression`

LBYL

Look before you leap. (三思而後行。) 這種編碼風格會在進行呼叫或查找之前，明確地測試先一個條件。這種風格與 *EAFP* 方式形成對比，且它的特色是會有許多 `if` 陳述式的存在。

在一個多執行緒環境中，LBYL 方式有在「三思」和「後行」之間引入了競態條件 (race condition) 的風險。例如以下程式碼 `if key in mapping: return mapping[key]`，如果另一個執行緒在測試之後但在查找之前，從 *mapping* 中移除了 *key*，則該程式碼就會失效。這個問題可以用鎖 (lock) 或使用 *EAFP* 編碼方式來解。

list (串列)

A built-in Python *sequence*. Despite its name it is more akin to an array in other languages than to a linked list since access to elements is $O(1)$.

list comprehension (串列綜合運算)

一種用來處理一個序列中的全部或部分元素，將處理結果以一個 `list` 回傳的簡要方法。`result = ['{:04x}'.format(x) for x in range(256) if x % 2 == 0]` 會生成一個字串 `list`，其中包含 0 到 255 範圍內，所有偶數的十六進位數 (0x..)。 `if` 子句是選擇性的。如果省略它，則 `range(256)` 中的所有元素都會被處理。

loader (載入器)

一個能載入模組的物件。它必須定義一個名 `load_module()` 的 *method* (方法)。載入器通常是被 *finder* (尋檢器) 回傳。更多細節請參閱 **PEP 302**，關於 *abstract base class* (抽象基底類)，請參閱 `importlib.abc.Loader`。

locale encoding (區域編碼)

在 Unix 上，它是 `LC_CTYPE` 區域設定的編碼。它可以用 `locale.setlocale(locale.LC_CTYPE, new_locale)` 來設定。

在 Windows 上，它是 ANSI 代碼頁 (code page，例如 "cp1252")。

在 Android 和 VxWorks 上，Python 使用 "utf-8" 作區域編碼。

`locale.getencoding()` can be used to get the locale encoding.

也請參考 *filesystem encoding and error handler*。

magic method (魔術方法)

special method (特殊方法) 的一個非正式同義詞。

mapping (對映)

一個容器物件，它支援任意鍵的查找，且能實作 *abstract base classes* (抽象基底類) 中，`collections.abc.Mapping` 或 `collections.abc.MutableMapping` 所指定的 *method*。範例包括 `dict`、`collections.defaultdict`、`collections.OrderedDict` 和 `collections.Counter`。

meta path finder (元路徑尋檢器)

一種經由搜尋 `sys.meta_path` 而回傳的 *finder* (尋檢器)。元路徑尋檢器與路徑項目尋檢器 (*path entry finder*) 相關但是不同。

關於元路徑尋檢器實作的 *method*，請參閱 `importlib.abc.MetaPathFinder`。

metaclass (元類)

一種 `class` 的 `class`。Class 定義過程會建立一個 `class` 名稱、一個 `class dictionary` (字典)，以及一個

base class (基底類) 的列表。Metaclass 負責接受這三個引數，建立該 class。大多數的物件導向程式語言會提供一個預設的實作。Python 的特之處在於它能建立自訂的 metaclass。大部分的使用者從未需要此工具，但是當需要時，metaclass 可以提供大且優雅的解決方案。它們已被用於記屬性存取、增加執行緒安全性、追物件建立、實作單例模式 (singleton)，以及許多其他的任務。

更多資訊可以在 metaclasses 章節中找到。

method (方法)

一個在 class 本體被定義的函式。如果 method 作其 class 實例的一個屬性被呼叫，則它將會得到該實例物件成它的第一個 *argument* (引數) (此引數通常被稱 `self`)。請參 *function* (函式) 和 *nested scope* (巢狀作用域)。

method resolution order (方法解析順序)

方法解析順序是在查找某個成員的過程中，base class (基底類) 被搜尋的順序。關於第 2.3 版至今，Python 直譯器所使用的演算法細節，請參 *Python 2.3 版方法解析順序*。

module (模組)

一個擔任 Python 程式碼的組織單位 (organizational unit) 的物件。模組有一個命名空間，它包含任意的 Python 物件。模組是藉由 *importing* 的過程，被載入至 Python。

另請參 *package* (套件)。

module spec (模組規格)

一個命名空間，它包含用於載入模組的 import 相關資訊。它是 `importlib.machinery.ModuleSpec` 的一個實例。

MRO

請參 *method resolution order* (方法解析順序)。

mutable (可變物件)

可變物件可以改變它們的值，但維持它們的 `id()`。另請參 *immutable* (不可變物件)。

named tuple (附名元組)

術語「named tuple (附名元組)」是指從 tuple 繼承的任何型或 class，且它的可索引 (indexable) 元素也可以用附名屬性來存取。這些型或 class 也可以具有其他的特性。

有些建型是 named tuple，包括由 `time.localtime()` 和 `os.stat()` 回傳的值。另一個例子是 `sys.float_info`：

```
>>> sys.float_info[1]           # indexed access
1024
>>> sys.float_info.max_exp      # named field access
1024
>>> isinstance(sys.float_info, tuple) # kind of tuple
True
```

Some named tuples are built-in types (such as the above examples). Alternatively, a named tuple can be created from a regular class definition that inherits from `tuple` and that defines named fields. Such a class can be written by hand, or it can be created by inheriting `typing.NamedTuple`, or with the factory function `collections.namedtuple()`. The latter techniques also add some extra methods that may not be found in hand-written or built-in named tuples.

namespace (命名空間)

變數被儲存的地方。命名空間是以 dictionary (字典) 被實作。有區域的、全域的及建的命名空間，而在物件中 (在 method 中) 也有巢狀的命名空間。命名空間藉由防止命名衝突，來支援模組化。例如，函式 `builtins.open` 和 `os.open()` 是透過它們的命名空間來區分彼此。命名空間也藉由明確地區分是哪個模組在實作一個函式，來增進可讀性及可維護性。例如，寫出 `random.seed()` 或 `itertools.islice()` 明確地表示，這些函式分是由 `random` 和 `itertools` 模組在實作。

namespace package (命名空間套件)

一個 *PEP 420 package* (套件)，它只能作子套件 (subpackage) 的一個容器。命名空間套件可能有實體的表示法，而且具體來它們不像是一個 *regular package* (正規套件)，因它們有 `__init__.py` 這個檔案。

另請參 *module* (模組)。

nested scope (巢狀作用域)

能參照外層定義 (enclosing definition) 中的變數的能力。舉例來說，一個函式如果是在另一個函式中被定義，則它便能參照外層函式中的變數。請注意，在預設情況下，巢狀作用域僅適用於參照，而無法用於賦值。區域變數能在最內層作用域中讀取及寫入。同樣地，全域變數是在全域命名空間中讀取及寫入。`nonlocal` 容許對外層作用域進行寫入。

new-style class (新式類)

Old name for the flavor of classes now used for all class objects. In earlier Python versions, only new-style classes could use Python's newer, versatile features like `__slots__`, descriptors, properties, `__getattr__()`, class methods, and static methods.

object (物件)

具有狀態 (屬性或值) 及被定義的行 (method) 的任何資料。它也是任何 *new-style class* (新式類) 的最終 base class (基底類)。

package (套件)

一個 Python 的 *module* (模組)，它可以包含子模組 (submodule) 或是遞階的子套件 (subpackage)。技術上而言，套件就是具有 `__path__` 屬性的一個 Python 模組。

另請參 *regular package* (正規套件) 和 *namespace package* (命名空間套件)。

parameter (參數)

在 *function* (函式) 或 *method* 定義中的一個命名實體 (named entity)，它指明該函式能接受的一個 *argument* (引數)，或在某些情況下指示多個引數。共有五種不同的參數類型：

- *positional-or-keyword* (位置或關鍵字)：指明一個可以按照位置或是作關鍵字引數被傳遞的引數。這是參數的預設類型，例如以下的 *foo* 和 *bar*：

```
def func(foo, bar=None): ...
```

- *positional-only* (僅限位置)：指明一個只能按照位置被提供的引數。在函式定義的參數列表中包含一個 `/` 字元，就可以在該字元前面定義僅限位置參數，例如以下的 *posonly1* 和 *posonly2*：

```
def func(posonly1, posonly2, /, positional_or_keyword): ...
```

- *keyword-only* (僅限關鍵字)：指明一個只能以關鍵字被提供的引數。在函式定義的參數列表中，包含一個任意數量位置參數 (var-positional parameter) 或是單純的 `*` 字元，就可以在其後方定義僅限關鍵字參數，例如以下的 *kw_only1* 和 *kw_only2*：

```
def func(arg, *, kw_only1, kw_only2): ...
```

- *var-positional* (任意數量位置)：指明一串能以任意序列被提供的位置引數 (在已被其他參數接受的任何位置引數之外)。這類參數是透過在其參數名稱字首加上 `*` 來定義的，例如以下的 *args*：

```
def func(*args, **kwargs): ...
```

- *var-keyword* (任意數量關鍵字)：指明可被提供的任意數量關鍵字引數 (在已被其他參數接受的任何關鍵字引數之外)。這類參數是透過在其參數名稱字首加上 `**` 來定義的，例如上面範例中的 *kwargs*。

參數可以指明引數是選擇性的或必需的，也可以一些選擇性的引數指定預設值。

另請參術語表的 *argument* (引數) 條目、常見問題中的引數和參數之間的差別、*inspect.Parameter* class、*function* 章節，以及 **PEP 362**。

path entry (路徑項目)

在 *import path* (引入路徑) 中的一個位置，而 *path based finder* (基於路徑的尋檢器) 會參考該位置來尋找要 import 的模組。

path entry finder (路徑項目尋檢器)

被 *sys.path_hooks* 中的一個可呼叫物件 (callable) (意即一個 *path entry hook*) 所回傳的一種 *finder*，它知道如何以一個 *path entry* 定位模組。

關於路徑項目尋檢器實作的 *method*，請參 `importlib.abc.PathEntryFinder`。

path entry hook (路徑項目)

A callable on the `sys.path_hooks` list which returns a *path entry finder* if it knows how to find modules on a specific *path entry*.

path based finder (基於路徑的尋檢器)

預設的元路徑尋檢器 (*meta path finder*) 之一，它會在一個 *import path* 中搜尋模組。

path-like object (類路徑物件)

一個表示檔案系統路徑的物件。類路徑物件可以是一個表示路徑的 *str* 或 *bytes* 物件，或是一個實作 `os.PathLike` 協定的物件。透過呼叫 `os.fspath()` 函式，一個支援 `os.PathLike` 協定的物件可以被轉為 *str* 或 *bytes* 檔案系統路徑；而 `os.fsdecode()` 及 `os.fsencode()` 則分別可用於確保 *str* 及 *bytes* 的結果。由 **PEP 519** 引入。

PEP

Python Enhancement Proposal (Python 增提案)。PEP 是一份設計明文件，它能 Python 社群提供資訊，或是描述 Python 的一個新功能或該功能的程序和環境。PEP 應該要提供簡潔的技術規範以及被提案功能的運作原理。

PEP 的存在目的，是要成重大新功能的提案、社群中關於某個問題的意見收集，以及已納入 Python 的設計策的記，這些過程的主要機制。PEP 的作者要負責在社群建立共識記反對意見。

請參 **PEP 1**。

portion (部分)

在單一中的一組檔案(也可能儲存在一個 zip 檔中)，這些檔案能對一個命名空間套件 (namespace package) 有所貢獻，如同 **PEP 420** 中的定義。

positional argument (位置引數)

請參 *argument* (引數)。

provisional API (暫行 API)

暫行 API 是指，從標準函式庫的向後相容性 (backwards compatibility) 保證中，故意被排除的 API。雖然此類介面，只要它們被標示暫行的，理論上不會有重大的變更，但如果核心開發人員認為有必要，也可能會出現向後不相容的變更（甚至包括移除該介面）。這種變更不會無端地生——只有 API 被納入之前未察覺的嚴重基本缺陷被揭露時，它們才會發生。

即使對於暫行 API，向後不相容的變更也會被視為「最後的解方案」——對於任何被發現的問題，仍然會盡可能找出一個向後相容的解方案。

這個過程使得標準函式庫能隨著時間不斷進化，而避免耗費過長的時間去鎖定有問題的設計錯誤。請參 **PEP 411** 了解更多細節。

provisional package (暫行套件)

請參 *provisional API* (暫行 API)。

Python 3000

Python 3.x 系列版本的稱（很久以前創造的，當時第 3 版的發布是在遠的未來。）也可以縮寫為 [Py3k]。

Pythonic (Python 風格的)

一個想法或一段程式碼，它應用了 Python 語言最常見的慣用語，而不是使用其他語言常見的概念來實作程式碼。例如，Python 中常見的一種習慣用法，是使用一個 `for` 陳述式，對一個可代物件的所有元素進行圈。許多其他語言有這種類型的架構，所以不熟悉 Python 的人有時會使用一個數值計數器來代替：

```
for i in range(len(food)):
    print(food[i])
```

相較之下，以下方法更簡潔、更具有 Python 風格：

```
for piece in food:
    print(piece)
```


qualified name (限定名稱)

一個「點分隔名稱」，它顯示從一個模組的全域作用域到該模組中定義的 class、函式或 method 的「路徑」，如 [PEP 3155](#) 中的定義。對於頂層的函式和 class 而言，限定名稱與其物件名稱相同：

```
>>> class C:
...     class D:
...         def meth(self):
...             pass
...
>>> C.__qualname__
'C'
>>> C.D.__qualname__
'C.D'
>>> C.D.meth.__qualname__
'C.D.meth'
```

當用於引用模組時，完全限定名 (*fully qualified name*) 是表示該模組的完整點分隔路徑，包括任何的父套件，例如 `email.mime.text`：

```
>>> import email.mime.text
>>> email.mime.text.__name__
'email.mime.text'
```

reference count (參照計數)

對於一個物件的參照次數。當一個物件的參照計數下降到零時，它會被解除配置 (deallocated)。參照計數通常在 Python 程式碼中看不到，但它 [是 CPython](#) 實作的一個關鍵元素。程式設計師可以呼叫 `getrefcount()` 函式來回傳一個特定物件的參照計數。

regular package (正規套件)

一個傳統的 *package* (套件)，例如一個包含 `__init__.py` 檔案的目錄。

另請參 [namespace package](#) (命名空間套件)。

__slots__

在 class 內部的一個宣告，它藉由預先宣告實例屬性的空間，以及消除實例 dictionary (字典)，來節省記憶體。雖然該技術很普遍，但它有點難以正確地使用，最好保留給那種在一個記憶體關鍵 (memory-critical) 的應用程式中存在大量實例的罕見情況。

sequence (序列)

An *iterable* which supports efficient element access using integer indices via the `__getitem__()` special method and defines a `__len__()` method that returns the length of the sequence. Some built-in sequence types are *list*, *str*, *tuple*, and *bytes*. Note that *dict* also supports `__getitem__()` and `__len__()`, but is considered a mapping rather than a sequence because the lookups use arbitrary *immutable* keys rather than integers.

The `collections.abc.Sequence` abstract base class defines a much richer interface that goes beyond just `__getitem__()` and `__len__()`, adding `count()`, `index()`, `__contains__()`, and `__reversed__()`. Types that implement this expanded interface can be registered explicitly using `register()`. For more documentation on sequence methods generally, see [Common Sequence Operations](#).

set comprehension (集合綜合運算)

一種緊密的方法，用來處理一個可代物件中的全部或部分元素，將處理結果以一個 set 回傳。results = {c for c in 'abracadabra' if c not in 'abc'} 會生一個字串 set: {'r', 'd'}。請參 [comprehensions](#)。

single dispatch (單一調度)

generic function (泛型函式) 調度的一種形式，在此，實作的選擇是基於單一引數的型。

slice (切片)

一個物件，它通常包含一段 *sequence* (序列) 的某一部分。建立一段切片的方法是使用下標符號 (subscript notation) `[]`，若要給出多個數字，則在數字之間使用冒號，例如 `variable_name[1:3:5]`。在括號 (下標) 符號的內部，會使用 *slice* 物件。

special method (特殊方法)

一種會被 Python 自動呼叫的 `method`，用於對某種型執行某種運算，例如加法。這種 `method` 的名稱會在開頭和結尾有兩個下底。Special method 在 `specialnames` 中有詳細明。

statement (陳述式)

陳述式是一個套組 (suite, 一個程式碼「區塊」) 中的一部分。陳述式可以是一個 *expression* (運算式)，或是含有關鍵字 (例如 `if`、`while` 或 `for`) 的多種結構之一。

static type checker

An external tool that reads Python code and analyzes it, looking for issues such as incorrect types. See also *type hints* and the *typing* module.

strong reference (參照)

In Python's C API, a strong reference is a reference to an object which is owned by the code holding the reference. The strong reference is taken by calling `Py_INCREF()` when the reference is created and released with `Py_DECREF()` when the reference is deleted.

`Py_NewRef()` 函式可用於建立一個對物件的參照。通常，在退出參照的作用域之前，必須在該參照上呼叫 `Py_DECREF()` 函式，以避免漏一個參照。

另請參 *borrowed reference* (借用參照)。

text encoding (文字編碼)

Python 中的字串是一個 Unicode 碼點 (code point) 的序列 (範圍在 `U+0000` -- `U+10FFFF` 之間)。若要儲存或傳送一個字串，它必須被序列化一個位元組序列。

將一個字串序列化位元組序列，稱「編碼」，而從位元組序列重新建立該字串則稱「解碼 (decoding)」。

有多種不同的文字序列化編解碼器 (*codecs*)，它們被統稱「文字編碼」。

text file (文字檔案)

一個能讀取和寫入 *str* 物件的一個 *file object* (檔案物件)。通常，文字檔案實際上是存取位元組導向的資料流 (byte-oriented datastream) 會自動處理 *text encoding* (文字編碼)。文字檔案的例子有：以文字模式 ('`r`' 或 '`w`') 開的檔案、`sys.stdin`、`sys.stdout` 以及 `io.StringIO` 的實例。

另請參 *binary file* (二進制檔案)，它是一個能讀取和寫入類位元組串物件 (*bytes-like object*) 的檔案物件。

triple-quoted string (三引號字串)

由三個雙引號 (") 或單引號 (') 的作邊界的一個字串。雖然它們有提供於單引號字串的任何額外功能，但基於許多原因，它們仍是很有用的。它們讓你可以在字串中包含未跳 (unescaped) 的單引號和雙引號，而且它們不需使用連續字元 (continuation character) 就可以跨越多行，這使得它們在編寫明字串時特有用。

type (型)

一個 Python 物件的型定了它是什類型的物件；每個物件都有一個型。一個物件的型可以用它的 `__class__` 屬性來存取，或以 `type(obj)` 來檢索。

type alias (型名)

一個型的同義詞，透過將型指定給一個識符 (identifier) 來建立。

型名對於簡化型提示 (*type hint*) 很有用。例如：

```
def remove_gray_shades(
    colors: list[tuple[int, int, int]]) -> list[tuple[int, int, int]]:
    pass
```

可以寫成這樣，更具有可讀性：

```
Color = tuple[int, int, int]

def remove_gray_shades(colors: list[Color]) -> list[Color]:
    pass
```

請參 *typing* 和 **PEP 484**，有此功能的描述。

type hint (型提示)

一種 *annotation* (釋)，它指定一個變數、一個 class 屬性或一個函式的參數或回傳值的預期型。

Type hints are optional and are not enforced by Python but they are useful to *static type checkers*. They can also aid IDEs with code completion and refactoring.

全域變數、class 屬性和函式（不含區域變數）的型提示，都可以使用 `typing.get_type_hints()` 來存取。

請參 `typing` 和 **PEP 484**，有此功能的描述。

universal newlines (通用行字元)

一種解譯文字流 (text stream) 的方式，會將以下所有的情識一行的結束：Unix 行尾慣例 `'\n'`、Windows 慣例 `'\r\n'` 和舊的 Macintosh 慣例 `'\r'`。請參 **PEP 278** 和 **PEP 3116**，以及用於 `bytes.splitlines()` 的附加用途。

variable annotation (變數釋)

一個變數或 class 屬性的 *annotation* (釋)。

釋變數或 class 屬性時，賦值是選擇性的：

```
class C:
    field: 'annotation'
```

變數釋通常用於型提示 (*type hint*)：例如，這個變數預期會取得 `int` (整數) 值：

```
count: int = 0
```

變數釋的語法在 `annassign` 章節有詳細的解釋。

請參 `function annotation` (函式釋)、**PEP 484** 和 **PEP 526**，皆有此功能的描述。關於釋的最佳實踐方法，另請參 `annotations-howto`。

virtual environment (擬環境)

一個協作隔離 (cooperatively isolated) 的執行環境，能讓 Python 的使用者和應用程式得以安裝和升級 Python 發套件，而不會對同一個系統上運行的其他 Python 應用程式的行生干擾。

另請參 `venv`。

virtual machine (擬機器)

一部完全由軟體所定義的電腦 (computer)。Python 的擬機器會執行由 *bytecode* (位元組碼) 編譯器所發出的位元組碼。

Zen of Python (Python 之)

Python 設計原則與哲學的列表，其容有助於理解和使用此語言。此列表可以透過在互動式提示字元後輸入 `'import this'` 來找到它。

關於這些文檔文件

這些文檔文件是透過 [Sphinx](#)（一個專為 Python 文檔文件所撰寫的文件處理器）將使用 [reStructuredText](#) 撰寫的原始檔轉換而成。

如同 Python 自身，透過自願者的努力下輸出文件與封裝後自動化執行工具。若想要回報臭蟲，請見 [reporting-bugs](#) 頁面，[包含](#)相關資訊。我們永遠歡迎新的自願者加入！

致謝：

- Fred L. Drake, Jr.，原始 Python 文件工具集的創造者以及一大部份內容的作者；
- 創造 [reStructuredText](#) 和 [Docutils](#) 工具組的 [Docutils](#) 專案；
- Fredrik Lundh 先生，[Sphinx](#) 從他的 [Alternative Python Reference](#) 計劃中獲得許多的好主意。

B.1 Python 文件的貢獻者們

許多人都曾為 Python 這門語言、Python 標準函式庫和 Python 文檔文件貢獻過。Python 所發出的原始碼中含有部份貢獻者的清單，請見 [Misc/ACKS](#)。

正因為 Python 社群的撰寫與貢獻才有這份這棒的文檔文件 -- 感謝所有貢獻過的人們！

沿革與授權

C.1 軟體沿革

Python 是由荷蘭數學和計算機科學研究學會（CWI，見 <https://www.cwi.nl/>）的 Guido van Rossum 於 1990 年代早期所創造，目的是作一種稱作 ABC 語言的後繼者。儘管 Python 包含了許多來自其他人的貢獻，Guido 仍是其主要作者。

1995 年，Guido 在維吉尼亞州雷斯頓的國家創新研究公司（CNRI，見 <https://www.cnri.reston.va.us/>）繼續他在 Python 的工作，在那發行了該軟體的多個版本。

2000 年五月，Guido 和 Python 核心開發團隊轉移到 BeOpen.com 成立了 BeOpen PythonLabs 團隊。同年十月，PythonLabs 團隊轉移到 Digital Creations（現 Zope Corporation；見 <https://www.zope.org/>）。2001 年，Python 軟體基金會（PSF，見 <https://www.python.org/psf/>）成立，這是一個專擁有 Python 相關的智慧財產權而創立的非營利組織。Zope Corporation 是 PSF 的一個贊助會員。

所有的 Python 版本都是開源的（有關開源的定義，參見 <https://opensource.org/>）。歷史上，大多數但非全部的 Python 版本，也是 GPL 相容的；以下表格總結各個版本的差異。

發行版本	源自	年份	擁有者	GPL 相容性？
0.9.0 至 1.2	不適用	1991-1995	CWI	是
1.3 至 1.5.2	1.2	1995-1999	CNRI	是
1.6	1.5.2	2000	CNRI	否
2.0	1.6	2000	BeOpen.com	否
1.6.1	1.6	2001	CNRI	否
2.1	2.0+1.6.1	2001	PSF	否
2.0.1	2.0+1.6.1	2001	PSF	是
2.1.1	2.1+2.0.1	2001	PSF	是
2.1.2	2.1.1	2002	PSF	是
2.1.3	2.1.2	2002	PSF	是
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C.3.1 Mersenne Twister

`_random` 模組包含了以 <http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/MT2002/emt19937ar.html> 的下載 容 基礎的程式碼。以下是原始程式碼的完整聲明：

```
A C-program for MT19937, with initialization improved 2002/1/26.
Coded by Takuji Nishimura and Makoto Matsumoto.

Before using, initialize the state by using init_genrand(seed)
or init_by_array(init_key, key_length).

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http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/emt.html
email: m-mat @ math.sci.hiroshima-u.ac.jp (remove space)
```


C.3.2 Sockets

The *socket* module uses the functions, `getaddrinfo()`, and `getnameinfo()`, which are coded in separate source files from the WIDE Project, <https://www.wide.ad.jp/>.

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```

```
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http://zooko.com/
mailto:zooko@zooko.com
```

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Modified by Jack Jansen, CWI, July 1995:
- Use binascii module to do the actual line-by-line conversion
  between ascii and binary. This results in a 1000-fold speedup. The C
  version is still 5 times faster, though.
- Arguments more compliant with Python standard
```

C.3.7 XML 遠端程序呼叫

`xmlrpc.client` 模組包含以下聲明：

```
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C.3.10 SipHash24

Python/pyhash.c 檔案包含 Marek Majkowski 基於 Dan Bernstein 的 SipHash24 演算法的實作。它包含以下聲明：

```
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Original location:
  https://github.com/majek/csiphash/

Solution inspired by code from:
  Samuel Neves (supercop/crypto_auth/siphash24/little)
  djb (supercop/crypto_auth/siphash24/little2)
  Jean-Philippe Aumasson (https://131002.net/siphash/siphash24.c)
```

C.3.11 strtod 與 dtoa

Python/dtoa.c 檔案提供了 C 的 dtoa 和 strtod 函式，用於將 C 的雙精度浮點數和字串互相轉F。該檔案是衍生自 David M. Gay 建立的同名檔案，後者現在可以從 <https://web.archive.org/web/20220517033456/http://www.netlib.org/fp/dtoa.c> 下載。於 2009 年 3 月 16 日所檢索的原始檔案包含以下版權與授權聲明：

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 *
 * *****/
```

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C.3.13 expat

The `pyexpat` extension is built using an included copy of the expat sources unless the build is configured `--with-system-expat`:

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C.3.14 libffi

除非在建置 `_ctypes` 擴充時設定 `--with-system-libffi`，否則該擴充會用一個含 `libffi` 原始碼的副本來建置：

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C.3.15 zlib

如果在系統上找到的 `zlib` 版本太舊以致於無法用於建置 `zlib` 擴充，則該擴充會用一個_F含 `zlib` 原始碼的副本來建置：

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```
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jloup@gzip.org
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```
Mark Adler
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C.3.16 cfuhash

`tracemalloc` 使用的雜_F表 (hash table) 實作，是以 `cfuhash` 專案_F基礎：

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C.3.17 libmpdec

除非在建置 `_decimal` 模組時設定 `F --with-system-libmpdec`, 否則該模組會用一個 `F` 含 `libmpdec` 函式庫的副本來建置:

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C.3.18 W3C C14N 測試套件

`test` 程式包中的 `C14N 2.0` 測試套件 (`Lib/test/xmltestdata/c14n-20/`) 是從 W3C 網站 <https://www.w3.org/TR/xml-c14n2-testcases/> 被檢索, 且是基於 3-clause BSD 授權被發 `F`:

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C.3.19 Audioop

The audioop module uses the code base in g771.c file of the SoX project. <https://sourceforge.net/projects/sox/files/sox/12.17.7/sox-12.17.7.tar.gz>

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C.3.20 asyncio

Parts of the *asyncio* module are incorporated from *uvloop 0.16*, which is distributed under the MIT license:

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









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

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





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





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






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