# The Python/C API

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# Contents

本手册描述了希望编写扩展模块并将 Python 解释器嵌入其应用程序中的 C 和 C++ 程序员可用的 API。同时可以参阅 extending-index ，其中描述了扩展编写的一般原则，但没有详细描述 API 函数。

CHAPTER 1

# 概述

Python 的应用编程接口（API）使得 C 和 C++ 程序员可以在多个层级上访问 Python 解释器。该 API 在 C++ 中同样可用，但为简化描述，通常将其称为 Python/C API。使用 Python/C API 有两个基本的理由。第一个理由是为了特定目的而编写 *扩展模块*；它们是扩展 Python 解释器功能的 C 模块。这可能是最常见的使用场景。第二个理由是将 Python 用作更大规模应用的组件；这种技巧通常被称为在一个应用中 *embedding* Python。

Writing an extension module is a relatively well-understood process, where a “cookbook” approach works well. There are several tools that automate the process to some extent. While people have embedded Python in other applications since its early existence, the process of embedding Python is less straightforward than writing an extension.

许多 API 函数在你嵌入或是扩展 Python 这两种场景下都能发挥作用；此外，大多数嵌入 Python 的应用程序也需要提供自定义扩展，因此在尝试在实际应用中嵌入 Python 之前先熟悉编写扩展应该会是个好主意。

## 1.1 包含文件

使用 Python/C API 所需要的全部函数、类型和宏定义可通过下面这行语句包含到你的代码之中：

```
#include "Python.h"
```

这意味着包含以下标准头文件：`<stdio.h>`，`<string.h>`，`<errno.h>`，`<limits.h>`，`<assert.h>` 和 `<stdlib.h>`（如果可用）。

**注解：** 由于 Python 可能会定义一些能在某些系统上影响标准头文件的预处理器定义，因此在包含任何标准头文件之前，你 *必须*先包含 `Python.h`。

Python.h 所定义的全部用户可见名称（由包含的标准头文件所定义的除外）都带有前缀 `Py` 或者 `_Py`。以 `_Py` 打头的名称是供 Python 实现内部使用的，不应被扩展编写者使用。结构成员名称没有保留前缀。

**Important:** user code should never define names that begin with `Py` or `_Py`. This confuses the reader, and jeopardizes the portability of the user code to future Python versions, which may define additional names beginning with one of these prefixes.

The header files are typically installed with Python. On Unix, these are located in the directories *prefix*/include/pythonversion/ and *exec_prefix*/include/pythonversion/, where prefix and exec_prefix are defined by the corresponding parameters to Python's **configure** script and *version* is sys.version[:3]. On Windows, the headers are installed in *prefix*/include, where prefix is the installation directory specified to the installer.

要包含头文件，请将两个目录（如果不同）都放到你所用编译器的包含搜索路径中。请 不要将父目录放入搜索路径然后使用 #include <pythonX.Y/Python.h>；这将使得多平台编译不可用，因为 prefix 下平台无关的头文件需要包含来自 exec_prefix 下特定平台的头文件。

C++ users should note that though the API is defined entirely using C, the header files do properly declare the entry points to be extern "C", so there is no need to do anything special to use the API from C++.

## 1.2 对象、类型和引用计数

大多数 Python/C API 函数都有一个或多个参数以及一个PyObject*类型的返回值。此类型是一个指针，指向表示一个任意 Python 对象的不透明数据类型。由于在大多数情况下（例如赋值、作用域规则和参数传递）Python 语言都会以同样的方式处理所有 Python 对象类型，因此它们由一个单独的 C 类型来表示是很适宜的。几乎所有 Python 对象都生存在堆上：你绝不会声明一个PyObject 类型的自动或静态变量，只有PyObject*类型的指针变量可以被声明。唯一的例外是 type 对象；由于此种对象永远不能被释放，所以它们通常是静态PyTypeObject 对象。

所有 Python 对象（甚至 Python 整数）都有一个 *type* 和一个 *reference count*。对象的类型确定它是什么类型的对象（例如整数、列表或用户定义函数；还有更多，如 types 中所述）。对于每个众所周知的类型，都有一个宏来检查对象是否属于该类型；例如，当（且仅当）*a* 所指的对象是 Python 列表时 PyList_Check(a) 为真。

### 1.2.1 引用计数

The reference count is important because today's computers have a finite (and often severely limited) memory size; it counts how many different places there are that have a reference to an object. Such a place could be another object, or a global (or static) C variable, or a local variable in some C function. When an object's reference count becomes zero, the object is deallocated. If it contains references to other objects, their reference count is decremented. Those other objects may be deallocated in turn, if this decrement makes their reference count become zero, and so on. (There's an obvious problem with objects that reference each other here; for now, the solution is "don't do that.")

Reference counts are always manipulated explicitly. The normal way is to use the macro Py_INCREF() to increment an object's reference count by one, and Py_DECREF() to decrement it by one. The Py_DECREF() macro is considerably more complex than the incref one, since it must check whether the reference count becomes zero and then cause the object's deallocator to be called. The deallocator is a function pointer contained in the object's type structure. The type-specific deallocator takes care of decrementing the reference counts for other objects contained in the object if this is a compound object type, such as a list, as well as performing any additional finalization that's needed. There's no chance that the reference count can overflow; at least as many bits are used to hold the reference count as there are distinct memory locations in virtual memory (assuming sizeof(Py_ssize_t) >= sizeof(void*)). Thus, the reference count increment is a simple operation.

It is not necessary to increment an object's reference count for every local variable that contains a pointer to an object. In theory, the object's reference count goes up by one when the variable is made to point to it and it goes down by one when the variable goes out of scope. However, these two cancel each other out, so at the end the reference count hasn't changed. The only real reason to use the reference count is to prevent the object from being deallocated as long as our variable is pointing to it. If we know that there is at least one other reference to the object that lives at least as long as our variable, there is no need to increment the reference count temporarily. An important situation where this arises is in objects that are passed as arguments to C functions in an extension module that are called from Python; the call mechanism guarantees to hold a reference to every argument for the duration of the call.

However, a common pitfall is to extract an object from a list and hold on to it for a while without incrementing its reference count. Some other operation might conceivably remove the object from the list, decrementing its reference count and possible deallocating it. The real danger is that innocent-looking operations may invoke arbitrary Python code which could do this; there is a code path which allows control to flow back to the user from a `Py_DECREF()`, so almost any operation is potentially dangerous.

A safe approach is to always use the generic operations (functions whose name begins with `PyObject_`, `PyNumber_`, `PySequence_` or `PyMapping_`). These operations always increment the reference count of the object they return. This leaves the caller with the responsibility to call `Py_DECREF()` when they are done with the result; this soon becomes second nature.

### Reference Count Details

The reference count behavior of functions in the Python/C API is best explained in terms of *ownership of references*. Ownership pertains to references, never to objects (objects are not owned: they are always shared). "Owning a reference" means being responsible for calling Py_DECREF on it when the reference is no longer needed. Ownership can also be transferred, meaning that the code that receives ownership of the reference then becomes responsible for eventually decref' ing it by calling `Py_DECREF()` or `Py_XDECREF()` when it' s no longer needed—or passing on this responsibility (usually to its caller). When a function passes ownership of a reference on to its caller, the caller is said to receive a *new* reference. When no ownership is transferred, the caller is said to *borrow* the reference. Nothing needs to be done for a borrowed reference.

Conversely, when a calling function passes in a reference to an object, there are two possibilities: the function *steals* a reference to the object, or it does not. *Stealing a reference* means that when you pass a reference to a function, that function assumes that it now owns that reference, and you are not responsible for it any longer.

Few functions steal references; the two notable exceptions are `PyList_SetItem()` and `PyTuple_SetItem()`, which steal a reference to the item (but not to the tuple or list into which the item is put!). These functions were designed to steal a reference because of a common idiom for populating a tuple or list with newly created objects; for example, the code to create the tuple `(1, 2, "three")` could look like this (forgetting about error handling for the moment; a better way to code this is shown below):

```
PyObject *t;

t = PyTuple_New(3);
PyTuple_SetItem(t, 0, PyInt_FromLong(1L));
PyTuple_SetItem(t, 1, PyInt_FromLong(2L));
PyTuple_SetItem(t, 2, PyString_FromString("three"));
```

Here, `PyInt_FromLong()` returns a new reference which is immediately stolen by `PyTuple_SetItem()`. When you want to keep using an object although the reference to it will be stolen, use `Py_INCREF()` to grab another reference before calling the reference-stealing function.

Incidentally, `PyTuple_SetItem()` is the *only* way to set tuple items; `PySequence_SetItem()` and `PyObject_SetItem()` refuse to do this since tuples are an immutable data type. You should only use `PyTuple_SetItem()` for tuples that you are creating yourself.

Equivalent code for populating a list can be written using `PyList_New()` and `PyList_SetItem()`.

However, in practice, you will rarely use these ways of creating and populating a tuple or list. There' s a generic function, `Py_BuildValue()`, that can create most common objects from C values, directed by a *format string*. For example, the above two blocks of code could be replaced by the following (which also takes care of the error checking):

```
PyObject *tuple, *list;

tuple = Py_BuildValue("(iis)", 1, 2, "three");
list = Py_BuildValue("[iis]", 1, 2, "three");
```

It is much more common to use *PyObject_SetItem()* and friends with items whose references you are only borrowing, like arguments that were passed in to the function you are writing. In that case, their behaviour regarding reference counts is much saner, since you don't have to increment a reference count so you can give a reference away ("have it be stolen"). For example, this function sets all items of a list (actually, any mutable sequence) to a given item:

```
int
set_all(PyObject *target, PyObject *item)
{
    int i, n;

    n = PyObject_Length(target);
    if (n < 0)
        return -1;
    for (i = 0; i < n; i++) {
        PyObject *index = PyInt_FromLong(i);
        if (!index)
            return -1;
        if (PyObject_SetItem(target, index, item) < 0) {
            Py_DECREF(index);
            return -1;
        }
        Py_DECREF(index);
    }
    return 0;
}
```

The situation is slightly different for function return values. While passing a reference to most functions does not change your ownership responsibilities for that reference, many functions that return a reference to an object give you ownership of the reference. The reason is simple: in many cases, the returned object is created on the fly, and the reference you get is the only reference to the object. Therefore, the generic functions that return object references, like *PyObject_GetItem()* and *PySequence_GetItem()*, always return a new reference (the caller becomes the owner of the reference).

It is important to realize that whether you own a reference returned by a function depends on which function you call only —*the plumage* (the type of the object passed as an argument to the function) *doesn't enter into it!* Thus, if you extract an item from a list using *PyList_GetItem()*, you don't own the reference —but if you obtain the same item from the same list using *PySequence_GetItem()* (which happens to take exactly the same arguments), you do own a reference to the returned object.

Here is an example of how you could write a function that computes the sum of the items in a list of integers; once using *PyList_GetItem()*, and once using *PySequence_GetItem()*.

```
long
sum_list(PyObject *list)
{
    int i, n;
    long total = 0;
    PyObject *item;

    n = PyList_Size(list);
    if (n < 0)
        return -1; /* Not a list */
    for (i = 0; i < n; i++) {
        item = PyList_GetItem(list, i); /* Can't fail */
        if (!PyInt_Check(item)) continue; /* Skip non-integers */
        total += PyInt_AsLong(item);
    }
    return total;
}
```

```
long
sum_sequence(PyObject *sequence)
{
    int i, n;
    long total = 0;
    PyObject *item;
    n = PySequence_Length(sequence);
    if (n < 0)
        return -1; /* Has no length */
    for (i = 0; i < n; i++) {
        item = PySequence_GetItem(sequence, i);
        if (item == NULL)
            return -1; /* Not a sequence, or other failure */
        if (PyInt_Check(item))
            total += PyInt_AsLong(item);
        Py_DECREF(item); /* Discard reference ownership */
    }
    return total;
}
```

### 1.2.2 类型

There are few other data types that play a significant role in the Python/C API; most are simple C types such as `int`, `long`, `double` and `char*`. A few structure types are used to describe static tables used to list the functions exported by a module or the data attributes of a new object type, and another is used to describe the value of a complex number. These will be discussed together with the functions that use them.

## 1.3 异常

Python 程序员只需要处理特定需要处理的错误异常；未处理的异常会自动传递给调用者，然后传递给调用者的调用者，依此类推，直到他们到达顶级解释器，在那里将它们报告给用户并伴随堆栈回溯。

For C programmers, however, error checking always has to be explicit. All functions in the Python/C API can raise exceptions, unless an explicit claim is made otherwise in a function' s documentation. In general, when a function encounters an error, it sets an exception, discards any object references that it owns, and returns an error indicator. If not documented otherwise, this indicator is either *NULL* or `-1`, depending on the function' s return type. A few functions return a Boolean true/false result, with false indicating an error. Very few functions return no explicit error indicator or have an ambiguous return value, and require explicit testing for errors with `PyErr_Occurred()`. These exceptions are always explicitly documented.

Exception state is maintained in per-thread storage (this is equivalent to using global storage in an unthreaded application). A thread can be in one of two states: an exception has occurred, or not. The function `PyErr_Occurred()` can be used to check for this: it returns a borrowed reference to the exception type object when an exception has occurred, and *NULL* otherwise. There are a number of functions to set the exception state: `PyErr_SetString()` is the most common (though not the most general) function to set the exception state, and `PyErr_Clear()` clears the exception state.

The full exception state consists of three objects (all of which can be *NULL*): the exception type, the corresponding exception value, and the traceback. These have the same meanings as the Python objects `sys.exc_type`, `sys.exc_value`, and `sys.exc_traceback`; however, they are not the same: the Python objects represent the last exception being handled by a Python `try` …`except` statement, while the C level exception state only exists while an exception is being passed on between C functions until it reaches the Python bytecode interpreter' s main loop, which takes care of transferring it to `sys.exc_type` and friends.

Note that starting with Python 1.5, the preferred, thread-safe way to access the exception state from Python code is to call the function `sys.exc_info()`, which returns the per-thread exception state for Python code. Also, the semantics of both ways to access the exception state have changed so that a function which catches an exception will save and restore its thread' s exception state so as to preserve the exception state of its caller. This prevents common bugs in exception handling code caused by an innocent-looking function overwriting the exception being handled; it also reduces the often unwanted lifetime extension for objects that are referenced by the stack frames in the traceback.

As a general principle, a function that calls another function to perform some task should check whether the called function raised an exception, and if so, pass the exception state on to its caller. It should discard any object references that it owns, and return an error indicator, but it should *not* set another exception —that would overwrite the exception that was just raised, and lose important information about the exact cause of the error.

A simple example of detecting exceptions and passing them on is shown in the `sum_sequence()` example above. It so happens that this example doesn' t need to clean up any owned references when it detects an error. The following example function shows some error cleanup. First, to remind you why you like Python, we show the equivalent Python code:

```
def incr_item(dict, key):
    try:
        item = dict[key]
    except KeyError:
        item = 0
    dict[key] = item + 1
```

Here is the corresponding C code, in all its glory:

```
int
incr_item(PyObject *dict, PyObject *key)
{
    /* Objects all initialized to NULL for Py_XDECREF */
    PyObject *item = NULL, *const_one = NULL, *incremented_item = NULL;
    int rv = -1; /* Return value initialized to -1 (failure) */

    item = PyObject_GetItem(dict, key);
    if (item == NULL) {
        /* Handle KeyError only: */
        if (!PyErr_ExceptionMatches(PyExc_KeyError))
            goto error;

        /* Clear the error and use zero: */
        PyErr_Clear();
        item = PyInt_FromLong(0L);
        if (item == NULL)
            goto error;
    }
    const_one = PyInt_FromLong(1L);
    if (const_one == NULL)
        goto error;

    incremented_item = PyNumber_Add(item, const_one);
    if (incremented_item == NULL)
        goto error;

    if (PyObject_SetItem(dict, key, incremented_item) < 0)
        goto error;
    rv = 0; /* Success */
    /* Continue with cleanup code */
```

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```
error:
    /* Cleanup code, shared by success and failure path */

    /* Use Py_XDECREF() to ignore NULL references */
    Py_XDECREF(item);
    Py_XDECREF(const_one);
    Py_XDECREF(incremented_item);

    return rv; /* -1 for error, 0 for success */
}
```

This example represents an endorsed use of the `goto` statement in C! It illustrates the use of *PyErr_ExceptionMatches()* and *PyErr_Clear()* to handle specific exceptions, and the use of *Py_XDECREF()* to dispose of owned references that may be *NULL* (note the `'X'` in the name; *Py_DECREF()* would crash when confronted with a *NULL* reference). It is important that the variables used to hold owned references are initialized to *NULL* for this to work; likewise, the proposed return value is initialized to `-1` (failure) and only set to success after the final call made is successful.

## 1.4 嵌入 Python

The one important task that only embedders (as opposed to extension writers) of the Python interpreter have to worry about is the initialization, and possibly the finalization, of the Python interpreter. Most functionality of the interpreter can only be used after the interpreter has been initialized.

The basic initialization function is *Py_Initialize()*. This initializes the table of loaded modules, and creates the fundamental modules `__builtin__`, `__main__`, `sys`, and `exceptions`. It also initializes the module search path (`sys.path`).

*Py_Initialize()* does not set the "script argument list" (`sys.argv`). If this variable is needed by Python code that will be executed later, it must be set explicitly with a call to `PySys_SetArgvEx(argc, argv, updatepath)` after the call to *Py_Initialize()*.

On most systems (in particular, on Unix and Windows, although the details are slightly different), *Py_Initialize()* calculates the module search path based upon its best guess for the location of the standard Python interpreter executable, assuming that the Python library is found in a fixed location relative to the Python interpreter executable. In particular, it looks for a directory named `lib/pythonX.Y` relative to the parent directory where the executable named `python` is found on the shell command search path (the environment variable `PATH`).

For instance, if the Python executable is found in `/usr/local/bin/python`, it will assume that the libraries are in `/usr/local/lib/pythonX.Y`. (In fact, this particular path is also the "fallback" location, used when no executable file named `python` is found along `PATH`.) The user can override this behavior by setting the environment variable `PYTHONHOME`, or insert additional directories in front of the standard path by setting `PYTHONPATH`.

The embedding application can steer the search by calling `Py_SetProgramName(file)` *before* calling *Py_Initialize()*. Note that `PYTHONHOME` still overrides this and `PYTHONPATH` is still inserted in front of the standard path. An application that requires total control has to provide its own implementation of *Py_GetPath()*, *Py_GetPrefix()*, *Py_GetExecPrefix()*, and *Py_GetProgramFullPath()* (all defined in `Modules/getpath.c`).

Sometimes, it is desirable to "uninitialize" Python. For instance, the application may want to start over (make another call to *Py_Initialize()*) or the application is simply done with its use of Python and wants to free memory allocated by Python. This can be accomplished by calling *Py_Finalize()*. The function *Py_IsInitialized()* returns true if Python is currently in the initialized state. More information about these functions is given in a later chapter. Notice that *Py_Finalize()* does *not* free all memory allocated by the Python interpreter, e.g. memory allocated by extension modules currently cannot be released.

## 1.5 调试构建

Python can be built with several macros to enable extra checks of the interpreter and extension modules. These checks tend to add a large amount of overhead to the runtime so they are not enabled by default.

A full list of the various types of debugging builds is in the file `Misc/SpecialBuilds.txt` in the Python source distribution. Builds are available that support tracing of reference counts, debugging the memory allocator, or low-level profiling of the main interpreter loop. Only the most frequently-used builds will be described in the remainder of this section.

Compiling the interpreter with the `Py_DEBUG` macro defined produces what is generally meant by "a debug build" of Python. `Py_DEBUG` is enabled in the Unix build by adding `--with-pydebug` to the `./configure` command. It is also implied by the presence of the not-Python-specific `_DEBUG` macro. When `Py_DEBUG` is enabled in the Unix build, compiler optimization is disabled.

除了前面描述的引用计数调试之外，还执行以下额外检查：

- 额外检查将添加到对象分配器。
- 额外的检查将添加到解析器和编译器中。
- Downcasts from wide types to narrow types are checked for loss of information.
- 许多断言被添加到字典和集合实现中。另外，集合对象包含 `test_c_api()` 方法。
- 添加输入参数的完整性检查到框架创建中。
- The storage for long ints is initialized with a known invalid pattern to catch reference to uninitialized digits.
- 添加底层跟踪和额外的异常检查到虚拟机的运行时中。
- Extra checks are added to the memory arena implementation.
- 添加额外调试到线程模块。

这里可能没有提到的额外的检查。

Defining `Py_TRACE_REFS` enables reference tracing. When defined, a circular doubly linked list of active objects is maintained by adding two extra fields to every *PyObject*. Total allocations are tracked as well. Upon exit, all existing references are printed. (In interactive mode this happens after every statement run by the interpreter.) Implied by `Py_DEBUG`.

有关更多详细信息，请参阅 Python 源代码中的 `Misc/SpecialBuilds.txt` 。

# CHAPTER 2

# The Very High Level Layer

The functions in this chapter will let you execute Python source code given in a file or a buffer, but they will not let you interact in a more detailed way with the interpreter.

Several of these functions accept a start symbol from the grammar as a parameter. The available start symbols are `Py_eval_input`, `Py_file_input`, and `Py_single_input`. These are described following the functions which accept them as parameters.

Note also that several of these functions take `FILE*` parameters. One particular issue which needs to be handled carefully is that the `FILE` structure for different C libraries can be different and incompatible. Under Windows (at least), it is possible for dynamically linked extensions to actually use different libraries, so care should be taken that `FILE*` parameters are only passed to these functions if it is certain that they were created by the same library that the Python runtime is using.

int **Py_Main**(int *argc*, char ***argv*)

The main program for the standard interpreter. This is made available for programs which embed Python. The *argc* and *argv* parameters should be prepared exactly as those which are passed to a C program's `main()` function. It is important to note that the argument list may be modified (but the contents of the strings pointed to by the argument list are not). The return value will be `0` if the interpreter exits normally (ie, without an exception), `1` if the interpreter exits due to an exception, or `2` if the parameter list does not represent a valid Python command line.

Note that if an otherwise unhandled `SystemExit` is raised, this function will not return `1`, but exit the process, as long as `Py_InspectFlag` is not set.

int **PyRun_AnyFile**(FILE **fp*, const char **filename*)

This is a simplified interface to `PyRun_AnyFileExFlags()` below, leaving *closeit* set to `0` and *flags* set to *NULL*.

int **PyRun_AnyFileFlags**(FILE **fp*, const char **filename*, *PyCompilerFlags* **flags*)

This is a simplified interface to `PyRun_AnyFileExFlags()` below, leaving the *closeit* argument set to `0`.

int **PyRun_AnyFileEx**(FILE **fp*, const char **filename*, int *closeit*)

This is a simplified interface to `PyRun_AnyFileExFlags()` below, leaving the *flags* argument set to *NULL*.

int **PyRun_AnyFileExFlags**(FILE **fp*, const char **filename*, int *closeit*, *PyCompilerFlags* **flags*)

If *fp* refers to a file associated with an interactive device (console or terminal input or Unix pseudo-terminal), return the value of `PyRun_InteractiveLoop()`, otherwise return the result of `PyRun_SimpleFile()`. If *filename* is *NULL*, this function uses `"???"` as the filename.

int **PyRun_SimpleString**(const char **command*)
This is a simplified interface to `PyRun_SimpleStringFlags()` below, leaving the *PyCompilerFlags** argument set to NULL.

int **PyRun_SimpleStringFlags**(const char **command*, PyCompilerFlags **flags*)
Executes the Python source code from *command* in the `__main__` module according to the *flags* argument. If `__main__` does not already exist, it is created. Returns `0` on success or `-1` if an exception was raised. If there was an error, there is no way to get the exception information. For the meaning of *flags*, see below.

Note that if an otherwise unhandled `SystemExit` is raised, this function will not return `-1`, but exit the process, as long as `Py_InspectFlag` is not set.

int **PyRun_SimpleFile**(FILE **fp*, const char **filename*)
This is a simplified interface to `PyRun_SimpleFileExFlags()` below, leaving *closeit* set to `0` and *flags* set to *NULL*.

int **PyRun_SimpleFileFlags**(FILE **fp*, const char **filename*, PyCompilerFlags **flags*)
This is a simplified interface to `PyRun_SimpleFileExFlags()` below, leaving *closeit* set to `0`.

int **PyRun_SimpleFileEx**(FILE **fp*, const char **filename*, int *closeit*)
This is a simplified interface to `PyRun_SimpleFileExFlags()` below, leaving *flags* set to *NULL*.

int **PyRun_SimpleFileExFlags**(FILE **fp*, const char **filename*, int *closeit*, PyCompilerFlags **flags*)
Similar to `PyRun_SimpleStringFlags()`, but the Python source code is read from *fp* instead of an in-memory string. *filename* should be the name of the file. If *closeit* is true, the file is closed before PyRun_SimpleFileExFlags returns.

int **PyRun_InteractiveOne**(FILE **fp*, const char **filename*)
This is a simplified interface to `PyRun_InteractiveOneFlags()` below, leaving *flags* set to *NULL*.

int **PyRun_InteractiveOneFlags**(FILE **fp*, const char **filename*, PyCompilerFlags **flags*)
Read and execute a single statement from a file associated with an interactive device according to the *flags* argument. The user will be prompted using `sys.ps1` and `sys.ps2`. Returns `0` when the input was executed successfully, `-1` if there was an exception, or an error code from the `errcode.h` include file distributed as part of Python if there was a parse error. (Note that `errcode.h` is not included by `Python.h`, so must be included specifically if needed.)

int **PyRun_InteractiveLoop**(FILE **fp*, const char **filename*)
This is a simplified interface to `PyRun_InteractiveLoopFlags()` below, leaving *flags* set to *NULL*.

int **PyRun_InteractiveLoopFlags**(FILE **fp*, const char **filename*, PyCompilerFlags **flags*)
Read and execute statements from a file associated with an interactive device until EOF is reached. The user will be prompted using `sys.ps1` and `sys.ps2`. Returns `0` at EOF.

struct _node* **PyParser_SimpleParseString**(const char **str*, int *start*)
This is a simplified interface to `PyParser_SimpleParseStringFlagsFilename()` below, leaving *filename* set to *NULL* and *flags* set to `0`.

struct _node* **PyParser_SimpleParseStringFlags**(const char **str*, int *start*, int *flags*)
This is a simplified interface to `PyParser_SimpleParseStringFlagsFilename()` below, leaving *filename* set to *NULL*.

struct _node* **PyParser_SimpleParseStringFlagsFilename**(const char **str*, const char **filename*, int *start*, int *flags*)
Parse Python source code from *str* using the start token *start* according to the *flags* argument. The result can be used to create a code object which can be evaluated efficiently. This is useful if a code fragment must be evaluated many times.

struct _node* **PyParser_SimpleParseFile**(FILE **fp*, const char **filename*, int *start*)
This is a simplified interface to `PyParser_SimpleParseFileFlags()` below, leaving *flags* set to `0`.

struct _node* **PyParser_SimpleParseFileFlags**(FILE **fp*, const char **filename*, int *start*, int *flags*)
Similar to `PyParser_SimpleParseStringFlagsFilename()`, but the Python source code is read from *fp* instead of an in-memory string.

*PyObject** **PyRun_String**(const char **str*, int *start*, *PyObject* **globals*, *PyObject* **locals*)
*Return value: New reference.* This is a simplified interface to `PyRun_StringFlags()` below, leaving *flags* set to *NULL*.

*PyObject** **PyRun_StringFlags**(const char **str*, int *start*, *PyObject* **globals*, *PyObject* **locals*, *PyCompilerFlags* **flags*)
*Return value: New reference.* Execute Python source code from *str* in the context specified by the dictionaries *globals* and *locals* with the compiler flags specified by *flags*. The parameter *start* specifies the start token that should be used to parse the source code.

Returns the result of executing the code as a Python object, or *NULL* if an exception was raised.

*PyObject** **PyRun_File**(FILE **fp*, const char **filename*, int *start*, *PyObject* **globals*, *PyObject* **locals*)
*Return value: New reference.* This is a simplified interface to `PyRun_FileExFlags()` below, leaving *closeit* set to `0` and *flags* set to *NULL*.

*PyObject** **PyRun_FileEx**(FILE **fp*, const char **filename*, int *start*, *PyObject* **globals*, *PyObject* **locals*, int *closeit*)
*Return value: New reference.* This is a simplified interface to `PyRun_FileExFlags()` below, leaving *flags* set to *NULL*.

*PyObject** **PyRun_FileFlags**(FILE **fp*, const char **filename*, int *start*, *PyObject* **globals*, *PyObject* **locals*, *PyCompilerFlags* **flags*)
*Return value: New reference.* This is a simplified interface to `PyRun_FileExFlags()` below, leaving *closeit* set to `0`.

*PyObject** **PyRun_FileExFlags**(FILE **fp*, const char **filename*, int *start*, *PyObject* **globals*, *PyObject* **locals*, int *closeit*, *PyCompilerFlags* **flags*)
*Return value: New reference.* Similar to `PyRun_StringFlags()`, but the Python source code is read from *fp* instead of an in-memory string. *filename* should be the name of the file. If *closeit* is true, the file is closed before `PyRun_FileExFlags()` returns.

*PyObject** **Py_CompileString**(const char **str*, const char **filename*, int *start*)
*Return value: New reference.* This is a simplified interface to `Py_CompileStringFlags()` below, leaving *flags* set to *NULL*.

*PyObject** **Py_CompileStringFlags**(const char **str*, const char **filename*, int *start*, *PyCompilerFlags* **flags*)
*Return value: New reference.* Parse and compile the Python source code in *str*, returning the resulting code object. The start token is given by *start*; this can be used to constrain the code which can be compiled and should be `Py_eval_input`, `Py_file_input`, or `Py_single_input`. The filename specified by *filename* is used to construct the code object and may appear in tracebacks or `SyntaxError` exception messages. This returns *NULL* if the code cannot be parsed or compiled.

*PyObject** **PyEval_EvalCode**(*PyCodeObject* **co*, *PyObject* **globals*, *PyObject* **locals*)
*Return value: New reference.* This is a simplified interface to `PyEval_EvalCodeEx()`, with just the code object, and the dictionaries of global and local variables. The other arguments are set to *NULL*.

*PyObject** **PyEval_EvalCodeEx**(*PyCodeObject* **co*, *PyObject* **globals*, *PyObject* **locals*, *PyObject* ***args*, int *argcount*, *PyObject* ***kws*, int *kwcount*, *PyObject* ***defs*, int *defcount*, *PyObject* **closure*)
Evaluate a precompiled code object, given a particular environment for its evaluation. This environment consists of dictionaries of global and local variables, arrays of arguments, keywords and defaults, and a closure tuple of cells.

*PyObject** **PyEval_EvalFrame** (PyFrameObject **f*)
Evaluate an execution frame. This is a simplified interface to PyEval_EvalFrameEx, for backward compatibility.

*PyObject** **PyEval_EvalFrameEx** (PyFrameObject **f*, int *throwflag*)
This is the main, unvarnished function of Python interpretation. It is literally 2000 lines long. The code object associated with the execution frame *f* is executed, interpreting bytecode and executing calls as needed. The additional *throwflag* parameter can mostly be ignored - if true, then it causes an exception to immediately be thrown; this is used for the `throw()` methods of generator objects.

int **PyEval_MergeCompilerFlags** (*PyCompilerFlags* **cf*)
This function changes the flags of the current evaluation frame, and returns true on success, false on failure.

int **Py_eval_input**
The start symbol from the Python grammar for isolated expressions; for use with `Py_CompileString()`.

int **Py_file_input**
The start symbol from the Python grammar for sequences of statements as read from a file or other source; for use with `Py_CompileString()`. This is the symbol to use when compiling arbitrarily long Python source code.

int **Py_single_input**
The start symbol from the Python grammar for a single statement; for use with `Py_CompileString()`. This is the symbol used for the interactive interpreter loop.

struct **PyCompilerFlags**
This is the structure used to hold compiler flags. In cases where code is only being compiled, it is passed as `int flags`, and in cases where code is being executed, it is passed as `PyCompilerFlags *flags`. In this case, `from __future__ import` can modify *flags*.

Whenever `PyCompilerFlags *flags` is *NULL*, `cf_flags` is treated as equal to `0`, and any modification due to `from __future__ import` is discarded.

```
struct PyCompilerFlags {
    int cf_flags;
}
```

int **CO_FUTURE_DIVISION**
This bit can be set in *flags* to cause division operator `/` to be interpreted as "true division" according to **PEP 238**.

CHAPTER 3

# 引用计数

本节介绍的宏被用于管理 Python 对象的引用计数。

void **Py_INCREF**(*PyObject* **o*)

Increment the reference count for object *o*. The object must not be *NULL*; if you aren't sure that it isn't *NULL*, use `Py_XINCREF()`.

void **Py_XINCREF**(*PyObject* **o*)

Increment the reference count for object *o*. The object may be *NULL*, in which case the macro has no effect.

void **Py_DECREF**(*PyObject* **o*)

Decrement the reference count for object *o*. The object must not be *NULL*; if you aren't sure that it isn't *NULL*, use `Py_XDECREF()`. If the reference count reaches zero, the object's type's deallocation function (which must not be *NULL*) is invoked.

> **警告：** 释放函数可导致任意 Python 代码被发起调用（例如当一个带有 `__del__()` 方法的类实例被释放时就是如此）。虽然此类代码中的异常不会被传播，但被执行的代码能够自由访问所有 Python 全局变量。这意味着任何可通过全局变量获取的对象在`Py_DECREF()` 被发起调用之前都应当处于完好状态。例如，从一个列表中删除对象的代码应当将被删除对象的引用拷贝到一个临时变量中，更新列表数据结构，然后再为临时变量调用`Py_DECREF()`。

void **Py_XDECREF**(*PyObject* **o*)

Decrement the reference count for object *o*. The object may be *NULL*, in which case the macro has no effect; otherwise the effect is the same as for `Py_DECREF()`, and the same warning applies.

void **Py_CLEAR**(*PyObject* **o*)

Decrement the reference count for object *o*. The object may be *NULL*, in which case the macro has no effect; otherwise the effect is the same as for `Py_DECREF()`, except that the argument is also set to *NULL*. The warning for `Py_DECREF()` does not apply with respect to the object passed because the macro carefully uses a temporary variable and sets the argument to *NULL* before decrementing its reference count.

当要减少在垃圾回收期间可能会被遍历的变量的值时，使用该宏是一个好主意。

2.4 新版功能.

以下函数适用于 Python 的运行时动态嵌入: `Py_IncRef(PyObject *o)`, `Py_DecRef(PyObject *o)`。它们分别只是*Py_XINCREF()* 和*Py_XDECREF()* 的简单导出函数版本。

以下函数或宏仅可在解释器核心内部使用: `_Py_Dealloc()`, `_Py_ForgetReference()`, `_Py_NewReference()` 以及全局变量 `_Py_RefTotal`。

CHAPTER 4

# 异常处理

The functions described in this chapter will let you handle and raise Python exceptions. It is important to understand some of the basics of Python exception handling. It works somewhat like the Unix `errno` variable: there is a global indicator (per thread) of the last error that occurred. Most functions don't clear this on success, but will set it to indicate the cause of the error on failure. Most functions also return an error indicator, usually *NULL* if they are supposed to return a pointer, or `-1` if they return an integer (exception: the `PyArg_*()` functions return `1` for success and `0` for failure).

When a function must fail because some function it called failed, it generally doesn't set the error indicator; the function it called already set it. It is responsible for either handling the error and clearing the exception or returning after cleaning up any resources it holds (such as object references or memory allocations); it should *not* continue normally if it is not prepared to handle the error. If returning due to an error, it is important to indicate to the caller that an error has been set. If the error is not handled or carefully propagated, additional calls into the Python/C API may not behave as intended and may fail in mysterious ways.

The error indicator consists of three Python objects corresponding to the Python variables `sys.exc_type`, `sys.exc_value` and `sys.exc_traceback`. API functions exist to interact with the error indicator in various ways. There is a separate error indicator for each thread.

void **PyErr_PrintEx**(int *set_sys_last_vars*)

Print a standard traceback to `sys.stderr` and clear the error indicator. **Unless** the error is a `SystemExit`. In that case the no traceback is printed and Python process will exit with the error code specified by the `SystemExit` instance.

Call this function **only** when the error indicator is set. Otherwise it will cause a fatal error!

If *set_sys_last_vars* is nonzero, the variables `sys.last_type`, `sys.last_value` and `sys.last_traceback` will be set to the type, value and traceback of the printed exception, respectively.

void **PyErr_Print**()

Alias for `PyErr_PrintEx(1)`.

*PyObject** **PyErr_Occurred**()

*Return value: Borrowed reference.* Test whether the error indicator is set. If set, return the exception *type* (the first argument to the last call to one of the `PyErr_Set*()` functions or to *`PyErr_Restore()`*). If not set, return *NULL*. You do not own a reference to the return value, so you do not need to *`Py_DECREF()`* it.

**注解:** Do not compare the return value to a specific exception; use *PyErr_ExceptionMatches()* instead, shown below. (The comparison could easily fail since the exception may be an instance instead of a class, in the case of a class exception, or it may be a subclass of the expected exception.)

int **PyErr_ExceptionMatches**(*PyObject* *exc*)
Equivalent to `PyErr_GivenExceptionMatches(PyErr_Occurred(), exc)`. This should only be called when an exception is actually set; a memory access violation will occur if no exception has been raised.

int **PyErr_GivenExceptionMatches**(*PyObject* *given*, *PyObject* *exc*)
Return true if the *given* exception matches the exception in *exc*. If *exc* is a class object, this also returns true when *given* is an instance of a subclass. If *exc* is a tuple, all exceptions in the tuple (and recursively in subtuples) are searched for a match.

void **PyErr_NormalizeException**(*PyObject***exc, *PyObject***val, *PyObject***tb)
Under certain circumstances, the values returned by *PyErr_Fetch()* below can be "unnormalized", meaning that `*exc` is a class object but `*val` is not an instance of the same class. This function can be used to instantiate the class in that case. If the values are already normalized, nothing happens. The delayed normalization is implemented to improve performance.

void **PyErr_Clear**()
Clear the error indicator. If the error indicator is not set, there is no effect.

void **PyErr_Fetch**(*PyObject* ***ptype*, *PyObject* ***pvalue*, *PyObject* ***ptraceback*)
Retrieve the error indicator into three variables whose addresses are passed. If the error indicator is not set, set all three variables to *NULL*. If it is set, it will be cleared and you own a reference to each object retrieved. The value and traceback object may be *NULL* even when the type object is not.

**注解:** This function is normally only used by code that needs to handle exceptions or by code that needs to save and restore the error indicator temporarily.

void **PyErr_Restore**(*PyObject* *type*, *PyObject* *value*, *PyObject* *traceback*)
Set the error indicator from the three objects. If the error indicator is already set, it is cleared first. If the objects are *NULL*, the error indicator is cleared. Do not pass a *NULL* type and non-*NULL* value or traceback. The exception type should be a class. Do not pass an invalid exception type or value. (Violating these rules will cause subtle problems later.) This call takes away a reference to each object: you must own a reference to each object before the call and after the call you no longer own these references. (If you don't understand this, don't use this function. I warned you.)

**注解:** This function is normally only used by code that needs to save and restore the error indicator temporarily; use *PyErr_Fetch()* to save the current exception state.

void **PyErr_SetString**(*PyObject* *type*, const char *message*)
This is the most common way to set the error indicator. The first argument specifies the exception type; it is normally one of the standard exceptions, e.g. `PyExc_RuntimeError`. You need not increment its reference count. The second argument is an error message; it is converted to a string object.

void **PyErr_SetObject**(*PyObject* *type*, *PyObject* *value*)
This function is similar to *PyErr_SetString()* but lets you specify an arbitrary Python object for the "value" of the exception.

*PyObject** **PyErr_Format**(*PyObject* *exception*, const char *format*, ...)
*Return value: Always NULL.* This function sets the error indicator and returns *NULL*. *exception* should be a Python

exception class. The *format* and subsequent parameters help format the error message; they have the same meaning and values as in `PyString_FromFormat()`.

void **PyErr_SetNone**(*PyObject *type*)
This is a shorthand for `PyErr_SetObject(type, Py_None)`.

int **PyErr_BadArgument**()
This is a shorthand for `PyErr_SetString(PyExc_TypeError, message)`, where *message* indicates that a built-in operation was invoked with an illegal argument. It is mostly for internal use.

*PyObject** **PyErr_NoMemory**()
*Return value: Always NULL.* This is a shorthand for `PyErr_SetNone(PyExc_MemoryError)`; it returns *NULL* so an object allocation function can write `return PyErr_NoMemory();` when it runs out of memory.

*PyObject** **PyErr_SetFromErrno**(*PyObject *type*)
*Return value: Always NULL.* This is a convenience function to raise an exception when a C library function has returned an error and set the C variable `errno`. It constructs a tuple object whose first item is the integer `errno` value and whose second item is the corresponding error message (gotten from `strerror()`), and then calls `PyErr_SetObject(type, object)`. On Unix, when the `errno` value is `EINTR`, indicating an interrupted system call, this calls `PyErr_CheckSignals()`, and if that set the error indicator, leaves it set to that. The function always returns *NULL*, so a wrapper function around a system call can write `return PyErr_SetFromErrno(type);` when the system call returns an error.

*PyObject** **PyErr_SetFromErrnoWithFilenameObject**(*PyObject *type*, *PyObject *filenameObject*)
Similar to `PyErr_SetFromErrno()`, with the additional behavior that if *filenameObject* is not *NULL*, it is passed to the constructor of *type* as a third parameter. In the case of exceptions such as `IOError` and `OSError`, this is used to define the `filename` attribute of the exception instance.

*PyObject** **PyErr_SetFromErrnoWithFilename**(*PyObject *type*, const char **filename*)
*Return value: Always NULL.* Similar to `PyErr_SetFromErrnoWithFilenameObject()`, but the filename is given as a C string.

*PyObject** **PyErr_SetFromWindowsErr**(int *ierr*)
*Return value: Always NULL.* This is a convenience function to raise `WindowsError`. If called with *ierr* of `0`, the error code returned by a call to `GetLastError()` is used instead. It calls the Win32 function `FormatMessage()` to retrieve the Windows description of error code given by *ierr* or `GetLastError()`, then it constructs a tuple object whose first item is the *ierr* value and whose second item is the corresponding error message (gotten from `FormatMessage()`), and then calls `PyErr_SetObject(PyExc_WindowsError, object)`. This function always returns *NULL*. Availability: Windows.

*PyObject** **PyErr_SetExcFromWindowsErr**(*PyObject *type*, int *ierr*)
*Return value: Always NULL.* Similar to `PyErr_SetFromWindowsErr()`, with an additional parameter specifying the exception type to be raised. Availability: Windows.

2.3 新版功能.

*PyObject** **PyErr_SetFromWindowsErrWithFilenameObject**(int *ierr*, *PyObject *filenameObject*)
Similar to `PyErr_SetFromWindowsErr()`, with the additional behavior that if *filenameObject* is not *NULL*, it is passed to the constructor of `WindowsError` as a third parameter. Availability: Windows.

*PyObject** **PyErr_SetFromWindowsErrWithFilename**(int *ierr*, const char **filename*)
*Return value: Always NULL.* Similar to `PyErr_SetFromWindowsErrWithFilenameObject()`, but the filename is given as a C string. Availability: Windows.

*PyObject** **PyErr_SetExcFromWindowsErrWithFilenameObject**(*PyObject *type*, int *ierr*, *PyObject *filename*)
Similar to `PyErr_SetFromWindowsErrWithFilenameObject()`, with an additional parameter specifying the exception type to be raised. Availability: Windows.

2.3 新版功能.

*PyObject** **PyErr_SetExcFromWindowsErrWithFilename**(*PyObject *type*, int *ierr*, const char **filename*)
*Return value: Always NULL.* Similar to `PyErr_SetFromWindowsErrWithFilename()`, with an additional parameter specifying the exception type to be raised. Availability: Windows.

2.3 新版功能.

void **PyErr_BadInternalCall**()
This is a shorthand for `PyErr_SetString(PyExc_SystemError, message)`, where *message* indicates that an internal operation (e.g. a Python/C API function) was invoked with an illegal argument. It is mostly for internal use.

int **PyErr_WarnEx**(*PyObject *category*, char **message*, int *stacklevel*)
Issue a warning message. The *category* argument is a warning category (see below) or *NULL*; the *message* argument is a message string. *stacklevel* is a positive number giving a number of stack frames; the warning will be issued from the currently executing line of code in that stack frame. A *stacklevel* of 1 is the function calling `PyErr_WarnEx()`, 2 is the function above that, and so forth.

This function normally prints a warning message to *sys.stderr*; however, it is also possible that the user has specified that warnings are to be turned into errors, and in that case this will raise an exception. It is also possible that the function raises an exception because of a problem with the warning machinery (the implementation imports the `warnings` module to do the heavy lifting). The return value is `0` if no exception is raised, or `-1` if an exception is raised. (It is not possible to determine whether a warning message is actually printed, nor what the reason is for the exception; this is intentional.) If an exception is raised, the caller should do its normal exception handling (for example, `Py_DECREF()` owned references and return an error value).

Warning categories must be subclasses of `PyExc_Warning`; `PyExc_Warning` is a subclass of `PyExc_Exception`; the default warning category is `PyExc_RuntimeWarning`. The standard Python warning categories are available as global variables whose names are enumerated at 标准警告类别.

For information about warning control, see the documentation for the `warnings` module and the `-W` option in the command line documentation. There is no C API for warning control.

int **PyErr_Warn**(*PyObject *category*, char **message*)
Issue a warning message. The *category* argument is a warning category (see below) or *NULL*; the *message* argument is a message string. The warning will appear to be issued from the function calling `PyErr_Warn()`, equivalent to calling `PyErr_WarnEx()` with a *stacklevel* of 1.

Deprecated; use `PyErr_WarnEx()` instead.

int **PyErr_WarnExplicit**(*PyObject *category*, const char **message*, const char **filename*, int *lineno*, const char **module*, *PyObject *registry*)
Issue a warning message with explicit control over all warning attributes. This is a straightforward wrapper around the Python function `warnings.warn_explicit()`, see there for more information. The *module* and *registry* arguments may be set to *NULL* to get the default effect described there.

int **PyErr_WarnPy3k**(char **message*, int *stacklevel*)
Issue a `DeprecationWarning` with the given *message* and *stacklevel* if the `Py_Py3kWarningFlag` flag is enabled.

2.6 新版功能.

int **PyErr_CheckSignals**()
This function interacts with Python’s signal handling. It checks whether a signal has been sent to the processes and if so, invokes the corresponding signal handler. If the `signal` module is supported, this can invoke a signal handler written in Python. In all cases, the default effect for `SIGINT` is to raise the `KeyboardInterrupt` exception. If an exception is raised the error indicator is set and the function returns `-1`; otherwise the function returns `0`. The error indicator may or may not be cleared if it was previously set.

void **PyErr_SetInterrupt**()
This function simulates the effect of a `SIGINT` signal arriving —the next time `PyErr_CheckSignals()` is

called, `KeyboardInterrupt` will be raised. It may be called without holding the interpreter lock.

int **PySignal_SetWakeupFd**(int *fd*)
This utility function specifies a file descriptor to which a `'\0'` byte will be written whenever a signal is received. It returns the previous such file descriptor. The value `-1` disables the feature; this is the initial state. This is equivalent to `signal.set_wakeup_fd()` in Python, but without any error checking. *fd* should be a valid file descriptor. The function should only be called from the main thread.

2.6 新版功能.

*PyObject** **PyErr_NewException**(char **name*, *PyObject* **base*, *PyObject* **dict*)
*Return value: New reference.* This utility function creates and returns a new exception class. The *name* argument must be the name of the new exception, a C string of the form `module.classname`. The *base* and *dict* arguments are normally *NULL*. This creates a class object derived from `Exception` (accessible in C as `PyExc_Exception`).

The `__module__` attribute of the new class is set to the first part (up to the last dot) of the *name* argument, and the class name is set to the last part (after the last dot). The *base* argument can be used to specify alternate base classes; it can either be only one class or a tuple of classes. The *dict* argument can be used to specify a dictionary of class variables and methods.

*PyObject** **PyErr_NewExceptionWithDoc**(char **name*, char **doc*, *PyObject* **base*, *PyObject* **dict*)
*Return value: New reference.* Same as `PyErr_NewException()`, except that the new exception class can easily be given a docstring: If *doc* is non-*NULL*, it will be used as the docstring for the exception class.

2.7 新版功能.

void **PyErr_WriteUnraisable**(*PyObject* **obj*)
This utility function prints a warning message to `sys.stderr` when an exception has been set but it is impossible for the interpreter to actually raise the exception. It is used, for example, when an exception occurs in an `__del__()` method.

The function is called with a single argument *obj* that identifies the context in which the unraisable exception occurred. If possible, the repr of *obj* will be printed in the warning message.

## 4.1 Unicode Exception Objects

The following functions are used to create and modify Unicode exceptions from C.

*PyObject** **PyUnicodeDecodeError_Create**(const char **encoding*, const char **object*, Py_ssize_t *length*, Py_ssize_t *start*, Py_ssize_t *end*, const char **reason*)
Create a `UnicodeDecodeError` object with the attributes *encoding*, *object*, *length*, *start*, *end* and *reason*.

*PyObject** **PyUnicodeEncodeError_Create**(const char **encoding*, const *Py_UNICODE* **object*, Py_ssize_t *length*, Py_ssize_t *start*, Py_ssize_t *end*, const char **reason*)
Create a `UnicodeEncodeError` object with the attributes *encoding*, *object*, *length*, *start*, *end* and *reason*.

*PyObject** **PyUnicodeTranslateError_Create**(const *Py_UNICODE* **object*, Py_ssize_t *length*, Py_ssize_t *start*, Py_ssize_t *end*, const char **reason*)
Create a `UnicodeTranslateError` object with the attributes *object*, *length*, *start*, *end* and *reason*.

*PyObject** **PyUnicodeDecodeError_GetEncoding**(*PyObject* **exc*)
*PyObject** **PyUnicodeEncodeError_GetEncoding**(*PyObject* **exc*)
Return the *encoding* attribute of the given exception object.

*PyObject** **PyUnicodeDecodeError_GetObject**(*PyObject* **exc*)
*PyObject** **PyUnicodeEncodeError_GetObject**(*PyObject* **exc*)

*PyObject** **PyUnicodeTranslateError_GetObject**(*PyObject *exc*)
Return the *object* attribute of the given exception object.

int **PyUnicodeDecodeError_GetStart**(*PyObject *exc*, Py_ssize_t **start*)
int **PyUnicodeEncodeError_GetStart**(*PyObject *exc*, Py_ssize_t **start*)
int **PyUnicodeTranslateError_GetStart**(*PyObject *exc*, Py_ssize_t **start*)
Get the *start* attribute of the given exception object and place it into **start*. *start* must not be *NULL*. Return `0` on success, `-1` on failure.

int **PyUnicodeDecodeError_SetStart**(*PyObject *exc*, Py_ssize_t *start*)
int **PyUnicodeEncodeError_SetStart**(*PyObject *exc*, Py_ssize_t *start*)
int **PyUnicodeTranslateError_SetStart**(*PyObject *exc*, Py_ssize_t *start*)
Set the *start* attribute of the given exception object to *start*. Return `0` on success, `-1` on failure.

int **PyUnicodeDecodeError_GetEnd**(*PyObject *exc*, Py_ssize_t **end*)
int **PyUnicodeEncodeError_GetEnd**(*PyObject *exc*, Py_ssize_t **end*)
int **PyUnicodeTranslateError_GetEnd**(*PyObject *exc*, Py_ssize_t **end*)
Get the *end* attribute of the given exception object and place it into **end*. *end* must not be *NULL*. Return `0` on success, `-1` on failure.

int **PyUnicodeDecodeError_SetEnd**(*PyObject *exc*, Py_ssize_t *end*)
int **PyUnicodeEncodeError_SetEnd**(*PyObject *exc*, Py_ssize_t *end*)
int **PyUnicodeTranslateError_SetEnd**(*PyObject *exc*, Py_ssize_t *end*)
Set the *end* attribute of the given exception object to *end*. Return `0` on success, `-1` on failure.

*PyObject** **PyUnicodeDecodeError_GetReason**(*PyObject *exc*)
*PyObject** **PyUnicodeEncodeError_GetReason**(*PyObject *exc*)
*PyObject** **PyUnicodeTranslateError_GetReason**(*PyObject *exc*)
Return the *reason* attribute of the given exception object.

int **PyUnicodeDecodeError_SetReason**(*PyObject *exc*, const char **reason*)
int **PyUnicodeEncodeError_SetReason**(*PyObject *exc*, const char **reason*)
int **PyUnicodeTranslateError_SetReason**(*PyObject *exc*, const char **reason*)
Set the *reason* attribute of the given exception object to *reason*. Return `0` on success, `-1` on failure.

## 4.2 Recursion Control

These two functions provide a way to perform safe recursive calls at the C level, both in the core and in extension modules. They are needed if the recursive code does not necessarily invoke Python code (which tracks its recursion depth automatically).

int **Py_EnterRecursiveCall**(const char **where*)
Marks a point where a recursive C-level call is about to be performed.

If `USE_STACKCHECK` is defined, this function checks if the OS stack overflowed using `PyOS_CheckStack()`. In this is the case, it sets a `MemoryError` and returns a nonzero value.

The function then checks if the recursion limit is reached. If this is the case, a `RuntimeError` is set and a nonzero value is returned. Otherwise, zero is returned.

*where* should be a string such as `" in instance check"` to be concatenated to the `RuntimeError` message caused by the recursion depth limit.

void **Py_LeaveRecursiveCall**()
Ends a `Py_EnterRecursiveCall()`. Must be called once for each *successful* invocation of `Py_EnterRecursiveCall()`.

## 4.3 标准异常

All standard Python exceptions are available as global variables whose names are PyExc_ followed by the Python exception name. These have the type *PyObject**; they are all class objects. For completeness, here are all the variables:

| C 名称 | Python 名称 | 注释 |
|---|---|---|
| PyExc_BaseException | BaseException | (1), (4) |
| PyExc_Exception | Exception | (1) |
| PyExc_StandardError | StandardError | (1) |
| PyExc_ArithmeticError | ArithmeticError | (1) |
| PyExc_AssertionError | AssertionError | |
| PyExc_AttributeError | AttributeError | |
| PyExc_BufferError | BufferError | |
| PyExc_EnvironmentError | EnvironmentError | (1) |
| PyExc_EOFError | EOFError | |
| PyExc_FloatingPointError | FloatingPointError | |
| PyExc_GeneratorExit | GeneratorExit | |
| PyExc_ImportError | ImportError | |
| PyExc_IndentationError | IndentationError | |
| PyExc_IndexError | IndexError | |
| PyExc_IOError | IOError | |
| PyExc_KeyError | KeyError | |
| PyExc_KeyboardInterrupt | KeyboardInterrupt | |
| PyExc_LookupError | LookupError | (1) |
| PyExc_MemoryError | MemoryError | |
| PyExc_NameError | NameError | |
| PyExc_NotImplementedError | NotImplementedError | |
| PyExc_OSError | OSError | |
| PyExc_OverflowError | OverflowError | |
| PyExc_ReferenceError | ReferenceError | (2) |
| PyExc_RuntimeError | RuntimeError | |
| PyExc_StopIteration | StopIteration | |
| PyExc_SyntaxError | SyntaxError | |
| PyExc_SystemError | SystemError | |
| PyExc_SystemExit | SystemExit | |
| PyExc_TabError | TabError | |
| PyExc_TypeError | TypeError | |
| PyExc_UnboundLocalError | UnboundLocalError | |
| PyExc_UnicodeDecodeError | UnicodeDecodeError | |
| PyExc_UnicodeEncodeError | UnicodeEncodeError | |
| PyExc_UnicodeError | UnicodeError | |
| PyExc_UnicodeTranslateError | UnicodeTranslateError | |
| PyExc_VMSError | VMSError | (5) |
| PyExc_ValueError | ValueError | |
| PyExc_WindowsError | WindowsError | (3) |
| PyExc_ZeroDivisionError | ZeroDivisionError | |

注释:

(1) 这是其他标准异常的基类。

(2) This is the same as weakref.ReferenceError.

(3) Only defined on Windows; protect code that uses this by testing that the preprocessor macro MS_WINDOWS is defined.

(4) 2.5 新版功能.

(5) Only defined on VMS; protect code that uses this by testing that the preprocessor macro __VMS is defined.

## 4.4 标准警告类别

All standard Python warning categories are available as global variables whose names are PyExc_ followed by the Python exception name. These have the type *PyObject **; they are all class objects. For completeness, here are all the variables:

| C 名称 | Python 名称 | 注释 |
|---|---|---|
| PyExc_Warning | Warning | (1) |
| PyExc_BytesWarning | BytesWarning | |
| PyExc_DeprecationWarning | DeprecationWarning | |
| PyExc_FutureWarning | FutureWarning | |
| PyExc_ImportWarning | ImportWarning | |
| PyExc_PendingDeprecationWarning | PendingDeprecationWarning | |
| PyExc_RuntimeWarning | RuntimeWarning | |
| PyExc_SyntaxWarning | SyntaxWarning | |
| PyExc_UnicodeWarning | UnicodeWarning | |
| PyExc_UserWarning | UserWarning | |

注释:

(1) 这是其他标准警告类别的基类。

## 4.5 String Exceptions

在 2.6 版更改: All exceptions to be raised or caught must be derived from BaseException. Trying to raise a string exception now raises TypeError.

CHAPTER 5

# 工具

本章中的函数执行各种实用工具任务，包括帮助 C 代码提升跨平台可移植性，在 C 中使用 Python 模块，以及解析函数参数并根据 C 中的值构建 Python 中的值等等。

## 5.1 操作系统实用程序

int **Py_FdIsInteractive** (FILE **fp*, const char **filename*)

Return true (nonzero) if the standard I/O file *fp* with name *filename* is deemed interactive. This is the case for files for which `isatty(fileno(fp))` is true. If the global flag `Py_InteractiveFlag` is true, this function also returns true if the *filename* pointer is *NULL* or if the name is equal to one of the strings `'<stdin>'` or `'???'`.

void **PyOS_AfterFork** ()

Function to update some internal state after a process fork; this should be called in the new process if the Python interpreter will continue to be used. If a new executable is loaded into the new process, this function does not need to be called.

int **PyOS_CheckStack** ()

Return true when the interpreter runs out of stack space. This is a reliable check, but is only available when `USE_STACKCHECK` is defined (currently on Windows using the Microsoft Visual C++ compiler). `USE_STACKCHECK` will be defined automatically; you should never change the definition in your own code.

PyOS_sighandler_t **PyOS_getsig** (int *i*)

Return the current signal handler for signal *i*. This is a thin wrapper around either `sigaction()` or `signal()`. Do not call those functions directly! `PyOS_sighandler_t` is a typedef alias for `void (*)(int)`.

PyOS_sighandler_t **PyOS_setsig** (int *i*, PyOS_sighandler_t *h*)

Set the signal handler for signal *i* to be *h*; return the old signal handler. This is a thin wrapper around either `sigaction()` or `signal()`. Do not call those functions directly! `PyOS_sighandler_t` is a typedef alias for `void (*)(int)`.

## 5.2 系统功能

These are utility functions that make functionality from the `sys` module accessible to C code. They all work with the current interpreter thread’ s `sys` module’ s dict, which is contained in the internal thread state structure.

*PyObject* ***PySys_GetObject** (char **name*)
Return value: Borrowed reference. Return the object *name* from the `sys` module or *NULL* if it does not exist, without setting an exception.

FILE ***PySys_GetFile** (char **name*, FILE **def*)
Return the `FILE*` associated with the object *name* in the `sys` module, or *def* if *name* is not in the module or is not associated with a `FILE*`.

int **PySys_SetObject** (char **name*, *PyObject* **v*)
Set *name* in the `sys` module to *v* unless *v* is *NULL*, in which case *name* is deleted from the sys module. Returns `0` on success, `-1` on error.

void **PySys_ResetWarnOptions** ()
Reset `sys.warnoptions` to an empty list.

void **PySys_AddWarnOption** (char **s*)
Append *s* to `sys.warnoptions`.

void **PySys_SetPath** (char **path*)
Set `sys.path` to a list object of paths found in *path* which should be a list of paths separated with the platform’ s search path delimiter (`:` on Unix, `;` on Windows).

void **PySys_WriteStdout** (const char **format*, ...)
Write the output string described by *format* to `sys.stdout`. No exceptions are raised, even if truncation occurs (see below).

*format* should limit the total size of the formatted output string to 1000 bytes or less –after 1000 bytes, the output string is truncated. In particular, this means that no unrestricted “%s” formats should occur; these should be limited using “%.<N>s” where <N> is a decimal number calculated so that <N> plus the maximum size of other formatted text does not exceed 1000 bytes. Also watch out for “%f”, which can print hundreds of digits for very large numbers.

If a problem occurs, or `sys.stdout` is unset, the formatted message is written to the real (C level) *stdout*.

void **PySys_WriteStderr** (const char **format*, ...)
As above, but write to `sys.stderr` or *stderr* instead.

## 5.3 过程控制

void **Py_FatalError** (const char **message*)
Print a fatal error message and kill the process. No cleanup is performed. This function should only be invoked when a condition is detected that would make it dangerous to continue using the Python interpreter; e.g., when the object administration appears to be corrupted. On Unix, the standard C library function `abort()` is called which will attempt to produce a `core` file.

void **Py_Exit** (int *status*)
Exit the current process. This calls `Py_Finalize()` and then calls the standard C library function `exit(status)`.

int **Py_AtExit** (void (**func*)())
Register a cleanup function to be called by `Py_Finalize()`. The cleanup function will be called with no arguments and should return no value. At most 32 cleanup functions can be registered. When the registration is

successful, `Py_AtExit()` returns `0`; on failure, it returns `-1`. The cleanup function registered last is called first. Each cleanup function will be called at most once. Since Python's internal finalization will have completed before the cleanup function, no Python APIs should be called by *func*.

## 5.4 导入模块

*PyObject** **`PyImport_ImportModule`**(const char **name*)

*Return value: New reference.* This is a simplified interface to `PyImport_ImportModuleEx()` below, leaving the *globals* and *locals* arguments set to *NULL* and *level* set to 0. When the *name* argument contains a dot (when it specifies a submodule of a package), the *fromlist* argument is set to the list `['*']` so that the return value is the named module rather than the top-level package containing it as would otherwise be the case. (Unfortunately, this has an additional side effect when *name* in fact specifies a subpackage instead of a submodule: the submodules specified in the package's `__all__` variable are loaded.) Return a new reference to the imported module, or *NULL* with an exception set on failure. Before Python 2.4, the module may still be created in the failure case — examine `sys.modules` to find out. Starting with Python 2.4, a failing import of a module no longer leaves the module in `sys.modules`.

在 2.4 版更改: Failing imports remove incomplete module objects.

在 2.6 版更改: Always uses absolute imports.

*PyObject** **`PyImport_ImportModuleNoBlock`**(const char **name*)

This version of `PyImport_ImportModule()` does not block. It's intended to be used in C functions that import other modules to execute a function. The import may block if another thread holds the import lock. The function `PyImport_ImportModuleNoBlock()` never blocks. It first tries to fetch the module from sys.modules and falls back to `PyImport_ImportModule()` unless the lock is held, in which case the function will raise an `ImportError`.

2.6 新版功能.

*PyObject** **`PyImport_ImportModuleEx`**(char **name*, *PyObject* **globals*, *PyObject* **locals*, *PyObject* **fromlist*)

*Return value: New reference.* Import a module. This is best described by referring to the built-in Python function `__import__()`, as the standard `__import__()` function calls this function directly.

The return value is a new reference to the imported module or top-level package, or *NULL* with an exception set on failure (before Python 2.4, the module may still be created in this case). Like for `__import__()`, the return value when a submodule of a package was requested is normally the top-level package, unless a non-empty *fromlist* was given.

在 2.4 版更改: Failing imports remove incomplete module objects.

在 2.6 版更改: The function is an alias for `PyImport_ImportModuleLevel()` with `-1` as level, meaning relative import.

*PyObject** **`PyImport_ImportModuleLevel`**(char **name*, *PyObject* **globals*, *PyObject* **locals*, *PyObject* **fromlist*, int *level*)

*Return value: New reference.* Import a module. This is best described by referring to the built-in Python function `__import__()`, as the standard `__import__()` function calls this function directly.

The return value is a new reference to the imported module or top-level package, or *NULL* with an exception set on failure. Like for `__import__()`, the return value when a submodule of a package was requested is normally the top-level package, unless a non-empty *fromlist* was given.

2.5 新版功能.

*PyObject** **`PyImport_Import`**(*PyObject* **name*)

*Return value: New reference.* This is a higher-level interface that calls the current "import hook function". It invokes the `__import__()` function from the `__builtins__` of the current globals. This means that the import is done using whatever import hooks are installed in the current environment, e.g. by `rexec` or `ihooks`.

在 2.6 版更改: Always uses absolute imports.

*PyObject** **PyImport_ReloadModule**(*PyObject *m*)
*Return value: New reference.* Reload a module. This is best described by referring to the built-in Python function `reload()`, as the standard `reload()` function calls this function directly. Return a new reference to the reloaded module, or *NULL* with an exception set on failure (the module still exists in this case).

*PyObject** **PyImport_AddModule**(const char **name*)
*Return value: Borrowed reference.* Return the module object corresponding to a module name. The *name* argument may be of the form `package.module`. First check the modules dictionary if there' s one there, and if not, create a new one and insert it in the modules dictionary. Return *NULL* with an exception set on failure.

**注解:** This function does not load or import the module; if the module wasn' t already loaded, you will get an empty module object. Use `PyImport_ImportModule()` or one of its variants to import a module. Package structures implied by a dotted name for *name* are not created if not already present.

*PyObject** **PyImport_ExecCodeModule**(char **name*, *PyObject *co*)
*Return value: New reference.* Given a module name (possibly of the form `package.module`) and a code object read from a Python bytecode file or obtained from the built-in function `compile()`, load the module. Return a new reference to the module object, or *NULL* with an exception set if an error occurred. Before Python 2.4, the module could still be created in error cases. Starting with Python 2.4, *name* is removed from `sys.modules` in error cases, and even if *name* was already in `sys.modules` on entry to `PyImport_ExecCodeModule()`. Leaving incompletely initialized modules in `sys.modules` is dangerous, as imports of such modules have no way to know that the module object is an unknown (and probably damaged with respect to the module author' s intents) state.

The module' s `__file__` attribute will be set to the code object' s `co_filename`.

This function will reload the module if it was already imported. See `PyImport_ReloadModule()` for the intended way to reload a module.

If *name* points to a dotted name of the form `package.module`, any package structures not already created will still not be created.

在 2.4 版更改: *name* is removed from `sys.modules` in error cases.

*PyObject** **PyImport_ExecCodeModuleEx**(char **name*, *PyObject *co*, char **pathname*)
*Return value: New reference.* Like `PyImport_ExecCodeModule()`, but the `__file__` attribute of the module object is set to *pathname* if it is non-`NULL`.

long **PyImport_GetMagicNumber**()
Return the magic number for Python bytecode files (a.k.a. `.pyc` and `.pyo` files). The magic number should be present in the first four bytes of the bytecode file, in little-endian byte order.

*PyObject** **PyImport_GetModuleDict**()
*Return value: Borrowed reference.* Return the dictionary used for the module administration (a.k.a. `sys.modules`). Note that this is a per-interpreter variable.

*PyObject** **PyImport_GetImporter**(*PyObject *path*)
Return an importer object for a `sys.path`/`pkg.__path__` item *path*, possibly by fetching it from the `sys.path_importer_cache` dict. If it wasn' t yet cached, traverse `sys.path_hooks` until a hook is found that can handle the path item. Return `None` if no hook could; this tells our caller it should fall back to the built-in import mechanism. Cache the result in `sys.path_importer_cache`. Return a new reference to the importer object.

2.6 新版功能.

void **_PyImport_Init**()
Initialize the import mechanism. For internal use only.

void **PyImport_Cleanup**()
Empty the module table. For internal use only.

void **_PyImport_Fini**()
Finalize the import mechanism. For internal use only.

*PyObject** **_PyImport_FindExtension**(char *, char *)
For internal use only.

*PyObject** **_PyImport_FixupExtension**(char *, char *)
For internal use only.

int **PyImport_ImportFrozenModule**(char **name*)
Load a frozen module named *name*. Return `1` for success, `0` if the module is not found, and `-1` with an exception set if the initialization failed. To access the imported module on a successful load, use `PyImport_ImportModule()`. (Note the misnomer —this function would reload the module if it was already imported.)

struct **_frozen**
This is the structure type definition for frozen module descriptors, as generated by the **freeze** utility (see `Tools/freeze/` in the Python source distribution). Its definition, found in `Include/import.h`, is:

```
struct _frozen {
    char *name;
    unsigned char *code;
    int size;
};
```

struct *_frozen** **PyImport_FrozenModules**
This pointer is initialized to point to an array of `struct _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.

int **PyImport_AppendInittab**(const char **name*, void (**initfunc*)(void))
Add a single module to the existing table of built-in modules. This is a convenience wrapper around `PyImport_ExtendInittab()`, returning `-1` if the table could not be extended. The new module can be imported by the name *name*, and uses the function *initfunc* as the initialization function called on the first attempted import. This should be called before `Py_Initialize()`.

struct **_inittab**
Structure describing a single entry in the list of built-in modules. Each of these structures gives the name and initialization function for a module built into the interpreter. Programs which embed Python may use an array of these structures in conjunction with `PyImport_ExtendInittab()` to provide additional built-in modules. The structure is defined in `Include/import.h` as:

```
struct _inittab {
    char *name;
    void (*initfunc)(void);
};
```

int **PyImport_ExtendInittab**(struct *_inittab* **newtab*)
Add a collection of modules to the table of built-in modules. The *newtab* array must end with a sentinel entry which contains *NULL* for the `name` field; failure to provide the sentinel value can result in a memory fault. Returns `0` on success or `-1` if insufficient memory could be allocated to extend the internal table. In the event of failure, no modules are added to the internal table. This should be called before `Py_Initialize()`.

## 5.5 数据 marshal 操作支持

这些例程允许 C 代码处理与 `marshal` 模块所用相同数据格式的序列化对象。其中有些函数可用来将数据写入这种序列化格式，另一些函数则可用来读取并恢复数据。用于存储 marshal 数据的文件必须以二进制模式打开。

数字值在存储时会将最低位字节放在开头。

The module supports two versions of the data format: version `0` is the historical version, version `1` (new in Python 2.4) shares interned strings in the file, and upon unmarshalling. Version 2 (new in Python 2.5) uses a binary format for floating point numbers. *Py_MARSHAL_VERSION* indicates the current file format (currently 2).

void **PyMarshal_WriteLongToFile**(long *value*, FILE **file*, int *version*)

Marshal a `long` integer, *value*, to *file*. This will only write the least-significant 32 bits of *value*; regardless of the size of the native `long` type.

在 2.4 版更改: *version* indicates the file format.

void **PyMarshal_WriteObjectToFile**(*PyObject* **value*, FILE **file*, int *version*)

Marshal a Python object, *value*, to *file*.

在 2.4 版更改: *version* indicates the file format.

*PyObject** **PyMarshal_WriteObjectToString**(*PyObject* **value*, int *version*)

*Return value: New reference.* Return a string object containing the marshalled representation of *value*.

在 2.4 版更改: *version* indicates the file format.

以下函数允许读取并恢复存储为 marshal 格式的值。

XXX What about error detection? It appears that reading past the end of the file will always result in a negative numeric value (where that's relevant), but it's not clear that negative values won't be handled properly when there's no error. What's the right way to tell? Should only non-negative values be written using these routines?

long **PyMarshal_ReadLongFromFile**(FILE **file*)

从打开用于读取的 `FILE*` 的对应数据流返回一个 C `long`。使用此函数只能读取 32 位的值，无论本机 `long` 类型的长度如何。

int **PyMarshal_ReadShortFromFile**(FILE **file*)

从打开用于读取的 `FILE*` 的对应数据流返回一个 C `short`。使用此函数只能读取 16 位的值，无论本机 `short` 的长度如何。

*PyObject** **PyMarshal_ReadObjectFromFile**(FILE **file*)

*Return value: New reference.* Return a Python object from the data stream in a `FILE*` opened for reading. On error, sets the appropriate exception (`EOFError` or `TypeError`) and returns *NULL*.

*PyObject** **PyMarshal_ReadLastObjectFromFile**(FILE **file*)

*Return value: New reference.* Return a Python object from the data stream in a `FILE*` opened for reading. Unlike `PyMarshal_ReadObjectFromFile()`, this function assumes that no further objects will be read from the file, allowing it to aggressively load file data into memory so that the de-serialization can operate from data in memory rather than reading a byte at a time from the file. Only use these variant if you are certain that you won't be reading anything else from the file. On error, sets the appropriate exception (`EOFError` or `TypeError`) and returns *NULL*.

*PyObject** **PyMarshal_ReadObjectFromString**(char **string*, Py_ssize_t *len*)

*Return value: New reference.* Return a Python object from the data stream in a character buffer containing *len* bytes pointed to by *string*. On error, sets the appropriate exception (`EOFError` or `TypeError`) and returns *NULL*.

在 2.5 版更改: This function used an `int` type for *len*. This might require changes in your code for properly supporting 64-bit systems.

## 5.6 解析参数并构建值变量

在创建你自己的扩展函数和方法时，这些函数是有用的。其它的信息和样例见 extending-index 。

这 些 函 数 描 述 的 前 三 个，*PyArg_ParseTuple()*，*PyArg_ParseTupleAndKeywords()*， 以及*PyArg_Parse()*， 它们都使用 格式化字符串来将函数期待的参数告知函数。这些函数都使用相同语法规则的格式化字符串。

一个格式化字符串包含 0 或者更多的格式单元。一个格式单元用来描述一个 Python 对象；它通常是一个字符或者由括号括起来的格式单元序列。除了少数例外，一个非括号序列的格式单元通常对应这些函数的具有单一地址的参数。在接下来的描述中，双引号内的表达式是格式单元；圆括号 () 内的是对应这个格式单元的 Python 对象类型；方括号 [] 内的是传递的 C 变量 (变量集) 类型。

These formats allow accessing an object as a contiguous chunk of memory. You don't have to provide raw storage for the returned unicode or bytes area. Also, you won't have to release any memory yourself, except with the `es`, `es#`, `et` and `et#` formats.

**`s` (string or Unicode) [const char *]** Convert a Python string or Unicode object to a C pointer to a character string. You must not provide storage for the string itself; a pointer to an existing string is stored into the character pointer variable whose address you pass. The C string is NUL-terminated. The Python string must not contain embedded NUL bytes; if it does, a `TypeError` exception is raised. Unicode objects are converted to C strings using the default encoding. If this conversion fails, a `UnicodeError` is raised.

**`s#` (string, Unicode or any read buffer compatible object) [const char *, int (or `Py_ssize_t`, see below)]** This variant on `s` stores into two C variables, the first one a pointer to a character string, the second one its length. In this case the Python string may contain embedded null bytes. Unicode objects pass back a pointer to the default encoded string version of the object if such a conversion is possible. All other read-buffer compatible objects pass back a reference to the raw internal data representation.

Starting with Python 2.5 the type of the length argument can be controlled by defining the macro `PY_SSIZE_T_CLEAN` before including `Python.h`. If the macro is defined, length is a `Py_ssize_t` rather than an int.

**`s*` (string, Unicode, or any buffer compatible object) [Py_buffer]** Similar to `s#`, this code fills a Py_buffer structure provided by the caller. The buffer gets locked, so that the caller can subsequently use the buffer even inside a `Py_BEGIN_ALLOW_THREADS` block; the caller is responsible for calling `PyBuffer_Release` with the structure after it has processed the data.

2.6 新版功能.

**`z` (string, Unicode or `None`) [const char *]** Like `s`, but the Python object may also be `None`, in which case the C pointer is set to *NULL*.

**`z#` (string, Unicode, `None` or any read buffer compatible object) [const char *, int]** This is to `s#` as `z` is to `s`.

**`z*` (string, Unicode, `None` or any buffer compatible object) [Py_buffer]** This is to `s*` as `z` is to `s`.

2.6 新版功能.

**`u` (Unicode) [Py_UNICODE *]** Convert a Python Unicode object to a C pointer to a NUL-terminated buffer of 16-bit Unicode (UTF-16) data. As with `s`, there is no need to provide storage for the Unicode data buffer; a pointer to the existing Unicode data is stored into the *Py_UNICODE* pointer variable whose address you pass.

**`u#` (Unicode) [Py_UNICODE *, int]** This variant on `u` stores into two C variables, the first one a pointer to a Unicode data buffer, the second one its length. Non-Unicode objects are handled by interpreting their read-buffer pointer as pointer to a *Py_UNICODE* array.

**`es` (string, Unicode or character buffer compatible object) [const char *encoding, char **buffer]** This variant on `s` is used for encoding Unicode and objects convertible to Unicode into a character buffer. It only works for encoded data without embedded NUL bytes.

This format requires two arguments. The first is only used as input, and must be a `const char*` which points to the name of an encoding as a NUL-terminated string, or *NULL*, in which case the default encoding is used. An exception is raised if the named encoding is not known to Python. The second argument must be a `char**`; the value of the pointer it references will be set to a buffer with the contents of the argument text. The text will be encoded in the encoding specified by the first argument.

`PyArg_ParseTuple()` 会分配一个足够大小的缓冲区，将编码后的数据拷贝进这个缓冲区并且设置 **buffer* 引用这个新分配的内存空间。调用者有责任在使用后调用 `PyMem_Free()` 去释放已经分配的缓冲区。

**`et` (string, Unicode or character buffer compatible object) [const char *encoding, char **buffer]** Same as `es` except that 8-bit string objects are passed through without recoding them. Instead, the implementation assumes that the string object uses the encoding passed in as parameter.

**`es#` (string, Unicode or character buffer compatible object) [const char *encoding, char **buffer, int *buffer_length]** This variant on `s#` is used for encoding Unicode and objects convertible to Unicode into a character buffer. Unlike the `es` format, this variant allows input data which contains NUL characters.

It requires three arguments. The first is only used as input, and must be a `const char*` which points to the name of an encoding as a NUL-terminated string, or *NULL*, in which case the default encoding is used. An exception is raised if the named encoding is not known to Python. The second argument must be a `char**`; the value of the pointer it references will be set to a buffer with the contents of the argument text. The text will be encoded in the encoding specified by the first argument. The third argument must be a pointer to an integer; the referenced integer will be set to the number of bytes in the output buffer.

有两种操作方式：

If **buffer* points a *NULL* pointer, the function will allocate a buffer of the needed size, copy the encoded data into this buffer and set **buffer* to reference the newly allocated storage. The caller is responsible for calling `PyMem_Free()` to free the allocated buffer after usage.

If **buffer* points to a non-*NULL* pointer (an already allocated buffer), `PyArg_ParseTuple()` will use this location as the buffer and interpret the initial value of **buffer_length* as the buffer size. It will then copy the encoded data into the buffer and NUL-terminate it. If the buffer is not large enough, a `TypeError` will be set. Note: starting from Python 3.6 a `ValueError` will be set.

在这两个例子中，**buffer_length* 被设置为编码后结尾不为 NUL 的数据的长度。

**`et#` (string, Unicode or character buffer compatible object) [const char *encoding, char **buffer, int *buffer_length]** Same as `es#` except that string objects are passed through without recoding them. Instead, the implementation assumes that the string object uses the encoding passed in as parameter.

**`b` (integer) [unsigned char]** 将一个非负的 Python 整型转化成一个无符号的微整型，存储在一个 C `unsigned char` 类型中。

**`B` (integer) [unsigned char]** 将一个 Python 整型转化成一个微整型并不检查溢出问题，存储在一个 C `unsigned char` 类型中。

2.3 新版功能.

**`h` (integer) [short int]** 将一个 Python 整型转化成一个 C `short int` 短整型。

**`H` (integer) [unsigned short int]** 将一个 Python 整型转化成一个 C `unsigned short int` 无符号短整型，并不检查溢出问题。

2.3 新版功能.

**`i` (integer) [int]** 将一个 Python 整型转化成一个 C `int` 整型。

**`I` (integer) [unsigned int]** 将一个 Python 整型转化成一个 C `unsigned int` 无符号整型，并不检查溢出问题。

2.3 新版功能.

**l (integer) [long int]** 将一个 Python 整型转化成一个 C `long int` 长整型。

**k (integer) [unsigned long]** Convert a Python integer or long integer to a C `unsigned long` without overflow checking.

2.3 新版功能.

**L (integer) [PY_LONG_LONG]** Convert a Python integer to a C `long long`. This format is only available on platforms that support `long long` (or `_int64` on Windows).

**K (integer) [unsigned PY_LONG_LONG]** Convert a Python integer or long integer to a C `unsigned long long` without overflow checking. This format is only available on platforms that support `unsigned long long` (or `unsigned _int64` on Windows).

2.3 新版功能.

**n (integer) [Py_ssize_t]** Convert a Python integer or long integer to a C `Py_ssize_t`.

2.5 新版功能.

**c (string of length 1) [char]** Convert a Python character, represented as a string of length 1, to a C `char`.

**f (float) [float]** 将一个 Python 浮点数转化成一个 C `float` 浮点数。

**d (float) [double]** 将一个 Python 浮点数转化成一个 C `double` 双精度浮点数。

**D (complex) [Py_complex]** 将一个 Python 复数类型转化成一个 C *Py_complex* Python 复数类型。

**O (object) [PyObject *]** Store a Python object (without any conversion) in a C object pointer. The C program thus receives the actual object that was passed. The object's reference count is not increased. The pointer stored is not *NULL*.

**O! (object) [*typeobject*, PyObject *]** 将一个 Python 对象存入一个 C 指针。和 `O` 类似，但是需要两个 C 参数：第一个是 Python 类型对象的地址，第二个是存储对象指针的 C 变量 ( *PyObject** 变量) 的地址。如果 Python 对象类型不对，会抛出 `TypeError` 异常。

**O& (object) [*converter*, *anything*]** Convert a Python object to a C variable through a *converter* function. This takes two arguments: the first is a function, the second is the address of a C variable (of arbitrary type), converted to `void *`. The *converter* function in turn is called as follows:

```
status = converter(object, address);
```

where *object* is the Python object to be converted and *address* is the `void*` argument that was passed to the *PyArg_Parse*()* function. The returned *status* should be `1` for a successful conversion and `0` if the conversion has failed. When the conversion fails, the *converter* function should raise an exception and leave the content of *address* unmodified.

**S (string) [PyStringObject *]** Like `O` but requires that the Python object is a string object. Raises `TypeError` if the object is not a string object. The C variable may also be declared as *PyObject**.

**U (Unicode string) [PyUnicodeObject *]** Like `O` but requires that the Python object is a Unicode object. Raises `TypeError` if the object is not a Unicode object. The C variable may also be declared as *PyObject**.

**t# (read-only character buffer) [char *, int]** Like `s#`, but accepts any object which implements the read-only buffer interface. The `char*` variable is set to point to the first byte of the buffer, and the `int` is set to the length of the buffer. Only single-segment buffer objects are accepted; `TypeError` is raised for all others.

**w (read-write character buffer) [char *]** Similar to `s`, but accepts any object which implements the read-write buffer interface. The caller must determine the length of the buffer by other means, or use `w#` instead. Only single-segment buffer objects are accepted; `TypeError` is raised for all others.

**w# (read-write character buffer) [char *, Py_ssize_t]** Like `s#`, but accepts any object which implements the read-write buffer interface. The `char *` variable is set to point to the first byte of the buffer, and the `Py_ssize_t` is set to the length of the buffer. Only single-segment buffer objects are accepted; `TypeError` is raised for all others.

**`w*` (read-write byte-oriented buffer) [Py_buffer]** This is to `w` what `s*` is to `s`.

2.6 新版功能.

**`(items)` (tuple) [*matching-items*]** 对象必须是 Python 序列，它的长度是 *items* 中格式单元的数量。C 参数必须对应 *items* 中每一个独立的格式单元。序列中的格式单元可能有嵌套。

> **注解:** Prior to Python version 1.5.2, this format specifier only accepted a tuple containing the individual parameters, not an arbitrary sequence. Code which previously caused `TypeError` to be raised here may now proceed without an exception. This is not expected to be a problem for existing code.

It is possible to pass Python long integers where integers are requested; however no proper range checking is done —the most significant bits are silently truncated when the receiving field is too small to receive the value (actually, the semantics are inherited from downcasts in C —your mileage may vary).

格式化字符串中还有一些其他的字符具有特殊的涵义。这些可能并不嵌套在圆括号中。它们是:

**`|`** Indicates that the remaining arguments in the Python argument list are optional. The C variables corresponding to optional arguments should be initialized to their default value —when an optional argument is not specified, `PyArg_ParseTuple()` does not touch the contents of the corresponding C variable(s).

**`:`** 格式单元的列表结束标志；冒号后的字符串被用来作为错误消息中的函数名 (`PyArg_ParseTuple()` 函数引发的 "关联值" 异常)。

**`;`** 格式单元的列表结束标志；分号后的字符串被用来作为错误消息取代默认的错误消息。`:` 和 `;` 相互排斥。

注意任何由调用者提供的 Python 对象引用是 借来的引用；不要递减它们的引用计数!

传递给这些函数的附加参数必须是由格式化字符串确定的变量的地址；这些都是用来存储输入元组的值。有一些情况，如上面的格式单元列表中所描述的，这些参数作为输入值使用；在这种情况下，它们应该匹配指定的相应的格式单元。

为了转换成功，*arg* 对象必须匹配格式并且格式必须用尽。成功的话，`PyArg_Parse*()` 函数返回 true，反之它们返回 false 并且引发一个合适的异常。当`PyArg_Parse*()` 函数因为某一个格式单元转化失败而失败时，对应的以及后续的格式单元地址内的变量都不会被使用。

int **`PyArg_ParseTuple`**(*PyObject* **args*, const char **format*, ...)
解析一个函数的参数，表达式中的参数按参数位置顺序存入局部变量中。成功返回 true；失败返回 false 并且引发相应的异常。

int **`PyArg_VaParse`**(*PyObject* **args*, const char **format*, va_list *vargs*)
和`PyArg_ParseTuple()` 相同，然而它接受一个 va_list 类型的参数而不是可变数量的参数集。

int **`PyArg_ParseTupleAndKeywords`**(*PyObject* **args*, *PyObject* **kw*, const char **format*, char **keywords[]*, ...)
Parse the parameters of a function that takes both positional and keyword parameters into local variables. Returns true on success; on failure, it returns false and raises the appropriate exception.

int **`PyArg_VaParseTupleAndKeywords`**(*PyObject* **args*, *PyObject* **kw*, const char **format*, char **keywords[]*, va_list *vargs*)
和`PyArg_ParseTupleAndKeywords()` 相同，然而它接受一个 va_list 类型的参数而不是可变数量的参数集。

int **`PyArg_Parse`**(*PyObject* **args*, const char **format*, ...)
Function used to deconstruct the argument lists of "old-style" functions —these are functions which use the `METH_OLDARGS` parameter parsing method. This is not recommended for use in parameter parsing in new code, and most code in the standard interpreter has been modified to no longer use this for that purpose. It does remain a convenient way to decompose other tuples, however, and may continue to be used for that purpose.

int **PyArg_UnpackTuple**(*PyObject* *args*, const char *name*, Py_ssize_t *min*, Py_ssize_t *max*, ...)

一个不使用格式化字符串指定参数类型的简单形式的参数检索。使用这种方法来检索参数的函数应该在函数或者方法表中声明`METH_VARARGS`。包含实际参数的元组应该以 *args* 形式被传入；它必须是一个实际的元组。元组的长度必须至少是 *min* 并且不超过 *max*；*min* 和 *max* 可能相同。额外的参数必须传递给函数，每一个参数必须是一个指向`PyObject*`类型变量的指针；它们将被赋值为 *args* 的值；它们将包含借来的引用。不在 *args* 里面的可选参数不会被赋值；由调用者完成初始化。函数成功则返回 true 并且如果 *args* 不是元组或者包含错误数量的元素则返回 false；如果失败了会引发一个异常。

这是一个使用此函数的示例，取自 `_weakref` 帮助模块用来弱化引用的源代码：

```
static PyObject *
weakref_ref(PyObject *self, PyObject *args)
{
    PyObject *object;
    PyObject *callback = NULL;
    PyObject *result = NULL;

    if (PyArg_UnpackTuple(args, "ref", 1, 2, &object, &callback)) {
        result = PyWeakref_NewRef(object, callback);
    }
    return result;
}
```

这个例子中调用`PyArg_UnpackTuple()`完全等价于调用`PyArg_ParseTuple()`：

```
PyArg_ParseTuple(args, "O|O:ref", &object, &callback)
```

2.2 新版功能.

在 2.5 版更改: This function used an `int` type for *min* and *max*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **Py_BuildValue**(const char *format*, ...)

*Return value: New reference.* Create a new value based on a format string similar to those accepted by the `PyArg_Parse*()` family of functions and a sequence of values. Returns the value or *NULL* in the case of an error; an exception will be raised if *NULL* is returned.

`Py_BuildValue()` does not always build a tuple. It builds a tuple only if its format string contains two or more format units. If the format string is empty, it returns `None`; if it contains exactly one format unit, it returns whatever object is described by that format unit. To force it to return a tuple of size `0` or one, parenthesize the format string.

When memory buffers are passed as parameters to supply data to build objects, as for the `s` and `s#` formats, the required data is copied. Buffers provided by the caller are never referenced by the objects created by `Py_BuildValue()`. In other words, if your code invokes `malloc()` and passes the allocated memory to `Py_BuildValue()`, your code is responsible for calling `free()` for that memory once `Py_BuildValue()` returns.

在下面的描述中，双引号的表达式使格式单元；圆括号 () 内的是格式单元将要返回的 Python 对象类型；方括号 [] 内的是传递的 C 变量 (变量集) 的类型

字符例如空格，制表符，冒号和逗号在格式化字符串中会被忽略 (但是不包括格式单元，如 `s#`)。这可以使很长的格式化字符串具有更好的可读性。

**s (string) [char *]** Convert a null-terminated C string to a Python object. If the C string pointer is *NULL*, `None` is used.

**s# (string) [char *, int]** Convert a C string and its length to a Python object. If the C string pointer is *NULL*, the length is ignored and `None` is returned.

**z (string or None) [char *]** 和 "s" 一样。

**`z#` (string or `None`) [char *, int]** 和 "s#"一样。

**`u` (Unicode string) [Py_UNICODE *]** Convert a null-terminated buffer of Unicode (UCS-2 or UCS-4) data to a Python Unicode object. If the Unicode buffer pointer is *NULL*, `None` is returned.

**`u#` (Unicode string) [Py_UNICODE *, int]** Convert a Unicode (UCS-2 or UCS-4) data buffer and its length to a Python Unicode object. If the Unicode buffer pointer is *NULL*, the length is ignored and `None` is returned.

**`i` (integer) [int]** 将一个 C `int` 整型转化成 Python 整型对象。

**`b` (integer) [char]** 将一个 C `char` 字符型转化成 Python 整型对象。

**`h` (integer) [short int]** 将一个 C `short int` 短整型转化成 Python 整型对象。

**`l` (integer) [long int]** 将一个 C `long int` 长整型转化成 Python 整型对象。

**`B` (integer) [unsigned char]** 将一个 C `unsigned char` 无符号字符型转化成 Python 整型对象。

**`H` (integer) [unsigned short int]** 将一个 C `unsigned long` 无符号短整型转化成 Python 整型对象。

**`I` (integer/long) [unsigned int]** Convert a C `unsigned int` to a Python integer object or a Python long integer object, if it is larger than `sys.maxint`.

**`k` (integer/long) [unsigned long]** Convert a C `unsigned long` to a Python integer object or a Python long integer object, if it is larger than `sys.maxint`.

**`L` (long) [PY_LONG_LONG]** Convert a C `long long` to a Python long integer object. Only available on platforms that support `long long`.

**`K` (long) [unsigned PY_LONG_LONG]** Convert a C `unsigned long long` to a Python long integer object. Only available on platforms that support `unsigned long long`.

**`n` (int) [Py_ssize_t]** Convert a C `Py_ssize_t` to a Python integer or long integer.

2.5 新版功能.

**`c` (string of length 1) [char]** Convert a C `int` representing a character to a Python string of length 1.

**`d` (float) [double]** 将一个 C `double` 双精度浮点数转化为 Python 浮点数类型数字。

**`f` (float) [float]** Same as `d`.

**`D` (complex) [Py_complex *]** 将一个 C `Py_complex` 类型的结构转化为 Python 复数类型。

**`O` (object) [PyObject *]** Pass a Python object untouched (except for its reference count, which is incremented by one). If the object passed in is a *NULL* pointer, it is assumed that this was caused because the call producing the argument found an error and set an exception. Therefore, `Py_BuildValue()` will return *NULL* but won't raise an exception. If no exception has been raised yet, `SystemError` is set.

**`S` (object) [PyObject *]** 和 "O"相同。

**`N` (object) [PyObject *]** Same as `O`, except it doesn't increment the reference count on the object. Useful when the object is created by a call to an object constructor in the argument list.

**`O&` (object) [*converter*, *anything*]** Convert *anything* to a Python object through a *converter* function. The function is called with *anything* (which should be compatible with `void *`) as its argument and should return a "new" Python object, or *NULL* if an error occurred.

**`(items)` (tuple) [*matching-items*]** 将一个 C 变量序列转换成 Python 元组并保持相同的元素数量

**`[items]` (list) [*matching-items*]** 将一个 C 变量序列转换成 Python 列表并保持相同的元素数量

**`{items}` (dictionary) [*matching-items*]** 将一个 C 变量序列转换成 Python 字典。每一对连续的 C 变量对作为一个元素插入字典中，分别作为关键字和值。

If there is an error in the format string, the `SystemError` exception is set and *NULL* returned.

*PyObject** **Py_VaBuildValue** (const char **format*, va_list *vargs*)
和`Py_BuildValue()` 相同，然而它接受一个 va_list 类型的参数而不是可变数量的参数集。

## 5.7 字符串转换与格式化

用于数字转换和格式化字符串输出的函数

int **PyOS_snprintf** (char **str*, size_t *size*, const char **format*, ...)
根据格式字符串 *format* 和额外参数，输出不超过 *size* 字节到 *str* 。请参见 Unix 手册页 `snprintf(2)` 。

int **PyOS_vsnprintf** (char **str*, size_t *size*, const char **format*, va_list *va*)
根据格式字符串 *format* 和变量参数列表 *va* ，不能输出超过 *size* 字节到 *str* 。请参见 Unix 手册页 `vsnprintf(2)` 。

`PyOS_snprintf()` and `PyOS_vsnprintf()` wrap the Standard C library functions `snprintf()` and `vsnprintf()`. Their purpose is to guarantee consistent behavior in corner cases, which the Standard C functions do not.

The wrappers ensure that *str*[*size*-1] is always `'\0'` upon return. They never write more than *size* bytes (including the trailing `'\0'` into str. Both functions require that `str != NULL`, `size > 0` and `format != NULL`.

If the platform doesn't have `vsnprintf()` and the buffer size needed to avoid truncation exceeds *size* by more than 512 bytes, Python aborts with a *Py_FatalError*.

这些函数的返回值（*rv* ）应按照以下规则被解释：

- 当 `0 <= rv < size` ，输出转换成功而且 *rv* 个字符被写入 *str* （不包含末尾 *str*[*rv*] 的 `'\0'` 字节）
- 当 `rv >= size` ，输出转换被截断并且成功需要一个带有 `rv + 1` 字节的缓冲区。在这种情况下，*str*[*size*-1] 的值是 `'\0'` 。
- 当 `rv < 0` ，会发生一些不好的事情。在这种情况下，*str*[*size*-1] 的值也是 `'\0'` ，但是 *str* 的其余部分未被定义。错误的确切原因取决于底层平台。

以下函数提供与语言环境无关的字符串到数字转换。

double **PyOS_string_to_double** (const char **s*, char ***endptr*, *PyObject* **overflow_exception*)
将字符串 `s` 转换为 `double` 类型，失败时引发 Python 异常。接受的字符串的集合对应于被 Python 的 `float()` 构造函数接受的字符串的集合，除了 `s` 必须没有前导或尾随空格。转换必须独立于当前的区域。

If `endptr` is `NULL`, convert the whole string. Raise ValueError and return `-1.0` if the string is not a valid representation of a floating-point number.

如果 `endptr` 不是 `NULL` ，尽可能多的转换字符串并将 `*endptr` 设置为指向第一个未转换的字符。如果字符串的初始段不是浮点数的有效的表达方式，将 `* endptr` 设置为指向字符串的开头，引发 ValueError 异常，并且返回 `-1.0` 。

如果 `s` 表示一个太大而不能存储在一个浮点数中的值（比方说，`"1e500"` 在许多平台上是一个字符串）然后如果 `overflow_exception` 是 `NULL` 返回 `Py_HUGE_VAL` （用适当的符号）并且不设置任何异常。在其他方面，`overflow_exception` 必须指向一个 Python 异常对象；引发异常并返回 `-1.0` 。在这两种情况下，设置 `*endptr` 指向转换值之后的第一个字符。

如果在转换期间发生任何其他错误（比如一个内存不足的错误），设置适当的 Python 异常并且返回 `-1.0` 。

2.7 新版功能.

double **PyOS_ascii_strtod** (const char **nptr*, char ***endptr*)
Convert a string to a `double`. This function behaves like the Standard C function `strtod()` does in the C locale. It does this without changing the current locale, since that would not be thread-safe.

*PyOS_ascii_strtod()* should typically be used for reading configuration files or other non-user input that should be locale independent.

See the Unix man page `strtod(2)` for details.

2.4 新版功能.

2.7 版后已移除: Use *PyOS_string_to_double()* instead.

char* **PyOS_ascii_formatd**(char **buffer*, size_t *buf_len*, const char **format*, double *d*)
Convert a `double` to a string using the `'.'` as the decimal separator. *format* is a `printf()`-style format string specifying the number format. Allowed conversion characters are `'e'`, `'E'`, `'f'`, `'F'`, `'g'` and `'G'`.

The return value is a pointer to *buffer* with the converted string or NULL if the conversion failed.

2.4 新版功能.

2.7 版后已移除: This function is removed in Python 2.7 and 3.1. Use `PyOS_double_to_string()` instead.

char* **PyOS_double_to_string**(double *val*, char *format_code*, int *precision*, int *flags*, int **ptype*)
转换 `double` *val* 为一个使用 *format_code*，*precision* 和 *flags* 的字符串

*format_code* must be one of `'e'`, `'E'`, `'f'`, `'F'`, `'g'`, `'G'` or `'r'`. For `'r'`, the supplied *precision* must be `0` and is ignored. The `'r'` format code specifies the standard `repr()` format.

*flags* can be zero or more of the values *Py_DTSF_SIGN*, *Py_DTSF_ADD_DOT_0*, or *Py_DTSF_ALT*, or-ed together:

- *Py_DTSF_SIGN* means to always precede the returned string with a sign character, even if *val* is non-negative.
- *Py_DTSF_ADD_DOT_0* means to ensure that the returned string will not look like an integer.
- *Py_DTSF_ALT* means to apply "alternate" formatting rules. See the documentation for the *PyOS_snprintf()* `'#'` specifier for details.

If *ptype* is non-NULL, then the value it points to will be set to one of *Py_DTST_FINITE*, *Py_DTST_INFINITE*, or *Py_DTST_NAN*, signifying that *val* is a finite number, an infinite number, or not a number, respectively.

The return value is a pointer to *buffer* with the converted string or *NULL* if the conversion failed. The caller is responsible for freeing the returned string by calling *PyMem_Free()*.

2.7 新版功能.

double **PyOS_ascii_atof**(const char **nptr*)
Convert a string to a `double` in a locale-independent way.

See the Unix man page `atof(2)` for details.

2.4 新版功能.

3.1 版后已移除: Use *PyOS_string_to_double()* instead.

char* **PyOS_stricmp**(char **s1*, char **s2*)
字符串不区分大小写。该函数几乎与 `strcmp()` 的工作方式相同，只是它忽略了大小写。

2.6 新版功能.

char* **PyOS_strnicmp**(char **s1*, char **s2*, Py_ssize_t *size*)
字符串不区分大小写。该函数几乎与 `strncmp()` 的工作方式相同，只是它忽略了大小写。

2.6 新版功能.

## 5.8 反射

*PyObject** **PyEval_GetBuiltins**()
*Return value: Borrowed reference.* 返回当前执行帧中内置函数的字典，如果当前没有帧正在执行，则返回线程状态的解释器。

*PyObject** **PyEval_GetLocals**()
*Return value: Borrowed reference.* Return a dictionary of the local variables in the current execution frame, or *NULL* if no frame is currently executing.

*PyObject** **PyEval_GetGlobals**()
*Return value: Borrowed reference.* Return a dictionary of the global variables in the current execution frame, or *NULL* if no frame is currently executing.

PyFrameObject* **PyEval_GetFrame**()
*Return value: Borrowed reference.* Return the current thread state's frame, which is *NULL* if no frame is currently executing.

int **PyFrame_GetLineNumber**(PyFrameObject **frame*)
返回 *frame* 当前正在执行的行号。

int **PyEval_GetRestricted**()
If there is a current frame and it is executing in restricted mode, return true, otherwise false.

const char* **PyEval_GetFuncName**(*PyObject* **func*)
如果 *func* 是函数、类或实例对象，则返回它的名称，否则返回 *func* 的类型的名称。

const char* **PyEval_GetFuncDesc**(*PyObject* **func*)
根据 *func* 的类型返回描述字符串。返回值包括函数和方法的"()", " constructor", " instance" 和" object"。与`PyEval_GetFuncName()` 的结果连接，结果将是 *func* 的描述。

## 5.9 编解码器注册与支持功能

int **PyCodec_Register**(*PyObject* **search_function*)
注册一个新的编解码器搜索函数。

作为副作用，其尝试加载 `encodings` 包，如果尚未完成，请确保它始终位于搜索函数列表的第一位。

int **PyCodec_KnownEncoding**(const char **encoding*)
Return `1` or `0` depending on whether there is a registered codec for the given *encoding*.

*PyObject** **PyCodec_Encode**(*PyObject* **object*, const char **encoding*, const char **errors*)
泛型编解码器基本编码 API。

*object* is passed through the encoder function found for the given *encoding* using the error handling method defined by *errors*. *errors* may be *NULL* to use the default method defined for the codec. Raises a `LookupError` if no encoder can be found.

*PyObject** **PyCodec_Decode**(*PyObject* **object*, const char **encoding*, const char **errors*)
泛型编解码器基本解码 API。

*object* is passed through the decoder function found for the given *encoding* using the error handling method defined by *errors*. *errors* may be *NULL* to use the default method defined for the codec. Raises a `LookupError` if no encoder can be found.

### 5.9.1 Codec 查找 API

In the following functions, the *encoding* string is looked up converted to all lower-case characters, which makes encodings looked up through this mechanism effectively case-insensitive. If no codec is found, a `KeyError` is set and *NULL* returned.

*PyObject** **PyCodec_Encoder**(const char **encoding*)
Get an encoder function for the given *encoding*.

*PyObject** **PyCodec_Decoder**(const char **encoding*)
Get a decoder function for the given *encoding*.

*PyObject** **PyCodec_IncrementalEncoder**(const char **encoding*, const char **errors*)
Get an `IncrementalEncoder` object for the given *encoding*.

*PyObject** **PyCodec_IncrementalDecoder**(const char **encoding*, const char **errors*)
Get an `IncrementalDecoder` object for the given *encoding*.

*PyObject** **PyCodec_StreamReader**(const char **encoding*, *PyObject* **stream*, const char **errors*)
Get a `StreamReader` factory function for the given *encoding*.

*PyObject** **PyCodec_StreamWriter**(const char **encoding*, *PyObject* **stream*, const char **errors*)
为给定的 *encoding* 获取一个 `StreamWriter` 工厂函数。

### 5.9.2 用于 Unicode 编码错误处理程序的注册表 API

int **PyCodec_RegisterError**(const char **name*, *PyObject* **error*)
Register the error handling callback function *error* under the given *name*. This callback function will be called by a codec when it encounters unencodable characters/undecodable bytes and *name* is specified as the error parameter in the call to the encode/decode function.

The callback gets a single argument, an instance of `UnicodeEncodeError`, `UnicodeDecodeError` or `UnicodeTranslateError` that holds information about the problematic sequence of characters or bytes and their offset in the original string (see *Unicode Exception Objects* for functions to extract this information). The callback must either raise the given exception, or return a two-item tuple containing the replacement for the problematic sequence, and an integer giving the offset in the original string at which encoding/decoding should be resumed.

成功则返回 "0"，失败则返回 "-1"

*PyObject** **PyCodec_LookupError**(const char **name*)
Lookup the error handling callback function registered under *name*. As a special case *NULL* can be passed, in which case the error handling callback for "strict" will be returned.

*PyObject** **PyCodec_StrictErrors**(*PyObject* **exc*)
Raise *exc* as an exception.

*PyObject** **PyCodec_IgnoreErrors**(*PyObject* **exc*)
Ignore the unicode error, skipping the faulty input.

*PyObject** **PyCodec_ReplaceErrors**(*PyObject* **exc*)
Replace the unicode encode error with `?` or `U+FFFD`.

*PyObject** **PyCodec_XMLCharRefReplaceErrors**(*PyObject* **exc*)
Replace the unicode encode error with XML character references.

*PyObject** **PyCodec_BackslashReplaceErrors**(*PyObject* **exc*)
Replace the unicode encode error with backslash escapes (`\x`, `\u` and `\U`).

CHAPTER 6

# 抽象对象层

本章中的函数与 Python 对象交互，无论其类型，或具有广泛类的对象类型（例如，所有数值类型，或所有序列类型）。当使用对象类型并不适用时，他们会产生一个 Python 异常。

这些函数是不可能用于未正确初始化的对象的，如一个列表对象被`PyList_New()` 创建，但其中的项目没有被设置为一些非 "NULL"的值。

## 6.1 对象协议

int **PyObject_Print** (*PyObject* *o, FILE *fp, int *flags*)

Print an object *o*, on file *fp*. Returns `-1` on error. The flags argument is used to enable certain printing options. The only option currently supported is `Py_PRINT_RAW`; if given, the `str()` of the object is written instead of the `repr()`.

int **PyObject_HasAttr** (*PyObject* *o, *PyObject* *attr_name*)

Returns `1` if *o* has the attribute *attr_name*, and `0` otherwise. This is equivalent to the Python expression `hasattr(o, attr_name)`. This function always succeeds.

int **PyObject_HasAttrString** (*PyObject* *o, const char *attr_name*)

Returns `1` if *o* has the attribute *attr_name*, and `0` otherwise. This is equivalent to the Python expression `hasattr(o, attr_name)`. This function always succeeds.

*PyObject** **PyObject_GetAttr** (*PyObject* *o, *PyObject* *attr_name*)

*Return value: New reference.* Retrieve an attribute named *attr_name* from object *o*. Returns the attribute value on success, or *NULL* on failure. This is the equivalent of the Python expression `o.attr_name`.

*PyObject** **PyObject_GetAttrString** (*PyObject* *o, const char *attr_name*)

*Return value: New reference.* Retrieve an attribute named *attr_name* from object *o*. Returns the attribute value on success, or *NULL* on failure. This is the equivalent of the Python expression `o.attr_name`.

*PyObject** **PyObject_GenericGetAttr** (*PyObject* *o, *PyObject* *name*)

Generic attribute getter function that is meant to be put into a type object' s `tp_getattro` slot. It looks for a descriptor in the dictionary of classes in the object' s MRO as well as an attribute in the object' s `__dict__` (if present). As outlined in descriptors, data descriptors take preference over instance attributes, while non-data descriptors don't. Otherwise, an `AttributeError` is raised.

int **PyObject_SetAttr** (*PyObject* *o, *PyObject* *attr_name, *PyObject* *v)
Set the value of the attribute named *attr_name*, for object *o*, to the value *v*. Raise an exception and return `-1` on failure; return `0` on success. This is the equivalent of the Python statement `o.attr_name = v`.

If *v* is *NULL*, the attribute is deleted, however this feature is deprecated in favour of using `PyObject_DelAttr()`.

int **PyObject_SetAttrString** (*PyObject* *o, const char *attr_name, *PyObject* *v)
Set the value of the attribute named *attr_name*, for object *o*, to the value *v*. Raise an exception and return `-1` on failure; return `0` on success. This is the equivalent of the Python statement `o.attr_name = v`.

If *v* is *NULL*, the attribute is deleted, however this feature is deprecated in favour of using `PyObject_DelAttrString()`.

int **PyObject_GenericSetAttr** (*PyObject* *o, *PyObject* *name, *PyObject* *value)
Generic attribute setter and deleter function that is meant to be put into a type object's `tp_setattro` slot. It looks for a data descriptor in the dictionary of classes in the object's MRO, and if found it takes preference over setting or deleting the attribute in the instance dictionary. Otherwise, the attribute is set or deleted in the object's `__dict__` (if present). On success, `0` is returned, otherwise an `AttributeError` is raised and `-1` is returned.

int **PyObject_DelAttr** (*PyObject* *o, *PyObject* *attr_name)
Delete attribute named *attr_name*, for object *o*. Returns `-1` on failure. This is the equivalent of the Python statement `del o.attr_name`.

int **PyObject_DelAttrString** (*PyObject* *o, const char *attr_name)
Delete attribute named *attr_name*, for object *o*. Returns `-1` on failure. This is the equivalent of the Python statement `del o.attr_name`.

*PyObject** **PyObject_RichCompare** (*PyObject* *o1, *PyObject* *o2, int opid)
*Return value: New reference.* Compare the values of *o1* and *o2* using the operation specified by *opid*, which must be one of `Py_LT`, `Py_LE`, `Py_EQ`, `Py_NE`, `Py_GT`, or `Py_GE`, corresponding to <, <=, ==, !=, >, or >= respectively. This is the equivalent of the Python expression `o1 op o2`, where `op` is the operator corresponding to *opid*. Returns the value of the comparison on success, or *NULL* on failure.

int **PyObject_RichCompareBool** (*PyObject* *o1, *PyObject* *o2, int opid)
Compare the values of *o1* and *o2* using the operation specified by *opid*, which must be one of `Py_LT`, `Py_LE`, `Py_EQ`, `Py_NE`, `Py_GT`, or `Py_GE`, corresponding to <, <=, ==, !=, >, or >= respectively. Returns `-1` on error, `0` if the result is false, `1` otherwise. This is the equivalent of the Python expression `o1 op o2`, where `op` is the operator corresponding to *opid*.

**注解:** If *o1* and *o2* are the same object, `PyObject_RichCompareBool()` will always return `1` for `Py_EQ` and `0` for `Py_NE`.

int **PyObject_Cmp** (*PyObject* *o1, *PyObject* *o2, int *result)
Compare the values of *o1* and *o2* using a routine provided by *o1*, if one exists, otherwise with a routine provided by *o2*. The result of the comparison is returned in *result*. Returns `-1` on failure. This is the equivalent of the Python statement `result = cmp(o1, o2)`.

int **PyObject_Compare** (*PyObject* *o1, *PyObject* *o2)
Compare the values of *o1* and *o2* using a routine provided by *o1*, if one exists, otherwise with a routine provided by *o2*. Returns the result of the comparison on success. On error, the value returned is undefined; use `PyErr_Occurred()` to detect an error. This is equivalent to the Python expression `cmp(o1, o2)`.

*PyObject** **PyObject_Repr** (*PyObject* *o)
*Return value: New reference.* Compute a string representation of object *o*. Returns the string representation on

success, *NULL* on failure. This is the equivalent of the Python expression `repr(o)`. Called by the `repr()` built-in function and by reverse quotes.

*PyObject** **PyObject_Str**(*PyObject *o*)
*Return value: New reference.* Compute a string representation of object *o*. Returns the string representation on success, *NULL* on failure. This is the equivalent of the Python expression `str(o)`. Called by the `str()` built-in function and by the `print` statement.

*PyObject** **PyObject_Bytes**(*PyObject *o*)
Compute a bytes representation of object *o*. In 2.x, this is just an alias for `PyObject_Str()`.

*PyObject** **PyObject_Unicode**(*PyObject *o*)
*Return value: New reference.* Compute a Unicode string representation of object *o*. Returns the Unicode string representation on success, *NULL* on failure. This is the equivalent of the Python expression `unicode(o)`. Called by the `unicode()` built-in function.

int **PyObject_IsInstance**(*PyObject *inst*, *PyObject *cls*)
Returns `1` if *inst* is an instance of the class *cls* or a subclass of *cls*, or `0` if not. On error, returns `-1` and sets an exception. If *cls* is a type object rather than a class object, `PyObject_IsInstance()` returns `1` if *inst* is of type *cls*. If *cls* is a tuple, the check will be done against every entry in *cls*. The result will be `1` when at least one of the checks returns `1`, otherwise it will be `0`. If *inst* is not a class instance and *cls* is neither a type object, nor a class object, nor a tuple, *inst* must have a `__class__` attribute —the class relationship of the value of that attribute with *cls* will be used to determine the result of this function.

2.1 新版功能.

在 2.2 版更改: Support for a tuple as the second argument added.

Subclass determination is done in a fairly straightforward way, but includes a wrinkle that implementors of extensions to the class system may want to be aware of. If `A` and `B` are class objects, `B` is a subclass of `A` if it inherits from `A` either directly or indirectly. If either is not a class object, a more general mechanism is used to determine the class relationship of the two objects. When testing if *B* is a subclass of *A*, if *A* is *B*, `PyObject_IsSubclass()` returns true. If *A* and *B* are different objects, *B*' s `__bases__` attribute is searched in a depth-first fashion for *A* —the presence of the `__bases__` attribute is considered sufficient for this determination.

int **PyObject_IsSubclass**(*PyObject *derived*, *PyObject *cls*)
Returns `1` if the class *derived* is identical to or derived from the class *cls*, otherwise returns `0`. In case of an error, returns `-1`. If *cls* is a tuple, the check will be done against every entry in *cls*. The result will be `1` when at least one of the checks returns `1`, otherwise it will be `0`. If either *derived* or *cls* is not an actual class object (or tuple), this function uses the generic algorithm described above.

2.1 新版功能.

在 2.3 版更改: Older versions of Python did not support a tuple as the second argument.

int **PyCallable_Check**(*PyObject *o*)
Determine if the object *o* is callable. Return `1` if the object is callable and `0` otherwise. This function always succeeds.

*PyObject** **PyObject_Call**(*PyObject *callable_object*, *PyObject *args*, *PyObject *kw*)
*Return value: New reference.* Call a callable Python object *callable_object*, with arguments given by the tuple *args*, and named arguments given by the dictionary *kw*. If no named arguments are needed, *kw* may be *NULL*. *args* must not be *NULL*, use an empty tuple if no arguments are needed. Returns the result of the call on success, or *NULL* on failure. This is the equivalent of the Python expression `apply(callable_object, args, kw)` or `callable_object(*args, **kw)`.

2.2 新版功能.

*PyObject** **PyObject_CallObject**(*PyObject *callable_object*, *PyObject *args*)
*Return value: New reference.* Call a callable Python object *callable_object*, with arguments given by the tuple *args*. If no arguments are needed, then *args* may be *NULL*. Returns the result of the call on success, or

*NULL* on failure. This is the equivalent of the Python expression `apply(callable_object, args)` or `callable_object(*args)`.

*PyObject** **PyObject_CallFunction**(*PyObject *callable*, char **format*, ...)
*Return value: New reference.* Call a callable Python object *callable*, with a variable number of C arguments. The C arguments are described using a `Py_BuildValue()` style format string. The format may be *NULL*, indicating that no arguments are provided. Returns the result of the call on success, or *NULL* on failure. This is the equivalent of the Python expression `apply(callable, args)` or `callable(*args)`. Note that if you only pass `PyObject *` args, `PyObject_CallFunctionObjArgs()` is a faster alternative.

*PyObject** **PyObject_CallMethod**(*PyObject *o*, char **method*, char **format*, ...)
*Return value: New reference.* Call the method named *method* of object *o* with a variable number of C arguments. The C arguments are described by a `Py_BuildValue()` format string that should produce a tuple. The format may be *NULL*, indicating that no arguments are provided. Returns the result of the call on success, or *NULL* on failure. This is the equivalent of the Python expression `o.method(args)`. Note that if you only pass `PyObject *` args, `PyObject_CallMethodObjArgs()` is a faster alternative.

*PyObject** **PyObject_CallFunctionObjArgs**(*PyObject *callable*, ..., NULL)
*Return value: New reference.* Call a callable Python object *callable*, with a variable number of `PyObject*` arguments. The arguments are provided as a variable number of parameters followed by *NULL*. Returns the result of the call on success, or *NULL* on failure.

2.2 新版功能.

*PyObject** **PyObject_CallMethodObjArgs**(*PyObject *o*, *PyObject *name*, ..., NULL)
*Return value: New reference.* Calls a method of the object *o*, where the name of the method is given as a Python string object in *name*. It is called with a variable number of `PyObject*` arguments. The arguments are provided as a variable number of parameters followed by *NULL*. Returns the result of the call on success, or *NULL* on failure.

2.2 新版功能.

long **PyObject_Hash**(*PyObject *o*)
Compute and return the hash value of an object *o*. On failure, return `-1`. This is the equivalent of the Python expression `hash(o)`.

long **PyObject_HashNotImplemented**(*PyObject *o*)
Set a `TypeError` indicating that `type(o)` is not hashable and return `-1`. This function receives special treatment when stored in a `tp_hash` slot, allowing a type to explicitly indicate to the interpreter that it is not hashable.

2.6 新版功能.

int **PyObject_IsTrue**(*PyObject *o*)
Returns `1` if the object *o* is considered to be true, and `0` otherwise. This is equivalent to the Python expression `not not o`. On failure, return `-1`.

int **PyObject_Not**(*PyObject *o*)
Returns `0` if the object *o* is considered to be true, and `1` otherwise. This is equivalent to the Python expression `not o`. On failure, return `-1`.

*PyObject** **PyObject_Type**(*PyObject *o*)
*Return value: New reference.* When *o* is non-*NULL*, returns a type object corresponding to the object type of object *o*. On failure, raises `SystemError` and returns *NULL*. This is equivalent to the Python expression `type(o)`. This function increments the reference count of the return value. There' s really no reason to use this function instead of the common expression `o->ob_type`, which returns a pointer of type `PyTypeObject*`, except when the incremented reference count is needed.

int **PyObject_TypeCheck**(*PyObject *o*, *PyTypeObject *type*)
Return true if the object *o* is of type *type* or a subtype of *type*. Both parameters must be non-*NULL*.

2.2 新版功能.

Py_ssize_t **PyObject_Length** (*PyObject *o*)
Py_ssize_t **PyObject_Size** (*PyObject *o*)

Return the length of object *o*. If the object *o* provides either the sequence and mapping protocols, the sequence length is returned. On error, `-1` is returned. This is the equivalent to the Python expression `len(o)`.

在 2.5 版更改: These functions returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyObject_GetItem** (*PyObject *o*, *PyObject *key*)

*Return value: New reference.* Return element of *o* corresponding to the object *key* or *NULL* on failure. This is the equivalent of the Python expression `o[key]`.

int **PyObject_SetItem** (*PyObject *o*, *PyObject *key*, *PyObject *v*)

Map the object *key* to the value *v*. Raise an exception and return `-1` on failure; return `0` on success. This is the equivalent of the Python statement `o[key] = v`.

int **PyObject_DelItem** (*PyObject *o*, *PyObject *key*)

Delete the mapping for *key* from *o*. Returns `-1` on failure. This is the equivalent of the Python statement `del o[key]`.

int **PyObject_AsFileDescriptor** (*PyObject *o*)

Derives a file descriptor from a Python object. If the object is an integer or long integer, its value is returned. If not, the object's `fileno()` method is called if it exists; the method must return an integer or long integer, which is returned as the file descriptor value. Returns `-1` on failure.

*PyObject** **PyObject_Dir** (*PyObject *o*)

*Return value: New reference.* This is equivalent to the Python expression `dir(o)`, returning a (possibly empty) list of strings appropriate for the object argument, or *NULL* if there was an error. If the argument is *NULL*, this is like the Python `dir()`, returning the names of the current locals; in this case, if no execution frame is active then *NULL* is returned but `PyErr_Occurred()` will return false.

*PyObject** **PyObject_GetIter** (*PyObject *o*)

*Return value: New reference.* This is equivalent to the Python expression `iter(o)`. It returns a new iterator for the object argument, or the object itself if the object is already an iterator. Raises `TypeError` and returns *NULL* if the object cannot be iterated.

## 6.2 数字协议

int **PyNumber_Check** (*PyObject *o*)

如果对象 *o* 提供数字的协议，返回真 `1`，否则返回假。这个函数不会调用失败。

*PyObject** **PyNumber_Add** (*PyObject *o1*, *PyObject *o2*)

*Return value: New reference.* Returns the result of adding *o1* and *o2*, or *NULL* on failure. This is the equivalent of the Python expression `o1 + o2`.

*PyObject** **PyNumber_Subtract** (*PyObject *o1*, *PyObject *o2*)

*Return value: New reference.* Returns the result of subtracting *o2* from *o1*, or *NULL* on failure. This is the equivalent of the Python expression `o1 - o2`.

*PyObject** **PyNumber_Multiply** (*PyObject *o1*, *PyObject *o2*)

*Return value: New reference.* Returns the result of multiplying *o1* and *o2*, or *NULL* on failure. This is the equivalent of the Python expression `o1 * o2`.

*PyObject** **PyNumber_Divide** (*PyObject *o1*, *PyObject *o2*)

*Return value: New reference.* Returns the result of dividing *o1* by *o2*, or *NULL* on failure. This is the equivalent of the Python expression `o1 / o2`.

*PyObject** **PyNumber_FloorDivide**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Return the floor of *o1* divided by *o2*, or *NULL* on failure. This is equivalent to the "classic" division of integers.

2.2 新版功能.

*PyObject** **PyNumber_TrueDivide**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Return a reasonable approximation for the mathematical value of *o1* divided by *o2*, or *NULL* on failure. The return value is "approximate" because binary floating point numbers are approximate; it is not possible to represent all real numbers in base two. This function can return a floating point value when passed two integers.

2.2 新版功能.

*PyObject** **PyNumber_Remainder**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the remainder of dividing *o1* by *o2*, or *NULL* on failure. This is the equivalent of the Python expression `o1 % o2`.

*PyObject** **PyNumber_Divmod**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* See the built-in function `divmod()`. Returns *NULL* on failure. This is the equivalent of the Python expression `divmod(o1, o2)`.

*PyObject** **PyNumber_Power**(*PyObject *o1*, *PyObject *o2*, *PyObject *o3*)
*Return value: New reference.* See the built-in function `pow()`. Returns *NULL* on failure. This is the equivalent of the Python expression `pow(o1, o2, o3)`, where *o3* is optional. If *o3* is to be ignored, pass `Py_None` in its place (passing *NULL* for *o3* would cause an illegal memory access).

*PyObject** **PyNumber_Negative**(*PyObject *o*)
*Return value: New reference.* Returns the negation of *o* on success, or *NULL* on failure. This is the equivalent of the Python expression `-o`.

*PyObject** **PyNumber_Positive**(*PyObject *o*)
*Return value: New reference.* Returns *o* on success, or *NULL* on failure. This is the equivalent of the Python expression `+o`.

*PyObject** **PyNumber_Absolute**(*PyObject *o*)
*Return value: New reference.* Returns the absolute value of *o*, or *NULL* on failure. This is the equivalent of the Python expression `abs(o)`.

*PyObject** **PyNumber_Invert**(*PyObject *o*)
*Return value: New reference.* Returns the bitwise negation of *o* on success, or *NULL* on failure. This is the equivalent of the Python expression `~o`.

*PyObject** **PyNumber_Lshift**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of left shifting *o1* by *o2* on success, or *NULL* on failure. This is the equivalent of the Python expression `o1 << o2`.

*PyObject** **PyNumber_Rshift**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of right shifting *o1* by *o2* on success, or *NULL* on failure. This is the equivalent of the Python expression `o1 >> o2`.

*PyObject** **PyNumber_And**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the "bitwise and" of *o1* and *o2* on success and *NULL* on failure. This is the equivalent of the Python expression `o1 & o2`.

*PyObject** **PyNumber_Xor**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the "bitwise exclusive or" of *o1* by *o2* on success, or *NULL* on failure. This is the equivalent of the Python expression `o1 ^ o2`.

*PyObject** **PyNumber_Or**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the "bitwise or" of *o1* and *o2* on success, or *NULL* on failure. This is the

equivalent of the Python expression `o1 | o2`.

*PyObject** **PyNumber_InPlaceAdd**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of adding *o1* and *o2*, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 += o2`.

*PyObject** **PyNumber_InPlaceSubtract**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of subtracting *o2* from *o1*, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 -= o2`.

*PyObject** **PyNumber_InPlaceMultiply**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of multiplying *o1* and *o2*, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 *= o2`.

*PyObject** **PyNumber_InPlaceDivide**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of dividing *o1* by *o2*, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 /= o2`.

*PyObject** **PyNumber_InPlaceFloorDivide**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the mathematical floor of dividing *o1* by *o2*, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 //= o2`.

2.2 新版功能.

*PyObject** **PyNumber_InPlaceTrueDivide**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Return a reasonable approximation for the mathematical value of *o1* divided by *o2*, or *NULL* on failure. The return value is "approximate" because binary floating point numbers are approximate; it is not possible to represent all real numbers in base two. This function can return a floating point value when passed two integers. The operation is done *in-place* when *o1* supports it.

2.2 新版功能.

*PyObject** **PyNumber_InPlaceRemainder**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the remainder of dividing *o1* by *o2*, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 %= o2`.

*PyObject** **PyNumber_InPlacePower**(*PyObject *o1*, *PyObject *o2*, *PyObject *o3*)
*Return value: New reference.* See the built-in function `pow()`. Returns *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 **= o2` when o3 is `Py_None`, or an in-place variant of `pow(o1, o2, o3)` otherwise. If *o3* is to be ignored, pass `Py_None` in its place (passing *NULL* for *o3* would cause an illegal memory access).

*PyObject** **PyNumber_InPlaceLshift**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of left shifting *o1* by *o2* on success, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 <<= o2`.

*PyObject** **PyNumber_InPlaceRshift**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the result of right shifting *o1* by *o2* on success, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 >>= o2`.

*PyObject** **PyNumber_InPlaceAnd**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the "bitwise and" of *o1* and *o2* on success and *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 &= o2`.

*PyObject** **PyNumber_InPlaceXor**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the "bitwise exclusive or" of *o1* by *o2* on success, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 ^= o2`.

*PyObject** **PyNumber_InPlaceOr**(*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Returns the "bitwise or" of *o1* and *o2* on success, or *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python statement `o1 |= o2`.

int **PyNumber_Coerce** (*PyObject* ***p1*, *PyObject* ***p2*)

This function takes the addresses of two variables of type `PyObject*`. If the objects pointed to by `*p1` and `*p2` have the same type, increment their reference count and return `0` (success). If the objects can be converted to a common numeric type, replace `*p1` and `*p2` by their converted value (with 'new' reference counts), and return `0`. If no conversion is possible, or if some other error occurs, return `-1` (failure) and don't increment the reference counts. The call `PyNumber_Coerce(&o1, &o2)` is equivalent to the Python statement `o1, o2 = coerce(o1, o2)`.

int **PyNumber_CoerceEx** (*PyObject* ***p1*, *PyObject* ***p2*)

This function is similar to `PyNumber_Coerce()`, except that it returns `1` when the conversion is not possible and when no error is raised. Reference counts are still not increased in this case.

*PyObject** **PyNumber_Int** (*PyObject* **o*)

*Return value: New reference.* Returns the *o* converted to an integer object on success, or *NULL* on failure. If the argument is outside the integer range a long object will be returned instead. This is the equivalent of the Python expression `int(o)`.

*PyObject** **PyNumber_Long** (*PyObject* **o*)

*Return value: New reference.* Returns the *o* converted to a long integer object on success, or *NULL* on failure. This is the equivalent of the Python expression `long(o)`.

*PyObject** **PyNumber_Float** (*PyObject* **o*)

*Return value: New reference.* Returns the *o* converted to a float object on success, or *NULL* on failure. This is the equivalent of the Python expression `float(o)`.

*PyObject** **PyNumber_Index** (*PyObject* **o*)

Returns the *o* converted to a Python int or long on success or *NULL* with a `TypeError` exception raised on failure.

2.5 新版功能.

*PyObject** **PyNumber_ToBase** (*PyObject* **n*, int *base*)

Returns the integer *n* converted to *base* as a string with a base marker of `'0b'`, `'0o'`, or `'0x'` if applicable. When *base* is not 2, 8, 10, or 16, the format is `'x#num'` where x is the base. If *n* is not an int object, it is converted with `PyNumber_Index()` first.

2.6 新版功能.

Py_ssize_t **PyNumber_AsSsize_t** (*PyObject* **o*, *PyObject* **exc*)

Returns *o* converted to a Py_ssize_t value if *o* can be interpreted as an integer. If *o* can be converted to a Python int or long but the attempt to convert to a Py_ssize_t value would raise an `OverflowError`, then the *exc* argument is the type of exception that will be raised (usually `IndexError` or `OverflowError`). If *exc* is *NULL*, then the exception is cleared and the value is clipped to *PY_SSIZE_T_MIN* for a negative integer or *PY_SSIZE_T_MAX* for a positive integer.

2.5 新版功能.

int **PyIndex_Check** (*PyObject* **o*)

Returns `1` if *o* is an index integer (has the nb_index slot of the tp_as_number structure filled in), and `0` otherwise.

2.5 新版功能.

## 6.3 序列协议

int **PySequence_Check** (*PyObject *o*)
Return `1` if the object provides sequence protocol, and `0` otherwise. This function always succeeds.

Py_ssize_t **PySequence_Size** (*PyObject *o*)
Py_ssize_t **PySequence_Length** (*PyObject *o*)
成功时返回序列中 *o* 的对象数, 失败时返回 "-1". 相当于 Python 的 "len(o)"表达式.

在 2.5 版更改: These functions returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PySequence_Concat** (*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Return the concatenation of *o1* and *o2* on success, and *NULL* on failure. This is the equivalent of the Python expression `o1 + o2`.

*PyObject** **PySequence_Repeat** (*PyObject *o*, Py_ssize_t *count*)
*Return value: New reference.* Return the result of repeating sequence object *o count* times, or *NULL* on failure. This is the equivalent of the Python expression `o * count`.

在 2.5 版更改: This function used an `int` type for *count*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PySequence_InPlaceConcat** (*PyObject *o1*, *PyObject *o2*)
*Return value: New reference.* Return the concatenation of *o1* and *o2* on success, and *NULL* on failure. The operation is done *in-place* when *o1* supports it. This is the equivalent of the Python expression `o1 += o2`.

*PyObject** **PySequence_InPlaceRepeat** (*PyObject *o*, Py_ssize_t *count*)
*Return value: New reference.* Return the result of repeating sequence object *o count* times, or *NULL* on failure. The operation is done *in-place* when *o* supports it. This is the equivalent of the Python expression `o *= count`.

在 2.5 版更改: This function used an `int` type for *count*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PySequence_GetItem** (*PyObject *o*, Py_ssize_t *i*)
*Return value: New reference.* Return the *i*th element of *o*, or *NULL* on failure. This is the equivalent of the Python expression `o[i]`.

在 2.5 版更改: This function used an `int` type for *i*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PySequence_GetSlice** (*PyObject *o*, Py_ssize_t *i1*, Py_ssize_t *i2*)
*Return value: New reference.* Return the slice of sequence object *o* between *i1* and *i2*, or *NULL* on failure. This is the equivalent of the Python expression `o[i1:i2]`.

在 2.5 版更改: This function used an `int` type for *i1* and *i2*. This might require changes in your code for properly supporting 64-bit systems.

int **PySequence_SetItem** (*PyObject *o*, Py_ssize_t *i*, *PyObject *v*)
将对象 *v* 赋值给 *o* 的第 *i* 号元素。失败时会引发异常并返回 `-1`；成功时返回 `0`。这相当于 Python 语句 `o[i] = v`。此函数 不会改变对 *v* 的引用。

If *v* is *NULL*, the element is deleted, however this feature is deprecated in favour of using `PySequence_DelItem()`.

在 2.5 版更改: This function used an `int` type for *i*. This might require changes in your code for properly supporting 64-bit systems.

int **PySequence_DelItem** (*PyObject *o*, Py_ssize_t *i*)
删除对象 *o* 的第 *i* 号元素。失败时返回 `-1`。这相当于 Python 语句 `del o[i]`。

在 2.5 版更改: This function used an `int` type for *i*. This might require changes in your code for properly supporting 64-bit systems.

int **PySequence_SetSlice** (*PyObject* *o, Py_ssize_t *i1*, Py_ssize_t *i2*, *PyObject* *v)
Assign the sequence object *v* to the slice in sequence object *o* from *i1* to *i2*. Raise an exception and return `-1` on failure; return `0` on success. This is the equivalent of the Python statement `o[i1:i2] = v`.

If *v* is *NULL*, the slice is deleted, however this feature is deprecated in favour of using `PySequence_DelSlice()`.

在 2.5 版更改: This function used an `int` type for *i1* and *i2*. This might require changes in your code for properly supporting 64-bit systems.

int **PySequence_DelSlice** (*PyObject* *o, Py_ssize_t *i1*, Py_ssize_t *i2*)
删除序列对象 *o* 的从 *i1* 到 *i2* 的切片。失败时返回 `-1`。这相当于 Python 语句 `del o[i1:i2]`。

在 2.5 版更改: This function used an `int` type for *i1* and *i2*. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PySequence_Count** (*PyObject* *o, *PyObject* *value)
返回 *value* 在 *o* 中出现的次数，即返回使得 `o[key] == value` 的键的数量。失败时返回 `-1`。这相当于 Python 表达式 `o.count(value)`。

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

int **PySequence_Contains** (*PyObject* *o, *PyObject* *value)
确定 *o* 是否包含 *value*。如果 *o* 中的某一项等于 *value*，则返回 `1`，否则返回 `0`。出错时，返回 `-1`。这相当于 Python 表达式 `value in o`。

Py_ssize_t **PySequence_Index** (*PyObject* *o, *PyObject* *value)
返回第一个索引 *i*, 其中 `o[i] == value`. 出错时, 返回 `-1`. 相当于 Python 的 "o.index(value)"表达式.

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PySequence_List** (*PyObject* *o)
*Return value: New reference.* Return a list object with the same contents as the arbitrary sequence *o*. The returned list is guaranteed to be new.

*PyObject** **PySequence_Tuple** (*PyObject* *o)
*Return value: New reference.* Return a tuple object with the same contents as the arbitrary sequence *o* or *NULL* on failure. If *o* is a tuple, a new reference will be returned, otherwise a tuple will be constructed with the appropriate contents. This is equivalent to the Python expression `tuple(o)`.

*PyObject** **PySequence_Fast** (*PyObject* *o, const char *m)
*Return value: New reference.* Return the sequence *o* as a list, unless it is already a tuple or list, in which case *o* is returned. Use `PySequence_Fast_GET_ITEM()` to access the members of the result. Returns *NULL* on failure. If the object is not a sequence, raises `TypeError` with *m* as the message text.

*PyObject** **PySequence_Fast_GET_ITEM** (*PyObject* *o, Py_ssize_t *i*)
*Return value: Borrowed reference.* Return the *i*th element of *o*, assuming that *o* was returned by `PySequence_Fast()`, *o* is not *NULL*, and that *i* is within bounds.

在 2.5 版更改: This function used an `int` type for *i*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject*** **PySequence_Fast_ITEMS** (*PyObject* *o)
Return the underlying array of PyObject pointers. Assumes that *o* was returned by `PySequence_Fast()` and *o* is not *NULL*.

请注意, 如果列表调整大小, 重新分配可能会重新定位 items 数组. 因此, 仅在序列无法更改的上下文中使用基础数组指针.

2.4 新版功能.

*PyObject** **PySequence_ITEM** (*PyObject* **o*, Py_ssize_t *i*)

*Return value: New reference.* Return the *i*th element of *o* or *NULL* on failure. Macro form of `PySequence_GetItem()` but without checking that `PySequence_Check()` on *o* is true and without adjustment for negative indices.

2.3 新版功能.

在 2.5 版更改: This function used an `int` type for *i*. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PySequence_Fast_GET_SIZE** (*PyObject* **o*)

Returns the length of *o*, assuming that *o* was returned by `PySequence_Fast()` and that *o* is not *NULL*. The size can also be gotten by calling `PySequence_Size()` on *o*, but `PySequence_Fast_GET_SIZE()` is faster because it can assume *o* is a list or tuple.

## 6.4 映射协议

int **PyMapping_Check** (*PyObject* **o*)

Return `1` if the object provides mapping protocol, and `0` otherwise. This function always succeeds.

Py_ssize_t **PyMapping_Size** (*PyObject* **o*)
Py_ssize_t **PyMapping_Length** (*PyObject* **o*)

Returns the number of keys in object *o* on success, and `-1` on failure. For objects that do not provide mapping protocol, this is equivalent to the Python expression `len(o)`.

在 2.5 版更改: These functions returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

int **PyMapping_DelItemString** (*PyObject* **o*, char **key*)

Remove the mapping for object *key* from the object *o*. Return `-1` on failure. This is equivalent to the Python statement `del o[key]`.

int **PyMapping_DelItem** (*PyObject* **o*, *PyObject* **key*)

Remove the mapping for object *key* from the object *o*. Return `-1` on failure. This is equivalent to the Python statement `del o[key]`.

int **PyMapping_HasKeyString** (*PyObject* **o*, char **key*)

On success, return `1` if the mapping object has the key *key* and `0` otherwise. This is equivalent to `o[key]`, returning `True` on success and `False` on an exception. This function always succeeds.

int **PyMapping_HasKey** (*PyObject* **o*, *PyObject* **key*)

Return `1` if the mapping object has the key *key* and `0` otherwise. This is equivalent to `o[key]`, returning `True` on success and `False` on an exception. This function always succeeds.

*PyObject** **PyMapping_Keys** (*PyObject* **o*)

*Return value: New reference.* On success, return a list of the keys in object *o*. On failure, return *NULL*. This is equivalent to the Python expression `o.keys()`.

*PyObject** **PyMapping_Values** (*PyObject* **o*)

*Return value: New reference.* On success, return a list of the values in object *o*. On failure, return *NULL*. This is equivalent to the Python expression `o.values()`.

*PyObject** **PyMapping_Items**(*PyObject *o*)

*Return value: New reference.* On success, return a list of the items in object *o*, where each item is a tuple containing a key-value pair. On failure, return *NULL*. This is equivalent to the Python expression `o.items()`.

*PyObject** **PyMapping_GetItemString**(*PyObject *o*, char **key*)

*Return value: New reference.* Return element of *o* corresponding to the object *key* or *NULL* on failure. This is the equivalent of the Python expression `o[key]`.

int **PyMapping_SetItemString**(*PyObject *o*, char **key*, *PyObject *v*)

Map the object *key* to the value *v* in object *o*. Returns `-1` on failure. This is the equivalent of the Python statement `o[key] = v`.

## 6.5 迭代器协议

2.2 新版功能.

迭代器有两个函数。

int **PyIter_Check**(*PyObject *o*)

返回 true ，如果对象 *o* 支持迭代器协议的话。

This function can return a false positive in the case of old-style classes because those classes always define a `tp_iternext` slot with logic that either invokes a `next()` method or raises a `TypeError`.

*PyObject** **PyIter_Next**(*PyObject *o*)

*Return value: New reference.* Return the next value from the iteration *o*. The object must be an iterator (it is up to the caller to check this). If there are no remaining values, returns *NULL* with no exception set. If an error occurs while retrieving the item, returns *NULL* and passes along the exception.

要为迭代器编写一个一个循环，C 代码应该看起来像这样

```c
PyObject *iterator = PyObject_GetIter(obj);
PyObject *item;

if (iterator == NULL) {
    /* propagate error */
}

while ((item = PyIter_Next(iterator))) {
    /* do something with item */
    ...
    /* release reference when done */
    Py_DECREF(item);
}

Py_DECREF(iterator);

if (PyErr_Occurred()) {
    /* propagate error */
}
else {
    /* continue doing useful work */
}
```

## 6.6 旧缓冲协议

This section describes the legacy buffer protocol, which has been introduced in Python 1.6. It is still supported but deprecated in the Python 2.x series. Python 3 introduces a new buffer protocol which fixes weaknesses and shortcomings of the protocol, and has been backported to Python 2.6. See *Buffers and Memoryview Objects* for more information.

int **PyObject_AsCharBuffer**(*PyObject* **obj*, const char ***buffer*, Py_ssize_t **buffer_len*)

返回一个可用作基于字符的输入的只读内存地址的指针。*obj* 参数必须支持单段字符缓冲接口。成功时返回 `0`，将 *buffer* 设为内存地址并将 *buffer_len* 设为缓冲区长度。出错时返回 `-1` 并设置一个 `TypeError`。

1.6 新版功能.

在 2.5 版更改: This function used an `int *` type for *buffer_len*. This might require changes in your code for properly supporting 64-bit systems.

int **PyObject_AsReadBuffer**(*PyObject* **obj*, const void ***buffer*, Py_ssize_t **buffer_len*)

返回一个指向包含任意数据的只读内存地址的指针。*obj* 参数必须支持单段可读缓冲接口。成功时返回 `0`，将 *buffer* 设为内存地址并将 *buffer_len* 设为缓冲区长度。出错时返回 `-1` 并设置一个 `TypeError`。

1.6 新版功能.

在 2.5 版更改: This function used an `int *` type for *buffer_len*. This might require changes in your code for properly supporting 64-bit systems.

int **PyObject_CheckReadBuffer**(*PyObject* **o*)

Returns `1` if *o* supports the single-segment readable buffer interface. Otherwise returns `0`.

2.2 新版功能.

int **PyObject_AsWriteBuffer**(*PyObject* **obj*, void ***buffer*, Py_ssize_t **buffer_len*)

Returns a pointer to a writeable memory location. The *obj* argument must support the single-segment, character buffer interface. On success, returns `0`, sets *buffer* to the memory location and *buffer_len* to the buffer length. Returns `-1` and sets a `TypeError` on error.

1.6 新版功能.

在 2.5 版更改: This function used an `int *` type for *buffer_len*. This might require changes in your code for properly supporting 64-bit systems.

CHAPTER 7

# 具体的对象层

本章中的函数特定于某些 Python 对象类型。将错误类型的对象传递给它们并不是一个好主意；如果您从 Python 程序接收到一个对象，但不确定它是否具有正确的类型，则必须首先执行类型检查；例如，要检查对象是否为字典，请使用 `PyDict_Check()`。本章的结构类似于 Python 对象类型的“家族树”。

> **警告：** While the functions described in this chapter carefully check the type of the objects which are passed in, many of them do not check for *NULL* being passed instead of a valid object. Allowing *NULL* to be passed in can cause memory access violations and immediate termination of the interpreter.

## 7.1 基本对象

本节描述 Python 类型对象和单一实例对象 象 None。

### 7.1.1 类型对象

**PyTypeObject**

对象的 C 结构用于描述 built-in 类型。

*PyObject** **PyType_Type**

This is the type object for type objects; it is the same object as `type` and `types.TypeType` in the Python layer.

int **PyType_Check** (*PyObject *o*)

如果对象 *o* 是一个类型对象，包括继承于标准类型对象的类型实例，返回真。在其它所有情况下返回假。

int **PyType_CheckExact** (*PyObject *o*)

如果对象 *o* 是一个类型对象，但不是标准类型对象的子类型时，返回真。在其它所有情况下返回假。

2.2 新版功能.

unsigned int **PyType_ClearCache**()

Clear the internal lookup cache. Return the current version tag.

2.6 新版功能.

void **PyType_Modified**(*PyTypeObject* *type)

Invalidate the internal lookup cache for the type and all of its subtypes. This function must be called after any manual modification of the attributes or base classes of the type.

2.6 新版功能.

int **PyType_HasFeature**(*PyObject* *o, int *feature*)

Return true if the type object *o* sets the feature *feature*. Type features are denoted by single bit flags.

int **PyType_IS_GC**(*PyObject* *o)

Return true if the type object includes support for the cycle detector; this tests the type flag `Py_TPFLAGS_HAVE_GC`.

2.0 新版功能.

int **PyType_IsSubtype**(*PyTypeObject* *a, *PyTypeObject* *b)

Return true if *a* is a subtype of *b*.

2.2 新版功能.

This function only checks for actual subtypes, which means that `__subclasscheck__()` is not called on *b*. Call `PyObject_IsSubclass()` to do the same check that `issubclass()` would do.

*PyObject** **PyType_GenericAlloc**(*PyTypeObject* *type, Py_ssize_t *nitems*)

*Return value: New reference.* 2.2 新版功能.

在 2.5 版更改: This function used an `int` type for *nitems*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyType_GenericNew**(*PyTypeObject* *type, *PyObject* *args, *PyObject* *kwds)

*Return value: New reference.* 2.2 新版功能.

int **PyType_Ready**(*PyTypeObject* *type)

Finalize a type object. This should be called on all type objects to finish their initialization. This function is responsible for adding inherited slots from a type' s base class. Return `0` on success, or return `-1` and sets an exception on error.

2.2 新版功能.

### 7.1.2 None 对象

请注意，`None` 的`PyTypeObject` 不会直接在 Python / C API 中公开。由于 `None` 是单例，测试对象标识（在 C 中使用 == ）就足够了。由于同样的原因，没有 `PyNone_Check()` 函数。

*PyObject** **Py_None**

Python `None` 对象，表示缺乏值。这个对象没有方法。它需要像引用计数一样处理任何其他对象。

**Py_RETURN_NONE**

Properly handle returning `Py_None` from within a C function.

2.4 新版功能.

## 7.2 数值对象

### 7.2.1 Plain Integer Objects

**PyIntObject**
This subtype of `PyObject` represents a Python integer object.

*PyTypeObject* **PyInt_Type**
This instance of `PyTypeObject` represents the Python plain integer type. This is the same object as `int` and `types.IntType`.

int **PyInt_Check** (*PyObject* *o)
Return true if *o* is of type `PyInt_Type` or a subtype of `PyInt_Type`.

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyInt_CheckExact** (*PyObject* *o)
Return true if *o* is of type `PyInt_Type`, but not a subtype of `PyInt_Type`.

2.2 新版功能.

*PyObject** **PyInt_FromString** (char *str, char **pend, int base)
*Return value: New reference.* Return a new `PyIntObject` or `PyLongObject` based on the string value in *str*, which is interpreted according to the radix in *base*. If *pend* is non-*NULL*, `*pend` will point to the first character in *str* which follows the representation of the number. If *base* is `0`, the radix will be determined based on the leading characters of *str*: if *str* starts with `'0x'` or `'0X'`, radix 16 will be used; if *str* starts with `'0'`, radix 8 will be used; otherwise radix 10 will be used. If *base* is not `0`, it must be between `2` and `36`, inclusive. Leading spaces are ignored. If there are no digits, `ValueError` will be raised. If the string represents a number too large to be contained within the machine's `long int` type and overflow warnings are being suppressed, a `PyLongObject` will be returned. If overflow warnings are not being suppressed, *NULL* will be returned in this case.

*PyObject** **PyInt_FromLong** (long ival)
*Return value: New reference.* Create a new integer object with a value of *ival*.

The current implementation keeps an array of integer objects for all integers between `-5` and `256`, when you create an int in that range you actually just get back a reference to the existing object. So it should be possible to change the value of `1`. I suspect the behaviour of Python in this case is undefined. :-)

*PyObject** **PyInt_FromSsize_t** (Py_ssize_t ival)
*Return value: New reference.* Create a new integer object with a value of *ival*. If the value is larger than `LONG_MAX` or smaller than `LONG_MIN`, a long integer object is returned.

2.5 新版功能.

*PyObject** **PyInt_FromSize_t** (size_t ival)
Create a new integer object with a value of *ival*. If the value exceeds `LONG_MAX`, a long integer object is returned.

2.5 新版功能.

long **PyInt_AsLong** (*PyObject* *io)
Will first attempt to cast the object to a `PyIntObject`, if it is not already one, and then return its value. If there is an error, `-1` is returned, and the caller should check `PyErr_Occurred()` to find out whether there was an error, or whether the value just happened to be `-1`.

long **PyInt_AS_LONG** (*PyObject* *io)
Return the value of the object *io*. No error checking is performed.

unsigned long **PyInt_AsUnsignedLongMask** (*PyObject* *io)
Will first attempt to cast the object to a `PyIntObject` or `PyLongObject`, if it is not already one, and then return its value as unsigned long. This function does not check for overflow.

2.3 新版功能.

unsigned PY_LONG_LONG **PyInt_AsUnsignedLongLongMask** (*PyObject *io*)
Will first attempt to cast the object to a `PyIntObject` or `PyLongObject`, if it is not already one, and then return its value as unsigned long long, without checking for overflow.

2.3 新版功能.

Py_ssize_t **PyInt_AsSsize_t** (*PyObject *io*)
Will first attempt to cast the object to a `PyIntObject` or `PyLongObject`, if it is not already one, and then return its value as `Py_ssize_t`.

2.5 新版功能.

long **PyInt_GetMax** ()
Return the system' s idea of the largest integer it can handle (`LONG_MAX`, as defined in the system header files).

int **PyInt_ClearFreeList** ()
Clear the integer free list. Return the number of items that could not be freed.

2.6 新版功能.

### 7.2.2 布尔对象

Python 中的布尔值是作为整数的子类实现的。只有 `Py_False` 和 `Py_True` 两个布尔值。因此，正常的创建和删除功能不适用于布尔值。但是，下列宏可用。

int **PyBool_Check** (*PyObject *o*)
如果 *o* 是 `PyBool_Type` 类型，则返回 true。

2.3 新版功能.

*PyObject** **Py_False**
Python 的 "False"对象。该对象没有任何方法。它应该象其它使用引用计数管理的对象一样使用。

*PyObject** **Py_True**
Python 的 "True"对象。该对象没有任何方法。它应该象其它使用引用计数管理的对象一样使用。

**Py_RETURN_FALSE**
从函数返回 `Py_False` 时，需要增加它的引用计数。

2.4 新版功能.

**Py_RETURN_TRUE**
从函数返回 `Py_True` 时，需要增加它的引用计数。

2.4 新版功能.

*PyObject** **PyBool_FromLong** (long *v*)
*Return value: New reference.* 根据 *v* 的实际值，返回一个 `Py_True` 或者 `Py_False` 的新引用。

2.3 新版功能.

### 7.2.3 Long Integer Objects

**PyLongObject**
This subtype of *PyObject* represents a Python long integer object.

*PyTypeObject* **PyLong_Type**
This instance of *PyTypeObject* represents the Python long integer type. This is the same object as `long` and `types.LongType`.

int **PyLong_Check** (*PyObject* **p*)
Return true if its argument is a *PyLongObject* or a subtype of *PyLongObject*.

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyLong_CheckExact** (*PyObject* **p*)
Return true if its argument is a *PyLongObject*, but not a subtype of *PyLongObject*.

2.2 新版功能.

*PyObject** **PyLong_FromLong** (long *v*)
*Return value: New reference.* Return a new *PyLongObject* object from *v*, or *NULL* on failure.

*PyObject** **PyLong_FromUnsignedLong** (unsigned long *v*)
*Return value: New reference.* Return a new *PyLongObject* object from a C `unsigned long`, or *NULL* on failure.

*PyObject** **PyLong_FromSsize_t** (Py_ssize_t *v*)
*Return value: New reference.* Return a new *PyLongObject* object from a C `Py_ssize_t`, or *NULL* on failure.

2.6 新版功能.

*PyObject** **PyLong_FromSize_t** (size_t *v*)
*Return value: New reference.* Return a new *PyLongObject* object from a C `size_t`, or *NULL* on failure.

2.6 新版功能.

*PyObject** **PyLong_FromLongLong** (PY_LONG_LONG *v*)
*Return value: New reference.* Return a new *PyLongObject* object from a C `long long`, or *NULL* on failure.

*PyObject** **PyLong_FromUnsignedLongLong** (unsigned PY_LONG_LONG *v*)
*Return value: New reference.* Return a new *PyLongObject* object from a C `unsigned long long`, or *NULL* on failure.

*PyObject** **PyLong_FromDouble** (double *v*)
*Return value: New reference.* Return a new *PyLongObject* object from the integer part of *v*, or *NULL* on failure.

*PyObject** **PyLong_FromString** (char **str*, char ***pend*, int *base*)
*Return value: New reference.* Return a new *PyLongObject* based on the string value in *str*, which is interpreted according to the radix in *base*. If *pend* is non-*NULL*, **pend* will point to the first character in *str* which follows the representation of the number. If *base* is `0`, the radix will be determined based on the leading characters of *str*: if *str* starts with `'0x'` or `'0X'`, radix 16 will be used; if *str* starts with `'0'`, radix 8 will be used; otherwise radix 10 will be used. If *base* is not `0`, it must be between `2` and `36`, inclusive. Leading spaces are ignored. If there are no digits, `ValueError` will be raised.

*PyObject** **PyLong_FromUnicode** (*Py_UNICODE* **u*, Py_ssize_t *length*, int *base*)
*Return value: New reference.* Convert a sequence of Unicode digits to a Python long integer value. The first parameter, *u*, points to the first character of the Unicode string, *length* gives the number of characters, and *base* is the radix for the conversion. The radix must be in the range [2, 36]; if it is out of range, `ValueError` will be raised.

1.6 新版功能.

在 2.5 版更改: This function used an `int` for *length*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyLong_FromVoidPtr**(void **p*)
*Return value: New reference.* Create a Python integer or long integer from the pointer *p*. The pointer value can be retrieved from the resulting value using `PyLong_AsVoidPtr()`.

1.5.2 新版功能.

在 2.5 版更改: If the integer is larger than LONG_MAX, a positive long integer is returned.

long **PyLong_AsLong**(*PyObject* **pylong*)
Return a C `long` representation of the contents of *pylong*. If *pylong* is greater than `LONG_MAX`, an `OverflowError` is raised and `-1` will be returned.

long **PyLong_AsLongAndOverflow**(*PyObject* **pylong*, int **overflow*)
Return a C `long` representation of the contents of *pylong*. If *pylong* is greater than `LONG_MAX` or less than `LONG_MIN`, set **overflow* to `1` or `-1`, respectively, and return `-1`; otherwise, set **overflow* to `0`. If any other exception occurs (for example a TypeError or MemoryError), then `-1` will be returned and **overflow* will be `0`.

2.7 新版功能.

PY_LONG_LONG **PyLong_AsLongLongAndOverflow**(*PyObject* **pylong*, int **overflow*)
Return a C `long long` representation of the contents of *pylong*. If *pylong* is greater than `PY_LLONG_MAX` or less than `PY_LLONG_MIN`, set **overflow* to `1` or `-1`, respectively, and return `-1`; otherwise, set **overflow* to `0`. If any other exception occurs (for example a TypeError or MemoryError), then `-1` will be returned and **overflow* will be `0`.

2.7 新版功能.

Py_ssize_t **PyLong_AsSsize_t**(*PyObject* **pylong*)
Return a C `Py_ssize_t` representation of the contents of *pylong*. If *pylong* is greater than `PY_SSIZE_T_MAX`, an `OverflowError` is raised and `-1` will be returned.

2.6 新版功能.

unsigned long **PyLong_AsUnsignedLong**(*PyObject* **pylong*)
Return a C `unsigned long` representation of the contents of *pylong*. If *pylong* is greater than `ULONG_MAX`, an `OverflowError` is raised.

PY_LONG_LONG **PyLong_AsLongLong**(*PyObject* **pylong*)
Return a C `long long` from a Python long integer. If *pylong* cannot be represented as a `long long`, an `OverflowError` is raised and `-1` is returned.

2.2 新版功能.

unsigned PY_LONG_LONG **PyLong_AsUnsignedLongLong**(*PyObject* **pylong*)
Return a C `unsigned long long` from a Python long integer. If *pylong* cannot be represented as an `unsigned long long`, an `OverflowError` is raised and `(unsigned long long)-1` is returned.

2.2 新版功能.

在 2.7 版更改: A negative *pylong* now raises `OverflowError`, not `TypeError`.

unsigned long **PyLong_AsUnsignedLongMask**(*PyObject* **io*)
Return a C `unsigned long` from a Python long integer, without checking for overflow.

Returns `(unsigned long)-1` on error. Use `PyErr_Occurred()` to disambiguate.

2.3 新版功能.

unsigned PY_LONG_LONG **PyLong_AsUnsignedLongLongMask**(*PyObject* **io*)
Return a C `unsigned long long` from a Python long integer, without checking for overflow.

Returns `(unsigned PY_LONG_LONG)-1` on error. Use `PyErr_Occurred()` to disambiguate.

2.3 新版功能.

double **PyLong_AsDouble**(*PyObject *pylong*)

Return a C `double` representation of the contents of *pylong*. If *pylong* cannot be approximately represented as a `double`, an `OverflowError` exception is raised and `-1.0` will be returned.

void* **PyLong_AsVoidPtr**(*PyObject *pylong*)

Convert a Python integer or long integer *pylong* to a C `void` pointer. If *pylong* cannot be converted, an `OverflowError` will be raised. This is only assured to produce a usable `void` pointer for values created with `PyLong_FromVoidPtr()`.

1.5.2 新版功能.

在 2.5 版更改: For values outside 0..LONG_MAX, both signed and unsigned integers are accepted.

### 7.2.4 浮点数对象

**PyFloatObject**

这个 C 类型`PyObject` 的子类型代表一个 Python 浮点数对象。

*PyTypeObject* **PyFloat_Type**

This instance of `PyTypeObject` represents the Python floating point type. This is the same object as `float` and `types.FloatType`.

int **PyFloat_Check**(*PyObject *p*)

当他的参数是一个 C 类型`PyFloatObject` 或者是 C 类型`PyFloatObject` 的子类型时，返回真。

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyFloat_CheckExact**(*PyObject *p*)

当他的参数是一个 C 类型`PyFloatObject` 但不是 C 类型`PyFloatObject` 的子类型时，返回真。

2.2 新版功能.

*PyObject** **PyFloat_FromString**(*PyObject *str*, char ***pend*)

*Return value: New reference.* Create a `PyFloatObject` object based on the string value in *str*, or *NULL* on failure. The *pend* argument is ignored. It remains only for backward compatibility.

*PyObject** **PyFloat_FromDouble**(double *v*)

*Return value: New reference.* Create a `PyFloatObject` object from *v*, or *NULL* on failure.

double **PyFloat_AsDouble**(*PyObject *pyfloat*)

返回一个代表 *pyfloat* 内容的 C 类型 `double`。如果 *float* 不是一个 Python 浮点数对象，但是包含 `__float__()` 方法，这个方法会首先被调用，将 *pyfloat* 转换成一个浮点数。失败时这个方法返回 `-1.0`，所以应该调用 C 函数`PyErr_Occurred()` 检查错误。

double **PyFloat_AS_DOUBLE**(*PyObject *pyfloat*)

返回一个 *pyfloat* 内容的 C `double` 表示，但没有错误检查。

*PyObject** **PyFloat_GetInfo**(void)

返回一个 structseq 实例，其中包含有关 float 的精度、最小值和最大值的信息。它是头文件 `float.h` 的一个简单包装。

2.6 新版功能.

double **PyFloat_GetMax**()

返回最大可表示的有限浮点数 *DBL_MAX* 为 C `double` 。

2.6 新版功能.

double **PyFloat_GetMin**()

返回最小可表示归一化正浮点数 *DBL_MIN* 为 C `double` 。

2.6 新版功能.

int **PyFloat_ClearFreeList**()

清空浮点数释放列表。返回无法释放的项目数。

2.6 新版功能.

void **PyFloat_AsString**(char **buf*, *PyFloatObject* **v*)

Convert the argument *v* to a string, using the same rules as `str()`. The length of *buf* should be at least 100.

This function is unsafe to call because it writes to a buffer whose length it does not know.

2.7 版后已移除: Use `PyObject_Str()` or `PyOS_double_to_string()` instead.

void **PyFloat_AsReprString**(char **buf*, *PyFloatObject* **v*)

Same as PyFloat_AsString, except uses the same rules as `repr()`. The length of *buf* should be at least 100.

This function is unsafe to call because it writes to a buffer whose length it does not know.

2.7 版后已移除: Use `PyObject_Repr()` or `PyOS_double_to_string()` instead.

### 7.2.5 复数对象

从 C API 看，Python 的复数对象由两个不同的部分实现：一个是在 Python 程序使用的 Python 对象，另外的是一个代表真正复数值的 C 结构体。API 提供了函数共同操作两者。

#### 表示复数的 C 结构体

需要注意的是接受这些结构体的作为参数并当做结果返回的函数，都是传递“值”而不是引用指针。此规则适用于整个 API。

**Py_complex**

这是一个对应 Python 复数对象的值部分的 C 结构体。绝大部分处理复数对象的函数都用这类型的结构体作为输入或者输出值，它可近似地定义为：

```
typedef struct {
   double real;
   double imag;
} Py_complex;
```

*Py_complex* **_Py_c_sum**(*Py_complex left*, *Py_complex right*)

返回两个复数的和，用 C 类型 `Py_complex` 表示。

*Py_complex* **_Py_c_diff**(*Py_complex left*, *Py_complex right*)

返回两个复数的差，用 C 类型 `Py_complex` 表示。

*Py_complex* **_Py_c_neg**(*Py_complex complex*)

返回复数 *complex* 的负值，用 C 类型 `Py_complex` 表示。

*Py_complex* **_Py_c_prod**(*Py_complex left*, *Py_complex right*)

返回两个复数的乘积，用 C 类型 `Py_complex` 表示。

*Py_complex* **_Py_c_quot**(*Py_complex dividend*, *Py_complex divisor*)

返回两个复数的商，用 C 类型 `Py_complex` 表示。

如果 *divisor* 为空，这个方法返回零并设置 `errno` 为 `EDOM`。

*Py_complex* **_Py_c_pow** (*Py_complex num*, *Py_complex exp*)
返回 *num* 的 *exp* 次幂，用 C 类型`Py_complex` 表示。

如果 *num* 为空且 *exp* 不是正实数，这个方法返回零并设置 `errno` 为 `EDOM`。

### 表示复数的 Python 对象

**PyComplexObject**
这个 C 类型`PyObject` 的子类型代表一个 Python 复数对象。

*PyTypeObject* **PyComplex_Type**
This instance of `PyTypeObject` represents the Python complex number type. It is the same object as `complex` and `types.ComplexType`.

int **PyComplex_Check** (*PyObject *p*)
如果它的变量是一个 C 类型`PyComplexObject` 或者是 C 类型`PyComplexObject` 的子类型，返回真。

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyComplex_CheckExact** (*PyObject *p*)
如果它的参数是一个 C 类型`PyComplexObject` 但不是 C 类型`PyComplexObject` 的子类型，返回真。

2.2 新版功能.

*PyObject** **PyComplex_FromCComplex** (*Py_complex v*)
*Return value: New reference.* 根据 C 类型`Py_complex` 的值生成一个新的 Python 复数对象。

*PyObject** **PyComplex_FromDoubles** (double *real*, double *imag*)
*Return value: New reference.* 根据 *real* 和 *imag* 返回一个新的 C 类型`PyComplexObject` 对象。

double **PyComplex_RealAsDouble** (*PyObject *op*)
以 C 类型 `double` 返回 *op* 的实部。

double **PyComplex_ImagAsDouble** (*PyObject *op*)
以 C 类型 `double` 返回 *op* 的虚部。

*Py_complex* **PyComplex_AsCComplex** (*PyObject *op*)
Return the `Py_complex` value of the complex number *op*. Upon failure, this method returns `-1.0` as a real value.

在 2.6 版更改: If *op* is not a Python complex number object but has a `__complex__()` method, this method will first be called to convert *op* to a Python complex number object.

## 7.3 序列对象

序列对象的一般操作在前一章中讨论过; 本节介绍 Python 语言固有的特定类型的序列对象。

### 7.3.1 字节数组对象

2.6 新版功能.

**PyByteArrayObject**
这个*PyObject* 的子类型表示一个 Python 字节数组对象。

*PyTypeObject* **PyByteArray_Type**
This instance of *PyTypeObject* represents the Python bytearray type; it is the same object as `bytearray` in the Python layer.

#### 类型检查宏

int **PyByteArray_Check**(*PyObject* *o)
当对象 *o* 是一个字节数组对象而且是一个字节数组类型的子类型实例时，返回真。

int **PyByteArray_CheckExact**(*PyObject* *o)
当对象 *o* 是一个字节数组对象，但不是一个字节数组类型的子类型实例时，返回真。

#### 直接 API 函数

*PyObject** **PyByteArray_FromObject**(*PyObject* *o)
Return a new bytearray object from any object, *o*, that implements the buffer protocol.

*PyObject** **PyByteArray_FromStringAndSize**(const char **string*, Py_ssize_t *len*)
Create a new bytearray object from *string* and its length, *len*. On failure, *NULL* is returned.

*PyObject** **PyByteArray_Concat**(*PyObject* **a*, *PyObject* **b*)
连接字节数组 *a* 和 *b* 并返回一个带有结果的新的字节数组。

Py_ssize_t **PyByteArray_Size**(*PyObject* **bytearray*)
Return the size of *bytearray* after checking for a *NULL* pointer.

char* **PyByteArray_AsString**(*PyObject* **bytearray*)
Return the contents of *bytearray* as a char array after checking for a *NULL* pointer.

int **PyByteArray_Resize**(*PyObject* **bytearray*, Py_ssize_t *len*)
将 *bytearray* 的内部缓冲区的大小调整为 *len*。

#### 宏

这些宏减低安全性以换取性能，它们不检查指针。

char* **PyByteArray_AS_STRING**(*PyObject* **bytearray*)
C 函数`PyByteArray_AsString()` 的宏版本。

Py_ssize_t **PyByteArray_GET_SIZE**(*PyObject* **bytearray*)
C 函数`PyByteArray_Size()` 的宏版本。

### 7.3.2 String/Bytes Objects

These functions raise `TypeError` when expecting a string parameter and are called with a non-string parameter.

---

**注解：** These functions have been renamed to PyBytes_* in Python 3.x. Unless otherwise noted, the PyBytes functions available in 3.x are aliased to their PyString_* equivalents to help porting.

---

**`PyStringObject`**
This subtype of *`PyObject`* represents a Python string object.

*PyTypeObject* **`PyString_Type`**
This instance of *`PyTypeObject`* represents the Python string type; it is the same object as `str` and `types.StringType` in the Python layer. .

int **`PyString_Check`** (*PyObject *o*)
Return true if the object *o* is a string object or an instance of a subtype of the string type.

在 2.2 版更改: Allowed subtypes to be accepted.

int **`PyString_CheckExact`** (*PyObject *o*)
Return true if the object *o* is a string object, but not an instance of a subtype of the string type.

2.2 新版功能.

*PyObject** **`PyString_FromString`** (const char **v*)
*Return value: New reference.* Return a new string object with a copy of the string *v* as value on success, and *NULL* on failure. The parameter *v* must not be *NULL*; it will not be checked.

*PyObject** **`PyString_FromStringAndSize`** (const char **v*, Py_ssize_t *len*)
*Return value: New reference.* Return a new string object with a copy of the string *v* as value and length *len* on success, and *NULL* on failure. If *v* is *NULL*, the contents of the string are uninitialized.

在 2.5 版更改: This function used an `int` type for *len*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **`PyString_FromFormat`** (const char **format*, ...)
*Return value: New reference.* Take a C `printf()`-style *format* string and a variable number of arguments, calculate the size of the resulting Python string and return a string with the values formatted into it. The variable arguments must be C types and must correspond exactly to the format characters in the *format* string. The following format characters are allowed:

| Format Characters | Type | Comment |
|---|---|---|
| `%%` | *n/a* | The literal % character. |
| `%c` | int | A single character, represented as a C int. |
| `%d` | int | Exactly equivalent to `printf("%d")`. |
| `%u` | unsigned int | Exactly equivalent to `printf("%u")`. |
| `%ld` | long | Exactly equivalent to `printf("%ld")`. |
| `%lu` | unsigned long | Exactly equivalent to `printf("%lu")`. |
| `%lld` | long long | Exactly equivalent to `printf("%lld")`. |
| `%llu` | unsigned long long | Exactly equivalent to `printf("%llu")`. |
| `%zd` | Py_ssize_t | Exactly equivalent to `printf("%zd")`. |
| `%zu` | size_t | Exactly equivalent to `printf("%zu")`. |
| `%i` | int | Exactly equivalent to `printf("%i")`. |
| `%x` | int | Exactly equivalent to `printf("%x")`. |
| `%s` | char* | A null-terminated C character array. |
| `%p` | void* | The hex representation of a C pointer. Mostly equivalent to `printf("%p")` except that it is guaranteed to start with the literal `0x` regardless of what the platform's `printf` yields. |

An unrecognized format character causes all the rest of the format string to be copied as-is to the result string, and any extra arguments discarded.

**注解：** The "*%lld*" and "*%llu*" format specifiers are only available when `HAVE_LONG_LONG` is defined.

在 2.7 版更改: Support for "*%lld*" and "*%llu*" added.

*PyObject** **PyString_FromFormatV**(const char **format*, va_list *vargs*)
*Return value: New reference.* Identical to `PyString_FromFormat()` except that it takes exactly two arguments.

Py_ssize_t **PyString_Size**(*PyObject* **string*)
Return the length of the string in string object *string*.

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyString_GET_SIZE**(*PyObject* **string*)
Macro form of `PyString_Size()` but without error checking.

在 2.5 版更改: This macro returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

char* **PyString_AsString**(*PyObject* **string*)
Return a NUL-terminated representation of the contents of *string*. The pointer refers to the internal buffer of *string*, not a copy. The data must not be modified in any way, unless the string was just created using

`PyString_FromStringAndSize(NULL, size)`. It must not be deallocated. If *string* is a Unicode object, this function computes the default encoding of *string* and operates on that. If *string* is not a string object at all, `PyString_AsString()` returns *NULL* and raises `TypeError`.

char* **PyString_AS_STRING**(*PyObject *string*)
Macro form of `PyString_AsString()` but without error checking. Only string objects are supported; no Unicode objects should be passed.

int **PyString_AsStringAndSize**(*PyObject *obj*, char ***buffer*, Py_ssize_t **length*)
Return a NUL-terminated representation of the contents of the object *obj* through the output variables *buffer* and *length*.

The function accepts both string and Unicode objects as input. For Unicode objects it returns the default encoded version of the object. If *length* is *NULL*, the resulting buffer may not contain NUL characters; if it does, the function returns `-1` and a `TypeError` is raised.

The buffer refers to an internal string buffer of *obj*, not a copy. The data must not be modified in any way, unless the string was just created using `PyString_FromStringAndSize(NULL, size)`. It must not be deallocated. If *string* is a Unicode object, this function computes the default encoding of *string* and operates on that. If *string* is not a string object at all, `PyString_AsStringAndSize()` returns `-1` and raises `TypeError`.

在 2.5 版更改: This function used an `int *` type for *length*. This might require changes in your code for properly supporting 64-bit systems.

void **PyString_Concat**(*PyObject **string*, *PyObject *newpart*)
Create a new string object in **string* containing the contents of *newpart* appended to *string*; the caller will own the new reference. The reference to the old value of *string* will be stolen. If the new string cannot be created, the old reference to *string* will still be discarded and the value of **string* will be set to *NULL*; the appropriate exception will be set.

void **PyString_ConcatAndDel**(*PyObject **string*, *PyObject *newpart*)
Create a new string object in **string* containing the contents of *newpart* appended to *string*. This version decrements the reference count of *newpart*.

int **_PyString_Resize**(*PyObject **string*, Py_ssize_t *newsize*)
A way to resize a string object even though it is "immutable". Only use this to build up a brand new string object; don't use this if the string may already be known in other parts of the code. It is an error to call this function if the refcount on the input string object is not one. Pass the address of an existing string object as an lvalue (it may be written into), and the new size desired. On success, **string* holds the resized string object and `0` is returned; the address in **string* may differ from its input value. If the reallocation fails, the original string object at **string* is deallocated, **string* is set to *NULL*, a memory exception is set, and `-1` is returned.

在 2.5 版更改: This function used an `int` type for *newsize*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyString_Format**(*PyObject *format*, *PyObject *args*)
*Return value: New reference.* Return a new string object from *format* and *args*. Analogous to `format % args`. The *args* argument must be a tuple or dict.

void **PyString_InternInPlace**(*PyObject **string*)
Intern the argument **string* in place. The argument must be the address of a pointer variable pointing to a Python string object. If there is an existing interned string that is the same as **string*, it sets **string* to it (decrementing the reference count of the old string object and incrementing the reference count of the interned string object), otherwise it leaves **string* alone and interns it (incrementing its reference count). (Clarification: even though there is a lot of talk about reference counts, think of this function as reference-count-neutral; you own the object after the call if and only if you owned it before the call.)

**注解:** This function is not available in 3.x and does not have a PyBytes alias.

*PyObject** **PyString_InternFromString** (const char **v*)
*Return value: New reference.* A combination of `PyString_FromString()` and `PyString_InternInPlace()`, returning either a new string object that has been interned, or a new ( "owned" ) reference to an earlier interned string object with the same value.

**注解:** This function is not available in 3.x and does not have a PyBytes alias.

*PyObject** **PyString_Decode** (const char **s*, Py_ssize_t *size*, const char **encoding*, const char **errors*)
*Return value: New reference.* Create an object by decoding *size* bytes of the encoded buffer *s* using the codec registered for *encoding*. *encoding* and *errors* have the same meaning as the parameters of the same name in the `unicode()` built-in function. The codec to be used is looked up using the Python codec registry. Return *NULL* if an exception was raised by the codec.

**注解:** This function is not available in 3.x and does not have a PyBytes alias.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyString_AsDecodedObject** (*PyObject* **str*, const char **encoding*, const char **errors*)
*Return value: New reference.* Decode a string object by passing it to the codec registered for *encoding* and return the result as Python object. *encoding* and *errors* have the same meaning as the parameters of the same name in the string `encode()` method. The codec to be used is looked up using the Python codec registry. Return *NULL* if an exception was raised by the codec.

**注解:** This function is not available in 3.x and does not have a PyBytes alias.

*PyObject** **PyString_Encode** (const char **s*, Py_ssize_t *size*, const char **encoding*, const char **errors*)
*Return value: New reference.* Encode the `char` buffer of the given size by passing it to the codec registered for *encoding* and return a Python object. *encoding* and *errors* have the same meaning as the parameters of the same name in the string `encode()` method. The codec to be used is looked up using the Python codec registry. Return *NULL* if an exception was raised by the codec.

**注解:** This function is not available in 3.x and does not have a PyBytes alias.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyString_AsEncodedObject** (*PyObject* **str*, const char **encoding*, const char **errors*)
*Return value: New reference.* Encode a string object using the codec registered for *encoding* and return the result as Python object. *encoding* and *errors* have the same meaning as the parameters of the same name in the string `encode()` method. The codec to be used is looked up using the Python codec registry. Return *NULL* if an exception was raised by the codec.

**注解:** This function is not available in 3.x and does not have a PyBytes alias.

### 7.3.3 Unicode Objects and Codecs

#### Unicode 对象

#### Unicode 类型

These are the basic Unicode object types used for the Unicode implementation in Python:

**Py_UNICODE**
This type represents the storage type which is used by Python internally as basis for holding Unicode ordinals. Python' s default builds use a 16-bit type for `Py_UNICODE` and store Unicode values internally as UCS2. It is also possible to build a UCS4 version of Python (most recent Linux distributions come with UCS4 builds of Python). These builds then use a 32-bit type for `Py_UNICODE` and store Unicode data internally as UCS4. On platforms where `wchar_t` is available and compatible with the chosen Python Unicode build variant, `Py_UNICODE` is a typedef alias for `wchar_t` to enhance native platform compatibility. On all other platforms, `Py_UNICODE` is a typedef alias for either `unsigned short` (UCS2) or `unsigned long` (UCS4).

Note that UCS2 and UCS4 Python builds are not binary compatible. Please keep this in mind when writing extensions or interfaces.

**PyUnicodeObject**
This subtype of `PyObject` represents a Python Unicode object.

*PyTypeObject* **PyUnicode_Type**
This instance of `PyTypeObject` represents the Python Unicode type. It is exposed to Python code as `unicode` and `types.UnicodeType`.

The following APIs are really C macros and can be used to do fast checks and to access internal read-only data of Unicode objects:

int **PyUnicode_Check** (*PyObject *o*)
Return true if the object *o* is a Unicode object or an instance of a Unicode subtype.

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyUnicode_CheckExact** (*PyObject *o*)
Return true if the object *o* is a Unicode object, but not an instance of a subtype.

2.2 新版功能.

Py_ssize_t **PyUnicode_GET_SIZE** (*PyObject *o*)
Return the size of the object. *o* has to be a `PyUnicodeObject` (not checked).

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyUnicode_GET_DATA_SIZE** (*PyObject *o*)
Return the size of the object' s internal buffer in bytes. *o* has to be a `PyUnicodeObject` (not checked).

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

*Py_UNICODE** **PyUnicode_AS_UNICODE** (*PyObject *o*)
Return a pointer to the internal `Py_UNICODE` buffer of the object. *o* has to be a `PyUnicodeObject` (not checked).

const char* **PyUnicode_AS_DATA** (*PyObject *o*)
Return a pointer to the internal buffer of the object. *o* has to be a `PyUnicodeObject` (not checked).

int **PyUnicode_ClearFreeList** ()
清空释放列表。返回所释放的条目数。

2.6 新版功能.

## Unicode 字符属性

Unicode provides many different character properties. The most often needed ones are available through these macros which are mapped to C functions depending on the Python configuration.

int **Py_UNICODE_ISSPACE**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is a whitespace character.

int **Py_UNICODE_ISLOWER**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is a lowercase character.

int **Py_UNICODE_ISUPPER**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is an uppercase character.

int **Py_UNICODE_ISTITLE**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is a titlecase character.

int **Py_UNICODE_ISLINEBREAK**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is a linebreak character.

int **Py_UNICODE_ISDECIMAL**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is a decimal character.

int **Py_UNICODE_ISDIGIT**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is a digit character.

int **Py_UNICODE_ISNUMERIC**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is a numeric character.

int **Py_UNICODE_ISALPHA**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is an alphabetic character.

int **Py_UNICODE_ISALNUM**(*Py_UNICODE ch*)
Return `1` or `0` depending on whether *ch* is an alphanumeric character.

These APIs can be used for fast direct character conversions:

*Py_UNICODE* **Py_UNICODE_TOLOWER**(*Py_UNICODE ch*)
Return the character *ch* converted to lower case.

*Py_UNICODE* **Py_UNICODE_TOUPPER**(*Py_UNICODE ch*)
Return the character *ch* converted to upper case.

*Py_UNICODE* **Py_UNICODE_TOTITLE**(*Py_UNICODE ch*)
Return the character *ch* converted to title case.

int **Py_UNICODE_TODECIMAL**(*Py_UNICODE ch*)
Return the character *ch* converted to a decimal positive integer. Return `-1` if this is not possible. This macro does not raise exceptions.

int **Py_UNICODE_TODIGIT**(*Py_UNICODE ch*)
Return the character *ch* converted to a single digit integer. Return `-1` if this is not possible. This macro does not raise exceptions.

double **Py_UNICODE_TONUMERIC**(*Py_UNICODE ch*)
Return the character *ch* converted to a double. Return `-1.0` if this is not possible. This macro does not raise exceptions.

### Plain Py_UNICODE

To create Unicode objects and access their basic sequence properties, use these APIs:

*PyObject** **PyUnicode_FromUnicode**(const *Py_UNICODE* **u*, Py_ssize_t *size*)

*Return value: New reference.* Create a Unicode object from the Py_UNICODE buffer *u* of the given size. *u* may be *NULL* which causes the contents to be undefined. It is the user's responsibility to fill in the needed data. The buffer is copied into the new object. If the buffer is not *NULL*, the return value might be a shared object. Therefore, modification of the resulting Unicode object is only allowed when *u* is *NULL*.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_FromStringAndSize**(const char **u*, Py_ssize_t *size*)

*Return value: New reference.* Create a Unicode object from the char buffer *u*. The bytes will be interpreted as being UTF-8 encoded. *u* may also be *NULL* which causes the contents to be undefined. It is the user's responsibility to fill in the needed data. The buffer is copied into the new object. If the buffer is not *NULL*, the return value might be a shared object. Therefore, modification of the resulting Unicode object is only allowed when *u* is *NULL*.

2.6 新版功能.

*PyObject* ***PyUnicode_FromString**(const char **u*)

*Return value: New reference.* Create a Unicode object from a UTF-8 encoded null-terminated char buffer *u*.

2.6 新版功能.

*PyObject** **PyUnicode_FromFormat**(const char **format*, ...)

*Return value: New reference.* Take a C `printf()`-style *format* string and a variable number of arguments, calculate the size of the resulting Python unicode string and return a string with the values formatted into it. The variable arguments must be C types and must correspond exactly to the format characters in the *format* string. The following format characters are allowed:

| 格式字符 | 类型 | 注释 |
|---|---|---|
| `%%` | 不适用 | 文字% 字符。 |
| `%c` | 整型 | 单个字符，表示为 C 语言的整型。 |
| `%d` | 整型 | Exactly equivalent to `printf("%d")`. |
| `%u` | 无符号整型 | Exactly equivalent to `printf("%u")`. |
| `%ld` | 长整型 | Exactly equivalent to `printf("%ld")`. |
| `%lu` | 无符号长整型 | Exactly equivalent to `printf("%lu")`. |
| `%zd` | Py_ssize_t | Exactly equivalent to `printf("%zd")`. |
| `%zu` | size_t | Exactly equivalent to `printf("%zu")`. |
| `%i` | 整型 | Exactly equivalent to `printf("%i")`. |
| `%x` | 整型 | Exactly equivalent to `printf("%x")`. |
| `%s` | char* | 以 null 为终止符的 C 字符数组。 |
| `%p` | void* | 一个 C 指针的十六进制表示形式。基本等价于 `printf("%p")` 但它会确保以字面值 `0x` 开头，不论系统平台上 `printf` 的输出是什么。 |
| `%U` | PyObject* | A unicode object. |
| `%V` | PyObject*, char * | A unicode object (which may be *NULL*) and a null-terminated C character array as a second parameter (which will be used, if the first parameter is *NULL*). |
| `%S` | PyObject* | The result of calling `PyObject_Unicode()`. |
| `%R` | PyObject* | The result of calling `PyObject_Repr()`. |

An unrecognized format character causes all the rest of the format string to be copied as-is to the result string, and any extra arguments discarded.

2.6 新版功能.

*PyObject** **PyUnicode_FromFormatV** (const char **format*, va_list *vargs*)

*Return value: New reference.* Identical to `PyUnicode_FromFormat()` except that it takes exactly two arguments.

2.6 新版功能.

*Py_UNICODE** **PyUnicode_AsUnicode** (*PyObject* **unicode*)

Return a read-only pointer to the Unicode object's internal `Py_UNICODE` buffer, *NULL* if *unicode* is not a Unicode object. Note that the resulting `Py_UNICODE*` string may contain embedded null characters, which would cause the string to be truncated when used in most C functions.

Py_ssize_t **PyUnicode_GetSize** (*PyObject* **unicode*)

Return the length of the Unicode object.

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_FromEncodedObject** (*PyObject* **obj*, const char **encoding*, const char **errors*)

*Return value: New reference.* Coerce an encoded object *obj* to a Unicode object and return a reference with incremented refcount.

String and other char buffer compatible objects are decoded according to the given encoding and using the error handling defined by errors. Both can be *NULL* to have the interface use the default values (see the next section for details).

All other objects, including Unicode objects, cause a `TypeError` to be set.

The API returns *NULL* if there was an error. The caller is responsible for decref'ing the returned objects.

*PyObject** **PyUnicode_FromObject** (*PyObject* **obj*)

*Return value: New reference.* Shortcut for `PyUnicode_FromEncodedObject(obj, NULL, "strict")` which is used throughout the interpreter whenever coercion to Unicode is needed.

If the platform supports `wchar_t` and provides a header file wchar.h, Python can interface directly to this type using the following functions. Support is optimized if Python's own `Py_UNICODE` type is identical to the system's `wchar_t`.

### wchar_t Support

`wchar_t` support for platforms which support it:

*PyObject** **PyUnicode_FromWideChar** (const wchar_t **w*, Py_ssize_t *size*)

*Return value: New reference.* Create a Unicode object from the `wchar_t` buffer *w* of the given *size*. Return *NULL* on failure.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyUnicode_AsWideChar** (*PyUnicodeObject* **unicode*, wchar_t **w*, Py_ssize_t *size*)

Copy the Unicode object contents into the `wchar_t` buffer *w*. At most *size* `wchar_t` characters are copied (excluding a possibly trailing 0-termination character). Return the number of `wchar_t` characters copied or `-1` in case of an error. Note that the resulting `wchar_t` string may or may not be 0-terminated. It is the responsibility of the caller to make sure that the `wchar_t` string is 0-terminated in case this is required by the application. Also, note that the `wchar_t*` string might contain null characters, which would cause the string to be truncated when used with most C functions.

在 2.5 版更改: This function returned an `int` type and used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

### Built-in Codecs

Python provides a set of built-in codecs which are written in C for speed. All of these codecs are directly usable via the following functions.

Many of the following APIs take two arguments encoding and errors, and they have the same semantics as the ones of the built-in `unicode()` Unicode object constructor.

Setting encoding to *NULL* causes the default encoding to be used which is ASCII. The file system calls should use `Py_FileSystemDefaultEncoding` as the encoding for file names. This variable should be treated as read-only: on some systems, it will be a pointer to a static string, on others, it will change at run-time (such as when the application invokes setlocale).

Error handling is set by errors which may also be set to *NULL* meaning to use the default handling defined for the codec. Default error handling for all built-in codecs is "strict" (`ValueError` is raised).

The codecs all use a similar interface. Only deviation from the following generic ones are documented for simplicity.

### Generic Codecs

These are the generic codec APIs:

*PyObject** **PyUnicode_Decode**(const char **s*, Py_ssize_t *size*, const char **encoding*, const char **errors*)

*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the encoded string *s*. *encoding* and *errors* have the same meaning as the parameters of the same name in the `unicode()` built-in function. The codec to be used is looked up using the Python codec registry. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_Encode**(const *Py_UNICODE* **s*, Py_ssize_t *size*, const char **encoding*, const char **errors*)

*Return value: New reference.* Encode the `Py_UNICODE` buffer *s* of the given *size* and return a Python string object. *encoding* and *errors* have the same meaning as the parameters of the same name in the Unicode `encode()` method. The codec to be used is looked up using the Python codec registry. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsEncodedString**(*PyObject* **unicode*, const char **encoding*, const char **errors*)

*Return value: New reference.* Encode a Unicode object and return the result as Python string object. *encoding* and *errors* have the same meaning as the parameters of the same name in the Unicode `encode()` method. The codec to be used is looked up using the Python codec registry. Return *NULL* if an exception was raised by the codec.

### UTF-8 Codecs

These are the UTF-8 codec APIs:

*PyObject** **PyUnicode_DecodeUTF8**(const char **s*, Py_ssize_t *size*, const char **errors*)

*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the UTF-8 encoded string *s*. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_DecodeUTF8Stateful**(const char *s, Py_ssize_t size, const char *errors, Py_ssize_t *consumed)

*Return value: New reference.* If *consumed* is *NULL*, behave like `PyUnicode_DecodeUTF8()`. If *consumed* is not *NULL*, trailing incomplete UTF-8 byte sequences will not be treated as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

2.4 新版功能.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_EncodeUTF8**(const *Py_UNICODE* *s, Py_ssize_t size, const char *errors)

*Return value: New reference.* Encode the `Py_UNICODE` buffer *s* of the given *size* using UTF-8 and return a Python string object. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsUTF8String**(*PyObject* *unicode)

*Return value: New reference.* Encode a Unicode object using UTF-8 and return the result as Python string object. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

### UTF-32 Codecs

These are the UTF-32 codec APIs:

*PyObject** **PyUnicode_DecodeUTF32**(const char *s, Py_ssize_t size, const char *errors, int *byteorder)

Decode *size* bytes from a UTF-32 encoded buffer string and return the corresponding Unicode object. *errors* (if non-*NULL*) defines the error handling. It defaults to "strict".

If *byteorder* is non-*NULL*, the decoder starts decoding using the given byte order:

```
*byteorder == -1: little endian
*byteorder == 0:  native order
*byteorder == 1:  big endian
```

If `*byteorder` is zero, and the first four bytes of the input data are a byte order mark (BOM), the decoder switches to this byte order and the BOM is not copied into the resulting Unicode string. If `*byteorder` is `-1` or `1`, any byte order mark is copied to the output.

After completion, **byteorder* is set to the current byte order at the end of input data.

In a narrow build code points outside the BMP will be decoded as surrogate pairs.

If *byteorder* is *NULL*, the codec starts in native order mode.

Return *NULL* if an exception was raised by the codec.

2.6 新版功能.

*PyObject** **PyUnicode_DecodeUTF32Stateful**(const char *s, Py_ssize_t size, const char *errors, int *byteorder, Py_ssize_t *consumed)

If *consumed* is *NULL*, behave like `PyUnicode_DecodeUTF32()`. If *consumed* is not *NULL*, `PyUnicode_DecodeUTF32Stateful()` will not treat trailing incomplete UTF-32 byte sequences (such as a number of bytes not divisible by four) as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

2.6 新版功能.

*PyObject** **PyUnicode_EncodeUTF32** (const *Py_UNICODE *s*, Py_ssize_t *size*, const char **errors*, int *byteorder*)

Return a Python bytes object holding the UTF-32 encoded value of the Unicode data in *s*. Output is written according to the following byte order:

```
byteorder == -1: little endian
byteorder == 0:  native byte order (writes a BOM mark)
byteorder == 1:  big endian
```

If byteorder is `0`, the output string will always start with the Unicode BOM mark (U+FEFF). In the other two modes, no BOM mark is prepended.

If *Py_UNICODE_WIDE* is not defined, surrogate pairs will be output as a single code point.

Return *NULL* if an exception was raised by the codec.

2.6 新版功能.

*PyObject** **PyUnicode_AsUTF32String** (*PyObject *unicode*)

Return a Python string using the UTF-32 encoding in native byte order. The string always starts with a BOM mark. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

2.6 新版功能.

### UTF-16 Codecs

These are the UTF-16 codec APIs:

*PyObject** **PyUnicode_DecodeUTF16** (const char **s*, Py_ssize_t *size*, const char **errors*, int **byteorder*)

*Return value: New reference.* Decode *size* bytes from a UTF-16 encoded buffer string and return the corresponding Unicode object. *errors* (if non-*NULL*) defines the error handling. It defaults to "strict".

If *byteorder* is non-*NULL*, the decoder starts decoding using the given byte order:

```
*byteorder == -1: little endian
*byteorder == 0:  native order
*byteorder == 1:  big endian
```

If `*byteorder` is zero, and the first two bytes of the input data are a byte order mark (BOM), the decoder switches to this byte order and the BOM is not copied into the resulting Unicode string. If `*byteorder` is `-1` or `1`, any byte order mark is copied to the output (where it will result in either a `\ufeff` or a `\uffe` character).

After completion, **byteorder* is set to the current byte order at the end of input data.

If *byteorder* is *NULL*, the codec starts in native order mode.

Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_DecodeUTF16Stateful** (const char **s*, Py_ssize_t *size*, const char **errors*, int **byteorder*, Py_ssize_t **consumed*)

*Return value: New reference.* If *consumed* is *NULL*, behave like `PyUnicode_DecodeUTF16()`. If *consumed* is not *NULL*, `PyUnicode_DecodeUTF16Stateful()` will not treat trailing incomplete UTF-16 byte sequences (such as an odd number of bytes or a split surrogate pair) as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

2.4 新版功能.

在 2.5 版更改: This function used an `int` type for *size* and an `int *` type for *consumed*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **`PyUnicode_EncodeUTF16`**(const *Py_UNICODE *s*, Py_ssize_t *size*, const char **errors*, int *byteorder*)
*Return value: New reference.* Return a Python string object holding the UTF-16 encoded value of the Unicode data in *s*. Output is written according to the following byte order:

```
byteorder == -1: little endian
byteorder == 0:  native byte order (writes a BOM mark)
byteorder == 1:  big endian
```

If byteorder is `0`, the output string will always start with the Unicode BOM mark (U+FEFF). In the other two modes, no BOM mark is prepended.

If *Py_UNICODE_WIDE* is defined, a single `Py_UNICODE` value may get represented as a surrogate pair. If it is not defined, each `Py_UNICODE` values is interpreted as a UCS-2 character.

Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **`PyUnicode_AsUTF16String`**(*PyObject *unicode*)
*Return value: New reference.* Return a Python string using the UTF-16 encoding in native byte order. The string always starts with a BOM mark. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

### UTF-7 Codecs

These are the UTF-7 codec APIs:

*PyObject** **`PyUnicode_DecodeUTF7`**(const char **s*, Py_ssize_t *size*, const char **errors*)
Create a Unicode object by decoding *size* bytes of the UTF-7 encoded string *s*. Return *NULL* if an exception was raised by the codec.

*PyObject** **`PyUnicode_DecodeUTF7Stateful`**(const char **s*, Py_ssize_t *size*, const char **errors*, Py_ssize_t **consumed*)
If *consumed* is *NULL*, behave like `PyUnicode_DecodeUTF7()`. If *consumed* is not *NULL*, trailing incomplete UTF-7 base-64 sections will not be treated as an error. Those bytes will not be decoded and the number of bytes that have been decoded will be stored in *consumed*.

*PyObject** **`PyUnicode_EncodeUTF7`**(const *Py_UNICODE *s*, Py_ssize_t *size*, int *base64SetO*, int *base64WhiteSpace*, const char **errors*)
Encode the `Py_UNICODE` buffer of the given size using UTF-7 and return a Python bytes object. Return *NULL* if an exception was raised by the codec.

If *base64SetO* is nonzero, "Set O" (punctuation that has no otherwise special meaning) will be encoded in base-64. If *base64WhiteSpace* is nonzero, whitespace will be encoded in base-64. Both are set to zero for the Python "utf-7" codec.

### Unicode-Escape Codecs

These are the "Unicode Escape" codec APIs:

*PyObject** **PyUnicode_DecodeUnicodeEscape**(const char **s*, Py_ssize_t *size*, const char **errors*)
*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the Unicode-Escape encoded string *s*. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_EncodeUnicodeEscape**(const *Py_UNICODE* **s*, Py_ssize_t *size*)
*Return value: New reference.* Encode the `Py_UNICODE` buffer of the given *size* using Unicode-Escape and return a Python string object. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsUnicodeEscapeString**(*PyObject* **unicode*)
*Return value: New reference.* Encode a Unicode object using Unicode-Escape and return the result as Python string object. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

### Raw-Unicode-Escape Codecs

These are the "Raw Unicode Escape" codec APIs:

*PyObject** **PyUnicode_DecodeRawUnicodeEscape**(const char **s*, Py_ssize_t *size*, const char **errors*)
*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the Raw-Unicode-Escape encoded string *s*. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_EncodeRawUnicodeEscape**(const *Py_UNICODE* **s*, Py_ssize_t *size*, const char **errors*)
*Return value: New reference.* Encode the `Py_UNICODE` buffer of the given *size* using Raw-Unicode-Escape and return a Python string object. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsRawUnicodeEscapeString**(*PyObject* **unicode*)
*Return value: New reference.* Encode a Unicode object using Raw-Unicode-Escape and return the result as Python string object. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

### Latin-1 Codecs

These are the Latin-1 codec APIs: Latin-1 corresponds to the first 256 Unicode ordinals and only these are accepted by the codecs during encoding.

*PyObject** **PyUnicode_DecodeLatin1**(const char **s*, Py_ssize_t *size*, const char **errors*)
*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the Latin-1 encoded string *s*. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_EncodeLatin1**(const *Py_UNICODE* **s*, Py_ssize_t *size*, const char **errors*)
*Return value: New reference.* Encode the `Py_UNICODE` buffer of the given *size* using Latin-1 and return a Python string object. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsLatin1String**(*PyObject* **unicode*)
*Return value: New reference.* Encode a Unicode object using Latin-1 and return the result as Python string object. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

### ASCII Codecs

These are the ASCII codec APIs. Only 7-bit ASCII data is accepted. All other codes generate errors.

*PyObject** **PyUnicode_DecodeASCII**(const char **s*, Py_ssize_t *size*, const char **errors*)
*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the ASCII encoded string *s*. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_EncodeASCII**(const *Py_UNICODE* **s*, Py_ssize_t *size*, const char **errors*)
*Return value: New reference.* Encode the `Py_UNICODE` buffer of the given *size* using ASCII and return a Python string object. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsASCIIString**(*PyObject* **unicode*)
*Return value: New reference.* Encode a Unicode object using ASCII and return the result as Python string object. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

### Character Map Codecs

This codec is special in that it can be used to implement many different codecs (and this is in fact what was done to obtain most of the standard codecs included in the `encodings` package). The codec uses mapping to encode and decode characters.

Decoding mappings must map single string characters to single Unicode characters, integers (which are then interpreted as Unicode ordinals) or `None` (meaning "undefined mapping" and causing an error).

Encoding mappings must map single Unicode characters to single string characters, integers (which are then interpreted as Latin-1 ordinals) or `None` (meaning "undefined mapping" and causing an error).

The mapping objects provided must only support the __getitem__ mapping interface.

If a character lookup fails with a LookupError, the character is copied as-is meaning that its ordinal value will be interpreted as Unicode or Latin-1 ordinal resp. Because of this, mappings only need to contain those mappings which map characters to different code points.

These are the mapping codec APIs:

*PyObject** **PyUnicode_DecodeCharmap**(const char **s*, Py_ssize_t *size*, *PyObject* **mapping*, const char **errors*)
*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the encoded string *s* using the given *mapping* object. Return *NULL* if an exception was raised by the codec. If *mapping* is *NULL* latin-1 decoding will be done. Else it can be a dictionary mapping byte or a unicode string, which is treated as a lookup table. Byte values greater that the length of the string and U+FFFE "characters" are treated as "undefined mapping".

在 2.4 版更改: Allowed unicode string as mapping argument.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_EncodeCharmap**(const *Py_UNICODE* **s*, Py_ssize_t *size*, *PyObject* **mapping*, const char **errors*)

*Return value: New reference.* Encode the `Py_UNICODE` buffer of the given *size* using the given *mapping* object and return a Python string object. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsCharmapString**(*PyObject* **unicode*, *PyObject* **mapping*)

*Return value: New reference.* Encode a Unicode object using the given *mapping* object and return the result as Python string object. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

The following codec API is special in that maps Unicode to Unicode.

*PyObject** **PyUnicode_TranslateCharmap**(const *Py_UNICODE* **s*, Py_ssize_t *size*, *PyObject* **table*, const char **errors*)

*Return value: New reference.* Translate a `Py_UNICODE` buffer of the given *size* by applying a character mapping *table* to it and return the resulting Unicode object. Return *NULL* when an exception was raised by the codec.

The *mapping* table must map Unicode ordinal integers to Unicode ordinal integers or `None` (causing deletion of the character).

Mapping tables need only provide the `__getitem__()` interface; dictionaries and sequences work well. Unmapped character ordinals (ones which cause a `LookupError`) are left untouched and are copied as-is.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

### MBCS codecs for Windows

These are the MBCS codec APIs. They are currently only available on Windows and use the Win32 MBCS converters to implement the conversions. Note that MBCS (or DBCS) is a class of encodings, not just one. The target encoding is defined by the user settings on the machine running the codec.

*PyObject** **PyUnicode_DecodeMBCS**(const char **s*, Py_ssize_t *size*, const char **errors*)

*Return value: New reference.* Create a Unicode object by decoding *size* bytes of the MBCS encoded string *s*. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_DecodeMBCSStateful**(const char **s*, int *size*, const char **errors*, int **consumed*)

If *consumed* is *NULL*, behave like `PyUnicode_DecodeMBCS()`. If *consumed* is not *NULL*, `PyUnicode_DecodeMBCSStateful()` will not decode trailing lead byte and the number of bytes that have been decoded will be stored in *consumed*.

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*PyObject** **PyUnicode_EncodeMBCS**(const *Py_UNICODE* **s*, Py_ssize_t *size*, const char **errors*)

*Return value: New reference.* Encode the `Py_UNICODE` buffer of the given *size* using MBCS and return a Python string object. Return *NULL* if an exception was raised by the codec.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_AsMBCSString** (*PyObject *unicode*)
    *Return value: New reference.* Encode a Unicode object using MBCS and return the result as Python string object. Error handling is "strict". Return *NULL* if an exception was raised by the codec.

### Methods & Slots

### Methods and Slot Functions

The following APIs are capable of handling Unicode objects and strings on input (we refer to them as strings in the descriptions) and return Unicode objects or integers as appropriate.

They all return *NULL* or `-1` if an exception occurs.

*PyObject** **PyUnicode_Concat** (*PyObject *left, PyObject *right*)
    *Return value: New reference.* Concat two strings giving a new Unicode string.

*PyObject** **PyUnicode_Split** (*PyObject *s, PyObject *sep*, Py_ssize_t *maxsplit*)
    *Return value: New reference.* Split a string giving a list of Unicode strings. If *sep* is *NULL*, splitting will be done at all whitespace substrings. Otherwise, splits occur at the given separator. At most *maxsplit* splits will be done. If negative, no limit is set. Separators are not included in the resulting list.

    在 2.5 版更改: This function used an `int` type for *maxsplit*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_Splitlines** (*PyObject *s*, int *keepend*)
    *Return value: New reference.* Split a Unicode string at line breaks, returning a list of Unicode strings. CRLF is considered to be one line break. If *keepend* is `0`, the Line break characters are not included in the resulting strings.

*PyObject** **PyUnicode_Translate** (*PyObject *str, PyObject *table*, const char **errors*)
    *Return value: New reference.* Translate a string by applying a character mapping table to it and return the resulting Unicode object.

    The mapping table must map Unicode ordinal integers to Unicode ordinal integers or `None` (causing deletion of the character).

    Mapping tables need only provide the `__getitem__()` interface; dictionaries and sequences work well. Unmapped character ordinals (ones which cause a `LookupError`) are left untouched and are copied as-is.

    *errors* has the usual meaning for codecs. It may be *NULL* which indicates to use the default error handling.

*PyObject** **PyUnicode_Join** (*PyObject *separator, PyObject *seq*)
    *Return value: New reference.* Join a sequence of strings using the given *separator* and return the resulting Unicode string.

Py_ssize_t **PyUnicode_Tailmatch** (*PyObject *str, PyObject *substr*, Py_ssize_t *start*, Py_ssize_t *end*, int *direction*)
    Return `1` if *substr* matches `str[start:end]` at the given tail end (*direction* == `-1` means to do a prefix match, *direction* == `1` a suffix match), `0` otherwise. Return `-1` if an error occurred.

    在 2.5 版更改: This function used an `int` type for *start* and *end*. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyUnicode_Find** (*PyObject *str, PyObject *substr*, Py_ssize_t *start*, Py_ssize_t *end*, int *direction*)
    Return the first position of *substr* in `str[start:end]` using the given *direction* (*direction* == `1` means to do a forward search, *direction* == `-1` a backward search). The return value is the index of the first match; a value of `-1` indicates that no match was found, and `-2` indicates that an error occurred and an exception has been set.

    在 2.5 版更改: This function used an `int` type for *start* and *end*. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyUnicode_Count** (*PyObject* **str*, *PyObject* **substr*, Py_ssize_t *start*, Py_ssize_t *end*)

Return the number of non-overlapping occurrences of *substr* in `str[start:end]`. Return `-1` if an error occurred.

在 2.5 版更改: This function returned an `int` type and used an `int` type for *start* and *end*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyUnicode_Replace** (*PyObject* **str*, *PyObject* **substr*, *PyObject* **replstr*, Py_ssize_t *maxcount*)

*Return value: New reference.* Replace at most *maxcount* occurrences of *substr* in *str* with *replstr* and return the resulting Unicode object. *maxcount* == `-1` means replace all occurrences.

在 2.5 版更改: This function used an `int` type for *maxcount*. This might require changes in your code for properly supporting 64-bit systems.

int **PyUnicode_Compare** (*PyObject* **left*, *PyObject* **right*)

Compare two strings and return `-1`, `0`, `1` for less than, equal, and greater than, respectively.

int **PyUnicode_RichCompare** (*PyObject* **left*, *PyObject* **right*, int *op*)

Rich compare two unicode strings and return one of the following:

- `NULL` in case an exception was raised
- `Py_True` or `Py_False` for successful comparisons
- `Py_NotImplemented` in case the type combination is unknown

Note that `Py_EQ` and `Py_NE` comparisons can cause a `UnicodeWarning` in case the conversion of the arguments to Unicode fails with a `UnicodeDecodeError`.

Possible values for *op* are `Py_GT`, `Py_GE`, `Py_EQ`, `Py_NE`, `Py_LT`, and `Py_LE`.

*PyObject** **PyUnicode_Format** (*PyObject* **format*, *PyObject* **args*)

*Return value: New reference.* Return a new string object from *format* and *args*; this is analogous to `format % args`.

int **PyUnicode_Contains** (*PyObject* **container*, *PyObject* **element*)

Check whether *element* is contained in *container* and return true or false accordingly.

*element* has to coerce to a one element Unicode string. `-1` is returned if there was an error.

### 7.3.4 Buffers and Memoryview Objects

Python objects implemented in C can export a group of functions called the "buffer interface." These functions can be used by an object to expose its data in a raw, byte-oriented format. Clients of the object can use the buffer interface to access the object data directly, without needing to copy it first.

Two examples of objects that support the buffer interface are strings and arrays. The string object exposes the character contents in the buffer interface's byte-oriented form. An array can only expose its contents via the old-style buffer interface. This limitation does not apply to Python 3, where `memoryview` objects can be constructed from arrays, too. Array elements may be multi-byte values.

An example user of the buffer interface is the file object's `write()` method. Any object that can export a series of bytes through the buffer interface can be written to a file. There are a number of format codes to `PyArg_ParseTuple()` that operate against an object's buffer interface, returning data from the target object.

Starting from version 1.6, Python has been providing Python-level buffer objects and a C-level buffer API so that any built-in or used-defined type can expose its characteristics. Both, however, have been deprecated because of various shortcomings, and have been officially removed in Python 3 in favour of a new C-level buffer API and a new Python-level object named `memoryview`.

The new buffer API has been backported to Python 2.6, and the `memoryview` object has been backported to Python 2.7. It is strongly advised to use them rather than the old APIs, unless you are blocked from doing so for compatibility reasons.

## The new-style Py_buffer struct

**Py_buffer**

void ***buf**
A pointer to the start of the memory for the object.

Py_ssize_t **len**
The total length of the memory in bytes.

int **readonly**
An indicator of whether the buffer is read only.

const char ***format**
A *NULL* terminated string in `struct` module style syntax giving the contents of the elements available through the buffer. If this is *NULL*, `"B"` (unsigned bytes) is assumed.

int **ndim**
The number of dimensions the memory represents as a multi-dimensional array. If it is `0`, `strides` and `suboffsets` must be *NULL*.

Py_ssize_t ***shape**
An array of `Py_ssize_t`s the length of `ndim` giving the shape of the memory as a multi-dimensional array. Note that `((*shape)[0] * ... * (*shape)[ndims-1])*itemsize` should be equal to `len`.

Py_ssize_t ***strides**
An array of `Py_ssize_t`s the length of `ndim` giving the number of bytes to skip to get to a new element in each dimension.

Py_ssize_t ***suboffsets**
An array of `Py_ssize_t`s the length of `ndim`. If these suboffset numbers are greater than or equal to 0, then the value stored along the indicated dimension is a pointer and the suboffset value dictates how many bytes to add to the pointer after de-referencing. A suboffset value that it negative indicates that no de-referencing should occur (striding in a contiguous memory block).

If all suboffsets are negative (i.e. no de-referencing is needed), then this field must be NULL (the default value).

Here is a function that returns a pointer to the element in an N-D array pointed to by an N-dimensional index when there are both non-NULL strides and suboffsets:

```c
void *get_item_pointer(int ndim, void *buf, Py_ssize_t *strides,
    Py_ssize_t *suboffsets, Py_ssize_t *indices) {
    char *pointer = (char*)buf;
    int i;
    for (i = 0; i < ndim; i++) {
        pointer += strides[i] * indices[i];
        if (suboffsets[i] >=0 ) {
            pointer = *((char**)pointer) + suboffsets[i];
        }
    }
    return (void*)pointer;
}
```

Py_ssize_t **itemsize**

This is a storage for the itemsize (in bytes) of each element of the shared memory. It is technically unnecessary as it can be obtained using `PyBuffer_SizeFromFormat()`, however an exporter may know this information without parsing the format string and it is necessary to know the itemsize for proper interpretation of striding. Therefore, storing it is more convenient and faster.

void ***internal**

This is for use internally by the exporting object. For example, this might be re-cast as an integer by the exporter and used to store flags about whether or not the shape, strides, and suboffsets arrays must be freed when the buffer is released. The consumer should never alter this value.

### Buffer related functions

int **PyObject_CheckBuffer**(*PyObject *obj*)

Return `1` if *obj* supports the buffer interface otherwise `0`.

int **PyObject_GetBuffer**(*PyObject *obj*, *Py_buffer *view*, int *flags*)

Export *obj* into a `Py_buffer`, *view*. These arguments must never be *NULL*. The *flags* argument is a bit field indicating what kind of buffer the caller is prepared to deal with and therefore what kind of buffer the exporter is allowed to return. The buffer interface allows for complicated memory sharing possibilities, but some caller may not be able to handle all the complexity but may want to see if the exporter will let them take a simpler view to its memory.

Some exporters may not be able to share memory in every possible way and may need to raise errors to signal to some consumers that something is just not possible. These errors should be a `BufferError` unless there is another error that is actually causing the problem. The exporter can use flags information to simplify how much of the `Py_buffer` structure is filled in with non-default values and/or raise an error if the object can't support a simpler view of its memory.

`0` is returned on success and `-1` on error.

The following table gives possible values to the *flags* arguments.

| Flag | Description |
|---|---|
| PyBUF_SIMPLE | This is the default flag state. The returned buffer may or may not have writable memory. The format of the data will be assumed to be unsigned bytes. This is a "stand-alone" flag constant. It never needs to be '\|' d to the others. The exporter will raise an error if it cannot provide such a contiguous buffer of bytes. |
| PyBUF_WRITABLE | The returned buffer must be writable. If it is not writable, then raise an error. |
| PyBUF_STRIDES | This implies PyBUF_ND. The returned buffer must provide strides information (i.e. the strides cannot be NULL). This would be used when the consumer can handle strided, discontiguous arrays. Handling strides automatically assumes you can handle shape. The exporter can raise an error if a strided representation of the data is not possible (i.e. without the suboffsets). |
| PyBUF_ND | The returned buffer must provide shape information. The memory will be assumed C-style contiguous (last dimension varies the fastest). The exporter may raise an error if it cannot provide this kind of contiguous buffer. If this is not given then shape will be *NULL*. |
| PyBUF_C_CONTIGUOUS PyBUF_F_CONTIGUOUS PyBUF_ANY_CONTIGUOUS | These flags indicate that the contiguity returned buffer must be respectively, C-contiguous (last dimension varies the fastest), Fortran contiguous (first dimension varies the fastest) or either one. All of these flags imply PyBUF_STRIDES and guarantee that the strides buffer info structure will be filled in correctly. |
| PyBUF_INDIRECT | This flag indicates the returned buffer must have suboffsets information (which can be NULL if no suboffsets are needed). This can be used when the consumer can handle indirect array referencing implied by these suboffsets. This implies PyBUF_STRIDES. |
| PyBUF_FORMAT | The returned buffer must have true format information if this flag is provided. This would be used when the consumer is going to be checking for what 'kind' of data is actually stored. An exporter should always be able to provide this information if requested. If format is not explicitly requested then the format must be returned as *NULL* (which means 'B', or unsigned bytes) |
| PyBUF_STRIDED | This is equivalent to (PyBUF_STRIDES \| PyBUF_WRITABLE). |
| PyBUF_STRIDED_RO | This is equivalent to (PyBUF_STRIDES). |
| PyBUF_RECORDS | This is equivalent to (PyBUF_STRIDES \| PyBUF_FORMAT \| PyBUF_WRITABLE). |
| PyBUF_RECORDS_RO | This is equivalent to (PyBUF_STRIDES \| PyBUF_FORMAT). |
| PyBUF_FULL | This is equivalent to (PyBUF_INDIRECT \| PyBUF_FORMAT \| PyBUF_WRITABLE). |
| PyBUF_FULL_RO | This is equivalent to (PyBUF_INDIRECT \| PyBUF_FORMAT). |
| PyBUF_CONTIG | This is equivalent to (PyBUF_ND \| PyBUF_WRITABLE). |
| PyBUF_CONTIG_RO | This is equivalent to (PyBUF_ND). |

void **PyBuffer_Release**(*Py_buffer *view*)

Release the buffer *view*. This should be called when the buffer is no longer being used as it may free memory from it.

Py_ssize_t **PyBuffer_SizeFromFormat**(const char *)

Return the implied *itemsize* from the struct-stype format.

int **PyBuffer_IsContiguous**(*Py_buffer *view*, char *fortran*)

Return 1 if the memory defined by the *view* is C-style (*fortran* is 'C') or Fortran-style (*fortran* is 'F') contiguous or either one (*fortran* is 'A'). Return 0 otherwise.

void **PyBuffer_FillContiguousStrides**(int *ndims*, Py_ssize_t **shape*, Py_ssize_t **strides*, int *itemsize*, char *fortran*)

Fill the *strides* array with byte-strides of a contiguous (C-style if *fortran* is 'C' or Fortran-style if *fortran* is 'F') array of the given shape with the given number of bytes per element.

int **PyBuffer_FillInfo**(*Py_buffer *view*, *PyObject *obj*, void **buf*, Py_ssize_t *len*, int *readonly*, int *infoflags*)
Fill in a buffer-info structure, *view*, correctly for an exporter that can only share a contiguous chunk of memory of "unsigned bytes" of the given length. Return `0` on success and `-1` (with raising an error) on error.

## MemoryView objects

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A `memoryview` object exposes the new C level buffer interface as a Python object which can then be passed around like any other object.

*PyObject* ***PyMemoryView_FromObject**(*PyObject *obj*)
Create a memoryview object from an object that defines the new buffer interface.

*PyObject* ***PyMemoryView_FromBuffer**(*Py_buffer *view*)
Create a memoryview object wrapping the given buffer-info structure *view*. The memoryview object then owns the buffer, which means you shouldn't try to release it yourself: it will be released on deallocation of the memoryview object.

*PyObject* ***PyMemoryView_GetContiguous**(*PyObject *obj*, int *buffertype*, char *order*)
Create a memoryview object to a contiguous chunk of memory (in either 'C' or 'F'ortran *order*) from an object that defines the buffer interface. If memory is contiguous, the memoryview object points to the original memory. Otherwise copy is made and the memoryview points to a new bytes object.

int **PyMemoryView_Check**(*PyObject *obj*)
Return true if the object *obj* is a memoryview object. It is not currently allowed to create subclasses of `memoryview`.

*Py_buffer* ***PyMemoryView_GET_BUFFER**(*PyObject *obj*)
Return a pointer to the buffer-info structure wrapped by the given object. The object **must** be a memoryview instance; this macro doesn't check its type, you must do it yourself or you will risk crashes.

## Old-style buffer objects

More information on the old buffer interface is provided in the section *Buffer Object Structures*, under the description for `PyBufferProcs`.

A "buffer object" is defined in the `bufferobject.h` header (included by `Python.h`). These objects look very similar to string objects at the Python programming level: they support slicing, indexing, concatenation, and some other standard string operations. However, their data can come from one of two sources: from a block of memory, or from another object which exports the buffer interface.

Buffer objects are useful as a way to expose the data from another object's buffer interface to the Python programmer. They can also be used as a zero-copy slicing mechanism. Using their ability to reference a block of memory, it is possible to expose any data to the Python programmer quite easily. The memory could be a large, constant array in a C extension, it could be a raw block of memory for manipulation before passing to an operating system library, or it could be used to pass around structured data in its native, in-memory format.

**PyBufferObject**
This subtype of `PyObject` represents a buffer object.

*PyTypeObject* **PyBuffer_Type**
The instance of `PyTypeObject` which represents the Python buffer type; it is the same object as `buffer` and `types.BufferType` in the Python layer. .

int **Py_END_OF_BUFFER**
This constant may be passed as the *size* parameter to `PyBuffer_FromObject()` or

*PyBuffer_FromReadWriteObject()*. It indicates that the new *PyBufferObject* should refer to *base* object from the specified *offset* to the end of its exported buffer. Using this enables the caller to avoid querying the *base* object for its length.

int **PyBuffer_Check** (*PyObject* *p)
Return true if the argument has type *PyBuffer_Type*.

*PyObject** **PyBuffer_FromObject** (*PyObject* *base, Py_ssize_t *offset*, Py_ssize_t *size*)
*Return value: New reference.* Return a new read-only buffer object. This raises `TypeError` if *base* doesn't support the read-only buffer protocol or doesn't provide exactly one buffer segment, or it raises `ValueError` if *offset* is less than zero. The buffer will hold a reference to the *base* object, and the buffer's contents will refer to the *base* object's buffer interface, starting as position *offset* and extending for *size* bytes. If *size* is `Py_END_OF_BUFFER`, then the new buffer's contents extend to the length of the *base* object's exported buffer data.

在 2.5 版更改: This function used an `int` type for *offset* and *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyBuffer_FromReadWriteObject** (*PyObject* *base, Py_ssize_t *offset*, Py_ssize_t *size*)
*Return value: New reference.* Return a new writable buffer object. Parameters and exceptions are similar to those for *PyBuffer_FromObject()*. If the *base* object does not export the writeable buffer protocol, then `TypeError` is raised.

在 2.5 版更改: This function used an `int` type for *offset* and *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyBuffer_FromMemory** (void *ptr, Py_ssize_t *size*)
*Return value: New reference.* Return a new read-only buffer object that reads from a specified location in memory, with a specified size. The caller is responsible for ensuring that the memory buffer, passed in as *ptr*, is not deallocated while the returned buffer object exists. Raises `ValueError` if *size* is less than zero. Note that `Py_END_OF_BUFFER` may *not* be passed for the *size* parameter; `ValueError` will be raised in that case.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyBuffer_FromReadWriteMemory** (void *ptr, Py_ssize_t *size*)
*Return value: New reference.* Similar to *PyBuffer_FromMemory()*, but the returned buffer is writable.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyBuffer_New** (Py_ssize_t *size*)
*Return value: New reference.* Return a new writable buffer object that maintains its own memory buffer of *size* bytes. `ValueError` is returned if *size* is not zero or positive. Note that the memory buffer (as returned by *PyObject_AsWriteBuffer()*) is not specifically aligned.

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

### 7.3.5 元组对象

**PyTupleObject**
这个*PyObject* 的子类型代表一个 Python 的元组对象。

*PyTypeObject* **PyTuple_Type**
This instance of *PyTypeObject* represents the Python tuple type; it is the same object as `tuple` and `types.TupleType` in the Python layer..

int **PyTuple_Check** (*PyObject* *p)
如果 *p* 是一个元组对象或者元组类型的子类型的实例，则返回真值。

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyTuple_CheckExact** (*PyObject* *p)
如果 *p* 是一个元组对象，而不是一个元组子类型的实例，则返回真值。

2.2 新版功能.

*PyObject** **PyTuple_New** (Py_ssize_t *len*)
*Return value: New reference.* Return a new tuple object of size *len*, or *NULL* on failure.

在 2.5 版更改: This function used an `int` type for *len*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyTuple_Pack** (Py_ssize_t *n*, ...)
*Return value: New reference.* Return a new tuple object of size *n*, or *NULL* on failure. The tuple values are initialized to the subsequent *n* C arguments pointing to Python objects. `PyTuple_Pack(2, a, b)` is equivalent to `Py_BuildValue("(OO)", a, b)`.

2.4 新版功能.

在 2.5 版更改: This function used an `int` type for *n*. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyTuple_Size** (*PyObject* *p)
Take a pointer to a tuple object, and return the size of that tuple.

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyTuple_GET_SIZE** (*PyObject* *p)
Return the size of the tuple *p*, which must be non-*NULL* and point to a tuple; no error checking is performed.

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyTuple_GetItem** (*PyObject* *p, Py_ssize_t *pos*)
*Return value: Borrowed reference.* Return the object at position *pos* in the tuple pointed to by *p*. If *pos* is out of bounds, return *NULL* and set an `IndexError` exception.

在 2.5 版更改: This function used an `int` type for *pos*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyTuple_GET_ITEM** (*PyObject* *p, Py_ssize_t *pos*)
*Return value: Borrowed reference.* Like `PyTuple_GetItem()`, but does no checking of its arguments.

在 2.5 版更改: This function used an `int` type for *pos*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyTuple_GetSlice** (*PyObject* *p, Py_ssize_t *low*, Py_ssize_t *high*)
*Return value: New reference.* Return the slice of the tuple pointed to by *p* between *low* and *high*, or *NULL* on failure. This is the equivalent of the Python expression `p[low:high]`. Indexing from the end of the list is not supported.

在 2.5 版更改: This function used an `int` type for *low* and *high*. This might require changes in your code for properly supporting 64-bit systems.

int **PyTuple_SetItem** (*PyObject* *p, Py_ssize_t *pos*, *PyObject* *o)
Insert a reference to object *o* at position *pos* of the tuple pointed to by *p*. Return `0` on success. If *pos* is out of bounds, return `-1` and set an `IndexError` exception.

---

**注解：** This function "steals" a reference to *o* and discards a reference to an item already in the tuple at the affected position.

---

在 2.5 版更改: This function used an `int` type for *pos*. This might require changes in your code for properly supporting 64-bit systems.

void **PyTuple_SET_ITEM**(*PyObject* **p*, Py_ssize_t *pos*, *PyObject* **o*)

Like `PyTuple_SetItem()`, but does no error checking, and should *only* be used to fill in brand new tuples.

---

**注解：** This macro "steals" a reference to *o*, and, unlike `PyTuple_SetItem()`, does *not* discard a reference to any item that is being replaced; any reference in the tuple at position *pos* will be leaked.

---

在 2.5 版更改: This function used an `int` type for *pos*. This might require changes in your code for properly supporting 64-bit systems.

int **_PyTuple_Resize**(*PyObject* ***p*, Py_ssize_t *newsize*)

Can be used to resize a tuple. *newsize* will be the new length of the tuple. Because tuples are *supposed* to be immutable, this should only be used if there is only one reference to the object. Do *not* use this if the tuple may already be known to some other part of the code. The tuple will always grow or shrink at the end. Think of this as destroying the old tuple and creating a new one, only more efficiently. Returns `0` on success. Client code should never assume that the resulting value of `*p` will be the same as before calling this function. If the object referenced by `*p` is replaced, the original `*p` is destroyed. On failure, returns `-1` and sets `*p` to *NULL*, and raises `MemoryError` or `SystemError`.

在 2.2 版更改: Removed unused third parameter, *last_is_sticky*.

在 2.5 版更改: This function used an `int` type for *newsize*. This might require changes in your code for properly supporting 64-bit systems.

int **PyTuple_ClearFreeList**()

清空释放列表。返回所释放的条目数。

2.6 新版功能.

### 7.3.6 列表对象

**PyListObject**

这个 C 类型`PyObject` 的子类型代表一个 Python 列表对象。

*PyTypeObject* **PyList_Type**

This instance of `PyTypeObject` represents the Python list type. This is the same object as `list` in the Python layer.

int **PyList_Check**(*PyObject* **p*)

如果 *p* 是一个列表对象或者是一个列表类型的子类型实例时，返回真。

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyList_CheckExact**(*PyObject* **p*)

当 *p* 是一个列表对象，但是不是列表类型的子类型实例时，返回真。

2.2 新版功能.

*PyObject** **PyList_New**(Py_ssize_t *len*)

*Return value: New reference.* Return a new list of length *len* on success, or *NULL* on failure.

**注解：** 当 *len* 大于零时，被返回的列表对象项目被设成 NULL。因此你不能用类似 C 函数`PySequence_SetItem()` 的抽象 API 或者用 C 函数`PyList_SetItem()` 将所有项目设置成真实对象前对 Python 代码公开这个对象。

在 2.5 版更改: This function used an `int` for *size*. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyList_Size**(*PyObject *list*)
返回 *list* 中列表对象的长度；这等于在列表对象调用 `len(list)` 。

在 2.5 版更改: This function returned an `int`. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PyList_GET_SIZE**(*PyObject *list*)
宏版本的 C 函数`PyList_Size()` ，没有错误检测。

在 2.5 版更改: This macro returned an `int`. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyList_GetItem**(*PyObject *list*, Py_ssize_t *index*)
*Return value: Borrowed reference.* Return the object at position *index* in the list pointed to by *list*. The position must be non-negative; indexing from the end of the list is not supported. If *index* is out of bounds (<0 or >=len(list)), return *NULL* and set an `IndexError` exception.

在 2.5 版更改: This function used an `int` for *index*. This might require changes in your code for properly supporting 64-bit systems.

*PyObject** **PyList_GET_ITEM**(*PyObject *list*, Py_ssize_t *i*)
*Return value: Borrowed reference.* 宏版本的 C 函数`PyList_GetItem()` ，没有错误检测。

在 2.5 版更改: This macro used an `int` for *i*. This might require changes in your code for properly supporting 64-bit systems.

int **PyList_SetItem**(*PyObject *list*, Py_ssize_t *index*, *PyObject *item*)
将列表中索引为 *index* 的项设为 *item*。成功时返回 `0`。如果 *index* 超出范围则返回 `-1` 并设定 `IndexError` 异常。

**注解：** 此函数会“偷走”一个对 *item* 的引用并丢弃一个对列表中受影响位置上的已有条目的引用。

在 2.5 版更改: This function used an `int` for *index*. This might require changes in your code for properly supporting 64-bit systems.

void **PyList_SET_ITEM**(*PyObject *list*, Py_ssize_t *i*, *PyObject *o*)
不带错误检测的宏版本`PyList_SetItem()`。这通常只被用于新列表中之前没有内容的位置进行填充。

**注解：** This macro “steals” a reference to *item*, and, unlike `PyList_SetItem()`, does *not* discard a reference to any item that it being replaced; any reference in *list* at position *i* will be leaked.

在 2.5 版更改: This macro used an `int` for *i*. This might require changes in your code for properly supporting 64-bit systems.

int **PyList_Insert**(*PyObject *list*, Py_ssize_t *index*, *PyObject *item*)
将条目 *item* 插入到列表 *list* 索引号 *index* 之前的位置。如果成功将返回 `0`；如果不成功则返回 `-1` 并设置一个异常。相当于 `list.insert(index, item)`。

在 2.5 版更改: This function used an `int` for *index*. This might require changes in your code for properly supporting 64-bit systems.

int **PyList_Append** (*PyObject *list*, *PyObject *item*)
将对象 *item* 添加到列表 *list* 的末尾。如果成功将返回 `0`；如果不成功则返回 `-1` 并设置一个异常。相当于 `list.append(item)`。

*PyObject** **PyList_GetSlice** (*PyObject *list*, Py_ssize_t *low*, Py_ssize_t *high*)
*Return value: New reference.* Return a list of the objects in *list* containing the objects *between low* and *high*. Return *NULL* and set an exception if unsuccessful. Analogous to `list[low:high]`. Indexing from the end of the list is not supported.

在 2.5 版更改: This function used an `int` for *low* and *high*. This might require changes in your code for properly supporting 64-bit systems.

int **PyList_SetSlice** (*PyObject *list*, Py_ssize_t *low*, Py_ssize_t *high*, *PyObject *itemlist*)
Set the slice of *list* between *low* and *high* to the contents of *itemlist*. Analogous to `list[low:high] = itemlist`. The *itemlist* may be *NULL*, indicating the assignment of an empty list (slice deletion). Return `0` on success, `-1` on failure. Indexing from the end of the list is not supported.

在 2.5 版更改: This function used an `int` for *low* and *high*. This might require changes in your code for properly supporting 64-bit systems.

int **PyList_Sort** (*PyObject *list*)
对 *list* 中的条目进行原地排序。成功时返回 `0`，失败时返回 `-1`。这等价于 `list.sort()`。

int **PyList_Reverse** (*PyObject *list*)
对 *list* 中的条目进行原地反转。成功时返回 `0`，失败时返回 `-1`。这等价于 `list.reverse()`。

*PyObject** **PyList_AsTuple** (*PyObject *list*)
*Return value: New reference.* 返回一个新的元组对象，其中包含 *list* 的内容；等价于 `tuple(list)`。

## 7.4 Mapping Objects

### 7.4.1 字典对象

**PyDictObject**
这个 `PyObject` 的子类型代表一个 Python 字典对象。

*PyTypeObject* **PyDict_Type**
This instance of `PyTypeObject` represents the Python dictionary type. This is exposed to Python programs as `dict` and `types.DictType`.

int **PyDict_Check** (*PyObject *p*)
如果 *p* 是字典对象或者字典类型的子类型的实例，则返回真。

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyDict_CheckExact** (*PyObject *p*)
如果 *p* 是字典对象但不是字典类型的子类型的实例，则返回真。

2.4 新版功能.

*PyObject** **PyDict_New** ()
*Return value: New reference.* Return a new empty dictionary, or *NULL* on failure.

*PyObject** **PyDictProxy_New** (*PyObject *dict*)
*Return value: New reference.* Return a proxy object for a mapping which enforces read-only behavior. This is normally used to create a proxy to prevent modification of the dictionary for non-dynamic class types.

2.2 新版功能.

void **PyDict_Clear** (*PyObject* *p)
清空现有字典的所有键值对。

int **PyDict_Contains** (*PyObject* *p, *PyObject* *key)
确定 *key* 是否包含在字典 *p* 中。如果 *key* 匹配上 *p* 的某一项，则返回 `1`，否则返回 `0`。返回 `-1` 表示出错。这等同于 Python 表达式 `key in p`。

2.4 新版功能.

*PyObject** **PyDict_Copy** (*PyObject* *p)
*Return value: New reference.* 返回与 *p* 包含相同键值对的新字典。

1.6 新版功能.

int **PyDict_SetItem** (*PyObject* *p, *PyObject* *key, *PyObject* *val)
使用 *key* 作为键将 *value* 插入字典 *p*。*key* 必须为*hashable*；如果不是，会抛出 `TypeError` 异常。成功返回 `0`，失败返回 `-1`。

int **PyDict_SetItemString** (*PyObject* *p, const char *key, *PyObject* *val)
Insert *value* into the dictionary *p* using *key* as a key. *key* should be a `char*`. The key object is created using `PyString_FromString(key)`. Return `0` on success or `-1` on failure.

int **PyDict_DelItem** (*PyObject* *p, *PyObject* *key)
使用键 *key* 删除字典 *p* 中的条目。*key* 必须是可哈希的；如果不是，则抛出 `TypeError` 异常。成功时返回 `0`，失败时返回 `-1`。

int **PyDict_DelItemString** (*PyObject* *p, char *key)
删除字典 *p* 中由字符串 *key* 作为键的条目。成功时返回 `0`，失败时返回 `-1`。

*PyObject** **PyDict_GetItem** (*PyObject* *p, *PyObject* *key)
*Return value: Borrowed reference.* Return the object from dictionary *p* which has a key *key*. Return *NULL* if the key *key* is not present, but *without* setting an exception.

*PyObject** **PyDict_GetItemString** (*PyObject* *p, const char *key)
*Return value: Borrowed reference.* This is the same as `PyDict_GetItem()`, but *key* is specified as a `char*`, rather than a `PyObject*`.

*PyObject** **PyDict_Items** (*PyObject* *p)
*Return value: New reference.* Return a `PyListObject` containing all the items from the dictionary, as in the dictionary method `dict.items()`.

*PyObject** **PyDict_Keys** (*PyObject* *p)
*Return value: New reference.* Return a `PyListObject` containing all the keys from the dictionary, as in the dictionary method `dict.keys()`.

*PyObject** **PyDict_Values** (*PyObject* *p)
*Return value: New reference.* Return a `PyListObject` containing all the values from the dictionary *p*, as in the dictionary method `dict.values()`.

Py_ssize_t **PyDict_Size** (*PyObject* *p)
返回字典中项目数，等价于对字典 *p* 使用 `len(p)`。

在 2.5 版更改: This function returned an `int` type. This might require changes in your code for properly supporting 64-bit systems.

int **PyDict_Next** (*PyObject* *p, Py_ssize_t *ppos, *PyObject* **pkey, *PyObject* **pvalue)
Iterate over all key-value pairs in the dictionary *p*. The `Py_ssize_t` referred to by *ppos* must be initialized to `0` prior to the first call to this function to start the iteration; the function returns true for each pair in the dictionary, and false once all pairs have been reported. The parameters *pkey* and *pvalue* should either point to `PyObject*` variables that will be filled in with each key and value, respectively, or may be *NULL*. Any references returned

through them are borrowed. *ppos* should not be altered during iteration. Its value represents offsets within the internal dictionary structure, and since the structure is sparse, the offsets are not consecutive.

例如

```
PyObject *key, *value;
Py_ssize_t pos = 0;

while (PyDict_Next(self->dict, &pos, &key, &value)) {
    /* do something interesting with the values... */
    ...
}
```

The dictionary *p* should not be mutated during iteration. It is safe (since Python 2.1) to modify the values of the keys as you iterate over the dictionary, but only so long as the set of keys does not change. For example:

```
PyObject *key, *value;
Py_ssize_t pos = 0;

while (PyDict_Next(self->dict, &pos, &key, &value)) {
    int i = PyInt_AS_LONG(value) + 1;
    PyObject *o = PyInt_FromLong(i);
    if (o == NULL)
        return -1;
    if (PyDict_SetItem(self->dict, key, o) < 0) {
        Py_DECREF(o);
        return -1;
    }
    Py_DECREF(o);
}
```

在 2.5 版更改: This function used an `int *` type for *ppos*. This might require changes in your code for properly supporting 64-bit systems.

int **PyDict_Merge**(*PyObject* *a, *PyObject* *b, int *override*)

对映射对象 *b* 进行迭代，将键值对添加到字典 *a*。*b* 可以是一个字典，或任何支持`PyMapping_Keys()`和`PyObject_GetItem()`的对象。如果 *override* 为真值，则如果在 *b* 中找到相同的键则 *a* 中已存在的相应键值对将被替换，否则如果在 *a* 中没有相同的键则只是添加键值对。当成功时返回 `0` 或者当引发异常时返回 `-1`。

2.2 新版功能.

int **PyDict_Update**(*PyObject* *a, *PyObject* *b)

这与 C 中的 `PyDict_Merge(a, b, 1)` 一样，也类似于 Python 中的 `a.update(b)`，差别在于`PyDict_Update()`在第二个参数没有"keys"属性时不会回退到迭代键值对的序列。当成功时返回 `0` 或者当引发异常时返回 `-1`。

2.2 新版功能.

int **PyDict_MergeFromSeq2**(*PyObject* *a, *PyObject* *seq2, int *override*)

将 *seq2* 中的键值对更新或合并到字典 *a*。*seq2* 必须为产生长度为 2 的用作键值对的元素的可迭代对象。当存在重复的键时，如果 *override* 真值则最后出现的键胜出。当成功时返回 `0` 或者当引发异常时返回 `-1`。等价的 Python 代码（返回值除外）：

```
def PyDict_MergeFromSeq2(a, seq2, override):
    for key, value in seq2:
        if override or key not in a:
            a[key] = value
```

2.2 新版功能.

## 7.5 其他对象

### 7.5.1 Class and Instance Objects

Note that the class objects described here represent old-style classes, which will go away in Python 3. When creating new types for extension modules, you will want to work with type objects (section 类型对象).

**PyClassObject**
The C structure of the objects used to describe built-in classes.

*PyObject** **PyClass_Type**
This is the type object for class objects; it is the same object as `types.ClassType` in the Python layer.

int **PyClass_Check** (*PyObject *o*)
Return true if the object *o* is a class object, including instances of types derived from the standard class object. Return false in all other cases.

int **PyClass_IsSubclass** (*PyObject *klass*, *PyObject *base*)
Return true if *klass* is a subclass of *base*. Return false in all other cases.

There are very few functions specific to instance objects.

*PyTypeObject* **PyInstance_Type**
Type object for class instances.

int **PyInstance_Check** (*PyObject *obj*)
Return true if *obj* is an instance.

*PyObject** **PyInstance_New** (*PyObject *class*, *PyObject *arg*, *PyObject *kw*)
*Return value: New reference.* Create a new instance of a specific class. The parameters *arg* and *kw* are used as the positional and keyword parameters to the object's constructor.

*PyObject** **PyInstance_NewRaw** (*PyObject *class*, *PyObject *dict*)
*Return value: New reference.* Create a new instance of a specific class without calling its constructor. *class* is the class of new object. The *dict* parameter will be used as the object's `__dict__`; if *NULL*, a new dictionary will be created for the instance.

### 7.5.2 函数对象

有一些特定于 Python 函数的函数。

**PyFunctionObject**
用于函数的 C 结构体。

*PyTypeObject* **PyFunction_Type**
这是一个 `PyTypeObject` 实例并表示 Python 函数类型。它作为 `types.FunctionType` 向 Python 程序员公开。

int **PyFunction_Check** (*PyObject *o*)
Return true if *o* is a function object (has type `PyFunction_Type`). The parameter must not be *NULL*.

*PyObject** **PyFunction_New** (*PyObject *code*, *PyObject *globals*)
*Return value: New reference.* 返回与代码对象 *code* 关联的新函数对象。*globals* 必须是一个字典，该函数可以访问全局变量。

The function's docstring, name and *__module__* are retrieved from the code object, the argument defaults and closure are set to *NULL*.

*PyObject** **PyFunction_GetCode** (*PyObject* **op*)
*Return value: Borrowed reference.* 返回与函数对象 *op* 关联的代码对象。

*PyObject** **PyFunction_GetGlobals** (*PyObject* **op*)
*Return value: Borrowed reference.* 返回与函数对象 *op* 相关联的全局字典。

*PyObject** **PyFunction_GetModule** (*PyObject* **op*)
*Return value: Borrowed reference.* 返回函数对象 *op* 的 *__module__* 属性，通常为一个包含了模块名称的字符串，但可以通过 Python 代码设为返回其他任意对象。

*PyObject** **PyFunction_GetDefaults** (*PyObject* **op*)
*Return value: Borrowed reference.* Return the argument default values of the function object *op*. This can be a tuple of arguments or *NULL*.

int **PyFunction_SetDefaults** (*PyObject* **op*, *PyObject* **defaults*)
Set the argument default values for the function object *op*. *defaults* must be *Py_None* or a tuple.

失败时引发 `SystemError` 异常并返回 `-1` 。

*PyObject** **PyFunction_GetClosure** (*PyObject* **op*)
*Return value: Borrowed reference.* Return the closure associated with the function object *op*. This can be *NULL* or a tuple of cell objects.

int **PyFunction_SetClosure** (*PyObject* **op*, *PyObject* **closure*)
Set the closure associated with the function object *op*. *closure* must be *Py_None* or a tuple of cell objects.

失败时引发 `SystemError` 异常并返回 `-1` 。

### 7.5.3 方法对象

There are some useful functions that are useful for working with method objects.

*PyTypeObject* **PyMethod_Type**
这个 `PyTypeObject` 实例代表 Python 方法类型。它作为 `types.MethodType` 向 Python 程序公开。

int **PyMethod_Check** (*PyObject* **o*)
Return true if *o* is a method object (has type `PyMethod_Type`). The parameter must not be *NULL*.

*PyObject** **PyMethod_New** (*PyObject* **func*, *PyObject* **self*, *PyObject* **class*)
*Return value: New reference.* Return a new method object, with *func* being any callable object; this is the function that will be called when the method is called. If this method should be bound to an instance, *self* should be the instance and *class* should be the class of *self*, otherwise *self* should be *NULL* and *class* should be the class which provides the unbound method..

*PyObject** **PyMethod_Class** (*PyObject* **meth*)
*Return value: Borrowed reference.* Return the class object from which the method *meth* was created; if this was created from an instance, it will be the class of the instance.

*PyObject** **PyMethod_GET_CLASS** (*PyObject* **meth*)
*Return value: Borrowed reference.* Macro version of `PyMethod_Class()` which avoids error checking.

*PyObject** **PyMethod_Function** (*PyObject* **meth*)
*Return value: Borrowed reference.* 返回关联到方法 *meth* 的函数对象。

*PyObject** **PyMethod_GET_FUNCTION** (*PyObject* **meth*)
*Return value: Borrowed reference.* 宏版本的 `PyMethod_Function()`，略去了错误检测。

*PyObject** **PyMethod_Self** (*PyObject* **meth*)
*Return value: Borrowed reference.* Return the instance associated with the method *meth* if it is bound, otherwise return *NULL*.

*PyObject** **PyMethod_GET_SELF** (*PyObject *meth*)

*Return value: Borrowed reference.* 宏版本的`PyMethod_Self()`，省略了错误检测。

int **PyMethod_ClearFreeList** ()

清空释放列表。返回所释放的条目数。

2.6 新版功能.

### 7.5.4 文件对象

Python' s built-in file objects are implemented entirely on the `FILE*` support from the C standard library. This is an implementation detail and may change in future releases of Python.

**PyFileObject**

This subtype of `PyObject` represents a Python file object.

*PyTypeObject* **PyFile_Type**

This instance of `PyTypeObject` represents the Python file type. This is exposed to Python programs as `file` and `types.FileType`.

int **PyFile_Check** (*PyObject *p*)

Return true if its argument is a `PyFileObject` or a subtype of `PyFileObject`.

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyFile_CheckExact** (*PyObject *p*)

Return true if its argument is a `PyFileObject`, but not a subtype of `PyFileObject`.

2.2 新版功能.

*PyObject** **PyFile_FromString** (char **filename*, char **mode*)

*Return value: New reference.* On success, return a new file object that is opened on the file given by *filename*, with a file mode given by *mode*, where *mode* has the same semantics as the standard C routine `fopen()`. On failure, return *NULL*.

*PyObject** **PyFile_FromFile** (FILE **fp*, char **name*, char **mode*, int (**close*)(FILE*))

*Return value: New reference.* Create a new `PyFileObject` from the already-open standard C file pointer, *fp*. The function *close* will be called when the file should be closed. Return *NULL* and close the file using *close* on failure. *close* is optional and can be set to *NULL*.

FILE* **PyFile_AsFile** (*PyObject *p*)

Return the file object associated with *p* as a `FILE*`.

If the caller will ever use the returned `FILE*` object while the *GIL* is released it must also call the `PyFile_IncUseCount()` and `PyFile_DecUseCount()` functions described below as appropriate.

void **PyFile_IncUseCount** (*PyFileObject *p*)

Increments the PyFileObject' s internal use count to indicate that the underlying `FILE*` is being used. This prevents Python from calling f_close() on it from another thread. Callers of this must call `PyFile_DecUseCount()` when they are finished with the `FILE*`. Otherwise the file object will never be closed by Python.

The *GIL* must be held while calling this function.

The suggested use is to call this after `PyFile_AsFile()` and before you release the GIL:

```
FILE *fp = PyFile_AsFile(p);
PyFile_IncUseCount(p);
/* ... */
Py_BEGIN_ALLOW_THREADS
do_something(fp);
```

(下页继续)

(续上页)

```
Py_END_ALLOW_THREADS
/* ... */
PyFile_DecUseCount(p);
```

2.6 新版功能.

void **PyFile_DecUseCount** (*PyFileObject *p*)

Decrements the PyFileObject’s internal unlocked_count member to indicate that the caller is done with its own use of the `FILE*`. This may only be called to undo a prior call to `PyFile_IncUseCount()`.

The *GIL* must be held while calling this function (see the example above).

2.6 新版功能.

*PyObject** **PyFile_GetLine** (*PyObject *p*, int *n*)

*Return value: New reference.* 等价于 `p.readline([n])` ，这个函数从对象 *p* 中读取一行。*p* 可以是文件对象或具有 `readline()` 方法的任何对象。如果 *n* 是 `0` ，则无论该行的长度如何，都会读取一行。如果 *n* 大于 “0“，则从文件中读取不超过 *n* 个字节；可以返回行的一部分。在这两种情况下，如果立即到达文件末尾，则返回空字符串。但是，如果 *n* 小于 `0` ，则无论长度如何都会读取一行，但是如果立即到达文件末尾，则引发 `EOFError`。

*PyObject** **PyFile_Name** (*PyObject *p*)

*Return value: Borrowed reference.* Return the name of the file specified by *p* as a string object.

void **PyFile_SetBufSize** (*PyFileObject *p*, int *n*)

Available on systems with `setvbuf()` only. This should only be called immediately after file object creation.

int **PyFile_SetEncoding** (*PyFileObject *p*, const char **enc*)

Set the file’s encoding for Unicode output to *enc*. Return `1` on success and `0` on failure.

2.3 新版功能.

int **PyFile_SetEncodingAndErrors** (*PyFileObject *p*, const char **enc*, *errors)

Set the file’s encoding for Unicode output to *enc*, and its error mode to *err*. Return `1` on success and `0` on failure.

2.6 新版功能.

int **PyFile_SoftSpace** (*PyObject *p*, int *newflag*)

This function exists for internal use by the interpreter. Set the `softspace` attribute of *p* to *newflag* and return the previous value. *p* does not have to be a file object for this function to work properly; any object is supported (thought its only interesting if the `softspace` attribute can be set). This function clears any errors, and will return `0` as the previous value if the attribute either does not exist or if there were errors in retrieving it. There is no way to detect errors from this function, but doing so should not be needed.

int **PyFile_WriteObject** (*PyObject *obj*, *PyObject *p*, int *flags*)

将对象 *obj* 写入文件对象 *p* 。*flags* 唯一支持的标志是 `Py_PRINT_RAW`；如果给定，则写入对象的 `str()` 而不是 `repr()`。成功时返回 `0`，失败时返回 `-1`。将设置适当的例外。

int **PyFile_WriteString** (const char **s*, *PyObject *p*)

将字符串 *s* 写入文件对象 *p*。成功返回 `0` 失败返回 `-1`；将设定相应的异常。

### 7.5.5 模块对象

There are only a few functions special to module objects.

*PyTypeObject* **PyModule_Type**
This instance of *PyTypeObject* represents the Python module type. This is exposed to Python programs as `types.ModuleType`.

int **PyModule_Check**(*PyObject* *p)
Return true if *p* is a module object, or a subtype of a module object.

在 2.2 版更改: Allowed subtypes to be accepted.

int **PyModule_CheckExact**(*PyObject* *p)
Return true if *p* is a module object, but not a subtype of *PyModule_Type*.

2.2 新版功能.

*PyObject** **PyModule_New**(const char *name)
*Return value: New reference.* Return a new module object with the `__name__` attribute set to *name*. Only the module's `__doc__` and `__name__` attributes are filled in; the caller is responsible for providing a `__file__` attribute.

*PyObject** **PyModule_GetDict**(*PyObject* *module)
*Return value: Borrowed reference.* Return the dictionary object that implements *module*'s namespace; this object is the same as the `__dict__` attribute of the module object. This function never fails. It is recommended extensions use other `PyModule_*()` and `PyObject_*()` functions rather than directly manipulate a module's `__dict__`.

char* **PyModule_GetName**(*PyObject* *module)
Return *module*'s `__name__` value. If the module does not provide one, or if it is not a string, `SystemError` is raised and *NULL* is returned.

char* **PyModule_GetFilename**(*PyObject* *module)
Return the name of the file from which *module* was loaded using *module*'s `__file__` attribute. If this is not defined, or if it is not a string, raise `SystemError` and return *NULL*.

int **PyModule_AddObject**(*PyObject* *module, const char *name, *PyObject* *value)
Add an object to *module* as *name*. This is a convenience function which can be used from the module's initialization function. This steals a reference to *value*. Return `-1` on error, `0` on success.

2.0 新版功能.

int **PyModule_AddIntConstant**(*PyObject* *module, const char *name, long *value*)
Add an integer constant to *module* as *name*. This convenience function can be used from the module's initialization function. Return `-1` on error, `0` on success.

2.0 新版功能.

int **PyModule_AddStringConstant**(*PyObject* *module, const char *name, const char *value)
Add a string constant to *module* as *name*. This convenience function can be used from the module's initialization function. The string *value* must be null-terminated. Return `-1` on error, `0` on success.

2.0 新版功能.

int **PyModule_AddIntMacro**(*PyObject* *module, macro)
Add an int constant to *module*. The name and the value are taken from *macro*. For example `PyModule_AddIntMacro(module, AF_INET)` adds the int constant *AF_INET* with the value of *AF_INET* to *module*. Return `-1` on error, `0` on success.

2.6 新版功能.

int **PyModule_AddStringMacro**(*PyObject* *module, macro)

Add a string constant to *module*.

2.6 新版功能.

### 7.5.6 迭代器对象

Python 提供了两个通用迭代器对象。第一个是序列迭代器，它使用支持 `__getitem__()` 方法的任意序列。第二个使用可调用对象和一个 sentinel 值，为序列中的每个项调用可调用对象，并在返回 sentinel 值时结束迭代。

*PyTypeObject* **PySeqIter_Type**

`PySeqIter_New()` 返回迭代器对象的类型对象和内置序列类型内置函数 `iter()` 的单参数形式。

2.2 新版功能.

int **PySeqIter_Check**(op)

如果 *op* 的类型为`PySeqIter_Type` 则返回 true。

2.2 新版功能.

*PyObject** **PySeqIter_New**(*PyObject *seq*)

*Return value: New reference.* 返回一个与常规序列对象一起使用的迭代器 *seq*。当序列订阅操作引发 `IndexError` 时，迭代结束。

2.2 新版功能.

*PyTypeObject* **PyCallIter_Type**

由函数`PyCallIter_New()` 和 `iter()` 内置函数的双参数形式返回的迭代器对象类型对象。

2.2 新版功能.

int **PyCallIter_Check**(op)

如果 *op* 的类型为`PyCallIter_Type` 则返回 true。

2.2 新版功能.

*PyObject** **PyCallIter_New**(*PyObject *callable*, *PyObject *sentinel*)

*Return value: New reference.* 返回一个新的迭代器。第一个参数 *callable* 可以是任何可以在没有参数的情况下调用的 Python 可调用对象；每次调用都应该返回迭代中的下一个项目。当 *callable* 返回等于 *sentinel* 的值时，迭代将终止。

2.2 新版功能.

### 7.5.7 描述符对象

“描述符”是描述对象的某些属性的对象。它们存在于类型对象的字典中。

*PyTypeObject* **PyProperty_Type**

内建描述符类型的类型对象。

2.2 新版功能.

*PyObject** **PyDescr_NewGetSet**(*PyTypeObject *type*, struct *PyGetSetDef *getset*)

*Return value: New reference.* 2.2 新版功能.

*PyObject** **PyDescr_NewMember**(*PyTypeObject *type*, struct *PyMemberDef *meth*)

*Return value: New reference.* 2.2 新版功能.

*PyObject** **PyDescr_NewMethod**(*PyTypeObject *type*, struct *PyMethodDef *meth*)

*Return value: New reference.* 2.2 新版功能.

*PyObject** **PyDescr_NewWrapper**(*PyTypeObject* **type*, struct wrapperbase **wrapper*, void **wrapped*)
*Return value: New reference.* 2.2 新版功能.

*PyObject** **PyDescr_NewClassMethod**(*PyTypeObject* **type*, *PyMethodDef* **method*)
*Return value: New reference.* 2.3 新版功能.

int **PyDescr_IsData**(*PyObject* **descr*)
如果描述符对象 *descr* 描述数据属性，则返回 true；如果描述方法，则返回 false。*descr* 必须是描述符对象；没有错误检查。

2.2 新版功能.

*PyObject** **PyWrapper_New**(*PyObject* *, *PyObject* *)
*Return value: New reference.* 2.2 新版功能.

### 7.5.8 切片对象

*PyTypeObject* **PySlice_Type**
The type object for slice objects. This is the same as `slice` and `types.SliceType`.

int **PySlice_Check**(*PyObject* **ob*)
Return true if *ob* is a slice object; *ob* must not be *NULL*.

*PyObject** **PySlice_New**(*PyObject* **start*, *PyObject* **stop*, *PyObject* **step*)
*Return value: New reference.* Return a new slice object with the given values. The *start*, *stop*, and *step* parameters are used as the values of the slice object attributes of the same names. Any of the values may be *NULL*, in which case the `None` will be used for the corresponding attribute. Return *NULL* if the new object could not be allocated.

int **PySlice_GetIndices**(PySliceObject **slice*, Py_ssize_t *length*, Py_ssize_t **start*, Py_ssize_t **stop*, Py_ssize_t **step*)
Retrieve the start, stop and step indices from the slice object *slice*, assuming a sequence of length *length*. Treats indices greater than *length* as errors.

Returns `0` on success and `-1` on error with no exception set (unless one of the indices was not `None` and failed to be converted to an integer, in which case `-1` is returned with an exception set).

You probably do not want to use this function. If you want to use slice objects in versions of Python prior to 2.3, you would probably do well to incorporate the source of `PySlice_GetIndicesEx()`, suitably renamed, in the source of your extension.

在 2.5 版更改: This function used an `int` type for *length* and an `int *` type for *start*, *stop*, and *step*. This might require changes in your code for properly supporting 64-bit systems.

int **PySlice_GetIndicesEx**(PySliceObject **slice*, Py_ssize_t *length*, Py_ssize_t **start*, Py_ssize_t **stop*, Py_ssize_t **step*, Py_ssize_t **slicelength*)
Usable replacement for `PySlice_GetIndices()`. Retrieve the start, stop, and step indices from the slice object *slice* assuming a sequence of length *length*, and store the length of the slice in *slicelength*. Out of bounds indices are clipped in a manner consistent with the handling of normal slices.

Returns `0` on success and `-1` on error with exception set.

2.3 新版功能.

在 2.5 版更改: This function used an `int` type for *length* and an `int *` type for *start*, *stop*, *step*, and *slicelength*. This might require changes in your code for properly supporting 64-bit systems.

### 7.5.9 Ellipsis Object

*PyObject* ***Py_Ellipsis***

The Python `Ellipsis` object. This object has no methods. It needs to be treated just like any other object with respect to reference counts. Like `Py_None` it is a singleton object.

### 7.5.10 弱引用对象

Python 支持"弱引用"作为一类对象。具体来说，有两种直接实现弱引用的对象。第一种就是简单的引用对象，第二种尽可能地作用为一个原对象的代理。

int **PyWeakref_Check**(ob)

如果"ob"是一个引用或者一个代理对象，则返回 true。

2.2 新版功能.

int **PyWeakref_CheckRef**(ob)

如果"ob"是一个引用，则返回 true。

2.2 新版功能.

int **PyWeakref_CheckProxy**(ob)

如果"ob"是一个代理对象，则返回 true。

2.2 新版功能.

*PyObject** **PyWeakref_NewRef**(*PyObject *ob*, *PyObject *callback*)

*Return value: New reference.* Return a weak reference object for the object *ob*. This will always return a new reference, but is not guaranteed to create a new object; an existing reference object may be returned. The second parameter, *callback*, can be a callable object that receives notification when *ob* is garbage collected; it should accept a single parameter, which will be the weak reference object itself. *callback* may also be `None` or *NULL*. If *ob* is not a weakly-referencable object, or if *callback* is not callable, `None`, or *NULL*, this will return *NULL* and raise `TypeError`.

2.2 新版功能.

*PyObject** **PyWeakref_NewProxy**(*PyObject *ob*, *PyObject *callback*)

*Return value: New reference.* Return a weak reference proxy object for the object *ob*. This will always return a new reference, but is not guaranteed to create a new object; an existing proxy object may be returned. The second parameter, *callback*, can be a callable object that receives notification when *ob* is garbage collected; it should accept a single parameter, which will be the weak reference object itself. *callback* may also be `None` or *NULL*. If *ob* is not a weakly-referencable object, or if *callback* is not callable, `None`, or *NULL*, this will return *NULL* and raise `TypeError`.

2.2 新版功能.

*PyObject** **PyWeakref_GetObject**(*PyObject *ref*)

*Return value: Borrowed reference.* 返回弱引用对象 ref 的被引用对象。如果被引用对象不再存在，则返回 `Py_None`。

2.2 新版功能.

> **警告：** 该函数返回被引用对象的一个 ** 借来的引用 **。这意味着除非你很清楚在你使用期间这个对象不可能被销毁，否则你应该始终对该对象调用`Py_INCREF()`。

*PyObject** **PyWeakref_GET_OBJECT**(*PyObject *ref*)

*Return value: Borrowed reference.* 类似`PyWeakref_GetObject()`，但实现为一个不做类型检查的宏。

2.2 新版功能.

### 7.5.11 胶囊

有关使用这些对象的更多信息请参阅 using-capsules。

2.7 新版功能.

**PyCapsule**

这个 *PyObject* 的子类型代表着一个任意值，当需要通过 Python 代码将任意值（以 `void*` 指针的形式）从 C 扩展模块传递给其他 C 代码时非常有用。它通常用于将指向一个模块中定义的 C 语言函数指针传递给其他模块，以便可以从那里调用它们。这允许通过正常的模块导入机制访问动态加载的模块中的 C API。

**PyCapsule_Destructor**

这种类型的一个析构器返回一个胶囊，定义如下：

```
typedef void (*PyCapsule_Destructor)(PyObject *);
```

参阅 *PyCapsule_New()* 来获取 PyCapsule_Destructor 返回值的语义。

int **PyCapsule_CheckExact** (*PyObject *p*)

如果参数是一个 *PyCapsule* 则返回 True

*PyObject** **PyCapsule_New** (void **pointer*, const char **name*, *PyCapsule_Destructor destructor*)

*Return value: New reference.* Create a *PyCapsule* encapsulating the *pointer*. The *pointer* argument may not be *NULL*.

On failure, set an exception and return *NULL*.

The *name* string may either be *NULL* or a pointer to a valid C string. If non-*NULL*, this string must outlive the capsule. (Though it is permitted to free it inside the *destructor*.)

If the *destructor* argument is not *NULL*, it will be called with the capsule as its argument when it is destroyed.

If this capsule will be stored as an attribute of a module, the *name* should be specified as `modulename.attributename`. This will enable other modules to import the capsule using *PyCapsule_Import()*.

void* **PyCapsule_GetPointer** (*PyObject *capsule*, const char **name*)

Retrieve the *pointer* stored in the capsule. On failure, set an exception and return *NULL*.

The *name* parameter must compare exactly to the name stored in the capsule. If the name stored in the capsule is *NULL*, the *name* passed in must also be *NULL*. Python uses the C function `strcmp()` to compare capsule names.

*PyCapsule_Destructor* **PyCapsule_GetDestructor** (*PyObject *capsule*)

Return the current destructor stored in the capsule. On failure, set an exception and return *NULL*.

It is legal for a capsule to have a *NULL* destructor. This makes a *NULL* return code somewhat ambiguous; use *PyCapsule_IsValid()* or *PyErr_Occurred()* to disambiguate.

void* **PyCapsule_GetContext** (*PyObject *capsule*)

Return the current context stored in the capsule. On failure, set an exception and return *NULL*.

It is legal for a capsule to have a *NULL* context. This makes a *NULL* return code somewhat ambiguous; use *PyCapsule_IsValid()* or *PyErr_Occurred()* to disambiguate.

const char* **PyCapsule_GetName** (*PyObject *capsule*)

Return the current name stored in the capsule. On failure, set an exception and return *NULL*.

It is legal for a capsule to have a *NULL* name. This makes a *NULL* return code somewhat ambiguous; use *PyCapsule_IsValid()* or *PyErr_Occurred()* to disambiguate.

void* **PyCapsule_Import** (const char **name*, int *no_block*)
Import a pointer to a C object from a capsule attribute in a module. The *name* parameter should specify the full name to the attribute, as in `module.attribute`. The *name* stored in the capsule must match this string exactly. If *no_block* is true, import the module without blocking (using `PyImport_ImportModuleNoBlock()`). If *no_block* is false, import the module conventionally (using `PyImport_ImportModule()`).

Return the capsule's internal *pointer* on success. On failure, set an exception and return *NULL*.

int **PyCapsule_IsValid** (*PyObject* **capsule*, const char **name*)
Determines whether or not *capsule* is a valid capsule. A valid capsule is non-*NULL*, passes `PyCapsule_CheckExact()`, has a non-*NULL* pointer stored in it, and its internal name matches the *name* parameter. (See `PyCapsule_GetPointer()` for information on how capsule names are compared.)

In other words, if `PyCapsule_IsValid()` returns a true value, calls to any of the accessors (any function starting with `PyCapsule_Get()`) are guaranteed to succeed.

Return a nonzero value if the object is valid and matches the name passed in. Return `0` otherwise. This function will not fail.

int **PyCapsule_SetContext** (*PyObject* **capsule*, void **context*)
Set the context pointer inside *capsule* to *context*.

Return `0` on success. Return nonzero and set an exception on failure.

int **PyCapsule_SetDestructor** (*PyObject* **capsule*, *PyCapsule_Destructor* *destructor*)
Set the destructor inside *capsule* to *destructor*.

Return `0` on success. Return nonzero and set an exception on failure.

int **PyCapsule_SetName** (*PyObject* **capsule*, const char **name*)
Set the name inside *capsule* to *name*. If non-*NULL*, the name must outlive the capsule. If the previous *name* stored in the capsule was not *NULL*, no attempt is made to free it.

Return `0` on success. Return nonzero and set an exception on failure.

int **PyCapsule_SetPointer** (*PyObject* **capsule*, void **pointer*)
Set the void pointer inside *capsule* to *pointer*. The pointer may not be *NULL*.

Return `0` on success. Return nonzero and set an exception on failure.

### 7.5.12 CObjects

> **警告:** The CObject API is deprecated as of Python 2.7. Please switch to the new 胶囊 API.

**PyCObject**
This subtype of `PyObject` represents an opaque value, useful for C extension modules who need to pass an opaque value (as a `void*` pointer) through Python code to other C code. It is often used to make a C function pointer defined in one module available to other modules, so the regular import mechanism can be used to access C APIs defined in dynamically loaded modules.

int **PyCObject_Check** (*PyObject* **p*)
Return true if its argument is a `PyCObject`.

*PyObject** **PyCObject_FromVoidPtr** (void* *cobj*, void (**destr*)(void *))
*Return value: New reference.* Create a `PyCObject` from the `void *` *cobj*. The *destr* function will be called when the object is reclaimed, unless it is *NULL*.

*PyObject** **PyCObject_FromVoidPtrAndDesc** (void* *cobj*, void* *desc*, void (**destr*)(void *, void *))
*Return value: New reference.* Create a `PyCObject` from the `void *` *cobj*. The *destr* function will be called when the object is reclaimed. The *desc* argument can be used to pass extra callback data for the destructor function.

void* **PyCObject_AsVoidPtr** (*PyObject** *self*)
Return the object `void *` that the `PyCObject` *self* was created with.

void* **PyCObject_GetDesc** (*PyObject** *self*)
Return the description `void *` that the `PyCObject` *self* was created with.

int **PyCObject_SetVoidPtr** (*PyObject** *self*, void* *cobj*)
Set the void pointer inside *self* to *cobj*. The `PyCObject` must not have an associated destructor. Return true on success, false on failure.

### 7.5.13 Cell 对象

"Cell"对象用于实现由多个作用域引用的变量。对于每个这样的变量，一个"Cell"对象为了存储该值而被创建；引用该值的每个堆栈框架的局部变量包含同样使用该变量的对外部作用域的"Cell"引用。访问该值时，将使用"Cell"中包含的值而不是单元格对象本身。这种对"Cell"对象的非关联化的引用需要支持生成的字节码；访问时不会自动非关联化这些内容。"Cell"对象在其他地方可能不太有用。

**PyCellObject**
用于 Cell 对象的 C 结构体。

*PyTypeObject* **PyCell_Type**
与 Cell 对象对应的类型对 象。

int **PyCell_Check** (ob)
Return true if *ob* is a cell object; *ob* must not be *NULL*.

*PyObject** **PyCell_New** (*PyObject* **ob*)
*Return value: New reference.* Create and return a new cell object containing the value *ob*. The parameter may be *NULL*.

*PyObject** **PyCell_Get** (*PyObject* **cell*)
*Return value: New reference.* 返回 cell 对象 *cell* 的内容。

*PyObject** **PyCell_GET** (*PyObject* **cell*)
*Return value: Borrowed reference.* Return the contents of the cell *cell*, but without checking that *cell* is non-*NULL* and a cell object.

int **PyCell_Set** (*PyObject* **cell*, *PyObject* **value*)
Set the contents of the cell object *cell* to *value*. This releases the reference to any current content of the cell. *value* may be *NULL*. *cell* must be non-*NULL*; if it is not a cell object, `-1` will be returned. On success, `0` will be returned.

void **PyCell_SET** (*PyObject* **cell*, *PyObject* **value*)
Sets the value of the cell object *cell* to *value*. No reference counts are adjusted, and no checks are made for safety; *cell* must be non-*NULL* and must be a cell object.

### 7.5.14 生成器对象

Generator objects are what Python uses to implement generator iterators. They are normally created by iterating over a function that yields values, rather than explicitly calling `PyGen_New()`.

**PyGenObject**
用于生成器对象的 C 结构体。

*PyTypeObject* **PyGen_Type**
与生成器对象对应的类型对 象。

int **PyGen_Check**(ob)
Return true if *ob* is a generator object; *ob* must not be *NULL*.

int **PyGen_CheckExact**(ob)
Return true if *ob*' s type is *PyGen_Type* is a generator object; *ob* must not be *NULL*.

*PyObject** **PyGen_New**(PyFrameObject **frame*)
*Return value: New reference.* Create and return a new generator object based on the *frame* object. A reference to *frame* is stolen by this function. The parameter must not be *NULL*.

### 7.5.15 DateTime 对象

`datetime` 模块提供了各种日期和时间对象。在使用任何这些函数之前，必须在你的源码中包含头文件 `datetime.h` (请注意此文件并未包含在 `Python.h` 中)，并且宏 `PyDateTime_IMPORT` 必须被发起调用，通常是作为模块初始化函数的一部分。这个宏会将指向特定 C 结构的指针放入一个静态变量 `PyDateTimeAPI` 中，它会由下面的宏来使用。

类型检查宏：

int **PyDate_Check**(*PyObject* **ob*)
Return true if *ob* is of type `PyDateTime_DateType` or a subtype of `PyDateTime_DateType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyDate_CheckExact**(*PyObject* **ob*)
Return true if *ob* is of type `PyDateTime_DateType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyDateTime_Check**(*PyObject* **ob*)
Return true if *ob* is of type `PyDateTime_DateTimeType` or a subtype of `PyDateTime_DateTimeType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyDateTime_CheckExact**(*PyObject* **ob*)
Return true if *ob* is of type `PyDateTime_DateTimeType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyTime_Check**(*PyObject* **ob*)
Return true if *ob* is of type `PyDateTime_TimeType` or a subtype of `PyDateTime_TimeType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyTime_CheckExact**(*PyObject* **ob*)
Return true if *ob* is of type `PyDateTime_TimeType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyDelta_Check** (*PyObject* *ob*)
Return true if *ob* is of type `PyDateTime_DeltaType` or a subtype of `PyDateTime_DeltaType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyDelta_CheckExact** (*PyObject* *ob*)
Return true if *ob* is of type `PyDateTime_DeltaType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyTZInfo_Check** (*PyObject* *ob*)
Return true if *ob* is of type `PyDateTime_TZInfoType` or a subtype of `PyDateTime_TZInfoType`. *ob* must not be *NULL*.

2.4 新版功能.

int **PyTZInfo_CheckExact** (*PyObject* *ob*)
Return true if *ob* is of type `PyDateTime_TZInfoType`. *ob* must not be *NULL*.

2.4 新版功能.

用于创建对象的宏：

*PyObject** **PyDate_FromDate** (int *year*, int *month*, int *day*)
*Return value: New reference.* Return a `datetime.date` object with the specified year, month and day.

2.4 新版功能.

*PyObject** **PyDateTime_FromDateAndTime** (int *year*, int *month*, int *day*, int *hour*, int *minute*, int *second*, int *usecond*)
*Return value: New reference.* Return a `datetime.datetime` object with the specified year, month, day, hour, minute, second and microsecond.

2.4 新版功能.

*PyObject** **PyTime_FromTime** (int *hour*, int *minute*, int *second*, int *usecond*)
*Return value: New reference.* Return a `datetime.time` object with the specified hour, minute, second and microsecond.

2.4 新版功能.

*PyObject** **PyDelta_FromDSU** (int *days*, int *seconds*, int *useconds*)
*Return value: New reference.* Return a `datetime.timedelta` object representing the given number of days, seconds and microseconds. Normalization is performed so that the resulting number of microseconds and seconds lie in the ranges documented for `datetime.timedelta` objects.

2.4 新版功能.

Macros to extract fields from date objects. The argument must be an instance of `PyDateTime_Date`, including subclasses (such as `PyDateTime_DateTime`). The argument must not be *NULL*, and the type is not checked:

int **PyDateTime_GET_YEAR** (PyDateTime_Date *o*)
以正整数的形式返回年份值。

2.4 新版功能.

int **PyDateTime_GET_MONTH** (PyDateTime_Date *o*)
返回月，从 0 到 12 的整数。

2.4 新版功能.

int **PyDateTime_GET_DAY** (PyDateTime_Date *o*)
返回日期，从 0 到 31 的整数。

2.4 新版功能.

Macros to extract fields from datetime objects. The argument must be an instance of `PyDateTime_DateTime`, including subclasses. The argument must not be *NULL*, and the type is not checked:

int **PyDateTime_DATE_GET_HOUR** (PyDateTime_DateTime **o*)
返回小时，从 0 到 23 的整数。

2.4 新版功能.

int **PyDateTime_DATE_GET_MINUTE** (PyDateTime_DateTime **o*)
返回分钟，从 0 到 59 的整数。

2.4 新版功能.

int **PyDateTime_DATE_GET_SECOND** (PyDateTime_DateTime **o*)
返回秒，从 0 到 59 的整数。

2.4 新版功能.

int **PyDateTime_DATE_GET_MICROSECOND** (PyDateTime_DateTime **o*)
返回微秒，从 0 到 999999 的整数。

2.4 新版功能.

Macros to extract fields from time objects. The argument must be an instance of `PyDateTime_Time`, including subclasses. The argument must not be *NULL*, and the type is not checked:

int **PyDateTime_TIME_GET_HOUR** (PyDateTime_Time **o*)
返回小时，从 0 到 23 的整数。

2.4 新版功能.

int **PyDateTime_TIME_GET_MINUTE** (PyDateTime_Time **o*)
返回分钟，从 0 到 59 的整数。

2.4 新版功能.

int **PyDateTime_TIME_GET_SECOND** (PyDateTime_Time **o*)
返回秒，从 0 到 59 的整数。

2.4 新版功能.

int **PyDateTime_TIME_GET_MICROSECOND** (PyDateTime_Time **o*)
返回微秒，从 0 到 999999 的整数。

2.4 新版功能.

一些便于模块实现 DB API 的宏:

*PyObject** **PyDateTime_FromTimestamp** (*PyObject* **args*)
*Return value: New reference.* Create and return a new `datetime.datetime` object given an argument tuple suitable for passing to `datetime.datetime.fromtimestamp()`.

2.4 新版功能.

*PyObject** **PyDate_FromTimestamp** (*PyObject* **args*)
*Return value: New reference.* Create and return a new `datetime.date` object given an argument tuple suitable for passing to `datetime.date.fromtimestamp()`.

2.4 新版功能.

### 7.5.16 集合对象

2.5 新版功能.

This section details the public API for `set` and `frozenset` objects. Any functionality not listed below is best accessed using the either the abstract object protocol (including `PyObject_CallMethod()`, `PyObject_RichCompareBool()`, `PyObject_Hash()`, `PyObject_Repr()`, `PyObject_IsTrue()`, `PyObject_Print()`, and `PyObject_GetIter()`) or the abstract number protocol (including `PyNumber_And()`, `PyNumber_Subtract()`, `PyNumber_Or()`, `PyNumber_Xor()`, `PyNumber_InPlaceAnd()`, `PyNumber_InPlaceSubtract()`, `PyNumber_InPlaceOr()`, and `PyNumber_InPlaceXor()`).

**PySetObject**

This subtype of `PyObject` is used to hold the internal data for both `set` and `frozenset` objects. It is like a `PyDictObject` in that it is a fixed size for small sets (much like tuple storage) and will point to a separate, variable sized block of memory for medium and large sized sets (much like list storage). None of the fields of this structure should be considered public and are subject to change. All access should be done through the documented API rather than by manipulating the values in the structure.

*PyTypeObject* **PySet_Type**

This is an instance of `PyTypeObject` representing the Python `set` type.

*PyTypeObject* **PyFrozenSet_Type**

This is an instance of `PyTypeObject` representing the Python `frozenset` type.

The following type check macros work on pointers to any Python object. Likewise, the constructor functions work with any iterable Python object.

int **PySet_Check**(*PyObject *p*)

Return true if *p* is a `set` object or an instance of a subtype.

2.6 新版功能.

int **PyFrozenSet_Check**(*PyObject *p*)

Return true if *p* is a `frozenset` object or an instance of a subtype.

2.6 新版功能.

int **PyAnySet_Check**(*PyObject *p*)

Return true if *p* is a `set` object, a `frozenset` object, or an instance of a subtype.

int **PyAnySet_CheckExact**(*PyObject *p*)

Return true if *p* is a `set` object or a `frozenset` object but not an instance of a subtype.

int **PyFrozenSet_CheckExact**(*PyObject *p*)

Return true if *p* is a `frozenset` object but not an instance of a subtype.

*PyObject** **PySet_New**(*PyObject *iterable*)

*Return value: New reference.* Return a new `set` containing objects returned by the *iterable*. The *iterable* may be *NULL* to create a new empty set. Return the new set on success or *NULL* on failure. Raise `TypeError` if *iterable* is not actually iterable. The constructor is also useful for copying a set (`c=set(s)`).

*PyObject** **PyFrozenSet_New**(*PyObject *iterable*)

*Return value: New reference.* Return a new `frozenset` containing objects returned by the *iterable*. The *iterable* may be *NULL* to create a new empty frozenset. Return the new set on success or *NULL* on failure. Raise `TypeError` if *iterable* is not actually iterable.

在 2.6 版更改: Now guaranteed to return a brand-new `frozenset`. Formerly, frozensets of zero-length were a singleton. This got in the way of building-up new frozensets with `PySet_Add()`.

The following functions and macros are available for instances of `set` or `frozenset` or instances of their subtypes.

Py_ssize_t **PySet_Size** (*PyObject* **anyset*)

Return the length of a `set` or `frozenset` object. Equivalent to `len(anyset)`. Raises a `PyExc_SystemError` if *anyset* is not a `set`, `frozenset`, or an instance of a subtype.

在 2.5 版更改: This function returned an `int`. This might require changes in your code for properly supporting 64-bit systems.

Py_ssize_t **PySet_GET_SIZE** (*PyObject* **anyset*)

Macro form of `PySet_Size()` without error checking.

int **PySet_Contains** (*PyObject* **anyset*, *PyObject* **key*)

Return `1` if found, `0` if not found, and `-1` if an error is encountered. Unlike the Python `__contains__()` method, this function does not automatically convert unhashable sets into temporary frozensets. Raise a `TypeError` if the *key* is unhashable. Raise `PyExc_SystemError` if *anyset* is not a `set`, `frozenset`, or an instance of a subtype.

int **PySet_Add** (*PyObject* **set*, *PyObject* **key*)

Add *key* to a `set` instance. Does not apply to `frozenset` instances. Return `0` on success or `-1` on failure. Raise a `TypeError` if the *key* is unhashable. Raise a `MemoryError` if there is no room to grow. Raise a `SystemError` if *set* is not an instance of `set` or its subtype.

在 2.6 版更改: Now works with instances of `frozenset` or its subtypes. Like `PyTuple_SetItem()` in that it can be used to fill-in the values of brand new frozensets before they are exposed to other code.

The following functions are available for instances of `set` or its subtypes but not for instances of `frozenset` or its subtypes.

int **PySet_Discard** (*PyObject* **set*, *PyObject* **key*)

Return `1` if found and removed, `0` if not found (no action taken), and `-1` if an error is encountered. Does not raise `KeyError` for missing keys. Raise a `TypeError` if the *key* is unhashable. Unlike the Python `discard()` method, this function does not automatically convert unhashable sets into temporary frozensets. Raise `PyExc_SystemError` if *set* is not an instance of `set` or its subtype.

*PyObject** **PySet_Pop** (*PyObject* **set*)

*Return value: New reference.* Return a new reference to an arbitrary object in the *set*, and removes the object from the *set*. Return *NULL* on failure. Raise `KeyError` if the set is empty. Raise a `SystemError` if *set* is not an instance of `set` or its subtype.

int **PySet_Clear** (*PyObject* **set*)

清空现有字典的所有键值对。

### 7.5.17 代码对象

代码对象是 CPython 实现的低级细节。每个代表一块尚未绑定到函数中的可执行代码。

**PyCodeObject**

用于描述代码对象的对象的 C 结构。此类型字段可随时更改。

*PyTypeObject* **PyCode_Type**

这是一个`PyTypeObject` 实例，其表示 Python 的 `code` 类型。

int **PyCode_Check** (*PyObject* **co*)

如果 *co* 是一个 `code` 对象则返回 true。

int **PyCode_GetNumFree** (*PyObject* **co*)

返回 *co* 中的自由变量数。

*PyCodeObject* ***PyCode_New**(int *argcount*, int *nlocals*, int *stacksize*, int *flags*, *PyObject* **code*, *PyObject* **consts*, *PyObject* **names*, *PyObject* **varnames*, *PyObject* **freevars*, *PyObject* **cellvars*, *PyObject* **filename*, *PyObject* **name*, int *firstlineno*, *PyObject* **lnotab*)

返回一个新的代码对象。如果你需要一个虚拟代码对象来创建一个代码帧，请使用`PyCode_NewEmpty()`。调用`PyCode_New()` 直接可以绑定到准确的 Python 版本，因为字节码的定义经常变化。

int **PyCode_NewEmpty**(const char **filename*, const char **funcname*, int *firstlineno*)

Return a new empty code object with the specified filename, function name, and first line number. It is illegal to `exec` or `eval()` the resulting code object.

CHAPTER 8

# Initialization, Finalization, and Threads

## 8.1 Initializing and finalizing the interpreter

void **Py_Initialize**()

Initialize the Python interpreter. In an application embedding Python, this should be called before using any other Python/C API functions; with the exception of *Py_SetProgramName()*, *Py_SetPythonHome()*, *PyEval_InitThreads()*, *PyEval_ReleaseLock()*, and *PyEval_AcquireLock()*. This initializes the table of loaded modules (`sys.modules`), and creates the fundamental modules `__builtin__`, `__main__` and `sys`. It also initializes the module search path (`sys.path`). It does not set `sys.argv`; use *PySys_SetArgvEx()* for that. This is a no-op when called for a second time (without calling *Py_Finalize()* first). There is no return value; it is a fatal error if the initialization fails.

void **Py_InitializeEx**(int *initsigs*)

This function works like *Py_Initialize()* if *initsigs* is `1`. If *initsigs* is `0`, it skips initialization registration of signal handlers, which might be useful when Python is embedded.

2.4 新版功能.

int **Py_IsInitialized**()

Return true (nonzero) when the Python interpreter has been initialized, false (zero) if not. After *Py_Finalize()* is called, this returns false until *Py_Initialize()* is called again.

void **Py_Finalize**()

Undo all initializations made by *Py_Initialize()* and subsequent use of Python/C API functions, and destroy all sub-interpreters (see *Py_NewInterpreter()* below) that were created and not yet destroyed since the last call to *Py_Initialize()*. Ideally, this frees all memory allocated by the Python interpreter. This is a no-op when called for a second time (without calling *Py_Initialize()* again first). There is no return value; errors during finalization are ignored.

This function is provided for a number of reasons. An embedding application might want to restart Python without having to restart the application itself. An application that has loaded the Python interpreter from a dynamically loadable library (or DLL) might want to free all memory allocated by Python before unloading the DLL. During a hunt for memory leaks in an application a developer might want to free all memory allocated by Python before exiting from the application.

**Bugs and caveats:** The destruction of modules and objects in modules is done in random order; this may cause destructors (`__del__()` methods) to fail when they depend on other objects (even functions) or modules. Dynamically loaded extension modules loaded by Python are not unloaded. Small amounts of memory allocated by the Python interpreter may not be freed (if you find a leak, please report it). Memory tied up in circular references between objects is not freed. Some memory allocated by extension modules may not be freed. Some extensions may not work properly if their initialization routine is called more than once; this can happen if an application calls `Py_Initialize()` and `Py_Finalize()` more than once.

## 8.2 Process-wide parameters

void **Py_SetProgramName**(char **name*)

This function should be called before `Py_Initialize()` is called for the first time, if it is called at all. It tells the interpreter the value of the `argv[0]` argument to the `main()` function of the program. This is used by `Py_GetPath()` and some other functions below to find the Python run-time libraries relative to the interpreter executable. The default value is `'python'`. The argument should point to a zero-terminated character string in static storage whose contents will not change for the duration of the program' s execution. No code in the Python interpreter will change the contents of this storage.

char* **Py_GetProgramName**()

Return the program name set with `Py_SetProgramName()`, or the default. The returned string points into static storage; the caller should not modify its value.

char* **Py_GetPrefix**()

Return the *prefix* for installed platform-independent files. This is derived through a number of complicated rules from the program name set with `Py_SetProgramName()` and some environment variables; for example, if the program name is `'/usr/local/bin/python'`, the prefix is `'/usr/local'`. The returned string points into static storage; the caller should not modify its value. This corresponds to the **prefix** variable in the top-level `Makefile` and the `--prefix` argument to the **configure** script at build time. The value is available to Python code as `sys.prefix`. It is only useful on Unix. See also the next function.

char* **Py_GetExecPrefix**()

Return the *exec-prefix* for installed platform-*dependent* files. This is derived through a number of complicated rules from the program name set with `Py_SetProgramName()` and some environment variables; for example, if the program name is `'/usr/local/bin/python'`, the exec-prefix is `'/usr/local'`. The returned string points into static storage; the caller should not modify its value. This corresponds to the **exec_prefix** variable in the top-level `Makefile` and the `--exec-prefix` argument to the **configure** script at build time. The value is available to Python code as `sys.exec_prefix`. It is only useful on Unix.

Background: The exec-prefix differs from the prefix when platform dependent files (such as executables and shared libraries) are installed in a different directory tree. In a typical installation, platform dependent files may be installed in the `/usr/local/plat` subtree while platform independent may be installed in `/usr/local`.

Generally speaking, a platform is a combination of hardware and software families, e.g. Sparc machines running the Solaris 2.x operating system are considered the same platform, but Intel machines running Solaris 2.x are another platform, and Intel machines running Linux are yet another platform. Different major revisions of the same operating system generally also form different platforms. Non-Unix operating systems are a different story; the installation strategies on those systems are so different that the prefix and exec-prefix are meaningless, and set to the empty string. Note that compiled Python bytecode files are platform independent (but not independent from the Python version by which they were compiled!).

System administrators will know how to configure the **mount** or **automount** programs to share `/usr/local` between platforms while having `/usr/local/plat` be a different filesystem for each platform.

char* **Py_GetProgramFullPath**()

Return the full program name of the Python executable; this is computed as a side-effect of deriving the default module search path from the program name (set by `Py_SetProgramName()` above). The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.executable`.

char* **Py_GetPath**()

Return the default module search path; this is computed from the program name (set by *Py_SetProgramName()* above) and some environment variables. The returned string consists of a series of directory names separated by a platform dependent delimiter character. The delimiter character is `':'` on Unix and Mac OS X, `';'` on Windows. The returned string points into static storage; the caller should not modify its value. The list `sys.path` is initialized with this value on interpreter startup; it can be (and usually is) modified later to change the search path for loading modules.

const char* **Py_GetVersion**()

Return the version of this Python interpreter. This is a string that looks something like

```
"1.5 (#67, Dec 31 1997, 22:34:28) [GCC 2.7.2.2]"
```

The first word (up to the first space character) is the current Python version; the first three characters are the major and minor version separated by a period. The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.version`.

const char* **Py_GetPlatform**()

Return the platform identifier for the current platform. On Unix, this is formed from the "official" name of the operating system, converted to lower case, followed by the major revision number; e.g., for Solaris 2.x, which is also known as SunOS 5.x, the value is `'sunos5'`. On Mac OS X, it is `'darwin'`. On Windows, it is `'win'`. The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.platform`.

const char* **Py_GetCopyright**()

Return the official copyright string for the current Python version, for example

`'Copyright 1991-1995 Stichting Mathematisch Centrum, Amsterdam'`

The returned string points into static storage; the caller should not modify its value. The value is available to Python code as `sys.copyright`.

const char* **Py_GetCompiler**()

Return an indication of the compiler used to build the current Python version, in square brackets, for example:

```
"[GCC 2.7.2.2]"
```

The returned string points into static storage; the caller should not modify its value. The value is available to Python code as part of the variable `sys.version`.

const char* **Py_GetBuildInfo**()

Return information about the sequence number and build date and time of the current Python interpreter instance, for example

```
"#67, Aug  1 1997, 22:34:28"
```

The returned string points into static storage; the caller should not modify its value. The value is available to Python code as part of the variable `sys.version`.

void **PySys_SetArgvEx**(int *argc*, char ***argv*, int *updatepath*)

Set `sys.argv` based on *argc* and *argv*. These parameters are similar to those passed to the program's `main()` function with the difference that the first entry should refer to the script file to be executed rather than the executable hosting the Python interpreter. If there isn't a script that will be run, the first entry in *argv* can be an empty string. If this function fails to initialize `sys.argv`, a fatal condition is signalled using *Py_FatalError()*.

If *updatepath* is zero, this is all the function does. If *updatepath* is non-zero, the function also modifies `sys.path` according to the following algorithm:

- If the name of an existing script is passed in `argv[0]`, the absolute path of the directory where the script is located is prepended to `sys.path`.
- Otherwise (that is, if *argc* is 0 or `argv[0]` doesn't point to an existing file name), an empty string is prepended to `sys.path`, which is the same as prepending the current working directory (`"."`).

**注解:** It is recommended that applications embedding the Python interpreter for purposes other than executing a single script pass `0` as *updatepath*, and update `sys.path` themselves if desired. See CVE-2008-5983.

On versions before 2.6.6, you can achieve the same effect by manually popping the first `sys.path` element after having called `PySys_SetArgv()`, for example using:

```
PyRun_SimpleString("import sys; sys.path.pop(0)\n");
```

2.6.6 新版功能.

void **PySys_SetArgv**(int *argc*, char ***argv*)
This function works like `PySys_SetArgvEx()` with *updatepath* set to `1`.

void **Py_SetPythonHome**(char **home*)
Set the default "home" directory, that is, the location of the standard Python libraries. See `PYTHONHOME` for the meaning of the argument string.

The argument should point to a zero-terminated character string in static storage whose contents will not change for the duration of the program's execution. No code in the Python interpreter will change the contents of this storage.

char* **Py_GetPythonHome**()
Return the default "home", that is, the value set by a previous call to `Py_SetPythonHome()`, or the value of the `PYTHONHOME` environment variable if it is set.

## 8.3 Thread State and the Global Interpreter Lock

The Python interpreter is not fully thread-safe. In order to support multi-threaded Python programs, there's a global lock, called the *global interpreter lock* or *GIL*, that must be held by the current thread before it can safely access Python objects. Without the lock, even the simplest operations could cause problems in a multi-threaded program: for example, when two threads simultaneously increment the reference count of the same object, the reference count could end up being incremented only once instead of twice.

Therefore, the rule exists that only the thread that has acquired the *GIL* may operate on Python objects or call Python/C API functions. In order to emulate concurrency of execution, the interpreter regularly tries to switch threads (see `sys.setcheckinterval()`). The lock is also released around potentially blocking I/O operations like reading or writing a file, so that other Python threads can run in the meantime.

The Python interpreter keeps some thread-specific bookkeeping information inside a data structure called `PyThreadState`. There's also one global variable pointing to the current `PyThreadState`: it can be retrieved using `PyThreadState_Get()`.

### 8.3.1 Releasing the GIL from extension code

Most extension code manipulating the *GIL* has the following simple structure:

```
Save the thread state in a local variable.
Release the global interpreter lock.
... Do some blocking I/O operation ...
Reacquire the global interpreter lock.
Restore the thread state from the local variable.
```

This is so common that a pair of macros exists to simplify it:

```
Py_BEGIN_ALLOW_THREADS
... Do some blocking I/O operation ...
Py_END_ALLOW_THREADS
```

The `Py_BEGIN_ALLOW_THREADS` macro opens a new block and declares a hidden local variable; the `Py_END_ALLOW_THREADS` macro closes the block. These two macros are still available when Python is compiled without thread support (they simply have an empty expansion).

When thread support is enabled, the block above expands to the following code:

```
PyThreadState *_save;

_save = PyEval_SaveThread();
...Do some blocking I/O operation...
PyEval_RestoreThread(_save);
```

Here is how these functions work: the global interpreter lock is used to protect the pointer to the current thread state. When releasing the lock and saving the thread state, the current thread state pointer must be retrieved before the lock is released (since another thread could immediately acquire the lock and store its own thread state in the global variable). Conversely, when acquiring the lock and restoring the thread state, the lock must be acquired before storing the thread state pointer.

**注解：** Calling system I/O functions is the most common use case for releasing the GIL, but it can also be useful before calling long-running computations which don't need access to Python objects, such as compression or cryptographic functions operating over memory buffers. For example, the standard `zlib` and `hashlib` modules release the GIL when compressing or hashing data.

### 8.3.2 非 Python 创建的线程

When threads are created using the dedicated Python APIs (such as the `threading` module), a thread state is automatically associated to them and the code showed above is therefore correct. However, when threads are created from C (for example by a third-party library with its own thread management), they don't hold the GIL, nor is there a thread state structure for them.

If you need to call Python code from these threads (often this will be part of a callback API provided by the aforementioned third-party library), you must first register these threads with the interpreter by creating a thread state data structure, then acquiring the GIL, and finally storing their thread state pointer, before you can start using the Python/C API. When you are done, you should reset the thread state pointer, release the GIL, and finally free the thread state data structure.

The `PyGILState_Ensure()` and `PyGILState_Release()` functions do all of the above automatically. The typical idiom for calling into Python from a C thread is:

```
PyGILState_STATE gstate;
gstate = PyGILState_Ensure();

/* Perform Python actions here. */
result = CallSomeFunction();
/* evaluate result or handle exception */

/* Release the thread. No Python API allowed beyond this point. */
PyGILState_Release(gstate);
```

Note that the `PyGILState_*()` functions assume there is only one global interpreter (created automatically by *Py_Initialize()*). Python supports the creation of additional interpreters (using *Py_NewInterpreter()*), but mixing multiple interpreters and the `PyGILState_*()` API is unsupported.

Another important thing to note about threads is their behaviour in the face of the C `fork()` call. On most systems with `fork()`, after a process forks only the thread that issued the fork will exist. That also means any locks held by other threads will never be released. Python solves this for `os.fork()` by acquiring the locks it uses internally before the fork, and releasing them afterwards. In addition, it resets any lock-objects in the child. When extending or embedding Python, there is no way to inform Python of additional (non-Python) locks that need to be acquired before or reset after a fork. OS facilities such as `pthread_atfork()` would need to be used to accomplish the same thing. Additionally, when extending or embedding Python, calling `fork()` directly rather than through `os.fork()` (and returning to or calling into Python) may result in a deadlock by one of Python's internal locks being held by a thread that is defunct after the fork. *PyOS_AfterFork()* tries to reset the necessary locks, but is not always able to.

### 8.3.3 高阶 API

These are the most commonly used types and functions when writing C extension code, or when embedding the Python interpreter:

**PyInterpreterState**

This data structure represents the state shared by a number of cooperating threads. Threads belonging to the same interpreter share their module administration and a few other internal items. There are no public members in this structure.

Threads belonging to different interpreters initially share nothing, except process state like available memory, open file descriptors and such. The global interpreter lock is also shared by all threads, regardless of to which interpreter they belong.

**PyThreadState**

This data structure represents the state of a single thread. The only public data member is *PyInterpreterState* `*interp`, which points to this thread's interpreter state.

void **PyEval_InitThreads**()

Initialize and acquire the global interpreter lock. It should be called in the main thread before creating a second thread or engaging in any other thread operations such as *PyEval_ReleaseLock()* or `PyEval_ReleaseThread(tstate)`. It is not needed before calling *PyEval_SaveThread()* or *PyEval_RestoreThread()*.

This is a no-op when called for a second time. It is safe to call this function before calling *Py_Initialize()*.

**注解：** When only the main thread exists, no GIL operations are needed. This is a common situation (most Python programs do not use threads), and the lock operations slow the interpreter down a bit. Therefore, the lock is not created initially. This situation is equivalent to having acquired the lock: when there is only a single thread, all object accesses are safe. Therefore, when this function initializes the global interpreter lock, it also acquires it. Before the Python `_thread` module creates a new thread, knowing that either it has the lock or the lock hasn't been created yet, it calls *PyEval_InitThreads()*. When this call returns, it is guaranteed that the lock has been created and that the calling thread has acquired it.

It is **not** safe to call this function when it is unknown which thread (if any) currently has the global interpreter lock.

This function is not available when thread support is disabled at compile time.

---

int **PyEval_ThreadsInitialized**()

Returns a non-zero value if *PyEval_InitThreads()* has been called. This function can be called without holding the GIL, and therefore can be used to avoid calls to the locking API when running single-threaded. This function is not available when thread support is disabled at compile time.

2.4 新版功能.

*PyThreadState** **PyEval_SaveThread**()

Release the global interpreter lock (if it has been created and thread support is enabled) and reset the thread state to *NULL*, returning the previous thread state (which is not *NULL*). If the lock has been created, the current thread must have acquired it. (This function is available even when thread support is disabled at compile time.)

void **PyEval_RestoreThread**(*PyThreadState *tstate*)

Acquire the global interpreter lock (if it has been created and thread support is enabled) and set the thread state to *tstate*, which must not be *NULL*. If the lock has been created, the current thread must not have acquired it, otherwise deadlock ensues. (This function is available even when thread support is disabled at compile time.)

*PyThreadState** **PyThreadState_Get**()

Return the current thread state. The global interpreter lock must be held. When the current thread state is *NULL*, this issues a fatal error (so that the caller needn't check for *NULL*).

*PyThreadState** **PyThreadState_Swap**(*PyThreadState *tstate*)

Swap the current thread state with the thread state given by the argument *tstate*, which may be *NULL*. The global interpreter lock must be held and is not released.

void **PyEval_ReInitThreads**()

This function is called from *PyOS_AfterFork()* to ensure that newly created child processes don't hold locks referring to threads which are not running in the child process.

The following functions use thread-local storage, and are not compatible with sub-interpreters:

PyGILState_STATE **PyGILState_Ensure**()

Ensure that the current thread is ready to call the Python C API regardless of the current state of Python, or of the global interpreter lock. This may be called as many times as desired by a thread as long as each call is matched with a call to *PyGILState_Release()*. In general, other thread-related APIs may be used between *PyGILState_Ensure()* and *PyGILState_Release()* calls as long as the thread state is restored to its previous state before the Release(). For example, normal usage of the *Py_BEGIN_ALLOW_THREADS* and *Py_END_ALLOW_THREADS* macros is acceptable.

The return value is an opaque "handle" to the thread state when *PyGILState_Ensure()* was called, and must be passed to *PyGILState_Release()* to ensure Python is left in the same state. Even though recursive calls are allowed, these handles *cannot* be shared - each unique call to *PyGILState_Ensure()* must save the handle for its call to *PyGILState_Release()*.

When the function returns, the current thread will hold the GIL and be able to call arbitrary Python code. Failure is a fatal error.

2.3 新版功能.

void **PyGILState_Release**(PyGILState_STATE)

Release any resources previously acquired. After this call, Python's state will be the same as it was prior to the corresponding *PyGILState_Ensure()* call (but generally this state will be unknown to the caller, hence the use of the GILState API).

Every call to `PyGILState_Ensure()` must be matched by a call to `PyGILState_Release()` on the same thread.

2.3 新版功能.

*PyThreadState** **PyGILState_GetThisThreadState**()

Get the current thread state for this thread. May return `NULL` if no GILState API has been used on the current thread. Note that the main thread always has such a thread-state, even if no auto-thread-state call has been made on the main thread. This is mainly a helper/diagnostic function.

2.3 新版功能.

The following macros are normally used without a trailing semicolon; look for example usage in the Python source distribution.

**Py_BEGIN_ALLOW_THREADS**

This macro expands to `{ PyThreadState *_save; _save = PyEval_SaveThread();`. Note that it contains an opening brace; it must be matched with a following `Py_END_ALLOW_THREADS` macro. See above for further discussion of this macro. It is a no-op when thread support is disabled at compile time.

**Py_END_ALLOW_THREADS**

This macro expands to `PyEval_RestoreThread(_save); }`. Note that it contains a closing brace; it must be matched with an earlier `Py_BEGIN_ALLOW_THREADS` macro. See above for further discussion of this macro. It is a no-op when thread support is disabled at compile time.

**Py_BLOCK_THREADS**

This macro expands to `PyEval_RestoreThread(_save);`: it is equivalent to `Py_END_ALLOW_THREADS` without the closing brace. It is a no-op when thread support is disabled at compile time.

**Py_UNBLOCK_THREADS**

This macro expands to `_save = PyEval_SaveThread();`: it is equivalent to `Py_BEGIN_ALLOW_THREADS` without the opening brace and variable declaration. It is a no-op when thread support is disabled at compile time.

### 8.3.4 Low-level API

All of the following functions are only available when thread support is enabled at compile time, and must be called only when the global interpreter lock has been created.

*PyInterpreterState** **PyInterpreterState_New**()

Create a new interpreter state object. The global interpreter lock need not be held, but may be held if it is necessary to serialize calls to this function.

void **PyInterpreterState_Clear**(*PyInterpreterState *interp*)

Reset all information in an interpreter state object. The global interpreter lock must be held.

void **PyInterpreterState_Delete**(*PyInterpreterState *interp*)

Destroy an interpreter state object. The global interpreter lock need not be held. The interpreter state must have been reset with a previous call to `PyInterpreterState_Clear()`.

*PyThreadState** **PyThreadState_New**(*PyInterpreterState *interp*)

Create a new thread state object belonging to the given interpreter object. The global interpreter lock need not be held, but may be held if it is necessary to serialize calls to this function.

void **PyThreadState_Clear**(*PyThreadState *tstate*)

Reset all information in a thread state object. The global interpreter lock must be held.

void **PyThreadState_Delete** (*PyThreadState* *tstate*)
Destroy a thread state object. The global interpreter lock need not be held. The thread state must have been reset with a previous call to `PyThreadState_Clear()`.

*PyObject** **PyThreadState_GetDict** ()
*Return value: Borrowed reference.* Return a dictionary in which extensions can store thread-specific state information. Each extension should use a unique key to use to store state in the dictionary. It is okay to call this function when no current thread state is available. If this function returns *NULL*, no exception has been raised and the caller should assume no current thread state is available.

在 2.3 版更改: Previously this could only be called when a current thread is active, and *NULL* meant that an exception was raised.

int **PyThreadState_SetAsyncExc** (long *id*, *PyObject* *exc*)
Asynchronously raise an exception in a thread. The *id* argument is the thread id of the target thread; *exc* is the exception object to be raised. This function does not steal any references to *exc*. To prevent naive misuse, you must write your own C extension to call this. Must be called with the GIL held. Returns the number of thread states modified; this is normally one, but will be zero if the thread id isn't found. If *exc* is `NULL`, the pending exception (if any) for the thread is cleared. This raises no exceptions.

2.3 新版功能.

void **PyEval_AcquireThread** (*PyThreadState* *tstate*)
Acquire the global interpreter lock and set the current thread state to *tstate*, which should not be *NULL*. The lock must have been created earlier. If this thread already has the lock, deadlock ensues.

`PyEval_RestoreThread()` is a higher-level function which is always available (even when thread support isn't enabled or when threads have not been initialized).

void **PyEval_ReleaseThread** (*PyThreadState* *tstate*)
Reset the current thread state to *NULL* and release the global interpreter lock. The lock must have been created earlier and must be held by the current thread. The *tstate* argument, which must not be *NULL*, is only used to check that it represents the current thread state —if it isn't, a fatal error is reported.

`PyEval_SaveThread()` is a higher-level function which is always available (even when thread support isn't enabled or when threads have not been initialized).

void **PyEval_AcquireLock** ()
Acquire the global interpreter lock. The lock must have been created earlier. If this thread already has the lock, a deadlock ensues.

> **警告:** This function does not change the current thread state. Please use `PyEval_RestoreThread()` or `PyEval_AcquireThread()` instead.

void **PyEval_ReleaseLock** ()
Release the global interpreter lock. The lock must have been created earlier.

> **警告:** This function does not change the current thread state. Please use `PyEval_SaveThread()` or `PyEval_ReleaseThread()` instead.

## 8.4 Sub-interpreter support

While in most uses, you will only embed a single Python interpreter, there are cases where you need to create several independent interpreters in the same process and perhaps even in the same thread. Sub-interpreters allow you to do that. You can switch between sub-interpreters using the `PyThreadState_Swap()` function. You can create and destroy them using the following functions:

*PyThreadState** **`Py_NewInterpreter`**()

Create a new sub-interpreter. This is an (almost) totally separate environment for the execution of Python code. In particular, the new interpreter has separate, independent versions of all imported modules, including the fundamental modules `builtins`, `__main__` and `sys`. The table of loaded modules (`sys.modules`) and the module search path (`sys.path`) are also separate. The new environment has no `sys.argv` variable. It has new standard I/O stream file objects `sys.stdin`, `sys.stdout` and `sys.stderr` (however these refer to the same underlying file descriptors).

The return value points to the first thread state created in the new sub-interpreter. This thread state is made in the current thread state. Note that no actual thread is created; see the discussion of thread states below. If creation of the new interpreter is unsuccessful, *NULL* is returned; no exception is set since the exception state is stored in the current thread state and there may not be a current thread state. (Like all other Python/C API functions, the global interpreter lock must be held before calling this function and is still held when it returns; however, unlike most other Python/C API functions, there needn't be a current thread state on entry.)

Extension modules are shared between (sub-)interpreters as follows: the first time a particular extension is imported, it is initialized normally, and a (shallow) copy of its module's dictionary is squirreled away. When the same extension is imported by another (sub-)interpreter, a new module is initialized and filled with the contents of this copy; the extension's `init` function is not called. Note that this is different from what happens when an extension is imported after the interpreter has been completely re-initialized by calling `Py_Finalize()` and `Py_Initialize()`; in that case, the extension's `initmodule` function *is* called again.

void **`Py_EndInterpreter`**(*PyThreadState *tstate*)

Destroy the (sub-)interpreter represented by the given thread state. The given thread state must be the current thread state. See the discussion of thread states below. When the call returns, the current thread state is *NULL*. All thread states associated with this interpreter are destroyed. (The global interpreter lock must be held before calling this function and is still held when it returns.) `Py_Finalize()` will destroy all sub-interpreters that haven't been explicitly destroyed at that point.

### 8.4.1 错误和警告

Because sub-interpreters (and the main interpreter) are part of the same process, the insulation between them isn't perfect —for example, using low-level file operations like `os.close()` they can (accidentally or maliciously) affect each other's open files. Because of the way extensions are shared between (sub-)interpreters, some extensions may not work properly; this is especially likely when the extension makes use of (static) global variables, or when the extension manipulates its module's dictionary after its initialization. It is possible to insert objects created in one sub-interpreter into a namespace of another sub-interpreter; this should be done with great care to avoid sharing user-defined functions, methods, instances or classes between sub-interpreters, since import operations executed by such objects may affect the wrong (sub-)interpreter's dictionary of loaded modules.

Also note that combining this functionality with `PyGILState_*()` APIs is delicate, because these APIs assume a bijection between Python thread states and OS-level threads, an assumption broken by the presence of sub-interpreters. It is highly recommended that you don't switch sub-interpreters between a pair of matching `PyGILState_Ensure()` and `PyGILState_Release()` calls. Furthermore, extensions (such as `ctypes`) using these APIs to allow calling of Python code from non-Python created threads will probably be broken when using sub-interpreters.

## 8.5 异步通知

A mechanism is provided to make asynchronous notifications to the main interpreter thread. These notifications take the form of a function pointer and a void pointer argument.

int **Py_AddPendingCall** (int (**func*)(void *), void **arg*)

Schedule a function to be called from the main interpreter thread. On success, `0` is returned and *func* is queued for being called in the main thread. On failure, `-1` is returned without setting any exception.

When successfully queued, *func* will be *eventually* called from the main interpreter thread with the argument *arg*. It will be called asynchronously with respect to normally running Python code, but with both these conditions met:

- on a *bytecode* boundary;
- with the main thread holding the *global interpreter lock* (*func* can therefore use the full C API).

*func* must return `0` on success, or `-1` on failure with an exception set. *func* won't be interrupted to perform another asynchronous notification recursively, but it can still be interrupted to switch threads if the global interpreter lock is released.

This function doesn't need a current thread state to run, and it doesn't need the global interpreter lock.

> **警告:** This is a low-level function, only useful for very special cases. There is no guarantee that *func* will be called as quick as possible. If the main thread is busy executing a system call, *func* won't be called before the system call returns. This function is generally **not** suitable for calling Python code from arbitrary C threads. Instead, use the *PyGILState API*.

2.7 新版功能.

## 8.6 分析和跟踪

The Python interpreter provides some low-level support for attaching profiling and execution tracing facilities. These are used for profiling, debugging, and coverage analysis tools.

Starting with Python 2.2, the implementation of this facility was substantially revised, and an interface from C was added. This C interface allows the profiling or tracing code to avoid the overhead of calling through Python-level callable objects, making a direct C function call instead. The essential attributes of the facility have not changed; the interface allows trace functions to be installed per-thread, and the basic events reported to the trace function are the same as had been reported to the Python-level trace functions in previous versions.

int **(*Py_tracefunc)** (*PyObject* **obj*, PyFrameObject **frame*, int *what*, *PyObject* **arg*)

The type of the trace function registered using `PyEval_SetProfile()` and `PyEval_SetTrace()`. The first parameter is the object passed to the registration function as *obj*, *frame* is the frame object to which the event pertains, *what* is one of the constants `PyTrace_CALL`, `PyTrace_EXCEPTION`, `PyTrace_LINE`, `PyTrace_RETURN`, `PyTrace_C_CALL`, `PyTrace_C_EXCEPTION`, or `PyTrace_C_RETURN`, and *arg* depends on the value of *what*:

| *what* 的值 | *arg* 的含义 |
|---|---|
| PyTrace_CALL | 总是Py_None. |
| PyTrace_EXCEPTION | sys.exc_info() 返回的异常信息。 |
| PyTrace_LINE | 总是Py_None. |
| PyTrace_RETURN | Value being returned to the caller, or *NULL* if caused by an exception. |
| PyTrace_C_CALL | 正在调用函数对象。 |
| PyTrace_C_EXCEPTION | 正在调用函数对象。 |
| PyTrace_C_RETURN | 正在调用函数对象。 |

int **PyTrace_CALL**
The value of the *what* parameter to a Py_tracefunc function when a new call to a function or method is being reported, or a new entry into a generator. Note that the creation of the iterator for a generator function is not reported as there is no control transfer to the Python bytecode in the corresponding frame.

int **PyTrace_EXCEPTION**
The value of the *what* parameter to a Py_tracefunc function when an exception has been raised. The callback function is called with this value for *what* when after any bytecode is processed after which the exception becomes set within the frame being executed. The effect of this is that as exception propagation causes the Python stack to unwind, the callback is called upon return to each frame as the exception propagates. Only trace functions receives these events; they are not needed by the profiler.

int **PyTrace_LINE**
The value passed as the *what* parameter to a trace function (but not a profiling function) when a line-number event is being reported.

int **PyTrace_RETURN**
The value for the *what* parameter to Py_tracefunc functions when a call is about to return.

int **PyTrace_C_CALL**
The value for the *what* parameter to Py_tracefunc functions when a C function is about to be called.

int **PyTrace_C_EXCEPTION**
The value for the *what* parameter to Py_tracefunc functions when a C function has raised an exception.

int **PyTrace_C_RETURN**
The value for the *what* parameter to Py_tracefunc functions when a C function has returned.

void **PyEval_SetProfile**(Py_tracefunc *func*, PyObject **obj*)
Set the profiler function to *func*. The *obj* parameter is passed to the function as its first parameter, and may be any Python object, or *NULL*. If the profile function needs to maintain state, using a different value for *obj* for each thread provides a convenient and thread-safe place to store it. The profile function is called for all monitored events except PyTrace_LINE and PyTrace_EXCEPTION.

void **PyEval_SetTrace**(Py_tracefunc *func*, PyObject **obj*)
Set the tracing function to *func*. This is similar to PyEval_SetProfile(), except the tracing function does receive line-number events and does not receive any event related to C function objects being called. Any trace function registered using PyEval_SetTrace() will not receive PyTrace_C_CALL, PyTrace_C_EXCEPTION or PyTrace_C_RETURN as a value for the *what* parameter.

PyObject* **PyEval_GetCallStats**(PyObject **self*)
Return a tuple of function call counts. There are constants defined for the positions within the tuple:

| Name | Value |
|---|---|
| PCALL_ALL | 0 |
| PCALL_FUNCTION | 1 |
| PCALL_FAST_FUNCTION | 2 |
| PCALL_FASTER_FUNCTION | 3 |
| PCALL_METHOD | 4 |
| PCALL_BOUND_METHOD | 5 |
| PCALL_CFUNCTION | 6 |
| PCALL_TYPE | 7 |
| PCALL_GENERATOR | 8 |
| PCALL_OTHER | 9 |
| PCALL_POP | 10 |

`PCALL_FAST_FUNCTION` means no argument tuple needs to be created. `PCALL_FASTER_FUNCTION` means that the fast-path frame setup code is used.

If there is a method call where the call can be optimized by changing the argument tuple and calling the function directly, it gets recorded twice.

This function is only present if Python is compiled with `CALL_PROFILE` defined.

## 8.7 高级调试器支持

These functions are only intended to be used by advanced debugging tools.

*PyInterpreterState** **PyInterpreterState_Head**()
Return the interpreter state object at the head of the list of all such objects.

2.2 新版功能.

*PyInterpreterState** **PyInterpreterState_Next**(*PyInterpreterState *interp*)
Return the next interpreter state object after *interp* from the list of all such objects.

2.2 新版功能.

*PyThreadState* * **PyInterpreterState_ThreadHead**(*PyInterpreterState *interp*)
Return the pointer to the first `PyThreadState` object in the list of threads associated with the interpreter *interp*.

2.2 新版功能.

*PyThreadState** **PyThreadState_Next**(*PyThreadState *tstate*)
Return the next thread state object after *tstate* from the list of all such objects belonging to the same `PyInterpreterState` object.

2.2 新版功能.

CHAPTER 9

# 内存管理

## 9.1 概述

Memory management in Python involves a private heap containing all Python objects and data structures. The management of this private heap is ensured internally by the *Python memory manager*. The Python memory manager has different components which deal with various dynamic storage management aspects, like sharing, segmentation, preallocation or caching.

At the lowest level, a raw memory allocator ensures that there is enough room in the private heap for storing all Python-related data by interacting with the memory manager of the operating system. On top of the raw memory allocator, several object-specific allocators operate on the same heap and implement distinct memory management policies adapted to the peculiarities of every object type. For example, integer objects are managed differently within the heap than strings, tuples or dictionaries because integers imply different storage requirements and speed/space tradeoffs. The Python memory manager thus delegates some of the work to the object-specific allocators, but ensures that the latter operate within the bounds of the private heap.

It is important to understand that the management of the Python heap is performed by the interpreter itself and that the user has no control over it, even if they regularly manipulate object pointers to memory blocks inside that heap. The allocation of heap space for Python objects and other internal buffers is performed on demand by the Python memory manager through the Python/C API functions listed in this document.

To avoid memory corruption, extension writers should never try to operate on Python objects with the functions exported by the C library: `malloc()`, `calloc()`, `realloc()` and `free()`. This will result in mixed calls between the C allocator and the Python memory manager with fatal consequences, because they implement different algorithms and operate on different heaps. However, one may safely allocate and release memory blocks with the C library allocator for individual purposes, as shown in the following example:

```
PyObject *res;
char *buf = (char *) malloc(BUFSIZ); /* for I/O */

if (buf == NULL)
    return PyErr_NoMemory();
...Do some I/O operation involving buf...
res = PyString_FromString(buf);
```

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```
free(buf); /* malloc'ed */
return res;
```

In this example, the memory request for the I/O buffer is handled by the C library allocator. The Python memory manager is involved only in the allocation of the string object returned as a result.

In most situations, however, it is recommended to allocate memory from the Python heap specifically because the latter is under control of the Python memory manager. For example, this is required when the interpreter is extended with new object types written in C. Another reason for using the Python heap is the desire to *inform* the Python memory manager about the memory needs of the extension module. Even when the requested memory is used exclusively for internal, highly-specific purposes, delegating all memory requests to the Python memory manager causes the interpreter to have a more accurate image of its memory footprint as a whole. Consequently, under certain circumstances, the Python memory manager may or may not trigger appropriate actions, like garbage collection, memory compaction or other preventive procedures. Note that by using the C library allocator as shown in the previous example, the allocated memory for the I/O buffer escapes completely the Python memory manager.

## 9.2 内存接口

The following function sets, modeled after the ANSI C standard, but specifying behavior when requesting zero bytes, are available for allocating and releasing memory from the Python heap:

void* **PyMem_Malloc**(size_t *n*)
: Allocates *n* bytes and returns a pointer of type `void*` to the allocated memory, or *NULL* if the request fails. Requesting zero bytes returns a distinct non-*NULL* pointer if possible, as if `PyMem_Malloc(1)` had been called instead. The memory will not have been initialized in any way.

void* **PyMem_Realloc**(void **p*, size_t *n*)
: Resizes the memory block pointed to by *p* to *n* bytes. The contents will be unchanged to the minimum of the old and the new sizes. If *p* is *NULL*, the call is equivalent to `PyMem_Malloc(n)`; else if *n* is equal to zero, the memory block is resized but is not freed, and the returned pointer is non-*NULL*. Unless *p* is *NULL*, it must have been returned by a previous call to *PyMem_Malloc()* or *PyMem_Realloc()*. If the request fails, *PyMem_Realloc()* returns *NULL* and *p* remains a valid pointer to the previous memory area.

void **PyMem_Free**(void **p*)
: Frees the memory block pointed to by *p*, which must have been returned by a previous call to *PyMem_Malloc()* or *PyMem_Realloc()*. Otherwise, or if `PyMem_Free(p)` has been called before, undefined behavior occurs. If *p* is *NULL*, no operation is performed.

The following type-oriented macros are provided for convenience. Note that *TYPE* refers to any C type.

TYPE* **PyMem_New**(TYPE, size_t *n*)
: Same as *PyMem_Malloc()*, but allocates `(n * sizeof(TYPE))` bytes of memory. Returns a pointer cast to `TYPE*`. The memory will not have been initialized in any way.

TYPE* **PyMem_Resize**(void **p*, TYPE, size_t *n*)
: Same as *PyMem_Realloc()*, but the memory block is resized to `(n * sizeof(TYPE))` bytes. Returns a pointer cast to `TYPE*`. On return, *p* will be a pointer to the new memory area, or *NULL* in the event of failure. This is a C preprocessor macro; p is always reassigned. Save the original value of p to avoid losing memory when handling errors.

void **PyMem_Del**(void **p*)
: 与*PyMem_Free()* 相同

In addition, the following macro sets are provided for calling the Python memory allocator directly, without involving the C API functions listed above. However, note that their use does not preserve binary compatibility across Python versions and is therefore deprecated in extension modules.

PyMem_MALLOC(), PyMem_REALLOC(), PyMem_FREE().

PyMem_NEW(), PyMem_RESIZE(), PyMem_DEL().

## 9.3 对象分配器

The following function sets, modeled after the ANSI C standard, but specifying behavior when requesting zero bytes, are available for allocating and releasing memory from the Python heap.

By default, these functions use *pymalloc memory allocator*.

> **警告：** The *GIL* must be held when using these functions.

void* **PyObject_Malloc**(size_t *n*)

Allocates *n* bytes and returns a pointer of type `void*` to the allocated memory, or *NULL* if the request fails.

Requesting zero bytes returns a distinct non-*NULL* pointer if possible, as if `PyObject_Malloc(1)` had been called instead. The memory will not have been initialized in any way.

void* **PyObject_Realloc**(void **p*, size_t *n*)

Resizes the memory block pointed to by *p* to *n* bytes. The contents will be unchanged to the minimum of the old and the new sizes.

If *p* is *NULL*, the call is equivalent to `PyObject_Malloc(n)`; else if *n* is equal to zero, the memory block is resized but is not freed, and the returned pointer is non-*NULL*.

Unless *p* is *NULL*, it must have been returned by a previous call to *PyObject_Malloc()*, *PyObject_Realloc()* or `PyObject_Calloc()`.

If the request fails, *PyObject_Realloc()* returns *NULL* and *p* remains a valid pointer to the previous memory area.

void **PyObject_Free**(void **p*)

Frees the memory block pointed to by *p*, which must have been returned by a previous call to *PyObject_Malloc()*, *PyObject_Realloc()* or `PyObject_Calloc()`. Otherwise, or if `PyObject_Free(p)` has been called before, undefined behavior occurs.

If *p* is *NULL*, no operation is performed.

In addition, the following macro sets are provided:

- `PyObject_MALLOC()`: alias to *PyObject_Malloc()*
- `PyObject_REALLOC()`: alias to *PyObject_Realloc()*
- `PyObject_FREE()`: alias to *PyObject_Free()*
- *PyObject_Del()*: alias to *PyObject_Free()*
- `PyObject_DEL()`: alias to `PyObject_FREE()` (so finally an alias to *PyObject_Free()*)

## 9.4 The pymalloc allocator

Python has a *pymalloc* allocator optimized for small objects (smaller or equal to 512 bytes) with a short lifetime. It uses memory mappings called "arenas" with a fixed size of 256 KiB. It falls back to `malloc()` and `realloc()` for allocations larger than 512 bytes.

*pymalloc* is the default allocator of `PyObject_Malloc()`.

The arena allocator uses the following functions:

- `mmap()` and `munmap()` if available,
- `malloc()` and `free()` otherwise.

在 2.7.7 版更改: The threshold changed from 256 to 512 bytes. The arena allocator now uses `mmap()` if available.

## 9.5 例子

Here is the example from section 概述, rewritten so that the I/O buffer is allocated from the Python heap by using the first function set:

```
PyObject *res;
char *buf = (char *) PyMem_Malloc(BUFSIZ); /* for I/O */

if (buf == NULL)
    return PyErr_NoMemory();
/* ...Do some I/O operation involving buf... */
res = PyString_FromString(buf);
PyMem_Free(buf); /* allocated with PyMem_Malloc */
return res;
```

The same code using the type-oriented function set:

```
PyObject *res;
char *buf = PyMem_New(char, BUFSIZ); /* for I/O */

if (buf == NULL)
    return PyErr_NoMemory();
/* ...Do some I/O operation involving buf... */
res = PyString_FromString(buf);
PyMem_Del(buf); /* allocated with PyMem_New */
return res;
```

Note that in the two examples above, the buffer is always manipulated via functions belonging to the same set. Indeed, it is required to use the same memory API family for a given memory block, so that the risk of mixing different allocators is reduced to a minimum. The following code sequence contains two errors, one of which is labeled as *fatal* because it mixes two different allocators operating on different heaps.

```
char *buf1 = PyMem_New(char, BUFSIZ);
char *buf2 = (char *) malloc(BUFSIZ);
char *buf3 = (char *) PyMem_Malloc(BUFSIZ);
...
PyMem_Del(buf3);  /* Wrong -- should be PyMem_Free()  */
free(buf2);       /* Right -- allocated via malloc()  */
free(buf1);       /* Fatal -- should be PyMem_Del()   */
```

In addition to the functions aimed at handling raw memory blocks from the Python heap, objects in Python are allocated and released with `PyObject_New()`, `PyObject_NewVar()` and `PyObject_Del()`.

These will be explained in the next chapter on defining and implementing new object types in C.

CHAPTER 10

# 对象实现支持

本章描述了定义新对象类型时所使用的函数、类型和宏。

## 10.1 在堆上分配对象

*PyObject** **_PyObject_New** (*PyTypeObject *type*)
: *Return value: New reference.*

*PyVarObject** **_PyObject_NewVar** (*PyTypeObject *type*, Py_ssize_t *size*)
: *Return value: New reference.* 在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

void **_PyObject_Del** (*PyObject *op*)

*PyObject** **PyObject_Init** (*PyObject *op*, *PyTypeObject *type*)
: *Return value: Borrowed reference.* 用它的类型和初始引用来初始化新分配对象 *op*。返回已初始化对象。如果 *type* 表明该对象参与循环垃圾检测器，则将其添加到检测器的观察对象集中。对象的其他字段不受影响。

*PyVarObject** **PyObject_InitVar** (*PyVarObject *op*, *PyTypeObject *type*, Py_ssize_t *size*)
: *Return value: Borrowed reference.* 它的功能和`PyObject_Init()`一样，并且会初始化变量大小对象的长度信息。

  在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

TYPE* **PyObject_New** (TYPE, *PyTypeObject *type*)
: *Return value: New reference.* 使用 C 结构类型 *TYPE* 和 Python 类型对象 *type* 分配一个新的 Python 对象。未在该 Python 对象标头中定义的字段不会被初始化；对象的引用计数将为一。内存分配大小由 type 对象的`tp_basicsize`字段来确定。

TYPE* **PyObject_NewVar** (TYPE, *PyTypeObject *type*, Py_ssize_t *size*)
: *Return value: New reference.* 使用 C 的数据结构类型 *TYPE* 和 Python 的类型对象 *type* 分配一个新的 Python 对象。Python 对象头文件中没有定义的字段不会被初始化。被分配的内存空间预留了 *TYPE* 结构加 *type* 对象中`tp_itemsize`字段提供的 *size* 字段的值。这对于实现类似元组这种能够在构造期决定自己大

小的对象是很实用的。将字段的数组嵌入到相同的内存分配中可以减少内存分配的次数，这提高了内存分配的效率。

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

void **PyObject_Del**(*PyObject* **op*)

释放由 `PyObject_New()` 或者 `PyObject_NewVar()` 分配内存的对象。这通常由对象的 type 字段定义的 `tp_dealloc` 处理函数来调用。调用这个函数以后 op 对象中的字段都不可以被访问，因为原分配的内存空间已不再是一个有效的 Python 对象。

*PyObject** **Py_InitModule**(char **name*, *PyMethodDef* **methods*)

*Return value: Borrowed reference.* Create a new module object based on a name and table of functions, returning the new module object.

在 2.3 版更改: Older versions of Python did not support *NULL* as the value for the *methods* argument.

*PyObject** **Py_InitModule3**(char **name*, *PyMethodDef* **methods*, char **doc*)

*Return value: Borrowed reference.* Create a new module object based on a name and table of functions, returning the new module object. If *doc* is non-*NULL*, it will be used to define the docstring for the module.

在 2.3 版更改: Older versions of Python did not support *NULL* as the value for the *methods* argument.

*PyObject** **Py_InitModule4**(char **name*, *PyMethodDef* **methods*, char **doc*, *PyObject* **self*, int *apiver*)

*Return value: Borrowed reference.* Create a new module object based on a name and table of functions, returning the new module object. If *doc* is non-*NULL*, it will be used to define the docstring for the module. If *self* is non-*NULL*, it will be passed to the functions of the module as their (otherwise *NULL*) first parameter. (This was added as an experimental feature, and there are no known uses in the current version of Python.) For *apiver*, the only value which should be passed is defined by the constant `PYTHON_API_VERSION`.

**注解:** Most uses of this function should probably be using the `Py_InitModule3()` instead; only use this if you are sure you need it.

在 2.3 版更改: Older versions of Python did not support *NULL* as the value for the *methods* argument.

*PyObject* **_Py_NoneStruct**

Object which is visible in Python as `None`. This should only be accessed using the `Py_None` macro, which evaluates to a pointer to this object.

## 10.2 Common Object Structures

There are a large number of structures which are used in the definition of object types for Python. This section describes these structures and how they are used.

All Python objects ultimately share a small number of fields at the beginning of the object's representation in memory. These are represented by the `PyObject` and `PyVarObject` types, which are defined, in turn, by the expansions of some macros also used, whether directly or indirectly, in the definition of all other Python objects.

**PyObject**

All object types are extensions of this type. This is a type which contains the information Python needs to treat a pointer to an object as an object. In a normal "release" build, it contains only the object's reference count and a pointer to the corresponding type object. It corresponds to the fields defined by the expansion of the `PyObject_HEAD` macro.

**PyVarObject**

This is an extension of `PyObject` that adds the `ob_size` field. This is only used for objects that have some notion of *length*. This type does not often appear in the Python/C API. It corresponds to the fields defined by the expansion of the `PyObject_VAR_HEAD` macro.

These macros are used in the definition of *PyObject* and *PyVarObject*:

**PyObject_HEAD**
This is a macro which expands to the declarations of the fields of the *PyObject* type; it is used when declaring new types which represent objects without a varying length. The specific fields it expands to depend on the definition of `Py_TRACE_REFS`. By default, that macro is not defined, and *PyObject_HEAD* expands to:

```
Py_ssize_t ob_refcnt;
PyTypeObject *ob_type;
```

When `Py_TRACE_REFS` is defined, it expands to:

```
PyObject *_ob_next, *_ob_prev;
Py_ssize_t ob_refcnt;
PyTypeObject *ob_type;
```

**PyObject_VAR_HEAD**
This is a macro which expands to the declarations of the fields of the *PyVarObject* type; it is used when declaring new types which represent objects with a length that varies from instance to instance. This macro always expands to:

```
PyObject_HEAD
Py_ssize_t ob_size;
```

Note that *PyObject_HEAD* is part of the expansion, and that its own expansion varies depending on the definition of `Py_TRACE_REFS`.

**Py_TYPE**(o)
This macro is used to access the `ob_type` member of a Python object. It expands to:

```
(((PyObject*)(o))->ob_type)
```

2.6 新版功能.

**Py_REFCNT**(o)
This macro is used to access the `ob_refcnt` member of a Python object. It expands to:

```
(((PyObject*)(o))->ob_refcnt)
```

2.6 新版功能.

**Py_SIZE**(o)
This macro is used to access the `ob_size` member of a Python object. It expands to:

```
(((PyVarObject*)(o))->ob_size)
```

2.6 新版功能.

**PyObject_HEAD_INIT**(type)
This is a macro which expands to initialization values for a new *PyObject* type. This macro expands to:

```
_PyObject_EXTRA_INIT
1, type,
```

**PyVarObject_HEAD_INIT**(type, size)
This is a macro which expands to initialization values for a new *PyVarObject* type, including the `ob_size` field. This macro expands to:

```
_PyObject_EXTRA_INIT
1, type, size,
```

**PyCFunction**

Type of the functions used to implement most Python callables in C. Functions of this type take two *PyObject** parameters and return one such value. If the return value is *NULL*, an exception shall have been set. If not *NULL*, the return value is interpreted as the return value of the function as exposed in Python. The function must return a new reference.

**PyMethodDef**

Structure used to describe a method of an extension type. This structure has four fields:

| 域 | C 类型 | 含义 |
|---|---|---|
| `ml_name` | char * | name of the method |
| `ml_meth` | PyCFunction | pointer to the C implementation |
| `ml_flags` | 整型 | flag bits indicating how the call should be constructed |
| `ml_doc` | char * | points to the contents of the docstring |

The `ml_meth` is a C function pointer. The functions may be of different types, but they always return *PyObject**. If the function is not of the *PyCFunction*, the compiler will require a cast in the method table. Even though *PyCFunction* defines the first parameter as *PyObject**, it is common that the method implementation uses the specific C type of the *self* object.

The `ml_flags` field is a bitfield which can include the following flags. The individual flags indicate either a calling convention or a binding convention. Of the calling convention flags, only *METH_VARARGS* and *METH_KEYWORDS* can be combined. Any of the calling convention flags can be combined with a binding flag.

**METH_VARARGS**

This is the typical calling convention, where the methods have the type *PyCFunction*. The function expects two *PyObject** values. The first one is the *self* object for methods; for module functions, it is the module object. The second parameter (often called *args*) is a tuple object representing all arguments. This parameter is typically processed using *PyArg_ParseTuple()* or *PyArg_UnpackTuple()*.

**METH_KEYWORDS**

Methods with these flags must be of type `PyCFunctionWithKeywords`. The function expects three parameters: *self*, *args*, and a dictionary of all the keyword arguments. The flag is typically combined with *METH_VARARGS*, and the parameters are typically processed using *PyArg_ParseTupleAndKeywords()*.

**METH_NOARGS**

Methods without parameters don't need to check whether arguments are given if they are listed with the *METH_NOARGS* flag. They need to be of type *PyCFunction*. The first parameter is typically named `self` and will hold a reference to the module or object instance. In all cases the second parameter will be *NULL*.

**METH_O**

Methods with a single object argument can be listed with the *METH_O* flag, instead of invoking *PyArg_ParseTuple()* with a `"O"` argument. They have the type *PyCFunction*, with the *self* parameter, and a *PyObject** parameter representing the single argument.

**METH_OLDARGS**

This calling convention is deprecated. The method must be of type *PyCFunction*. The second argument is *NULL* if no arguments are given, a single object if exactly one argument is given, and a tuple of objects if more than one argument is given. There is no way for a function using this convention to distinguish between a call with multiple arguments and a call with a tuple as the only argument.

These two constants are not used to indicate the calling convention but the binding when use with methods of classes. These may not be used for functions defined for modules. At most one of these flags may be set for any given method.

**METH_CLASS**
The method will be passed the type object as the first parameter rather than an instance of the type. This is used to create *class methods*, similar to what is created when using the `classmethod()` built-in function.

2.3 新版功能.

**METH_STATIC**
The method will be passed *NULL* as the first parameter rather than an instance of the type. This is used to create *static methods*, similar to what is created when using the `staticmethod()` built-in function.

2.3 新版功能.

One other constant controls whether a method is loaded in place of another definition with the same method name.

**METH_COEXIST**
The method will be loaded in place of existing definitions. Without *METH_COEXIST*, the default is to skip repeated definitions. Since slot wrappers are loaded before the method table, the existence of a *sq_contains* slot, for example, would generate a wrapped method named `__contains__()` and preclude the loading of a corresponding PyCFunction with the same name. With the flag defined, the PyCFunction will be loaded in place of the wrapper object and will co-exist with the slot. This is helpful because calls to PyCFunctions are optimized more than wrapper object calls.

2.4 新版功能.

**PyMemberDef**
Structure which describes an attribute of a type which corresponds to a C struct member. Its fields are:

| 域 | C 类型 | 含义 |
|---|---|---|
| `name` | char * | name of the member |
| `type` | 整型 | the type of the member in the C struct |
| `offset` | Py_ssize_t | the offset in bytes that the member is located on the type’s object struct |
| `flags` | 整型 | flag bits indicating if the field should be read-only or writable |
| `doc` | char * | points to the contents of the docstring |

`type` can be one of many `T_` macros corresponding to various C types. When the member is accessed in Python, it will be converted to the equivalent Python type.

| Macro name | C 类型 |
|---|---|
| T_SHORT | short |
| T_INT | 整型 |
| T_LONG | 长整型 |
| T_FLOAT | 浮点数 |
| T_DOUBLE | double |
| T_STRING | char * |
| T_OBJECT | PyObject * |
| T_OBJECT_EX | PyObject * |
| T_CHAR | char |
| T_BYTE | char |
| T_UBYTE | unsigned char |
| T_UINT | 无符号整型 |
| T_USHORT | unsigned short |
| T_ULONG | 无符号长整型 |
| T_BOOL | char |
| T_LONGLONG | long long |
| T_ULONGLONG | 无符号 long long |
| T_PYSSIZET | Py_ssize_t |

T_OBJECT and T_OBJECT_EX differ in that T_OBJECT returns None if the member is *NULL* and T_OBJECT_EX raises an AttributeError. Try to use T_OBJECT_EX over T_OBJECT because T_OBJECT_EX handles use of the del statement on that attribute more correctly than T_OBJECT.

flags can be 0 for write and read access or READONLY for read-only access. Using T_STRING for type implies READONLY. Only T_OBJECT and T_OBJECT_EX members can be deleted. (They are set to *NULL*).

**PyGetSetDef**

Structure to define property-like access for a type. See also description of the *PyTypeObject.tp_getset* slot.

| 域 | C 类型 | 含义 |
|---|---|---|
| 名称 | char * | attribute name |
| get | getter | C Function to get the attribute |
| set | setter | optional C function to set or delete the attribute, if omitted the attribute is readonly |
| doc | char * | optional docstring |
| closure | void * | optional function pointer, providing additional data for getter and setter |

The get function takes one *PyObject** parameter (the instance) and a function pointer (the associated closure):

```
typedef PyObject *(*getter)(PyObject *, void *);
```

It should return a new reference on success or *NULL* with a set exception on failure.

set functions take two *PyObject** parameters (the instance and the value to be set) and a function pointer (the associated closure):

```
typedef int (*setter)(PyObject *, PyObject *, void *);
```

In case the attribute should be deleted the second parameter is *NULL*. Should return 0 on success or -1 with a set exception on failure.

*PyObject** **Py_FindMethod**(*PyMethodDef table[]*, *PyObject *ob*, char **name*)

*Return value: New reference.* Return a bound method object for an extension type implemented in C. This can be useful in the implementation of a *tp_getattro* or *tp_getattr* handler that does not use the *PyObject_GenericGetAttr()* function.

## 10.3 类型对象

Perhaps one of the most important structures of the Python object system is the structure that defines a new type: the *PyTypeObject* structure. Type objects can be handled using any of the PyObject_*() or PyType_*() functions, but do not offer much that's interesting to most Python applications. These objects are fundamental to how objects behave, so they are very important to the interpreter itself and to any extension module that implements new types.

Type objects are fairly large compared to most of the standard types. The reason for the size is that each type object stores a large number of values, mostly C function pointers, each of which implements a small part of the type's functionality. The fields of the type object are examined in detail in this section. The fields will be described in the order in which they occur in the structure.

Typedefs: unaryfunc, binaryfunc, ternaryfunc, inquiry, coercion, intargfunc, intintargfunc, intobjargproc, intintobjargproc, objobjargproc, destructor, freefunc, printfunc, getattrfunc, getattrofunc, setattrfunc, setattrofunc, cmpfunc, reprfunc, hashfunc

The structure definition for *PyTypeObject* can be found in Include/object.h. For convenience of reference, this repeats the definition found there:

```c
typedef struct _typeobject {
    PyObject_VAR_HEAD
    char *tp_name; /* For printing, in format "<module>.<name>" */
    int tp_basicsize, tp_itemsize; /* For allocation */

    /* Methods to implement standard operations */

    destructor tp_dealloc;
    printfunc tp_print;
    getattrfunc tp_getattr;
    setattrfunc tp_setattr;
    cmpfunc tp_compare;
    reprfunc tp_repr;

    /* Method suites for standard classes */

    PyNumberMethods *tp_as_number;
    PySequenceMethods *tp_as_sequence;
    PyMappingMethods *tp_as_mapping;

    /* More standard operations (here for binary compatibility) */

    hashfunc tp_hash;
    ternaryfunc tp_call;
    reprfunc tp_str;
    getattrofunc tp_getattro;
    setattrofunc tp_setattro;

    /* Functions to access object as input/output buffer */
    PyBufferProcs *tp_as_buffer;

    /* Flags to define presence of optional/expanded features */
    long tp_flags;

    char *tp_doc; /* Documentation string */

    /* Assigned meaning in release 2.0 */
    /* call function for all accessible objects */
    traverseproc tp_traverse;

    /* delete references to contained objects */
    inquiry tp_clear;

    /* Assigned meaning in release 2.1 */
    /* rich comparisons */
    richcmpfunc tp_richcompare;

    /* weak reference enabler */
    long tp_weaklistoffset;

    /* Added in release 2.2 */
    /* Iterators */
    getiterfunc tp_iter;
    iternextfunc tp_iternext;

    /* Attribute descriptor and subclassing stuff */
    struct PyMethodDef *tp_methods;
```

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```
    struct PyMemberDef *tp_members;
    struct PyGetSetDef *tp_getset;
    struct _typeobject *tp_base;
    PyObject *tp_dict;
    descrgetfunc tp_descr_get;
    descrsetfunc tp_descr_set;
    long tp_dictoffset;
    initproc tp_init;
    allocfunc tp_alloc;
    newfunc tp_new;
    freefunc tp_free; /* Low-level free-memory routine */
    inquiry tp_is_gc; /* For PyObject_IS_GC */
    PyObject *tp_bases;
    PyObject *tp_mro; /* method resolution order */
    PyObject *tp_cache;
    PyObject *tp_subclasses;
    PyObject *tp_weaklist;

} PyTypeObject;
```

The type object structure extends the `PyVarObject` structure. The `ob_size` field is used for dynamic types (created by `type_new()`, usually called from a class statement). Note that `PyType_Type` (the metatype) initializes `tp_itemsize`, which means that its instances (i.e. type objects) *must* have the `ob_size` field.

*PyObject** **PyObject._ob_next**
*PyObject** **PyObject._ob_prev**

These fields are only present when the macro `Py_TRACE_REFS` is defined. Their initialization to *NULL* is taken care of by the `PyObject_HEAD_INIT` macro. For statically allocated objects, these fields always remain *NULL*. For dynamically allocated objects, these two fields are used to link the object into a doubly-linked list of *all* live objects on the heap. This could be used for various debugging purposes; currently the only use is to print the objects that are still alive at the end of a run when the environment variable `PYTHONDUMPREFS` is set.

These fields are not inherited by subtypes.

Py_ssize_t **PyObject.ob_refcnt**

This is the type object's reference count, initialized to `1` by the `PyObject_HEAD_INIT` macro. Note that for statically allocated type objects, the type's instances (objects whose `ob_type` points back to the type) do *not* count as references. But for dynamically allocated type objects, the instances *do* count as references.

This field is not inherited by subtypes.

在 2.5 版更改: This field used to be an `int` type. This might require changes in your code for properly supporting 64-bit systems.

*PyTypeObject** **PyObject.ob_type**

This is the type's type, in other words its metatype. It is initialized by the argument to the `PyObject_HEAD_INIT` macro, and its value should normally be `&PyType_Type`. However, for dynamically loadable extension modules that must be usable on Windows (at least), the compiler complains that this is not a valid initializer. Therefore, the convention is to pass *NULL* to the `PyObject_HEAD_INIT` macro and to initialize this field explicitly at the start of the module's initialization function, before doing anything else. This is typically done like this:

```
Foo_Type.ob_type = &PyType_Type;
```

This should be done before any instances of the type are created. `PyType_Ready()` checks if `ob_type` is *NULL*, and if so, initializes it: in Python 2.2, it is set to `&PyType_Type`; in Python 2.2.1 and later it is initialized to the `ob_type` field of the base class. `PyType_Ready()` will not change this field if it is non-zero.

In Python 2.2, this field is not inherited by subtypes. In 2.2.1, and in 2.3 and beyond, it is inherited by subtypes.

Py_ssize_t **PyVarObject.ob_size**

For statically allocated type objects, this should be initialized to zero. For dynamically allocated type objects, this field has a special internal meaning.

This field is not inherited by subtypes.

char* **PyTypeObject.tp_name**

Pointer to a NUL-terminated string containing the name of the type. For types that are accessible as module globals, the string should be the full module name, followed by a dot, followed by the type name; for built-in types, it should be just the type name. If the module is a submodule of a package, the full package name is part of the full module name. For example, a type named `T` defined in module `M` in subpackage `Q` in package `P` should have the *tp_name* initializer `"P.Q.M.T"`.

For dynamically allocated type objects, this should just be the type name, and the module name explicitly stored in the type dict as the value for key `'__module__'`.

For statically allocated type objects, the tp_name field should contain a dot. Everything before the last dot is made accessible as the `__module__` attribute, and everything after the last dot is made accessible as the `__name__` attribute.

If no dot is present, the entire *tp_name* field is made accessible as the `__name__` attribute, and the `__module__` attribute is undefined (unless explicitly set in the dictionary, as explained above). This means your type will be impossible to pickle. Additionally, it will not be listed in module documentations created with pydoc.

This field is not inherited by subtypes.

Py_ssize_t **PyTypeObject.tp_basicsize**
Py_ssize_t **PyTypeObject.tp_itemsize**

These fields allow calculating the size in bytes of instances of the type.

There are two kinds of types: types with fixed-length instances have a zero *tp_itemsize* field, types with variable-length instances have a non-zero *tp_itemsize* field. For a type with fixed-length instances, all instances have the same size, given in *tp_basicsize*.

For a type with variable-length instances, the instances must have an `ob_size` field, and the instance size is *tp_basicsize* plus N times *tp_itemsize*, where N is the "length" of the object. The value of N is typically stored in the instance's `ob_size` field. There are exceptions: for example, long ints use a negative `ob_size` to indicate a negative number, and N is `abs(ob_size)` there. Also, the presence of an `ob_size` field in the instance layout doesn't mean that the instance structure is variable-length (for example, the structure for the list type has fixed-length instances, yet those instances have a meaningful `ob_size` field).

The basic size includes the fields in the instance declared by the macro *PyObject_HEAD* or *PyObject_VAR_HEAD* (whichever is used to declare the instance struct) and this in turn includes the `_ob_prev` and `_ob_next` fields if they are present. This means that the only correct way to get an initializer for the *tp_basicsize* is to use the `sizeof` operator on the struct used to declare the instance layout. The basic size does not include the GC header size (this is new in Python 2.2; in 2.1 and 2.0, the GC header size was included in *tp_basicsize*).

These fields are inherited separately by subtypes. If the base type has a non-zero *tp_itemsize*, it is generally not safe to set *tp_itemsize* to a different non-zero value in a subtype (though this depends on the implementation of the base type).

A note about alignment: if the variable items require a particular alignment, this should be taken care of by the value of *tp_basicsize*. Example: suppose a type implements an array of `double`. *tp_itemsize* is `sizeof(double)`. It is the programmer's responsibility that *tp_basicsize* is a multiple of `sizeof(double)` (assuming this is the alignment requirement for `double`).

destructor **PyTypeObject.tp_dealloc**

A pointer to the instance destructor function. This function must be defined unless the type guarantees that its instances will never be deallocated (as is the case for the singletons `None` and `Ellipsis`).

The destructor function is called by the `Py_DECREF()` and `Py_XDECREF()` macros when the new reference count is zero. At this point, the instance is still in existence, but there are no references to it. The destructor function should free all references which the instance owns, free all memory buffers owned by the instance (using the freeing function corresponding to the allocation function used to allocate the buffer), and finally (as its last action) call the type's `tp_free` function. If the type is not subtypable (doesn't have the `Py_TPFLAGS_BASETYPE` flag bit set), it is permissible to call the object deallocator directly instead of via `tp_free`. The object deallocator should be the one used to allocate the instance; this is normally `PyObject_Del()` if the instance was allocated using `PyObject_New()` or `PyObject_VarNew()`, or `PyObject_GC_Del()` if the instance was allocated using `PyObject_GC_New()` or `PyObject_GC_NewVar()`.

This field is inherited by subtypes.

printfunc **PyTypeObject.tp_print**

An optional pointer to the instance print function.

The print function is only called when the instance is printed to a *real* file; when it is printed to a pseudo-file (like a `StringIO` instance), the instance's `tp_repr` or `tp_str` function is called to convert it to a string. These are also called when the type's `tp_print` field is *NULL*. A type should never implement `tp_print` in a way that produces different output than `tp_repr` or `tp_str` would.

The print function is called with the same signature as `PyObject_Print()`: `int tp_print(PyObject *self, FILE *file, int flags)`. The *self* argument is the instance to be printed. The *file* argument is the stdio file to which it is to be printed. The *flags* argument is composed of flag bits. The only flag bit currently defined is `Py_PRINT_RAW`. When the `Py_PRINT_RAW` flag bit is set, the instance should be printed the same way as `tp_str` would format it; when the `Py_PRINT_RAW` flag bit is clear, the instance should be printed the same was as `tp_repr` would format it. It should return `-1` and set an exception condition when an error occurred during the comparison.

It is possible that the `tp_print` field will be deprecated. In any case, it is recommended not to define `tp_print`, but instead to rely on `tp_repr` and `tp_str` for printing.

This field is inherited by subtypes.

getattrfunc **PyTypeObject.tp_getattr**

An optional pointer to the get-attribute-string function.

This field is deprecated. When it is defined, it should point to a function that acts the same as the `tp_getattro` function, but taking a C string instead of a Python string object to give the attribute name. The signature is

```
PyObject * tp_getattr(PyObject *o, char *attr_name);
```

This field is inherited by subtypes together with `tp_getattro`: a subtype inherits both `tp_getattr` and `tp_getattro` from its base type when the subtype's `tp_getattr` and `tp_getattro` are both *NULL*.

setattrfunc **PyTypeObject.tp_setattr**

An optional pointer to the function for setting and deleting attributes.

This field is deprecated. When it is defined, it should point to a function that acts the same as the `tp_setattro` function, but taking a C string instead of a Python string object to give the attribute name. The signature is

```
PyObject * tp_setattr(PyObject *o, char *attr_name, PyObject *v);
```

The *v* argument is set to *NULL* to delete the attribute. This field is inherited by subtypes together with `tp_setattro`: a subtype inherits both `tp_setattr` and `tp_setattro` from its base type when the subtype's `tp_setattr` and `tp_setattro` are both *NULL*.

cmpfunc **PyTypeObject.tp_compare**

An optional pointer to the three-way comparison function.

The signature is the same as for *PyObject_Compare()*. The function should return `1` if *self* greater than *other*, `0` if *self* is equal to *other*, and `-1` if *self* less than *other*. It should return `-1` and set an exception condition when an error occurred during the comparison.

This field is inherited by subtypes together with *tp_richcompare* and *tp_hash*: a subtypes inherits all three of *tp_compare*, *tp_richcompare*, and *tp_hash* when the subtype's *tp_compare*, *tp_richcompare*, and *tp_hash* are all *NULL*.

reprfunc **PyTypeObject.tp_repr**

An optional pointer to a function that implements the built-in function `repr()`.

The signature is the same as for *PyObject_Repr()*; it must return a string or a Unicode object. Ideally, this function should return a string that, when passed to `eval()`, given a suitable environment, returns an object with the same value. If this is not feasible, it should return a string starting with `'<'` and ending with `'>'` from which both the type and the value of the object can be deduced.

When this field is not set, a string of the form `<%s object at %p>` is returned, where `%s` is replaced by the type name, and `%p` by the object's memory address.

This field is inherited by subtypes.

*PyNumberMethods** **tp_as_number**

Pointer to an additional structure that contains fields relevant only to objects which implement the number protocol. These fields are documented in *Number Object Structures*.

The `tp_as_number` field is not inherited, but the contained fields are inherited individually.

*PySequenceMethods** **tp_as_sequence**

Pointer to an additional structure that contains fields relevant only to objects which implement the sequence protocol. These fields are documented in *Sequence Object Structures*.

The `tp_as_sequence` field is not inherited, but the contained fields are inherited individually.

*PyMappingMethods** **tp_as_mapping**

Pointer to an additional structure that contains fields relevant only to objects which implement the mapping protocol. These fields are documented in *Mapping Object Structures*.

The `tp_as_mapping` field is not inherited, but the contained fields are inherited individually.

hashfunc **PyTypeObject.tp_hash**

An optional pointer to a function that implements the built-in function `hash()`.

The signature is the same as for *PyObject_Hash()*; it must return a C long. The value `-1` should not be returned as a normal return value; when an error occurs during the computation of the hash value, the function should set an exception and return `-1`.

This field can be set explicitly to *PyObject_HashNotImplemented()* to block inheritance of the hash method from a parent type. This is interpreted as the equivalent of `__hash__ = None` at the Python level, causing `isinstance(o, collections.Hashable)` to correctly return `False`. Note that the converse is also true - setting `__hash__ = None` on a class at the Python level will result in the `tp_hash` slot being set to *PyObject_HashNotImplemented()*.

When this field is not set, two possibilities exist: if the *tp_compare* and *tp_richcompare* fields are both *NULL*, a default hash value based on the object's address is returned; otherwise, a `TypeError` is raised.

This field is inherited by subtypes together with *tp_richcompare* and *tp_compare*: a subtypes inherits all three of *tp_compare*, *tp_richcompare*, and *tp_hash*, when the subtype's *tp_compare*, *tp_richcompare* and *tp_hash* are all *NULL*.

ternaryfunc **PyTypeObject.tp_call**

An optional pointer to a function that implements calling the object. This should be *NULL* if the object is not callable. The signature is the same as for *PyObject_Call()*.

This field is inherited by subtypes.

reprfunc **PyTypeObject.tp_str**

An optional pointer to a function that implements the built-in operation `str()`. (Note that `str` is a type now, and `str()` calls the constructor for that type. This constructor calls *PyObject_Str()* to do the actual work, and *PyObject_Str()* will call this handler.)

The signature is the same as for *PyObject_Str()*; it must return a string or a Unicode object. This function should return a "friendly" string representation of the object, as this is the representation that will be used by the print statement.

When this field is not set, *PyObject_Repr()* is called to return a string representation.

This field is inherited by subtypes.

getattrofunc **PyTypeObject.tp_getattro**

An optional pointer to the get-attribute function.

The signature is the same as for *PyObject_GetAttr()*. It is usually convenient to set this field to *PyObject_GenericGetAttr()*, which implements the normal way of looking for object attributes.

This field is inherited by subtypes together with *tp_getattr*: a subtype inherits both *tp_getattr* and *tp_getattro* from its base type when the subtype's *tp_getattr* and *tp_getattro* are both *NULL*.

setattrofunc **PyTypeObject.tp_setattro**

An optional pointer to the function for setting and deleting attributes.

The signature is the same as for *PyObject_SetAttr()*, but setting *v* to *NULL* to delete an attribute must be supported. It is usually convenient to set this field to *PyObject_GenericSetAttr()*, which implements the normal way of setting object attributes.

This field is inherited by subtypes together with *tp_setattr*: a subtype inherits both *tp_setattr* and *tp_setattro* from its base type when the subtype's *tp_setattr* and *tp_setattro* are both *NULL*.

*PyBufferProcs** **PyTypeObject.tp_as_buffer**

Pointer to an additional structure that contains fields relevant only to objects which implement the buffer interface. These fields are documented in *Buffer Object Structures*.

The *tp_as_buffer* field is not inherited, but the contained fields are inherited individually.

long **PyTypeObject.tp_flags**

This field is a bit mask of various flags. Some flags indicate variant semantics for certain situations; others are used to indicate that certain fields in the type object (or in the extension structures referenced via `tp_as_number`, `tp_as_sequence`, `tp_as_mapping`, and *tp_as_buffer*) that were historically not always present are valid; if such a flag bit is clear, the type fields it guards must not be accessed and must be considered to have a zero or *NULL* value instead.

Inheritance of this field is complicated. Most flag bits are inherited individually, i.e. if the base type has a flag bit set, the subtype inherits this flag bit. The flag bits that pertain to extension structures are strictly inherited if the extension structure is inherited, i.e. the base type's value of the flag bit is copied into the subtype together with a pointer to the extension structure. The *Py_TPFLAGS_HAVE_GC* flag bit is inherited together with the *tp_traverse* and *tp_clear* fields, i.e. if the *Py_TPFLAGS_HAVE_GC* flag bit is clear in the subtype and the *tp_traverse* and *tp_clear* fields in the subtype exist (as indicated by the *Py_TPFLAGS_HAVE_RICHCOMPARE* flag bit) and have *NULL* values.

The following bit masks are currently defined; these can be ORed together using the `|` operator to form the value of the *tp_flags* field. The macro *PyType_HasFeature()* takes a type and a flags value, *tp* and *f*, and checks whether `tp->tp_flags & f` is non-zero.

**Py_TPFLAGS_HAVE_GETCHARBUFFER**
If this bit is set, the *PyBufferProcs* struct referenced by *tp_as_buffer* has the `bf_getcharbuffer` field.

**Py_TPFLAGS_HAVE_SEQUENCE_IN**
If this bit is set, the *PySequenceMethods* struct referenced by `tp_as_sequence` has the `sq_contains` field.

**Py_TPFLAGS_GC**
This bit is obsolete. The bit it used to name is no longer in use. The symbol is now defined as zero.

**Py_TPFLAGS_HAVE_INPLACEOPS**
If this bit is set, the *PySequenceMethods* struct referenced by `tp_as_sequence` and the *PyNumberMethods* structure referenced by `tp_as_number` contain the fields for in-place operators. In particular, this means that the *PyNumberMethods* structure has the fields `nb_inplace_add`, `nb_inplace_subtract`, `nb_inplace_multiply`, `nb_inplace_divide`, `nb_inplace_remainder`, `nb_inplace_power`, `nb_inplace_lshift`, `nb_inplace_rshift`, `nb_inplace_and`, `nb_inplace_xor`, and `nb_inplace_or`; and the *PySequenceMethods* struct has the fields `sq_inplace_concat` and `sq_inplace_repeat`.

**Py_TPFLAGS_CHECKTYPES**
If this bit is set, the binary and ternary operations in the *PyNumberMethods* structure referenced by `tp_as_number` accept arguments of arbitrary object types, and do their own type conversions if needed. If this bit is clear, those operations require that all arguments have the current type as their type, and the caller is supposed to perform a coercion operation first. This applies to `nb_add`, `nb_subtract`, `nb_multiply`, `nb_divide`, `nb_remainder`, `nb_divmod`, `nb_power`, `nb_lshift`, `nb_rshift`, `nb_and`, `nb_xor`, and `nb_or`.

**Py_TPFLAGS_HAVE_RICHCOMPARE**
If this bit is set, the type object has the *tp_richcompare* field, as well as the *tp_traverse* and the *tp_clear* fields.

**Py_TPFLAGS_HAVE_WEAKREFS**
If this bit is set, the *tp_weaklistoffset* field is defined. Instances of a type are weakly referenceable if the type’s *tp_weaklistoffset* field has a value greater than zero.

**Py_TPFLAGS_HAVE_ITER**
If this bit is set, the type object has the *tp_iter* and *tp_iternext* fields.

**Py_TPFLAGS_HAVE_CLASS**
If this bit is set, the type object has several new fields defined starting in Python 2.2: *tp_methods*, *tp_members*, *tp_getset*, *tp_base*, *tp_dict*, *tp_descr_get*, *tp_descr_set*, *tp_dictoffset*, *tp_init*, *tp_alloc*, *tp_new*, *tp_free*, *tp_is_gc*, *tp_bases*, *tp_mro*, *tp_cache*, *tp_subclasses*, and *tp_weaklist*.

**Py_TPFLAGS_HEAPTYPE**
This bit is set when the type object itself is allocated on the heap. In this case, the `ob_type` field of its instances is considered a reference to the type, and the type object is INCREF’ed when a new instance is created, and DECREF’ed when an instance is destroyed (this does not apply to instances of subtypes; only the type referenced by the instance’s ob_type gets INCREF’ed or DECREF’ed).

**Py_TPFLAGS_BASETYPE**
This bit is set when the type can be used as the base type of another type. If this bit is clear, the type cannot be subtyped (similar to a “final” class in Java).

**Py_TPFLAGS_READY**
This bit is set when the type object has been fully initialized by *PyType_Ready()*.

**Py_TPFLAGS_READYING**
This bit is set while *PyType_Ready()* is in the process of initializing the type object.

**Py_TPFLAGS_HAVE_GC**
This bit is set when the object supports garbage collection. If this bit is set, instances must be created using *PyObject_GC_New()* and destroyed using *PyObject_GC_Del()*. More information in section 使对象类型支持循环垃圾回收. This bit also implies that the GC-related fields *tp_traverse* and *tp_clear* are present in the type object; but those fields also exist when *Py_TPFLAGS_HAVE_GC* is clear but *Py_TPFLAGS_HAVE_RICHCOMPARE* is set.

**Py_TPFLAGS_DEFAULT**
This is a bitmask of all the bits that pertain to the existence of certain fields in the type object and its extension structures. Currently, it includes the following bits: *Py_TPFLAGS_HAVE_GETCHARBUFFER*, *Py_TPFLAGS_HAVE_SEQUENCE_IN*, *Py_TPFLAGS_HAVE_INPLACEOPS*, *Py_TPFLAGS_HAVE_RICHCOMPARE*, *Py_TPFLAGS_HAVE_WEAKREFS*, *Py_TPFLAGS_HAVE_ITER*, and *Py_TPFLAGS_HAVE_CLASS*.

char* **PyTypeObject.tp_doc**
An optional pointer to a NUL-terminated C string giving the docstring for this type object. This is exposed as the `__doc__` attribute on the type and instances of the type.

This field is *not* inherited by subtypes.

The following three fields only exist if the *Py_TPFLAGS_HAVE_RICHCOMPARE* flag bit is set.

*traverseproc* **PyTypeObject.tp_traverse**
An optional pointer to a traversal function for the garbage collector. This is only used if the *Py_TPFLAGS_HAVE_GC* flag bit is set. More information about Python's garbage collection scheme can be found in section 使对象类型支持循环垃圾回收.

The *tp_traverse* pointer is used by the garbage collector to detect reference cycles. A typical implementation of a *tp_traverse* function simply calls *Py_VISIT()* on each of the instance's members that are Python objects. For example, this is function `local_traverse()` from the `thread` extension module:

```
static int
local_traverse(localobject *self, visitproc visit, void *arg)
{
    Py_VISIT(self->args);
    Py_VISIT(self->kw);
    Py_VISIT(self->dict);
    return 0;
}
```

Note that *Py_VISIT()* is called only on those members that can participate in reference cycles. Although there is also a `self->key` member, it can only be *NULL* or a Python string and therefore cannot be part of a reference cycle.

On the other hand, even if you know a member can never be part of a cycle, as a debugging aid you may want to visit it anyway just so the `gc` module's `get_referents()` function will include it.

Note that *Py_VISIT()* requires the *visit* and *arg* parameters to `local_traverse()` to have these specific names; don't name them just anything.

This field is inherited by subtypes together with *tp_clear* and the *Py_TPFLAGS_HAVE_GC* flag bit: the flag bit, *tp_traverse*, and *tp_clear* are all inherited from the base type if they are all zero in the subtype *and* the subtype has the *Py_TPFLAGS_HAVE_RICHCOMPARE* flag bit set.

*inquiry* **PyTypeObject.tp_clear**
An optional pointer to a clear function for the garbage collector. This is only used if the *Py_TPFLAGS_HAVE_GC* flag bit is set.

The *tp_clear* member function is used to break reference cycles in cyclic garbage detected by the garbage collector. Taken together, all *tp_clear* functions in the system must combine to break all reference cycles. This is subtle, and if in any doubt supply a *tp_clear* function. For example, the tuple type does not implement a *tp_clear* function, because it's possible to prove that no reference cycle can be composed entirely of tuples. Therefore the *tp_clear* functions of other types must be sufficient to break any cycle containing a tuple. This isn't immediately obvious, and there's rarely a good reason to avoid implementing *tp_clear*.

Implementations of *tp_clear* should drop the instance's references to those of its members that may be Python objects, and set its pointers to those members to *NULL*, as in the following example:

```
static int
local_clear(localobject *self)
{
    Py_CLEAR(self->key);
    Py_CLEAR(self->args);
    Py_CLEAR(self->kw);
    Py_CLEAR(self->dict);
    return 0;
}
```

The *Py_CLEAR()* macro should be used, because clearing references is delicate: the reference to the contained object must not be decremented until after the pointer to the contained object is set to *NULL*. This is because decrementing the reference count may cause the contained object to become trash, triggering a chain of reclamation activity that may include invoking arbitrary Python code (due to finalizers, or weakref callbacks, associated with the contained object). If it's possible for such code to reference *self* again, it's important that the pointer to the contained object be *NULL* at that time, so that *self* knows the contained object can no longer be used. The *Py_CLEAR()* macro performs the operations in a safe order.

Because the goal of *tp_clear* functions is to break reference cycles, it's not necessary to clear contained objects like Python strings or Python integers, which can't participate in reference cycles. On the other hand, it may be convenient to clear all contained Python objects, and write the type's *tp_dealloc* function to invoke *tp_clear*.

More information about Python's garbage collection scheme can be found in section 使对象类型支持循环垃圾回收.

This field is inherited by subtypes together with *tp_traverse* and the *Py_TPFLAGS_HAVE_GC* flag bit: the flag bit, *tp_traverse*, and *tp_clear* are all inherited from the base type if they are all zero in the subtype *and* the subtype has the *Py_TPFLAGS_HAVE_RICHCOMPARE* flag bit set.

richcmpfunc **PyTypeObject.tp_richcompare**

An optional pointer to the rich comparison function, whose signature is `PyObject *tp_richcompare(PyObject *a, PyObject *b, int op)`.

The function should return the result of the comparison (usually `Py_True` or `Py_False`). If the comparison is undefined, it must return `Py_NotImplemented`, if another error occurred it must return `NULL` and set an exception condition.

**注解：** If you want to implement a type for which only a limited set of comparisons makes sense (e.g. == and !=, but not < and friends), directly raise `TypeError` in the rich comparison function.

This field is inherited by subtypes together with *tp_compare* and *tp_hash*: a subtype inherits all three of *tp_compare*, *tp_richcompare*, and *tp_hash*, when the subtype's *tp_compare*, *tp_richcompare*, and *tp_hash* are all *NULL*.

The following constants are defined to be used as the third argument for *tp_richcompare* and for *PyObject_RichCompare()*:

| 常数 | 对照 |
|---|---|
| Py_LT | < |
| Py_LE | <= |
| Py_EQ | == |
| Py_NE | != |
| Py_GT | > |
| Py_GE | >= |

The next field only exists if the *Py_TPFLAGS_HAVE_WEAKREFS* flag bit is set.

long **PyTypeObject.tp_weaklistoffset**

If the instances of this type are weakly referenceable, this field is greater than zero and contains the offset in the instance structure of the weak reference list head (ignoring the GC header, if present); this offset is used by `PyObject_ClearWeakRefs()` and the `PyWeakref_*()` functions. The instance structure needs to include a field of type *PyObject** which is initialized to *NULL*.

Do not confuse this field with *tp_weaklist*; that is the list head for weak references to the type object itself.

This field is inherited by subtypes, but see the rules listed below. A subtype may override this offset; this means that the subtype uses a different weak reference list head than the base type. Since the list head is always found via *tp_weaklistoffset*, this should not be a problem.

When a type defined by a class statement has no `__slots__` declaration, and none of its base types are weakly referenceable, the type is made weakly referenceable by adding a weak reference list head slot to the instance layout and setting the *tp_weaklistoffset* of that slot' s offset.

When a type' s `__slots__` declaration contains a slot named `__weakref__`, that slot becomes the weak reference list head for instances of the type, and the slot' s offset is stored in the type' s *tp_weaklistoffset*.

When a type' s `__slots__` declaration does not contain a slot named `__weakref__`, the type inherits its *tp_weaklistoffset* from its base type.

The next two fields only exist if the *Py_TPFLAGS_HAVE_ITER* flag bit is set.

getiterfunc **PyTypeObject.tp_iter**

An optional pointer to a function that returns an iterator for the object. Its presence normally signals that the instances of this type are iterable (although sequences may be iterable without this function, and classic instances always have this function, even if they don' t define an `__iter__()` method).

This function has the same signature as *PyObject_GetIter()*.

This field is inherited by subtypes.

iternextfunc **PyTypeObject.tp_iternext**

An optional pointer to a function that returns the next item in an iterator. When the iterator is exhausted, it must return *NULL*; a `StopIteration` exception may or may not be set. When another error occurs, it must return *NULL* too. Its presence normally signals that the instances of this type are iterators (although classic instances always have this function, even if they don' t define a `next()` method).

Iterator types should also define the *tp_iter* function, and that function should return the iterator instance itself (not a new iterator instance).

This function has the same signature as *PyIter_Next()*.

This field is inherited by subtypes.

The next fields, up to and including *tp_weaklist*, only exist if the *Py_TPFLAGS_HAVE_CLASS* flag bit is set.

struct *PyMethodDef** **PyTypeObject.tp_methods**

An optional pointer to a static *NULL*-terminated array of *PyMethodDef* structures, declaring regular methods of this type.

For each entry in the array, an entry is added to the type's dictionary (see `tp_dict` below) containing a method descriptor.

This field is not inherited by subtypes (methods are inherited through a different mechanism).

struct *PyMemberDef** **PyTypeObject.tp_members**

An optional pointer to a static *NULL*-terminated array of `PyMemberDef` structures, declaring regular data members (fields or slots) of instances of this type.

For each entry in the array, an entry is added to the type's dictionary (see `tp_dict` below) containing a member descriptor.

This field is not inherited by subtypes (members are inherited through a different mechanism).

struct *PyGetSetDef** **PyTypeObject.tp_getset**

An optional pointer to a static *NULL*-terminated array of `PyGetSetDef` structures, declaring computed attributes of instances of this type.

For each entry in the array, an entry is added to the type's dictionary (see `tp_dict` below) containing a getset descriptor.

This field is not inherited by subtypes (computed attributes are inherited through a different mechanism).

*PyTypeObject** **PyTypeObject.tp_base**

An optional pointer to a base type from which type properties are inherited. At this level, only single inheritance is supported; multiple inheritance require dynamically creating a type object by calling the metatype.

This field is not inherited by subtypes (obviously), but it defaults to `&PyBaseObject_Type` (which to Python programmers is known as the type `object`).

*PyObject** **PyTypeObject.tp_dict**

The type's dictionary is stored here by `PyType_Ready()`.

This field should normally be initialized to *NULL* before PyType_Ready is called; it may also be initialized to a dictionary containing initial attributes for the type. Once `PyType_Ready()` has initialized the type, extra attributes for the type may be added to this dictionary only if they don't correspond to overloaded operations (like `__add__()`).

This field is not inherited by subtypes (though the attributes defined in here are inherited through a different mechanism).

descrgetfunc **PyTypeObject.tp_descr_get**

An optional pointer to a "descriptor get" function.

The function signature is

```
PyObject * tp_descr_get(PyObject *self, PyObject *obj, PyObject *type);
```

This field is inherited by subtypes.

descrsetfunc **PyTypeObject.tp_descr_set**

An optional pointer to a function for setting and deleting a descriptor's value.

The function signature is

```
int tp_descr_set(PyObject *self, PyObject *obj, PyObject *value);
```

The *value* argument is set to *NULL* to delete the value. This field is inherited by subtypes.

long **PyTypeObject.tp_dictoffset**

If the instances of this type have a dictionary containing instance variables, this field is non-zero and contains the offset in the instances of the type of the instance variable dictionary; this offset is used by `PyObject_GenericGetAttr()`.

Do not confuse this field with `tp_dict`; that is the dictionary for attributes of the type object itself.

If the value of this field is greater than zero, it specifies the offset from the start of the instance structure. If the value is less than zero, it specifies the offset from the *end* of the instance structure. A negative offset is more expensive to use, and should only be used when the instance structure contains a variable-length part. This is used for example to add an instance variable dictionary to subtypes of `str` or `tuple`. Note that the `tp_basicsize` field should account for the dictionary added to the end in that case, even though the dictionary is not included in the basic object layout. On a system with a pointer size of 4 bytes, `tp_dictoffset` should be set to `-4` to indicate that the dictionary is at the very end of the structure.

The real dictionary offset in an instance can be computed from a negative `tp_dictoffset` as follows:

```
dictoffset = tp_basicsize + abs(ob_size)*tp_itemsize + tp_dictoffset
if dictoffset is not aligned on sizeof(void*):
    round up to sizeof(void*)
```

where `tp_basicsize`, `tp_itemsize` and `tp_dictoffset` are taken from the type object, and `ob_size` is taken from the instance. The absolute value is taken because long ints use the sign of `ob_size` to store the sign of the number. (There' s never a need to do this calculation yourself; it is done for you by `_PyObject_GetDictPtr()`.)

This field is inherited by subtypes, but see the rules listed below. A subtype may override this offset; this means that the subtype instances store the dictionary at a difference offset than the base type. Since the dictionary is always found via `tp_dictoffset`, this should not be a problem.

When a type defined by a class statement has no `__slots__` declaration, and none of its base types has an instance variable dictionary, a dictionary slot is added to the instance layout and the `tp_dictoffset` is set to that slot' s offset.

When a type defined by a class statement has a `__slots__` declaration, the type inherits its `tp_dictoffset` from its base type.

(Adding a slot named `__dict__` to the `__slots__` declaration does not have the expected effect, it just causes confusion. Maybe this should be added as a feature just like `__weakref__` though.)

initproc **PyTypeObject.tp_init**

An optional pointer to an instance initialization function.

This function corresponds to the `__init__()` method of classes. Like `__init__()`, it is possible to create an instance without calling `__init__()`, and it is possible to reinitialize an instance by calling its `__init__()` method again.

The function signature is

```
int tp_init(PyObject *self, PyObject *args, PyObject *kwds)
```

The self argument is the instance to be initialized; the *args* and *kwds* arguments represent positional and keyword arguments of the call to `__init__()`.

The `tp_init` function, if not *NULL*, is called when an instance is created normally by calling its type, after the type' s `tp_new` function has returned an instance of the type. If the `tp_new` function returns an instance of some other type that is not a subtype of the original type, no `tp_init` function is called; if `tp_new` returns an instance of a subtype of the original type, the subtype' s `tp_init` is called. (VERSION NOTE: described here is what is implemented in Python 2.2.1 and later. In Python 2.2, the `tp_init` of the type of the object returned by `tp_new` was always called, if not *NULL*.)

This field is inherited by subtypes.

allocfunc **PyTypeObject.tp_alloc**

An optional pointer to an instance allocation function.

The function signature is

```
PyObject *tp_alloc(PyTypeObject *self, Py_ssize_t nitems)
```

The purpose of this function is to separate memory allocation from memory initialization. It should return a pointer to a block of memory of adequate length for the instance, suitably aligned, and initialized to zeros, but with `ob_refcnt` set to `1` and `ob_type` set to the type argument. If the type' s *`tp_itemsize`* is non-zero, the object' s `ob_size` field should be initialized to *nitems* and the length of the allocated memory block should be `tp_basicsize + nitems*tp_itemsize`, rounded up to a multiple of `sizeof(void*)`; otherwise, *nitems* is not used and the length of the block should be *`tp_basicsize`*.

Do not use this function to do any other instance initialization, not even to allocate additional memory; that should be done by *`tp_new`*.

This field is inherited by static subtypes, but not by dynamic subtypes (subtypes created by a class statement); in the latter, this field is always set to *`PyType_GenericAlloc()`*, to force a standard heap allocation strategy. That is also the recommended value for statically defined types.

newfunc **`PyTypeObject.tp_new`**

An optional pointer to an instance creation function.

If this function is *NULL* for a particular type, that type cannot be called to create new instances; presumably there is some other way to create instances, like a factory function.

The function signature is

```
PyObject *tp_new(PyTypeObject *subtype, PyObject *args, PyObject *kwds)
```

The subtype argument is the type of the object being created; the *args* and *kwds* arguments represent positional and keyword arguments of the call to the type. Note that subtype doesn' t have to equal the type whose *`tp_new`* function is called; it may be a subtype of that type (but not an unrelated type).

The *`tp_new`* function should call `subtype->tp_alloc(subtype, nitems)` to allocate space for the object, and then do only as much further initialization as is absolutely necessary. Initialization that can safely be ignored or repeated should be placed in the *`tp_init`* handler. A good rule of thumb is that for immutable types, all initialization should take place in *`tp_new`*, while for mutable types, most initialization should be deferred to *`tp_init`*.

This field is inherited by subtypes, except it is not inherited by static types whose *`tp_base`* is *NULL* or `&PyBaseObject_Type`. The latter exception is a precaution so that old extension types don' t become callable simply by being linked with Python 2.2.

destructor **`PyTypeObject.tp_free`**

An optional pointer to an instance deallocation function.

The signature of this function has changed slightly: in Python 2.2 and 2.2.1, its signature is `destructor`:

```
void tp_free(PyObject *)
```

In Python 2.3 and beyond, its signature is `freefunc`:

```
void tp_free(void *)
```

The only initializer that is compatible with both versions is `_PyObject_Del`, whose definition has suitably adapted in Python 2.3.

This field is inherited by static subtypes, but not by dynamic subtypes (subtypes created by a class statement); in the latter, this field is set to a deallocator suitable to match *`PyType_GenericAlloc()`* and the value of the *`Py_TPFLAGS_HAVE_GC`* flag bit.

*inquiry* **PyTypeObject.tp_is_gc**
An optional pointer to a function called by the garbage collector.

The garbage collector needs to know whether a particular object is collectible or not. Normally, it is sufficient to look at the object' s type' s *tp_flags* field, and check the *Py_TPFLAGS_HAVE_GC* flag bit. But some types have a mixture of statically and dynamically allocated instances, and the statically allocated instances are not collectible. Such types should define this function; it should return `1` for a collectible instance, and `0` for a non-collectible instance. The signature is

```
int tp_is_gc(PyObject *self)
```

(The only example of this are types themselves. The metatype, *PyType_Type*, defines this function to distinguish between statically and dynamically allocated types.)

This field is inherited by subtypes. (VERSION NOTE: in Python 2.2, it was not inherited. It is inherited in 2.2.1 and later versions.)

*PyObject** **PyTypeObject.tp_bases**
Tuple of base types.

This is set for types created by a class statement. It should be *NULL* for statically defined types.

This field is not inherited.

*PyObject** **PyTypeObject.tp_mro**
Tuple containing the expanded set of base types, starting with the type itself and ending with `object`, in Method Resolution Order.

This field is not inherited; it is calculated fresh by *PyType_Ready()*.

*PyObject** **PyTypeObject.tp_cache**
Unused. Not inherited. Internal use only.

*PyObject** **PyTypeObject.tp_subclasses**
List of weak references to subclasses. Not inherited. Internal use only.

*PyObject** **PyTypeObject.tp_weaklist**
Weak reference list head, for weak references to this type object. Not inherited. Internal use only.

The remaining fields are only defined if the feature test macro `COUNT_ALLOCS` is defined, and are for internal use only. They are documented here for completeness. None of these fields are inherited by subtypes. See the `PYTHONSHOWALLOCCOUNT` environment variable.

Py_ssize_t **PyTypeObject.tp_allocs**
Number of allocations.

Py_ssize_t **PyTypeObject.tp_frees**
Number of frees.

Py_ssize_t **PyTypeObject.tp_maxalloc**
Maximum simultaneously allocated objects.

*PyTypeObject** **PyTypeObject.tp_next**
Pointer to the next type object with a non-zero *tp_allocs* field.

Also, note that, in a garbage collected Python, tp_dealloc may be called from any Python thread, not just the thread which created the object (if the object becomes part of a refcount cycle, that cycle might be collected by a garbage collection on any thread). This is not a problem for Python API calls, since the thread on which tp_dealloc is called will own the Global Interpreter Lock (GIL). However, if the object being destroyed in turn destroys objects from some other C or C++ library, care should be taken to ensure that destroying those objects on the thread which called tp_dealloc will not violate any assumptions of the library.

## 10.4 Number Object Structures

**PyNumberMethods**

This structure holds pointers to the functions which an object uses to implement the number protocol. Almost every function below is used by the function of similar name documented in the 数字协议 section.

Here is the structure definition:

```
typedef struct {
     binaryfunc nb_add;
     binaryfunc nb_subtract;
     binaryfunc nb_multiply;
     binaryfunc nb_divide;
     binaryfunc nb_remainder;
     binaryfunc nb_divmod;
     ternaryfunc nb_power;
     unaryfunc nb_negative;
     unaryfunc nb_positive;
     unaryfunc nb_absolute;
     inquiry nb_nonzero;       /* Used by PyObject_IsTrue */
     unaryfunc nb_invert;
     binaryfunc nb_lshift;
     binaryfunc nb_rshift;
     binaryfunc nb_and;
     binaryfunc nb_xor;
     binaryfunc nb_or;
     coercion nb_coerce;       /* Used by the coerce() function */
     unaryfunc nb_int;
     unaryfunc nb_long;
     unaryfunc nb_float;
     unaryfunc nb_oct;
     unaryfunc nb_hex;

     /* Added in release 2.0 */
     binaryfunc nb_inplace_add;
     binaryfunc nb_inplace_subtract;
     binaryfunc nb_inplace_multiply;
     binaryfunc nb_inplace_divide;
     binaryfunc nb_inplace_remainder;
     ternaryfunc nb_inplace_power;
     binaryfunc nb_inplace_lshift;
     binaryfunc nb_inplace_rshift;
     binaryfunc nb_inplace_and;
     binaryfunc nb_inplace_xor;
     binaryfunc nb_inplace_or;

     /* Added in release 2.2 */
     binaryfunc nb_floor_divide;
     binaryfunc nb_true_divide;
     binaryfunc nb_inplace_floor_divide;
     binaryfunc nb_inplace_true_divide;

     /* Added in release 2.5 */
     unaryfunc nb_index;
} PyNumberMethods;
```

Binary and ternary functions may receive different kinds of arguments, depending on the flag bit *Py_TPFLAGS_CHECKTYPES*:

- If *Py_TPFLAGS_CHECKTYPES* is not set, the function arguments are guaranteed to be of the object's type; the caller is responsible for calling the coercion method specified by the `nb_coerce` member to convert the arguments:

  coercion **PyNumberMethods.nb_coerce**
  
  This function is used by *PyNumber_CoerceEx()* and has the same signature. The first argument is always a pointer to an object of the defined type. If the conversion to a common "larger" type is possible, the function replaces the pointers with new references to the converted objects and returns `0`. If the conversion is not possible, the function returns `1`. If an error condition is set, it will return `-1`.

- If the *Py_TPFLAGS_CHECKTYPES* flag is set, binary and ternary functions must check the type of all their operands, and implement the necessary conversions (at least one of the operands is an instance of the defined type). This is the recommended way; with Python 3 coercion will disappear completely.

If the operation is not defined for the given operands, binary and ternary functions must return `Py_NotImplemented`, if another error occurred they must return `NULL` and set an exception.

## 10.5 Mapping Object Structures

**PyMappingMethods**

This structure holds pointers to the functions which an object uses to implement the mapping protocol. It has three members:

lenfunc **PyMappingMethods.mp_length**

This function is used by *PyMapping_Length()* and *PyObject_Size()*, and has the same signature. This slot may be set to *NULL* if the object has no defined length.

binaryfunc **PyMappingMethods.mp_subscript**

This function is used by *PyObject_GetItem()* and has the same signature. This slot must be filled for the *PyMapping_Check()* function to return `1`, it can be *NULL* otherwise.

objobjargproc **PyMappingMethods.mp_ass_subscript**

This function is used by *PyObject_SetItem()* and *PyObject_DelItem()*. It has the same signature as *PyObject_SetItem()*, but *v* can also be set to *NULL* to delete an item. If this slot is *NULL*, the object does not support item assignment and deletion.

## 10.6 Sequence Object Structures

**PySequenceMethods**

This structure holds pointers to the functions which an object uses to implement the sequence protocol.

lenfunc **PySequenceMethods.sq_length**

This function is used by *PySequence_Size()* and *PyObject_Size()*, and has the same signature.

binaryfunc **PySequenceMethods.sq_concat**

This function is used by *PySequence_Concat()* and has the same signature. It is also used by the + operator, after trying the numeric addition via the `nb_add` slot.

ssizeargfunc **PySequenceMethods.sq_repeat**

This function is used by *PySequence_Repeat()* and has the same signature. It is also used by the `*` operator, after trying numeric multiplication via the `nb_multiply` slot.

ssizeargfunc **PySequenceMethods.sq_item**

This function is used by *PySequence_GetItem()* and has the same signature. This slot must be filled for the *PySequence_Check()* function to return `1`, it can be *NULL* otherwise.

Negative indexes are handled as follows: if the `sq_length` slot is filled, it is called and the sequence length is used to compute a positive index which is passed to `sq_item`. If `sq_length` is *NULL*, the index is passed as is to the function.

ssizeobjargproc **PySequenceMethods.sq_ass_item**
This function is used by *PySequence_SetItem()* and has the same signature. This slot may be left to *NULL* if the object does not support item assignment and deletion.

objobjproc **PySequenceMethods.sq_contains**
This function may be used by *PySequence_Contains()* and has the same signature. This slot may be left to *NULL*, in this case *PySequence_Contains()* simply traverses the sequence until it finds a match.

binaryfunc **PySequenceMethods.sq_inplace_concat**
This function is used by *PySequence_InPlaceConcat()* and has the same signature. It should modify its first operand, and return it.

ssizeargfunc **PySequenceMethods.sq_inplace_repeat**
This function is used by *PySequence_InPlaceRepeat()* and has the same signature. It should modify its first operand, and return it.

## 10.7 Buffer Object Structures

The buffer interface exports a model where an object can expose its internal data as a set of chunks of data, where each chunk is specified as a pointer/length pair. These chunks are called *segments* and are presumed to be non-contiguous in memory.

If an object does not export the buffer interface, then its *tp_as_buffer* member in the *PyTypeObject* structure should be *NULL*. Otherwise, the *tp_as_buffer* will point to a *PyBufferProcs* structure.

**注解:** It is very important that your *PyTypeObject* structure uses *Py_TPFLAGS_DEFAULT* for the value of the *tp_flags* member rather than `0`. This tells the Python runtime that your *PyBufferProcs* structure contains the `bf_getcharbuffer` slot. Older versions of Python did not have this member, so a new Python interpreter using an old extension needs to be able to test for its presence before using it.

**PyBufferProcs**
Structure used to hold the function pointers which define an implementation of the buffer protocol.

The first slot is `bf_getreadbuffer`, of type *readbufferproc*. If this slot is *NULL*, then the object does not support reading from the internal data. This is non-sensical, so implementors should fill this in, but callers should test that the slot contains a non-*NULL* value.

The next slot is `bf_getwritebuffer` having type *writebufferproc*. This slot may be *NULL* if the object does not allow writing into its returned buffers.

The third slot is `bf_getsegcount`, with type *segcountproc*. This slot must not be *NULL* and is used to inform the caller how many segments the object contains. Simple objects such as *PyString_Type* and *PyBuffer_Type* objects contain a single segment.

The last slot is `bf_getcharbuffer`, of type *charbufferproc*. This slot will only be present if the *Py_TPFLAGS_HAVE_GETCHARBUFFER* flag is present in the *tp_flags* field of the object's *PyTypeObject*. Before using this slot, the caller should test whether it is present by using the *PyType_HasFeature()* function. If the flag is present, `bf_getcharbuffer` may be *NULL*, indicating that the object's contents cannot be used as *8-bit characters*. The slot function may also raise an error if the object's contents cannot be interpreted as 8-bit characters. For example, if the object is an array which is configured to hold floating point values, an exception may be raised if a caller attempts to use `bf_getcharbuffer` to fetch a sequence of 8-bit characters. This notion of exporting the internal buffers as "text" is used to distinguish between objects that are binary in nature, and those which have character-based content.

---

**注解:** The current policy seems to state that these characters may be multi-byte characters. This implies that a buffer size of *N* does not mean there are *N* characters present.

---

**Py_TPFLAGS_HAVE_GETCHARBUFFER**
Flag bit set in the type structure to indicate that the `bf_getcharbuffer` slot is known. This being set does not indicate that the object supports the buffer interface or that the `bf_getcharbuffer` slot is non-*NULL*.

Py_ssize_t **(*readbufferproc)** (*PyObject *self*, Py_ssize_t *segment*, void ***ptrptr*)
Return a pointer to a readable segment of the buffer in `*ptrptr`. This function is allowed to raise an exception, in which case it must return `-1`. The *segment* which is specified must be zero or positive, and strictly less than the number of segments returned by the `bf_getsegcount` slot function. On success, it returns the length of the segment, and sets `*ptrptr` to a pointer to that memory.

Py_ssize_t **(*writebufferproc)** (*PyObject *self*, Py_ssize_t *segment*, void ***ptrptr*)
Return a pointer to a writable memory buffer in `*ptrptr`, and the length of that segment as the function return value. The memory buffer must correspond to buffer segment *segment*. Must return `-1` and set an exception on error. `TypeError` should be raised if the object only supports read-only buffers, and `SystemError` should be raised when *segment* specifies a segment that doesn't exist.

Py_ssize_t **(*segcountproc)** (*PyObject *self*, Py_ssize_t **lenp*)
Return the number of memory segments which comprise the buffer. If *lenp* is not *NULL*, the implementation must report the sum of the sizes (in bytes) of all segments in `*lenp`. The function cannot fail.

Py_ssize_t **(*charbufferproc)** (*PyObject *self*, Py_ssize_t *segment*, char ***ptrptr*)
Return the size of the segment *segment* that *ptrptr* is set to. `*ptrptr` is set to the memory buffer. Returns `-1` on error.

## 10.8 使对象类型支持循环垃圾回收

Python 对循环引用的垃圾检测与回收需要"容器"对象类型的支持，此类型的容器对象中可能包含其它容器对象。不保存其它对象的引用的类型，或者只保存原子类型（如数字或字符串）的引用的类型，不需要显式提供垃圾回收的支持。

若要创建一个容器类，类型对象的 `tp_flags` 字段必须包含 `Py_TPFLAGS_HAVE_GC` 并提供一个 `tp_traverse` 处理的实现。如果该类型的实例是可变的，还需要实现 `tp_clear` 。

**Py_TPFLAGS_HAVE_GC**
设置了此标志位的类型的对象必须符合此处记录的规则。为方便起见，下文把这些对象称为容器对象。

容器类型的构造函数必须符合两个规则:

1. 必须使用 `PyObject_GC_New()` 或 `PyObject_GC_NewVar()` 为这些对象分配内存。
2. 初始化了所有可能包含其他容器的引用的字段后，它必须调用 `PyObject_GC_Track()` 。

TYPE* **PyObject_GC_New** (TYPE, *PyTypeObject *type*)
类似于 `PyObject_New()` ，适用于设置了 `Py_TPFLAGS_HAVE_GC` 标签的容器对象。

TYPE* **PyObject_GC_NewVar** (TYPE, *PyTypeObject *type*, Py_ssize_t *size*)
类似于 `PyObject_NewVar()` ，适用于设置了 `Py_TPFLAGS_HAVE_GC` 标签的容器对象。

在 2.5 版更改: This function used an `int` type for *size*. This might require changes in your code for properly supporting 64-bit systems.

TYPE* **PyObject_GC_Resize**(TYPE, *PyVarObject* *op, Py_ssize_t *newsize*)
Resize an object allocated by `PyObject_NewVar()`. Returns the resized object or *NULL* on failure. *op* must not be tracked by the collector yet.

在 2.5 版更改: This function used an `int` type for *newsize*. This might require changes in your code for properly supporting 64-bit systems.

void **PyObject_GC_Track**(*PyObject* *op)
把对象 *op* 加入到垃圾回收器跟踪的容器对象中。对象在被回收器跟踪时必须保持有效的，因为回收器可能在任何时候开始运行。在`tp_traverse` 处理前的所有字段变为有效后，必须调用此函数，通常在靠近构造函数末尾的位置。

void **_PyObject_GC_TRACK**(*PyObject* *op)
`PyObject_GC_Track()` 的宏实现版本。它不能被用于扩展模块。

同样的，对象的释放器必须符合两个类似的规则：

1. 在引用其它容器的字段失效前，必须调用`PyObject_GC_UnTrack()` 。
2. 必须使用`PyObject_GC_Del()` 释放对象的内存。

void **PyObject_GC_Del**(void *op)
释放对象的内存，该对象初始化时由`PyObject_GC_New()` 或`PyObject_GC_NewVar()` 分配内存。

void **PyObject_GC_UnTrack**(void *op)
从回收器跟踪的容器对象集合中移除 *op* 对象。请注意可以在此对象上再次调用`PyObject_GC_Track()` 以将其加回到被跟踪对象集合。释放器 (`tp_dealloc` 句柄) 应当在`tp_traverse` 句柄所使用的任何字段失效之前为对象调用此函数。

void **_PyObject_GC_UNTRACK**(*PyObject* *op)
`PyObject_GC_UnTrack()` 的使用宏实现的版本。不能用于扩展模块。

`tp_traverse` 处理接收以下类型的函数形参。

int **(*visitproc)**(*PyObject* *object, void *arg)
传给`tp_traverse` 处理的访问函数的类型。*object* 是容器中需要被遍历的一个对象，第三个形参对应于`tp_traverse` 处理的 *arg* 。Python 核心使用多个访问者函数实现循环引用的垃圾检测，不需要用户自行实现访问者函数。

`tp_traverse` 处理必须是以下类型：

int **(*traverseproc)**(*PyObject* *self, *visitproc* visit, void *arg)
Traversal function for a container object. Implementations must call the *visit* function for each object directly contained by *self*, with the parameters to *visit* being the contained object and the *arg* value passed to the handler. The *visit* function must not be called with a *NULL* object argument. If *visit* returns a non-zero value that value should be returned immediately.

为了简化`tp_traverse` 处理的实现，Python 提供了一个`Py_VISIT()` 宏。若要使用这个宏，必须把`tp_traverse` 的参数命名为 *visit* 和 *arg* 。

void **Py_VISIT**(*PyObject* *o)
If *o* is not *NULL*, call the *visit* callback, with arguments *o* and *arg*. If *visit* returns a non-zero value, then return it. Using this macro, `tp_traverse` handlers look like:

```
static int
my_traverse(Noddy *self, visitproc visit, void *arg)
{
    Py_VISIT(self->foo);
    Py_VISIT(self->bar);
    return 0;
}
```

2.4 新版功能.

The `tp_clear` handler must be of the `inquiry` type, or *NULL* if the object is immutable.

int **(*inquiry)**(*PyObject* **self*)

丢弃产生循环引用的引用。不可变对象不需要声明此方法，因为他们不可能直接产生循环引用。需要注意的是，对象在调用此方法后必须仍是有效的（不能对引用只调用`Py_DECREF()` 方法）。当垃圾回收器检测到该对象在循环引用中时，此方法会被调用。

# APPENDIX A

## 术语对照表

**>>>** 交互式终端中默认的 Python 提示符。往往会显示于能以交互方式在解释器里执行的样例代码之前。

**...** The default Python prompt of the interactive shell when entering code for an indented code block, when within a pair of matching left and right delimiters (parentheses, square brackets, curly braces or triple quotes), or after specifying a decorator.

**2to3** 一个将 Python 2.x 代码转换为 Python 3.x 代码的工具，能够处理大部分通过解析源码并遍历解析树可检测到的不兼容问题。

2to3 包含在标准库中，模块名为 `lib2to3`；并提供一个独立入口点 `Tools/scripts/2to3`。参见 2to3-reference。

**abstract base class –抽象基类** Abstract base classes complement *duck-typing* by providing a way to define interfaces when other techniques like `hasattr()` would be clumsy or subtly wrong (for example with magic methods). ABCs introduce virtual subclasses, which are classes that don't inherit from a class but are still recognized by `isinstance()` and `issubclass()`; see the `abc` module documentation. Python comes with many built-in ABCs for data structures (in the `collections` module), numbers (in the `numbers` module), and streams (in the `io` module). You can create your own ABCs with the `abc` module.

**argument –参数** A value passed to a *function* (or *method*) when calling the function. There are two types of arguments:

- 关键字参数: 在函数调用中前面带有标识符（例如 `name=`）或者作为包含在前面带有 `**` 的字典里的值传入。举例来说，`3` 和 `5` 在以下对 `complex()` 的调用中均属于关键字参数:

```
complex(real=3, imag=5)
complex(**{'real': 3, 'imag': 5})
```

- 位置参数: 不属于关键字参数的参数。位置参数可出现于参数列表的开头以及/或者作为前面带有 `*` 的*iterable* 里的元素被传入。举例来说，`3` 和 `5` 在以下调用中均属于位置参数:

```
complex(3, 5)
complex(*(3, 5))
```

参数会被赋值给函数体中对应的局部变量。有关赋值规则参见 calls 一节。根据语法，任何表达式都可用来表示一个参数；最终算出的值会被赋给对应的局部变量。

See also the *parameter* glossary entry and the FAQ question on the difference between arguments and parameters.

**attribute –属性** 关联到一个对象的值，可以使用点号表达式通过其名称来引用。例如，如果一个对象 *o* 具有一个属性 *a*，就可以用 *o.a* 来引用它。

**BDFL** Benevolent Dictator For Life, a.k.a. Guido van Rossum, Python' s creator.

**bytes-like object –字节类对象** An object that supports the *buffer protocol*, like `str`, `bytearray` or `memoryview`. Bytes-like objects can be used for various operations that expect binary data, such as compression, saving to a binary file or sending over a socket. Some operations need the binary data to be mutable, in which case not all bytes-like objects can apply.

**bytecode –字节码** Python source code is compiled into bytecode, the internal representation of a Python program in the CPython interpreter. The bytecode is also cached in `.pyc` and `.pyo` files so that executing the same file is faster the second time (recompilation from source to bytecode can be avoided). This "intermediate language" is said to run on a *virtual machine* that executes the machine code corresponding to each bytecode. Do note that bytecodes are not expected to work between different Python virtual machines, nor to be stable between Python releases.

字节码指令列表可以在 dis 模块的文档中查看。

**class –类** 用来创建用户定义对象的模板。类定义通常包含对该类的实例进行操作的方法定义。

**classic class** Any class which does not inherit from `object`. See *new-style class*. Classic classes have been removed in Python 3.

**coercion –强制类型转换** The implicit conversion of an instance of one type to another during an operation which involves two arguments of the same type. For example, `int(3.15)` converts the floating point number to the integer `3`, but in `3+4.5`, each argument is of a different type (one int, one float), and both must be converted to the same type before they can be added or it will raise a `TypeError`. Coercion between two operands can be performed with the `coerce` built-in function; thus, `3+4.5` is equivalent to calling `operator.add(*coerce(3, 4.5))` and results in `operator.add(3.0, 4.5)`. Without coercion, all arguments of even compatible types would have to be normalized to the same value by the programmer, e.g., `float(3)+4.5` rather than just `3+4.5`.

**complex number –复数** 对普通实数系统的扩展，其中所有数字都被表示为一个实部和一个虚部的和。虚数是虚数单位（`-1` 的平方根）的实倍数，通常在数学中写为 `i`，在工程学中写为 `j`。Python 内置了对复数的支持，采用工程学标记方式；虚部带有一个 `j` 后缀，例如 `3+1j`。如果需要 `math` 模块内对象的对应复数版本，请使用 `cmath`，复数的使用是一个比较高级的数学特性。如果你感觉没有必要，忽略它们也几乎不会有任何问题。

**context manager –上下文管理器** 在 `with` 语句中使用，通过定义 `__enter__()` 和 `__exit__()` 方法来控制环境状态的对象。参见 **PEP 343**。

**CPython** Python 编程语言的规范实现，在 python.org 上发布。"CPython" 一词用于在必要时将此实现与其他实现例如 Jython 或 IronPython 相区别。

**decorator –装饰器** 返回值为另一个函数的函数，通常使用 `@wrapper` 语法形式来进行函数变换。装饰器的常见例子包括 `classmethod()` 和 `staticmethod()`。

装饰器语法只是一种语法糖，以下两个函数定义在语义上完全等价:

```
def f(...):
    ...
f = staticmethod(f)

@staticmethod
def f(...):
    ...
```

同的样概念也适用于类，但通常较少这样使用。有关装饰器的详情可参见 函数定义和 类定义的文档。

**descriptor –描述器** Any *new-style* 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.

有关描述符的方法的详情可参看 descriptors。

**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 view –字典视图** The objects returned from `dict.viewkeys()`, `dict.viewvalues()`, and `dict.viewitems()` are called dictionary views. They provide a dynamic view on the dictionary' s entries, which means that when the dictionary changes, the view reflects these changes. To force the dictionary view to become a full list use `list(dictview)`. See dict-views.

**docstring –文档字符串** 作为类、函数或模块之内的第一个表达式出现的字符串字面值。它在代码执行时会被忽略，但会被解释器识别并放入所在类、函数或模块的 `__doc__` 属性中。由于它可用于代码内省，因此是对象存放文档的规范位置。

**duck-typing –鸭子类型** 指一种编程风格，它并不依靠查找对象类型来确定其是否具有正确的接口，而是直接调用或使用其方法或属性（"看起来像鸭子，叫起来也像鸭子，那么肯定就是鸭子。"）由于强调接口而非特定类型，设计良好的代码可通过允许多态替代来提升灵活性。鸭子类型避免使用 `type()` 或 `isinstance()` 检测。(但要注意鸭子类型可以使用抽象基类 作为补充。) 而往往会采用 `hasattr()` 检测或是*EAFP* 编程。

**EAFP** "求原谅比求许可更容易"的英文缩写。这种 Python 常用代码编写风格会假定所需的键或属性存在，并在假定错误时捕获异常。这种简洁快速风格的特点就是大量运用 `try` 和 `except` 语句。于其相对的则是所谓*LBYL* 风格，常见于 C 等许多其他语言。

**expression –表达式** A piece of syntax which can be evaluated to some value. In other words, an expression is an accumulation of expression elements like literals, names, attribute access, operators or function calls which all return a value. In contrast to many other languages, not all language constructs are expressions. There are also *statement*s which cannot be used as expressions, such as `print` or `if`. Assignments are also statements, not expressions.

**extension module –扩展模块** 以 C 或 C++ 编写的模块，使用 Python 的 C API 来与语言核心以及用户代码进行交互。

**file object –文件对象** 对外提供面向文件 API 以使用下层资源的对象（带有 `read()` 或 `write()` 这样的方法）。根据其创建方式的不同，文件对象可以处理对真实磁盘文件，对其他类型存储，或是对通讯设备的访问（例如标准输入/输出、内存缓冲区、套接字、管道等等）。文件对象也被称为 文件类对象或 流。

There are actually three categories of file objects: raw binary files, buffered binary files and text files. Their interfaces are defined in the `io` module. The canonical way to create a file object is by using the `open()` function.

**file-like object –文件类对象** *file object* 的同义词。

**finder –查找器** An object that tries to find the *loader* for a module. It must implement a method named `find_module()`. See **PEP 302** for details.

**floor division –向下取整除法** 向下舍入到最接近的整数的数学除法。向下取整除法的运算符是 `//` 。例如，表达式 `11 // 4` 的计算结果是 `2` ，而与之相反的是浮点数的真正除法返回 `2.75` 。注意 `(-11) // 4` 会返回 `-3` 因为这是 `-2.75` 向下舍入得到的结果。见 **PEP 238** 。

**function –函数** 可以向调用者返回某个值的一组语句。还可以向其传入零个或多个参数 并在函数体执行中被使用。另见*parameter*, *method* 和 function 等节。

**__future__** A pseudo-module which programmers can use to enable new language features which are not compatible with the current interpreter. For example, the expression `11/4` currently evaluates to `2`. If the module in which it is executed had enabled *true division* by executing:

```
from __future__ import division
```

the expression 11/4 would evaluate to 2.75. By importing the __future__ module and evaluating its variables, you can see when a new feature was first added to the language and when it will become the default:

```
>>> import __future__
>>> __future__.division
_Feature((2, 2, 0, 'alpha', 2), (3, 0, 0, 'alpha', 0), 8192)
```

**garbage collection –垃圾回收** The process of freeing memory when it is not used anymore. Python performs garbage collection via reference counting and a cyclic garbage collector that is able to detect and break reference cycles.

**generator –生成器** A function which returns an iterator. It looks like a normal function except that it contains yield statements for producing a series of values usable in a for-loop or that can be retrieved one at a time with the next() function. Each yield temporarily suspends processing, remembering the location execution state (including local variables and pending try-statements). When the generator resumes, it picks up where it left off (in contrast to functions which start fresh on every invocation).

**generator expression –生成器表达式** An expression that returns an iterator. It looks like a normal expression followed by a for expression defining a loop variable, range, and an optional if expression. The combined expression generates values for an enclosing function:

```
>>> sum(i*i for i in range(10))         # sum of squares 0, 1, 4, ... 81
285
```

**GIL** 参见*global interpreter lock*。

**global interpreter lock –全局解释器锁** *CPython* 解释器所采用的一种机制，它确保同一时刻只有一个线程在执行 Python *bytecode*。此机制通过设置对象模型（包括 dict 等重要内置类型）针对并发访问的隐式安全简化了 CPython 实现。给整个解释器加锁使得解释器多线程运行更方便，其代价则是牺牲了在多处理器上的并行性。

不过，某些标准库或第三方库的扩展模块被设计为在执行计算密集型任务如压缩或哈希时释放 GIL。此外，在执行 I/O 操作时也总是会释放 GIL。

创建一个（以更精细粒度来锁定共享数据的）"自由线程"解释器的努力从未获得成功，因为这会牺牲在普通单处理器情况下的性能。据信克服这种性能问题的措施将导致实现变得更复杂，从而更难以维护。

**hashable –可哈希** 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__() or __cmp__() method). Hashable objects which compare equal must have the same hash value.

可哈希性使得对象能够作为字典键或集合成员使用，因为这些数据结构要在内部使用哈希值。

All of Python's immutable built-in objects are hashable, while no mutable containers (such as lists or dictionaries) are. Objects which are instances of user-defined classes are hashable by default; they all compare unequal (except with themselves), and their hash value is derived from their id().

**IDLE** Python 的 IDE，"集成开发与学习环境"的英文缩写。是 Python 标准发行版附带的基本编程器和解释器环境。

**immutable –不可变** 具有固定值的对象。不可变对象包括数字、字符串和元组。这样的对象不能被改变。如果必须存储一个不同的值，则必须创建新的对象。它们在需要常量哈希值的地方起着重要作用，例如作为字典中的键。

**integer division** Mathematical division discarding any remainder. For example, the expression 11/4 currently evaluates to 2 in contrast to the 2.75 returned by float division. Also called *floor division*. When dividing two integers the outcome will always be another integer (having the floor function applied to it). However, if one of the operands is another numeric type (such as a `float`), the result will be coerced (see *coercion*) to a common type. For example, an integer divided by a float will result in a float value, possibly with a decimal fraction. Integer division can be forced by using the `//` operator instead of the `/` operator. See also *__future__*.

**importing –导入** 令一个模块中的 Python 代码能为另一个模块中的 Python 代码所使用的过程。

**importer –导入器** 查找并加载模块的对象；此对象既属于*finder* 又属于*loader*。

**interactive –交互** Python 带有一个交互式解释器，即你可以在解释器提示符后输入语句和表达式，立即执行并查看其结果。只需不带参数地启动 `python` 命令（也可以在你的计算机开始菜单中选择相应菜单项）。在测试新想法或检验模块和包的时候用这种方式会非常方便（请记得使用 `help(x)`）。

**interpreted –解释型** Python 一是种解释型语言，与之相对的是编译型语言，虽然两者的区别由于字节码编译器的存在而会有所模糊。这意味着源文件可以直接运行而不必显式地创建可执行文件再运行。解释型语言通常具有比编译型语言更短的开发/调试周期，但是其程序往往运行得更慢。参见*interactive*。

**iterable –可迭代对象** 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` and `file` and objects of any classes you define with an `__iter__()` or `__getitem__()` method. 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 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.

更多信息可查看 typeiter。

**key function –键函数** 键函数或称整理函数，是能够返回用于排序或排位的值的可调用对象。例如，`locale.strxfrm()` 可用于生成一个符合特定区域排序约定的排序键。

A number of tools in Python accept key functions to control how elements are ordered or grouped. They include `min()`, `max()`, `sorted()`, `list.sort()`, `heapq.nsmallest()`, `heapq.nlargest()`, and `itertools.groupby()`.

There are several ways to create a key function. For example. the `str.lower()` method can serve as a key function for case insensitive sorts. Alternatively, an ad-hoc key function can be built from a `lambda` expression such as `lambda r: (r[0], r[2])`. Also, the `operator` module provides three key function constructors: `attrgetter()`, `itemgetter()`, and `methodcaller()`. See the Sorting HOW TO for examples of how to create and use key functions.

**keyword argument –关键字参数** 参见*argument*。

**lambda** 由一个单独*expression* 构成的匿名内联函数，表达式会在调用时被求值。创建 lambda 函数的句法为 `lambda [parameters]: expression`

**LBYL** "先查看后跳跃"的英文缩写。这种代码编写风格会在进行调用或查找之前显式地检查前提条件。此风格与*EAFP* 方式恰成对比，其特点是大量使用 `if` 语句。

在多线程环境中，LBYL 方式会导致"查看"和"跳跃"之间发生条件竞争风险。例如，以下代码 `if key in mapping: return mapping[key]` 可能由于在检查操作之后其他线程从 *mapping* 中移除了 *key* 而出错。这种问题可通过加锁或使用 EAFP 方式来解决。

**list –列表** Python 内置的一种*sequence*。虽然名为列表，但更类似于其他语言中的数组而非链接列表，因为访问元素的时间复杂度为 O(1)。

**list comprehension –列表推导式** A compact way to process all or part of the elements in a sequence and return a list with the results. `result = ["0x%02x" % x for x in range(256) if x % 2 == 0]` generates a list of strings containing even hex numbers (0x..) in the range from 0 to 255. The `if` clause is optional. If omitted, all elements in `range(256)` are processed.

**loader –加载器** An object that loads a module. It must define a method named `load_module()`. A loader is typically returned by a *finder*. See **PEP 302** for details.

**magic method –魔术方法** *special method* 的非正式同义词。

**mapping –映射** A container object that supports arbitrary key lookups and implements the methods specified in the `Mapping` or `MutableMapping` abstract base classes. Examples include `dict`, `collections.defaultdict`, `collections.OrderedDict` and `collections.Counter`.

**metaclass –元类** 一种用于创建类的类。类定义包含类名、类字典和基类列表。元类负责接受上述三个参数并创建相应的类。大部分面向对象的编程语言都会提供一个默认实现。Python 的特别之处在于可以创建自定义元类。大部分用户永远不需要这个工具，但当需要出现时，元类可提供强大而优雅的解决方案。它们已被用于记录属性访问日志、添加线程安全性、跟踪对象创建、实现单例，以及其他许多任务。

更多详情参见 metaclasses。

**method 方法** 在类内部定义的函数。如果作为该类的实例的一个属性来调用，方法将会获取实例对象作为其第一个*argument* (通常命名为 `self`)。参见*function* 和*nested scope*。

**method resolution order –方法解析顺序** 方法解析顺序就是在查找成员时搜索全部基类所用的先后顺序。请查看 Python 2.3 方法解析顺序 了解自 2.3 版起 Python 解析器所用相关算法的详情。

**module 模块** 此对象是 Python 代码的一种组织单位。各模块具有独立的命名空间，可包含任意 Python 对象。模块可通过*importing* 操作被加载到 Python 中。

另见*package*。

**MRO** 参见*method resolution order*。

**mutable –可变** 可变对象可以在其 `id()` 保持固定的情况下改变其取值。另请参见*immutable*。

**named tuple –具名元组** Any tuple-like class whose indexable elements are also accessible using named attributes (for example, `time.localtime()` returns a tuple-like object where the *year* is accessible either with an index such as `t[0]` or with a named attribute like `t.tm_year`).

A named tuple can be a built-in type such as `time.struct_time`, or it can be created with a regular class definition. A full featured named tuple can also be created with the factory function `collections.namedtuple()`. The latter approach automatically provides extra features such as a self-documenting representation like `Employee(name='jones', title='programmer')`.

**namespace –命名空间** The place where a variable is stored. Namespaces are implemented as dictionaries. There are the local, global and built-in namespaces as well as nested namespaces in objects (in methods). Namespaces support modularity by preventing naming conflicts. For instance, the functions `__builtin__.open()` and `os.open()` are distinguished by their namespaces. Namespaces also aid readability and maintainability by making it clear which module implements a function. For instance, writing `random.seed()` or `itertools.izip()` makes it clear that those functions are implemented by the `random` and `itertools` modules, respectively.

**nested scope –嵌套作用域** The ability to refer to a variable in an enclosing definition. For instance, a function defined inside another function can refer to variables in the outer function. Note that nested scopes work only for reference and not for assignment which will always write to the innermost scope. In contrast, local variables both read and write in the innermost scope. Likewise, global variables read and write to the global namespace.

**new-style class –新式类** Any class which inherits from `object`. This includes all built-in types like `list` and `dict`. Only new-style classes can use Python's newer, versatile features like `__slots__`, descriptors, properties, and `__getattribute__()`.

More information can be found in newstyle.

**object –对象** 任何具有状态（属性或值）以及预定义行为（方法）的数据。object 也是任何*new-style class* 的最顶层基类名。

**package –包** 一种可包含子模块或递归地包含子包的 Python *module*。从技术上说，包是带有 `__path__` 属性的 Python 模块。

**parameter –形参** A named entity in a *function* (or method) definition that specifies an *argument* (or in some cases, arguments) that the function can accept. There are four types of parameters:

- *positional-or-keyword*：位置或关键字，指定一个可以作为位置参数 传入也可以作为关键字参数 传入的实参。这是默认的形参类型，例如下面的 *foo* 和 *bar*:

```
def func(foo, bar=None): ...
```

- *positional-only*：仅限位置，指定一个只能按位置传入的参数。Python 中没有定义仅限位置形参的语法。但是一些内置函数有仅限位置形参（比如 `abs()`）。
- *var-positional*：可变位置，指定可以提供由一个任意数量的位置参数构成的序列（附加在其他形参已接受的位置参数之后）。这种形参可通过在形参名称前加缀 `*` 来定义，例如下面的 *args*:

```
def func(*args, **kwargs): ...
```

- *var-keyword*：可变关键字，指定可以提供任意数量的关键字参数（附加在其他形参已接受的关键字参数之后）。这种形参可通过在形参名称前加缀 `**` 来定义，例如上面的 *kwargs*。

形参可以同时指定可选和必选参数，也可以为某些可选参数指定默认值。

See also the *argument* glossary entry, the FAQ question on the difference between arguments and parameters, and the function section.

**PEP** "Python 增强提议"的英文缩写。一个 PEP 就是一份设计文档，用来向 Python 社区提供信息，或描述一个 Python 的新增特性及其进度或环境。PEP 应当提供精确的技术规格和所提议特性的原理说明。

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参见 **PEP 1**。

**positional argument –位置参数** 参见*argument*。

**Python 3000** Python 3.x 发布路线的昵称（这个名字在版本 3 的发布还遥遥无期的时候就已出现了）。有时也被缩写为"Py3k"。

**Pythonic** 指一个思路或一段代码紧密遵循了 Python 语言最常用的风格和理念，而不是使用其他语言中通用的概念来实现代码。例如，Python 的常用风格是使用 `for` 语句循环来遍历一个可迭代对象中的所有元素。许多其他语言没有这样的结构，因此不熟悉 Python 的人有时会选择使用一个数字计数器:

```
for i in range(len(food)):
    print food[i]
```

而相应的更简洁更 Pythonic 的方法是这样的:

```
for piece in food:
    print piece
```

**reference count –引用计数** 对特定对象的引用的数量。当一个对象的引用计数降为零时，所分配资源将被释放。引用计数对 Python 代码来说通常是不可见的，但它是*CPython* 实现的一个关键元素。sys 模块定义了一个 getrefcount() 函数，程序员可调用它来返回特定对象的引用计数。

**__slots__** A declaration inside a *new-style class* that saves memory by pre-declaring space for instance attributes and eliminating instance dictionaries. Though popular, the technique is somewhat tricky to get right and is best reserved for rare cases where there are large numbers of instances in a memory-critical application.

**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 unicode. 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.

**slice –切片** An object usually containing a portion of a *sequence*. A slice is created using the subscript notation, [] with colons between numbers when several are given, such as in variable_name[1:3:5]. The bracket (subscript) notation uses slice objects internally (or in older versions, __getslice__() and __setslice__()).

**special method –特殊方法** 一种由 Python 隐式调用的方法，用来对某个类型执行特定操作例如相加等等。这种方法的名称的首尾都为双下划线。特殊方法的文档参见 specialnames。

**statement –语句** 语句是程序段（一个代码“块”）的组成单位。一条语句可以是一个*expression* 或某个带有关键字的结构，例如 if、while 或 for。

**struct sequence** A tuple with named elements. Struct sequences expose an interface similiar to *named tuple* in that elements can be accessed either by index or as an attribute. However, they do not have any of the named tuple methods like _make() or _asdict(). Examples of struct sequences include sys.float_info and the return value of os.stat().

**triple-quoted string –三引号字符串** 首尾各带三个连续双引号（"）或者单引号（'）的字符串。它们在功能上与首尾各用一个引号标注的字符串没有什么不同，但是有多种用处。它们允许你在字符串内包含未经转义的单引号和双引号，并且可以跨越多行而无需使用连接符，在编写文档字符串时特别好用。

**type –类型** 类型决定一个 Python 对象属于什么种类；每个对象都具有一种类型。要知道对象的类型，可以访问它的 __class__ 属性，或是通过 type(obj) 来获取。

**universal newlines –通用换行** A manner of interpreting text streams in which all of the following are recognized as ending a line: the Unix end-of-line convention '\n', the Windows convention '\r\n', and the old Macintosh convention '\r'. See **PEP 278** and **PEP 3116**, as well as str.splitlines() for an additional use.

**virtual environment –虚拟环境** 一种采用协作式隔离的运行时环境，允许 Python 用户和应用程序在安装和升级 Python 分发包时不会干扰到同一系统上运行的其他 Python 应用程序的行为。

**virtual machine –虚拟机** 一台完全通过软件定义的计算机。Python 虚拟机可执行字节码编译器所生成的*bytecode*。

**Zen of Python –Python 之禅** 列出 Python 设计的原则与哲学，有助于理解与使用这种语言。查看其具体内容可在交互模式提示符中输入“import this”。

APPENDIX B

# 文档说明

这些文档生成自 reStructuredText 原文档，由 Sphinx（一个专门为 Python 文档写的文档生成器）创建。

本文档和它所用工具链的开发完全是由志愿者完成的，这和 Python 本身一样。如果您想参与进来，请阅读 reporting-bugs 了解如何参与。我们随时欢迎新的志愿者！

特别鸣谢：

- Fred L. Drake, Jr.，创造了用于早期 Python 文档的工具链，以及撰写了非常多的文档；
- Docutils 软件包 项目，创建了 reStructuredText 文本格式和 Docutils 软件套件；
- Fredrik Lundh，Sphinx 从他的 Alternative Python Reference 项目中获得了很多好的想法。

## B.1 Python 文档的贡献者

有很多对 Python 语言，Python 标准库和 Python 文档有贡献的人，随 Python 源代码发布的 Misc/ACKS 文件列出了部分贡献者。

有了 Python 社区的输入和贡献，Python 才有了如此出色的文档 - 谢谢你们！

APPENDIX C

# 历史和许可证

## C.1 该软件的历史

Python 由荷兰数学和计算机科学研究学会（CWI，见 https://www.cwi.nl/ ）的 Guido van Rossum 于 1990 年代初设计，作为一门叫做 ABC 的语言的替代品。尽管 Python 包含了许多来自其他人的贡献，Guido 仍是其主要作者。

1995 年，Guido 在弗吉尼亚州的国家创新研究公司（CNRI，见 https://www.cnri.reston.va.us/ ）继续他在 Python 上的工作，并在那里发布了该软件的多个版本。

2000 年五月，Guido 和 Python 核心开发团队转到 BeOpen.com 并组建了 BeOpen PythonLabs 团队。同年十月，PythonLabs 团队转到 Digital Creations (现为 Zope Corporation；见 https://www.zope.org/)。2001 年，Python 软件基金会 (PSF，见 https://www.python.org/psf/) 成立，这是一个专为拥有 Python 相关知识产权而创建的非营利组织。Zope Corporation 现在是 PSF 的赞助成员。

所有的 Python 版本都是开源的（有关开源的定义参阅 https://opensource.org/ ）。历史上，绝大多数 Python 版本是 GPL 兼容的；下表总结了各个版本情况。

| 发布版本 | 源自 | 年份 | 所有者 | GPL 兼容？ |
|---|---|---|---|---|
| 0.9.0 至 1.2 | n/a | 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 |
| 2.2 及更高 | 2.1.1 | 2001 至今 | PSF | 是 |

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---

感谢众多在 Guido 指导下工作的外部志愿者，使得这些发布成为可能。

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### C.3.1 Mersenne Twister

`_random` 模块包含基于 http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/MT2002/emt19937ar.html 下载的代码。以下是原始代码的完整注释（声明）：

```
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 套接字

socket 模块使用 getaddrinfo() 和 getnameinfo() 函数，这些函数源代码在 WIDE 项目（http://www.wide.ad.jp/）的单独源文件中。

```
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```

### C.3.3 Floating point exception control

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```
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```

### C.3.4 MD5 message digest algorithm

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L. Peter Deutsch
ghost@aladdin.com

Independent implementation of MD5 (RFC 1321).

This code implements the MD5 Algorithm defined in RFC 1321, whose
text is available at
      http://www.ietf.org/rfc/rfc1321.txt
The code is derived from the text of the RFC, including the test suite
(section A.5) but excluding the rest of Appendix A.  It does not include
any code or documentation that is identified in the RFC as being
copyrighted.

The original and principal author of md5.h is L. Peter Deutsch
<ghost@aladdin.com>.  Other authors are noted in the change history
that follows (in reverse chronological order):

2002-04-13 lpd Removed support for non-ANSI compilers; removed
      references to Ghostscript; clarified derivation from RFC 1321;
      now handles byte order either statically or dynamically.
1999-11-04 lpd Edited comments slightly for automatic TOC extraction.
1999-10-18 lpd Fixed typo in header comment (ansi2knr rather than md5);
      added conditionalization for C++ compilation from Martin
      Purschke <purschke@bnl.gov>.
1999-05-03 lpd Original version.
```

### C.3.5 异步套接字服务

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### C.3.8 UUencode 与 UUdecode 函数

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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
```

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```
  version is still 5 times faster, though.
- Arguments more compliant with Python standard
```

### C.3.9 XML 远程过程调用

The xmlrpclib module contains the following notice:

```
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```

### C.3.11 Select kqueue

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```

### C.3.12 strtod and dtoa

`Python/dtoa.c` 文件提供了 C 语言的 dtoa 和 strtod 函数，用于将 C 语言的双精度型和字符串进行转换，该文件由 David M. Gay 的同名文件派生而来，当前可从 http://www.netlib.org/fp/ 下载。2009 年 3 月 16 日检索到的原始文件包含以下版权和许可声明:

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```

### C.3.13 OpenSSL

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除非使用 `--with-system-expat` 配置了构建，否则 `pyexpat` 扩展都是用包含 expat 源的拷贝构建的:

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### C.3.16 zlib

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# APPENDIX D

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