Python Frequently Asked Questions

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CAPÍTULO 1

General Python FAQ

1.1 General Information

1.1.1 What is Python?

Python is an interpreted, interactive, object-oriented programming language. It incorporates modules, exceptions, dynamic typing, very high level dynamic data types, and classes. Python combines remarkable power with very clear syntax. It has interfaces to many system calls and libraries, as well as to various window systems, and is extensible in C or C++. It is also usable as an extension language for applications that need a programmable interface. Finally, Python is portable: it runs on many Unix variants, on the Mac, and on Windows 2000 and later.

To find out more, start with tutorial-index. The Beginner's Guide to Python links to other introductory tutorials and resources for learning Python.

1.1.2 What is the Python Software Foundation?

The Python Software Foundation is an independent non-profit organization that holds the copyright on Python versions 2.1 and newer. The PSF's mission is to advance open source technology related to the Python programming language and to publicize the use of Python. The PSF's home page is at https://www.python.org/psf/.

Donations to the PSF are tax-exempt in the US. If you use Python and find it helpful, please contribute via the PSF donation page.

1.1.3 Are there copyright restrictions on the use of Python?

You can do anything you want with the source, as long as you leave the copyrights in and display those copyrights in any documentation about Python that you produce. If you honor the copyright rules, it's OK to use Python for commercial use, to sell copies of Python in source or binary form (modified or unmodified), or to sell products that incorporate Python in some form. We would still like to know about all commercial use of Python, of course.

See the PSF license page to find further explanations and a link to the full text of the license.

The Python logo is trademarked, and in certain cases permission is required to use it. Consult the Trademark Usage Policy for more information.

1.1.4 Why was Python created in the first place?

Here's a *very* brief summary of what started it all, written by Guido van Rossum:

> I had extensive experience with implementing an interpreted language in the ABC group at CWI, and from working with this group I had learned a lot about language design. This is the origin of many Python features, including the use of indentation for statement grouping and the inclusion of very-high-level data types (although the details are all different in Python).
>
> I had a number of gripes about the ABC language, but also liked many of its features. It was impossible to extend the ABC language (or its implementation) to remedy my complaints – in fact its lack of extensibility was one of its biggest problems. I had some experience with using Modula-2+ and talked with the designers of Modula-3 and read the Modula-3 report. Modula-3 is the origin of the syntax and semantics used for exceptions, and some other Python features.
>
> I was working in the Amoeba distributed operating system group at CWI. We needed a better way to do system administration than by writing either C programs or Bourne shell scripts, since Amoeba had its own system call interface which wasn't easily accessible from the Bourne shell. My experience with error handling in Amoeba made me acutely aware of the importance of exceptions as a programming language feature.
>
> It occurred to me that a scripting language with a syntax like ABC but with access to the Amoeba system calls would fill the need. I realized that it would be foolish to write an Amoeba-specific language, so I decided that I needed a language that was generally extensible.
>
> During the 1989 Christmas holidays, I had a lot of time on my hand, so I decided to give it a try. During the next year, while still mostly working on it in my own time, Python was used in the Amoeba project with increasing success, and the feedback from colleagues made me add many early improvements.
>
> In February 1991, after just over a year of development, I decided to post to USENET. The rest is in the `Misc/HISTORY` file.

1.1.5 What is Python good for?

Python is a high-level general-purpose programming language that can be applied to many different classes of problems.

The language comes with a large standard library that covers areas such as string processing (regular expressions, Unicode, calculating differences between files), Internet protocols (HTTP, FTP, SMTP, XML-RPC, POP, IMAP, CGI programming), software engineering (unit testing, logging, profiling, parsing Python code), and operating system interfaces (system calls, filesystems, TCP/IP sockets). Look at the table of contents for library-index to get an idea of what's available. A wide variety of third-party extensions are also available. Consult the Python Package Index to find packages of interest to you.

1.1.6 How does the Python version numbering scheme work?

Python versions are numbered A.B.C or A.B. A is the major version number – it is only incremented for really major changes in the language. B is the minor version number, incremented for less earth-shattering changes. C is the micro-level – it is incremented for each bugfix release. See **PEP 6** for more information about bugfix releases.

Not all releases are bugfix releases. In the run-up to a new major release, a series of development releases are made, denoted as alpha, beta, or release candidate. Alphas are early releases in which interfaces aren't yet finalized; it's not unexpected to see an interface change between two alpha releases. Betas are more stable, preserving existing interfaces but possibly adding new modules, and release candidates are frozen, making no changes except as needed to fix critical bugs.

Alpha, beta and release candidate versions have an additional suffix. The suffix for an alpha version is «aN» for some small number N, the suffix for a beta version is «bN» for some small number N, and the suffix for a release candidate version is «cN» for some small number N. In other words, all versions labeled 2.0aN precede the versions labeled 2.0bN, which precede versions labeled 2.0cN, and *those* precede 2.0.

You may also find version numbers with a «+» suffix, e.g. «2.2+». These are unreleased versions, built directly from the CPython development repository. In practice, after a final minor release is made, the version is incremented to the next minor version, which becomes the «a0» version, e.g. «2.4a0».

See also the documentation for `sys.version`, `sys.hexversion`, and `sys.version_info`.

1.1.7 How do I obtain a copy of the Python source?

The latest Python source distribution is always available from python.org, at https://www.python.org/downloads/. The latest development sources can be obtained at https://github.com/python/cpython/.

The source distribution is a gzipped tar file containing the complete C source, Sphinx-formatted documentation, Python library modules, example programs, and several useful pieces of freely distributable software. The source will compile and run out of the box on most UNIX platforms.

Consult the Getting Started section of the Python Developer's Guide for more information on getting the source code and compiling it.

1.1.8 How do I get documentation on Python?

The standard documentation for the current stable version of Python is available at https://docs.python.org/3/. PDF, plain text, and downloadable HTML versions are also available at https://docs.python.org/3/download.html.

The documentation is written in reStructuredText and processed by the Sphinx documentation tool. The reStructuredText source for the documentation is part of the Python source distribution.

1.1.9 I've never programmed before. Is there a Python tutorial?

There are numerous tutorials and books available. The standard documentation includes tutorial-index.

Consult the Beginner's Guide to find information for beginning Python programmers, including lists of tutorials.

1.1.10 Is there a newsgroup or mailing list devoted to Python?

There is a newsgroup, `comp.lang.python`, and a mailing list, python-list. The newsgroup and mailing list are gatewayed into each other – if you can read news it's unnecessary to subscribe to the mailing list. `comp.lang.python` is high-traffic, receiving hundreds of postings every day, and Usenet readers are often more able to cope with this volume.

Announcements of new software releases and events can be found in comp.lang.python.announce, a low-traffic moderated list that receives about five postings per day. It's available as the python-announce mailing list.

More info about other mailing lists and newsgroups can be found at https://www.python.org/community/lists/.

1.1.11 How do I get a beta test version of Python?

Alpha and beta releases are available from https://www.python.org/downloads/. All releases are announced on the comp.lang.python and comp.lang.python.announce newsgroups and on the Python home page at https://www.python.org/; an RSS feed of news is available.

You can also access the development version of Python through Git. See The Python Developer's Guide for details.

1.1.12 How do I submit bug reports and patches for Python?

To report a bug or submit a patch, please use the Roundup installation at https://bugs.python.org/.

You must have a Roundup account to report bugs; this makes it possible for us to contact you if we have follow-up questions. It will also enable Roundup to send you updates as we act on your bug. If you had previously used SourceForge to report bugs to Python, you can obtain your Roundup password through Roundup's password reset procedure.

For more information on how Python is developed, consult the Python Developer's Guide.

1.1.13 Are there any published articles about Python that I can reference?

It's probably best to cite your favorite book about Python.

The very first article about Python was written in 1991 and is now quite outdated.

> Guido van Rossum and Jelke de Boer, «Interactively Testing Remote Servers Using the Python Programming Language», CWI Quarterly, Volume 4, Issue 4 (December 1991), Amsterdam, pp 283–303.

1.1.14 Are there any books on Python?

Yes, there are many, and more are being published. See the python.org wiki at https://wiki.python.org/moin/PythonBooks for a list.

You can also search online bookstores for «Python» and filter out the Monty Python references; or perhaps search for «Python» and «language».

1.1.15 Where in the world is www.python.org located?

The Python project's infrastructure is located all over the world and is managed by the Python Infrastructure Team. Details here.

1.1.16 Why is it called Python?

When he began implementing Python, Guido van Rossum was also reading the published scripts from «Monty Python's Flying Circus», a BBC comedy series from the 1970s. Van Rossum thought he needed a name that was short, unique, and slightly mysterious, so he decided to call the language Python.

1.1.17 Do I have to like «Monty Python's Flying Circus»?

No, but it helps. :)

1.2 Python in the real world

1.2.1 How stable is Python?

Very stable. New, stable releases have been coming out roughly every 6 to 18 months since 1991, and this seems likely to continue. Currently there are usually around 18 months between major releases.

The developers issue «bugfix» releases of older versions, so the stability of existing releases gradually improves. Bugfix releases, indicated by a third component of the version number (e.g. 3.5.3, 3.6.2), are managed for stability; only fixes for known problems are included in a bugfix release, and it's guaranteed that interfaces will remain the same throughout a series of bugfix releases.

The latest stable releases can always be found on the Python download page. There are two production-ready versions of Python: 2.x and 3.x. The recommended version is 3.x, which is supported by most widely used libraries. Although 2.x is still widely used, it will not be maintained after January 1, 2020.

1.2.2 How many people are using Python?

There are probably tens of thousands of users, though it's difficult to obtain an exact count.

Python is available for free download, so there are no sales figures, and it's available from many different sites and packaged with many Linux distributions, so download statistics don't tell the whole story either.

The comp.lang.python newsgroup is very active, but not all Python users post to the group or even read it.

1.2.3 Have any significant projects been done in Python?

See https://www.python.org/about/success for a list of projects that use Python. Consulting the proceedings for past Python conferences will reveal contributions from many different companies and organizations.

High-profile Python projects include the Mailman mailing list manager and the Zope application server. Several Linux distributions, most notably Red Hat, have written part or all of their installer and system administration software in Python. Companies that use Python internally include Google, Yahoo, and Lucasfilm Ltd.

1.2.4 What new developments are expected for Python in the future?

See https://www.python.org/dev/peps/ for the Python Enhancement Proposals (PEPs). PEPs are design documents describing a suggested new feature for Python, providing a concise technical specification and a rationale. Look for a PEP titled «Python X.Y Release Schedule», where X.Y is a version that hasn't been publicly released yet.

New development is discussed on the python-dev mailing list.

1.2.5 Is it reasonable to propose incompatible changes to Python?

In general, no. There are already millions of lines of Python code around the world, so any change in the language that invalidates more than a very small fraction of existing programs has to be frowned upon. Even if you can provide a conversion program, there's still the problem of updating all documentation; many books have been written about Python, and we don't want to invalidate them all at a single stroke.

Providing a gradual upgrade path is necessary if a feature has to be changed. **PEP 5** describes the procedure followed for introducing backward-incompatible changes while minimizing disruption for users.

1.2.6 Is Python a good language for beginning programmers?

Yes.

It is still common to start students with a procedural and statically typed language such as Pascal, C, or a subset of C++ or Java. Students may be better served by learning Python as their first language. Python has a very simple and consistent syntax and a large standard library and, most importantly, using Python in a beginning programming course lets students concentrate on important programming skills such as problem decomposition and data type design. With Python, students can be quickly introduced to basic concepts such as loops and procedures. They can probably even work with user-defined objects in their very first course.

For a student who has never programmed before, using a statically typed language seems unnatural. It presents additional complexity that the student must master and slows the pace of the course. The students are trying to learn to think like a computer, decompose problems, design consistent interfaces, and encapsulate data. While learning to use a statically typed language is important in the long term, it is not necessarily the best topic to address in the students" first programming course.

Many other aspects of Python make it a good first language. Like Java, Python has a large standard library so that students can be assigned programming projects very early in the course that *do* something. Assignments aren't restricted to the standard four-function calculator and check balancing programs. By using the standard library, students can gain the satisfaction of working on realistic applications as they learn the fundamentals of programming. Using the standard library also teaches students about code reuse. Third-party modules such as PyGame are also helpful in extending the students" reach.

Python's interactive interpreter enables students to test language features while they're programming. They can keep a window with the interpreter running while they enter their program's source in another window. If they can't remember the methods for a list, they can do something like this:

```
>>> L = []
>>> dir(L)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__',
'__dir__', '__doc__', '__eq__', '__format__', '__ge__',
'__getattribute__', '__getitem__', '__gt__', '__hash__', '__iadd__',
'__imul__', '__init__', '__iter__', '__le__', '__len__', '__lt__',
'__mul__', '__ne__', '__new__', '__reduce__', '__reduce_ex__',
'__repr__', '__reversed__', '__rmul__', '__setattr__', '__setitem__',
'__sizeof__', '__str__', '__subclasshook__', 'append', 'clear',
```

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```
'copy', 'count', 'extend', 'index', 'insert', 'pop', 'remove',
'reverse', 'sort']
>>> [d for d in dir(L) if '__' not in d]
['append', 'clear', 'copy', 'count', 'extend', 'index', 'insert', 'pop', 'remove',
↪'reverse', 'sort']

>>> help(L.append)
Help on built-in function append:

append(...)
    L.append(object) -> None -- append object to end

>>> L.append(1)
>>> L
[1]
```

With the interpreter, documentation is never far from the student as they are programming.

There are also good IDEs for Python. IDLE is a cross-platform IDE for Python that is written in Python using Tkinter. PythonWin is a Windows-specific IDE. Emacs users will be happy to know that there is a very good Python mode for Emacs. All of these programming environments provide syntax highlighting, auto-indenting, and access to the interactive interpreter while coding. Consult the Python wiki for a full list of Python editing environments.

If you want to discuss Python's use in education, you may be interested in joining the edu-sig mailing list.

CAPÍTULO 2

Programming FAQ

2.1 General Questions

2.1.1 Is there a source code level debugger with breakpoints, single-stepping, etc.?

Yes.

Several debuggers for Python are described below, and the built-in function `breakpoint()` allows you to drop into any of them.

The pdb module is a simple but adequate console-mode debugger for Python. It is part of the standard Python library, and is `documented in the Library Reference Manual`. You can also write your own debugger by using the code for pdb as an example.

The IDLE interactive development environment, which is part of the standard Python distribution (normally available as Tools/scripts/idle), includes a graphical debugger.

PythonWin is a Python IDE that includes a GUI debugger based on pdb. The Pythonwin debugger colors breakpoints and has quite a few cool features such as debugging non-Pythonwin programs. Pythonwin is available as part of the Python for Windows Extensions project and as a part of the ActivePython distribution (see https://www.activestate.com/activepython).

Boa Constructor is an IDE and GUI builder that uses wxWidgets. It offers visual frame creation and manipulation, an object inspector, many views on the source like object browsers, inheritance hierarchies, doc string generated html documentation, an advanced debugger, integrated help, and Zope support.

Eric is an IDE built on PyQt and the Scintilla editing component.

Pydb is a version of the standard Python debugger pdb, modified for use with DDD (Data Display Debugger), a popular graphical debugger front end. Pydb can be found at http://bashdb.sourceforge.net/pydb/ and DDD can be found at https://www.gnu.org/software/ddd.

There are a number of commercial Python IDEs that include graphical debuggers. They include:

- Wing IDE (https://wingware.com/)
- Komodo IDE (https://komodoide.com/)

- PyCharm (https://www.jetbrains.com/pycharm/)

2.1.2 Is there a tool to help find bugs or perform static analysis?

Yes.

PyChecker is a static analysis tool that finds bugs in Python source code and warns about code complexity and style. You can get PyChecker from http://pychecker.sourceforge.net/.

Pylint is another tool that checks if a module satisfies a coding standard, and also makes it possible to write plug-ins to add a custom feature. In addition to the bug checking that PyChecker performs, Pylint offers some additional features such as checking line length, whether variable names are well-formed according to your coding standard, whether declared interfaces are fully implemented, and more. https://docs.pylint.org/ provides a full list of Pylint's features.

Static type checkers such as Mypy, Pyre, and Pytype can check type hints in Python source code.

2.1.3 How can I create a stand-alone binary from a Python script?

You don't need the ability to compile Python to C code if all you want is a stand-alone program that users can download and run without having to install the Python distribution first. There are a number of tools that determine the set of modules required by a program and bind these modules together with a Python binary to produce a single executable.

One is to use the freeze tool, which is included in the Python source tree as `Tools/freeze`. It converts Python byte code to C arrays; a C compiler you can embed all your modules into a new program, which is then linked with the standard Python modules.

It works by scanning your source recursively for import statements (in both forms) and looking for the modules in the standard Python path as well as in the source directory (for built-in modules). It then turns the bytecode for modules written in Python into C code (array initializers that can be turned into code objects using the marshal module) and creates a custom-made config file that only contains those built-in modules which are actually used in the program. It then compiles the generated C code and links it with the rest of the Python interpreter to form a self-contained binary which acts exactly like your script.

Obviously, freeze requires a C compiler. There are several other utilities which don't. One is Thomas Heller's py2exe (Windows only) at

> http://www.py2exe.org/

Another tool is Anthony Tuininga's cx_Freeze.

2.1.4 Are there coding standards or a style guide for Python programs?

Yes. The coding style required for standard library modules is documented as **PEP 8**.

2.2 Core Language

2.2.1 Why am I getting an UnboundLocalError when the variable has a value?

It can be a surprise to get the UnboundLocalError in previously working code when it is modified by adding an assignment statement somewhere in the body of a function.

This code:

```
>>> x = 10
>>> def bar():
...     print(x)
>>> bar()
10
```

works, but this code:

```
>>> x = 10
>>> def foo():
...     print(x)
...     x += 1
```

results in an UnboundLocalError:

```
>>> foo()
Traceback (most recent call last):
  ...
UnboundLocalError: local variable 'x' referenced before assignment
```

This is because when you make an assignment to a variable in a scope, that variable becomes local to that scope and shadows any similarly named variable in the outer scope. Since the last statement in foo assigns a new value to `x`, the compiler recognizes it as a local variable. Consequently when the earlier `print(x)` attempts to print the uninitialized local variable and an error results.

In the example above you can access the outer scope variable by declaring it global:

```
>>> x = 10
>>> def foobar():
...     global x
...     print(x)
...     x += 1
>>> foobar()
10
```

This explicit declaration is required in order to remind you that (unlike the superficially analogous situation with class and instance variables) you are actually modifying the value of the variable in the outer scope:

```
>>> print(x)
11
```

You can do a similar thing in a nested scope using the `nonlocal` keyword:

```
>>> def foo():
...    x = 10
...    def bar():
...        nonlocal x
...        print(x)
...        x += 1
...    bar()
...    print(x)
>>> foo()
10
11
```

2.2.2 What are the rules for local and global variables in Python?

In Python, variables that are only referenced inside a function are implicitly global. If a variable is assigned a value anywhere within the function's body, it's assumed to be a local unless explicitly declared as global.

Though a bit surprising at first, a moment's consideration explains this. On one hand, requiring `global` for assigned variables provides a bar against unintended side-effects. On the other hand, if `global` was required for all global references, you'd be using `global` all the time. You'd have to declare as global every reference to a built-in function or to a component of an imported module. This clutter would defeat the usefulness of the `global` declaration for identifying side-effects.

2.2.3 Why do lambdas defined in a loop with different values all return the same result?

Assume you use a for loop to define a few different lambdas (or even plain functions), e.g.:

```
>>> squares = []
>>> for x in range(5):
...     squares.append(lambda: x**2)
```

This gives you a list that contains 5 lambdas that calculate `x**2`. You might expect that, when called, they would return, respectively, `0`, `1`, `4`, `9`, and `16`. However, when you actually try you will see that they all return `16`:

```
>>> squares[2]()
16
>>> squares[4]()
16
```

This happens because `x` is not local to the lambdas, but is defined in the outer scope, and it is accessed when the lambda is called — not when it is defined. At the end of the loop, the value of `x` is `4`, so all the functions now return `4**2`, i.e. `16`. You can also verify this by changing the value of `x` and see how the results of the lambdas change:

```
>>> x = 8
>>> squares[2]()
64
```

In order to avoid this, you need to save the values in variables local to the lambdas, so that they don't rely on the value of the global `x`:

```
>>> squares = []
>>> for x in range(5):
...     squares.append(lambda n=x: n**2)
```

Here, `n=x` creates a new variable `n` local to the lambda and computed when the lambda is defined so that it has the same value that `x` had at that point in the loop. This means that the value of `n` will be `0` in the first lambda, `1` in the second, `2` in the third, and so on. Therefore each lambda will now return the correct result:

```
>>> squares[2]()
4
>>> squares[4]()
16
```

Note that this behaviour is not peculiar to lambdas, but applies to regular functions too.

2.2.4 How do I share global variables across modules?

The canonical way to share information across modules within a single program is to create a special module (often called config or cfg). Just import the config module in all modules of your application; the module then becomes available as a global name. Because there is only one instance of each module, any changes made to the module object get reflected everywhere. For example:

config.py:

```
x = 0   # Default value of the 'x' configuration setting
```

mod.py:

```
import config
config.x = 1
```

main.py:

```
import config
import mod
print(config.x)
```

Note that using a module is also the basis for implementing the Singleton design pattern, for the same reason.

2.2.5 What are the «best practices» for using import in a module?

In general, don't use `from modulename import *`. Doing so clutters the importer's namespace, and makes it much harder for linters to detect undefined names.

Import modules at the top of a file. Doing so makes it clear what other modules your code requires and avoids questions of whether the module name is in scope. Using one import per line makes it easy to add and delete module imports, but using multiple imports per line uses less screen space.

It's good practice if you import modules in the following order:

1. standard library modules – e.g. `sys`, `os`, `getopt`, `re`
2. third-party library modules (anything installed in Python's site-packages directory) – e.g. mx.DateTime, ZODB, PIL.Image, etc.
3. locally-developed modules

It is sometimes necessary to move imports to a function or class to avoid problems with circular imports. Gordon McMillan says:

> Circular imports are fine where both modules use the «import <module>» form of import. They fail when the 2nd module wants to grab a name out of the first («from module import name») and the import is at the top level. That's because names in the 1st are not yet available, because the first module is busy importing the 2nd.

In this case, if the second module is only used in one function, then the import can easily be moved into that function. By the time the import is called, the first module will have finished initializing, and the second module can do its import.

It may also be necessary to move imports out of the top level of code if some of the modules are platform-specific. In that case, it may not even be possible to import all of the modules at the top of the file. In this case, importing the correct modules in the corresponding platform-specific code is a good option.

Only move imports into a local scope, such as inside a function definition, if it's necessary to solve a problem such as avoiding a circular import or are trying to reduce the initialization time of a module. This technique is especially helpful if many of the imports are unnecessary depending on how the program executes. You may also want to move imports into a function if the modules are only ever used in that function. Note that loading a module the first time may be expensive because of the one time initialization of the module, but loading a module multiple times is virtually free, costing only a couple of dictionary lookups. Even if the module name has gone out of scope, the module is probably available in `sys.modules`.

2.2.6 Why are default values shared between objects?

This type of bug commonly bites neophyte programmers. Consider this function:

```
def foo(mydict={}):  # Danger: shared reference to one dict for all calls
    ... compute something ...
    mydict[key] = value
    return mydict
```

The first time you call this function, `mydict` contains a single item. The second time, `mydict` contains two items because when `foo()` begins executing, `mydict` starts out with an item already in it.

It is often expected that a function call creates new objects for default values. This is not what happens. Default values are created exactly once, when the function is defined. If that object is changed, like the dictionary in this example, subsequent calls to the function will refer to this changed object.

By definition, immutable objects such as numbers, strings, tuples, and `None`, are safe from change. Changes to mutable objects such as dictionaries, lists, and class instances can lead to confusion.

Because of this feature, it is good programming practice to not use mutable objects as default values. Instead, use `None` as the default value and inside the function, check if the parameter is `None` and create a new list/dictionary/whatever if it is. For example, don't write:

```
def foo(mydict={}):
    ...
```

but:

```
def foo(mydict=None):
    if mydict is None:
        mydict = {}  # create a new dict for local namespace
```

This feature can be useful. When you have a function that's time-consuming to compute, a common technique is to cache the parameters and the resulting value of each call to the function, and return the cached value if the same value is requested again. This is called «memoizing», and can be implemented like this:

```
# Callers can only provide two parameters and optionally pass _cache by keyword
def expensive(arg1, arg2, *, _cache={}):
    if (arg1, arg2) in _cache:
        return _cache[(arg1, arg2)]

    # Calculate the value
    result = ... expensive computation ...
    _cache[(arg1, arg2)] = result           # Store result in the cache
    return result
```

You could use a global variable containing a dictionary instead of the default value; it's a matter of taste.

2.2.7 How can I pass optional or keyword parameters from one function to another?

Collect the arguments using the `*` and `**` specifiers in the function's parameter list; this gives you the positional arguments as a tuple and the keyword arguments as a dictionary. You can then pass these arguments when calling another function by using `*` and `**`:

```
def f(x, *args, **kwargs):
    ...
    kwargs['width'] = '14.3c'
    ...
    g(x, *args, **kwargs)
```

2.2.8 What is the difference between arguments and parameters?

Parameters are defined by the names that appear in a function definition, whereas *arguments* are the values actually passed to a function when calling it. Parameters define what types of arguments a function can accept. For example, given the function definition:

```
def func(foo, bar=None, **kwargs):
    pass
```

foo, *bar* and *kwargs* are parameters of `func`. However, when calling `func`, for example:

```
func(42, bar=314, extra=somevar)
```

the values `42`, `314`, and `somevar` are arguments.

2.2.9 Why did changing list "y" also change list "x"?

If you wrote code like:

```
>>> x = []
>>> y = x
>>> y.append(10)
>>> y
[10]
>>> x
[10]
```

you might be wondering why appending an element to `y` changed `x` too.

There are two factors that produce this result:

1) Variables are simply names that refer to objects. Doing `y = x` doesn't create a copy of the list – it creates a new variable `y` that refers to the same object `x` refers to. This means that there is only one object (the list), and both `x` and `y` refer to it.

2) Lists are *mutable*, which means that you can change their content.

After the call to `append()`, the content of the mutable object has changed from `[]` to `[10]`. Since both the variables refer to the same object, using either name accesses the modified value `[10]`.

If we instead assign an immutable object to `x`:

```
>>> x = 5  # ints are immutable
>>> y = x
>>> x = x + 1  # 5 can't be mutated, we are creating a new object here
>>> x
6
>>> y
5
```

we can see that in this case `x` and `y` are not equal anymore. This is because integers are *immutable*, and when we do `x = x + 1` we are not mutating the int `5` by incrementing its value; instead, we are creating a new object (the int `6`) and assigning it to `x` (that is, changing which object `x` refers to). After this assignment we have two objects (the ints `6` and `5`) and two variables that refer to them (`x` now refers to `6` but `y` still refers to `5`).

Some operations (for example `y.append(10)` and `y.sort()`) mutate the object, whereas superficially similar operations (for example `y = y + [10]` and `sorted(y)`) create a new object. In general in Python (and in all cases in the standard library) a method that mutates an object will return `None` to help avoid getting the two types of operations confused. So if you mistakenly write `y.sort()` thinking it will give you a sorted copy of `y`, you'll instead end up with `None`, which will likely cause your program to generate an easily diagnosed error.

However, there is one class of operations where the same operation sometimes has different behaviors with different types: the augmented assignment operators. For example, `+=` mutates lists but not tuples or ints (`a_list += [1, 2, 3]` is equivalent to `a_list.extend([1, 2, 3])` and mutates `a_list`, whereas `some_tuple += (1, 2, 3)` and `some_int += 1` create new objects).

In other words:

- If we have a mutable object (`list`, `dict`, `set`, etc.), we can use some specific operations to mutate it and all the variables that refer to it will see the change.
- If we have an immutable object (`str`, `int`, `tuple`, etc.), all the variables that refer to it will always see the same value, but operations that transform that value into a new value always return a new object.

If you want to know if two variables refer to the same object or not, you can use the `is` operator, or the built-in function `id()`.

2.2.10 How do I write a function with output parameters (call by reference)?

Remember that arguments are passed by assignment in Python. Since assignment just creates references to objects, there's no alias between an argument name in the caller and callee, and so no call-by-reference per se. You can achieve the desired effect in a number of ways.

1) By returning a tuple of the results:

```
def func2(a, b):
    a = 'new-value'        # a and b are local names
    b = b + 1              # assigned to new objects
    return a, b            # return new values

x, y = 'old-value', 99
x, y = func2(x, y)
print(x, y)                # output: new-value 100
```

This is almost always the clearest solution.

2) By using global variables. This isn't thread-safe, and is not recommended.

3) By passing a mutable (changeable in-place) object:

```
def func1(a):
    a[0] = 'new-value'     # 'a' references a mutable list
    a[1] = a[1] + 1        # changes a shared object

args = ['old-value', 99]
func1(args)
print(args[0], args[1])    # output: new-value 100
```

4) By passing in a dictionary that gets mutated:

```
def func3(args):
    args['a'] = 'new-value'     # args is a mutable dictionary
    args['b'] = args['b'] + 1   # change it in-place

args = {'a': 'old-value', 'b': 99}
func3(args)
print(args['a'], args['b'])
```

5) Or bundle up values in a class instance:

```
class callByRef:
    def __init__(self, **args):
        for (key, value) in args.items():
            setattr(self, key, value)

def func4(args):
    args.a = 'new-value'        # args is a mutable callByRef
    args.b = args.b + 1         # change object in-place

args = callByRef(a='old-value', b=99)
func4(args)
print(args.a, args.b)
```

There's almost never a good reason to get this complicated.

Your best choice is to return a tuple containing the multiple results.

2.2.11 How do you make a higher order function in Python?

You have two choices: you can use nested scopes or you can use callable objects. For example, suppose you wanted to define `linear(a,b)` which returns a function `f(x)` that computes the value `a*x+b`. Using nested scopes:

```
def linear(a, b):
    def result(x):
        return a * x + b
    return result
```

Or using a callable object:

```
class linear:

    def __init__(self, a, b):
        self.a, self.b = a, b

    def __call__(self, x):
        return self.a * x + self.b
```

In both cases,

```
taxes = linear(0.3, 2)
```

gives a callable object where `taxes(10e6) == 0.3 * 10e6 + 2`.

The callable object approach has the disadvantage that it is a bit slower and results in slightly longer code. However, note that a collection of callables can share their signature via inheritance:

```
class exponential(linear):
    # __init__ inherited
    def __call__(self, x):
        return self.a * (x ** self.b)
```

Object can encapsulate state for several methods:

```
class counter:

    value = 0

    def set(self, x):
        self.value = x

    def up(self):
        self.value = self.value + 1

    def down(self):
        self.value = self.value - 1

count = counter()
inc, dec, reset = count.up, count.down, count.set
```

Here `inc()`, `dec()` and `reset()` act like functions which share the same counting variable.

2.2.12 How do I copy an object in Python?

In general, try `copy.copy()` or `copy.deepcopy()` for the general case. Not all objects can be copied, but most can.

Some objects can be copied more easily. Dictionaries have a `copy()` method:

```
newdict = olddict.copy()
```

Sequences can be copied by slicing:

```
new_l = l[:]
```

2.2.13 How can I find the methods or attributes of an object?

For an instance x of a user-defined class, `dir(x)` returns an alphabetized list of the names containing the instance attributes and methods and attributes defined by its class.

2.2.14 How can my code discover the name of an object?

Generally speaking, it can't, because objects don't really have names. Essentially, assignment always binds a name to a value; the same is true of `def` and `class` statements, but in that case the value is a callable. Consider the following code:

```
>>> class A:
...     pass
...
>>> B = A
>>> a = B()
>>> b = a
>>> print(b)
<__main__.A object at 0x16D07CC>
>>> print(a)
<__main__.A object at 0x16D07CC>
```

Arguably the class has a name: even though it is bound to two names and invoked through the name B the created instance is still reported as an instance of class A. However, it is impossible to say whether the instance's name is a or b, since both names are bound to the same value.

Generally speaking it should not be necessary for your code to «know the names» of particular values. Unless you are deliberately writing introspective programs, this is usually an indication that a change of approach might be beneficial.

In comp.lang.python, Fredrik Lundh once gave an excellent analogy in answer to this question:

> The same way as you get the name of that cat you found on your porch: the cat (object) itself cannot tell you its name, and it doesn't really care – so the only way to find out what it's called is to ask all your neighbours (namespaces) if it's their cat (object)…
>
> ….and don't be surprised if you'll find that it's known by many names, or no name at all!

2.2.15 What's up with the comma operator's precedence?

Comma is not an operator in Python. Consider this session:

```
>>> "a" in "b", "a"
(False, 'a')
```

Since the comma is not an operator, but a separator between expressions the above is evaluated as if you had entered:

```
("a" in "b"), "a"
```

not:

```
"a" in ("b", "a")
```

The same is true of the various assignment operators (=, += etc). They are not truly operators but syntactic delimiters in assignment statements.

2.2.16 Is there an equivalent of C's «?:» ternary operator?

Yes, there is. The syntax is as follows:

```
[on_true] if [expression] else [on_false]

x, y = 50, 25
small = x if x < y else y
```

Before this syntax was introduced in Python 2.5, a common idiom was to use logical operators:

```
[expression] and [on_true] or [on_false]
```

However, this idiom is unsafe, as it can give wrong results when *on_true* has a false boolean value. Therefore, it is always better to use the `... if ... else ...` form.

2.2.17 Is it possible to write obfuscated one-liners in Python?

Yes. Usually this is done by nesting `lambda` within `lambda`. See the following three examples, due to Ulf Bartelt:

```
from functools import reduce

# Primes < 1000
print(list(filter(None,map(lambda y:y*reduce(lambda x,y:x*y!=0,
map(lambda x,y=y:y%x,range(2,int(pow(y,0.5)+1))),1),range(2,1000)))))

# First 10 Fibonacci numbers
print(list(map(lambda x,f=lambda x,f:(f(x-1,f)+f(x-2,f)) if x>1 else 1:
f(x,f), range(10))))

# Mandelbrot set
print((lambda Ru,Ro,Iu,Io,IM,Sx,Sy:reduce(lambda x,y:x+y,map(lambda y,
Iu=Iu,Io=Io,Ru=Ru,Ro=Ro,Sy=Sy,L=lambda yc,Iu=Iu,Io=Io,Ru=Ru,Ro=Ro,i=IM,
Sx=Sx,Sy=Sy:reduce(lambda x,y:x+y,map(lambda x,xc=Ru,yc=yc,Ru=Ru,Ro=Ro,
i=i,Sx=Sx,F=lambda xc,yc,x,y,k,f=lambda xc,yc,x,y,k,f:(k<=0)or (x*x+y*y
>=4.0) or 1+f(xc,yc,x*x-y*y+xc,2.0*x*y+yc,k-1,f):f(xc,yc,x,y,k,f):chr(
64+F(Ru+x*(Ro-Ru)/Sx,yc,0,0,i)),range(Sx))):L(Iu+y*(Io-Iu)/Sy),range(Sy
))))(-2.1, 0.7, -1.2, 1.2, 30, 80, 24))
#    \___ ___/  \___ ___/  |   |   |__ lines on screen
#        V          V      |   |______ columns on screen
#        |          |      |__________ maximum of "iterations"
#        |          |_________________ range on y axis
#        |____________________________ range on x axis
```

Don't try this at home, kids!

2.2.18 What does the slash(/) in the parameter list of a function mean?

A slash in the argument list of a function denotes that the parameters prior to it are positional-only. Positional-only parameters are the ones without an externally-usable name. Upon calling a function that accepts positional-only parameters, arguments are mapped to parameters based solely on their position. For example, `pow()` is a function that accepts positional-only parameters. Its documentation looks like this:

```
>>> help(pow)
Help on built-in function pow in module builtins:

pow(x, y, z=None, /)
   Equivalent to x**y (with two arguments) or x**y % z (with three arguments)

   Some types, such as ints, are able to use a more efficient algorithm when
   invoked using the three argument form.
```

The slash at the end of the parameter list means that all three parameters are positional-only. Thus, calling `pow()` with keyword aguments would lead to an error:

```
>>> pow(x=3, y=4)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: pow() takes no keyword arguments
```

Note that as of this writing this is only documentational and no valid syntax in Python, although there is **PEP 570**, which proposes a syntax for position-only parameters in Python.

2.3 Numbers and strings

2.3.1 How do I specify hexadecimal and octal integers?

To specify an octal digit, precede the octal value with a zero, and then a lower or uppercase «o». For example, to set the variable «a» to the octal value «10» (8 in decimal), type:

```
>>> a = 0o10
>>> a
8
```

Hexadecimal is just as easy. Simply precede the hexadecimal number with a zero, and then a lower or uppercase «x». Hexadecimal digits can be specified in lower or uppercase. For example, in the Python interpreter:

```
>>> a = 0xa5
>>> a
165
>>> b = 0XB2
>>> b
178
```

2.3.2 Why does -22 // 10 return -3?

It's primarily driven by the desire that `i % j` have the same sign as `j`. If you want that, and also want:

```
i == (i // j) * j + (i % j)
```

then integer division has to return the floor. C also requires that identity to hold, and then compilers that truncate `i // j` need to make `i % j` have the same sign as `i`.

There are few real use cases for `i % j` when `j` is negative. When `j` is positive, there are many, and in virtually all of them it's more useful for `i % j` to be `>= 0`. If the clock says 10 now, what did it say 200 hours ago? `-190 % 12 == 2` is useful; `-190 % 12 == -10` is a bug waiting to bite.

2.3.3 How do I convert a string to a number?

For integers, use the built-in `int()` type constructor, e.g. `int('144') == 144`. Similarly, `float()` converts to floating-point, e.g. `float('144') == 144.0`.

By default, these interpret the number as decimal, so that `int('0144') == 144` and `int('0x144')` raises `ValueError`. `int(string, base)` takes the base to convert from as a second optional argument, so `int('0x144', 16) == 324`. If the base is specified as 0, the number is interpreted using Python's rules: a leading "0o" indicates octal, and "0x" indicates a hex number.

Do not use the built-in function `eval()` if all you need is to convert strings to numbers. `eval()` will be significantly slower and it presents a security risk: someone could pass you a Python expression that might have unwanted side effects. For example, someone could pass `__import__('os').system("rm -rf $HOME")` which would erase your home directory.

`eval()` also has the effect of interpreting numbers as Python expressions, so that e.g. `eval('09')` gives a syntax error because Python does not allow leading "0" in a decimal number (except "0").

2.3.4 How do I convert a number to a string?

To convert, e.g., the number 144 to the string "144", use the built-in type constructor `str()`. If you want a hexadecimal or octal representation, use the built-in functions `hex()` or `oct()`. For fancy formatting, see the f-strings and formatstrings sections, e.g. `"{:04d}".format(144)` yields `'0144'` and `"{:.3f}".format(1.0/3.0)` yields `'0.333'`.

2.3.5 How do I modify a string in place?

You can't, because strings are immutable. In most situations, you should simply construct a new string from the various parts you want to assemble it from. However, if you need an object with the ability to modify in-place unicode data, try using an `io.StringIO` object or the `array` module:

```
>>> import io
>>> s = "Hello, world"
>>> sio = io.StringIO(s)
>>> sio.getvalue()
'Hello, world'
>>> sio.seek(7)
7
>>> sio.write("there!")
6
>>> sio.getvalue()
'Hello, there!'
```

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```
>>> import array
>>> a = array.array('u', s)
>>> print(a)
array('u', 'Hello, world')
>>> a[0] = 'y'
>>> print(a)
array('u', 'yello, world')
>>> a.tounicode()
'yello, world'
```

2.3.6 How do I use strings to call functions/methods?

There are various techniques.

- The best is to use a dictionary that maps strings to functions. The primary advantage of this technique is that the strings do not need to match the names of the functions. This is also the primary technique used to emulate a case construct:

```
def a():
    pass

def b():
    pass

dispatch = {'go': a, 'stop': b}  # Note lack of parens for funcs

dispatch[get_input()]()  # Note trailing parens to call function
```

- Use the built-in function `getattr()`:

```
import foo
getattr(foo, 'bar')()
```

Note that `getattr()` works on any object, including classes, class instances, modules, and so on.

This is used in several places in the standard library, like this:

```
class Foo:
    def do_foo(self):
        ...

    def do_bar(self):
        ...

f = getattr(foo_instance, 'do_' + opname)
f()
```

- Use `locals()` or `eval()` to resolve the function name:

```
def myFunc():
    print("hello")

fname = "myFunc"
```

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```
f = locals()[fname]
f()

f = eval(fname)
f()
```

Note: Using `eval()` is slow and dangerous. If you don't have absolute control over the contents of the string, someone could pass a string that resulted in an arbitrary function being executed.

2.3.7 Is there an equivalent to Perl's chomp() for removing trailing newlines from strings?

You can use `S.rstrip("\r\n")` to remove all occurrences of any line terminator from the end of the string `S` without removing other trailing whitespace. If the string `S` represents more than one line, with several empty lines at the end, the line terminators for all the blank lines will be removed:

```
>>> lines = ("line 1 \r\n"
...          "\r\n"
...          "\r\n")
>>> lines.rstrip("\n\r")
'line 1 '
```

Since this is typically only desired when reading text one line at a time, using `S.rstrip()` this way works well.

2.3.8 Is there a scanf() or sscanf() equivalent?

Not as such.

For simple input parsing, the easiest approach is usually to split the line into whitespace-delimited words using the `split()` method of string objects and then convert decimal strings to numeric values using `int()` or `float()`. `split()` supports an optional «sep» parameter which is useful if the line uses something other than whitespace as a separator.

For more complicated input parsing, regular expressions are more powerful than C's `sscanf()` and better suited for the task.

2.3.9 What does "UnicodeDecodeError" or "UnicodeEncodeError" error mean?

See the unicode-howto.

2.4 Performance

2.4.1 My program is too slow. How do I speed it up?

That's a tough one, in general. First, here are a list of things to remember before diving further:

- Performance characteristics vary across Python implementations. This FAQ focuses on *CPython*.
- Behaviour can vary across operating systems, especially when talking about I/O or multi-threading.

- You should always find the hot spots in your program *before* attempting to optimize any code (see the `profile` module).
- Writing benchmark scripts will allow you to iterate quickly when searching for improvements (see the `timeit` module).
- It is highly recommended to have good code coverage (through unit testing or any other technique) before potentially introducing regressions hidden in sophisticated optimizations.

That being said, there are many tricks to speed up Python code. Here are some general principles which go a long way towards reaching acceptable performance levels:

- Making your algorithms faster (or changing to faster ones) can yield much larger benefits than trying to sprinkle micro-optimization tricks all over your code.
- Use the right data structures. Study documentation for the bltin-types and the `collections` module.
- When the standard library provides a primitive for doing something, it is likely (although not guaranteed) to be faster than any alternative you may come up with. This is doubly true for primitives written in C, such as builtins and some extension types. For example, be sure to use either the `list.sort()` built-in method or the related `sorted()` function to do sorting (and see the sortinghowto for examples of moderately advanced usage).
- Abstractions tend to create indirections and force the interpreter to work more. If the levels of indirection outweigh the amount of useful work done, your program will be slower. You should avoid excessive abstraction, especially under the form of tiny functions or methods (which are also often detrimental to readability).

If you have reached the limit of what pure Python can allow, there are tools to take you further away. For example, Cython can compile a slightly modified version of Python code into a C extension, and can be used on many different platforms. Cython can take advantage of compilation (and optional type annotations) to make your code significantly faster than when interpreted. If you are confident in your C programming skills, you can also write a C extension module yourself.

Ver también:

The wiki page devoted to performance tips.

2.4.2 What is the most efficient way to concatenate many strings together?

`str` and `bytes` objects are immutable, therefore concatenating many strings together is inefficient as each concatenation creates a new object. In the general case, the total runtime cost is quadratic in the total string length.

To accumulate many `str` objects, the recommended idiom is to place them into a list and call `str.join()` at the end:

```
chunks = []
for s in my_strings:
    chunks.append(s)
result = ''.join(chunks)
```

(another reasonably efficient idiom is to use `io.StringIO`)

To accumulate many `bytes` objects, the recommended idiom is to extend a `bytearray` object using in-place concatenation (the += operator):

```
result = bytearray()
for b in my_bytes_objects:
    result += b
```

2.5 Sequences (Tuples/Lists)

2.5.1 How do I convert between tuples and lists?

The type constructor `tuple(seq)` converts any sequence (actually, any iterable) into a tuple with the same items in the same order.

For example, `tuple([1, 2, 3])` yields `(1, 2, 3)` and `tuple('abc')` yields `('a', 'b', 'c')`. If the argument is a tuple, it does not make a copy but returns the same object, so it is cheap to call `tuple()` when you aren't sure that an object is already a tuple.

The type constructor `list(seq)` converts any sequence or iterable into a list with the same items in the same order. For example, `list((1, 2, 3))` yields `[1, 2, 3]` and `list('abc')` yields `['a', 'b', 'c']`. If the argument is a list, it makes a copy just like `seq[:]` would.

2.5.2 What's a negative index?

Python sequences are indexed with positive numbers and negative numbers. For positive numbers 0 is the first index 1 is the second index and so forth. For negative indices -1 is the last index and -2 is the penultimate (next to last) index and so forth. Think of `seq[-n]` as the same as `seq[len(seq)-n]`.

Using negative indices can be very convenient. For example `S[:-1]` is all of the string except for its last character, which is useful for removing the trailing newline from a string.

2.5.3 How do I iterate over a sequence in reverse order?

Use the `reversed()` built-in function, which is new in Python 2.4:

```
for x in reversed(sequence):
    ...  # do something with x ...
```

This won't touch your original sequence, but build a new copy with reversed order to iterate over.

With Python 2.3, you can use an extended slice syntax:

```
for x in sequence[::-1]:
    ...  # do something with x ...
```

2.5.4 How do you remove duplicates from a list?

See the Python Cookbook for a long discussion of many ways to do this:

> https://code.activestate.com/recipes/52560/

If you don't mind reordering the list, sort it and then scan from the end of the list, deleting duplicates as you go:

```
if mylist:
    mylist.sort()
    last = mylist[-1]
    for i in range(len(mylist)-2, -1, -1):
        if last == mylist[i]:
            del mylist[i]
        else:
            last = mylist[i]
```

If all elements of the list may be used as set keys (i.e. they are all *hashable*) this is often faster

```
mylist = list(set(mylist))
```

This converts the list into a set, thereby removing duplicates, and then back into a list.

2.5.5 How do you make an array in Python?

Use a list:

```
["this", 1, "is", "an", "array"]
```

Lists are equivalent to C or Pascal arrays in their time complexity; the primary difference is that a Python list can contain objects of many different types.

The `array` module also provides methods for creating arrays of fixed types with compact representations, but they are slower to index than lists. Also note that the Numeric extensions and others define array-like structures with various characteristics as well.

To get Lisp-style linked lists, you can emulate cons cells using tuples:

```
lisp_list = ("like",  ("this",  ("example", None) ) )
```

If mutability is desired, you could use lists instead of tuples. Here the analogue of lisp car is `lisp_list[0]` and the analogue of cdr is `lisp_list[1]`. Only do this if you're sure you really need to, because it's usually a lot slower than using Python lists.

2.5.6 How do I create a multidimensional list?

You probably tried to make a multidimensional array like this:

```
>>> A = [[None] * 2] * 3
```

This looks correct if you print it:

```
>>> A
[[None, None], [None, None], [None, None]]
```

But when you assign a value, it shows up in multiple places:

```
>>> A[0][0] = 5
>>> A
[[5, None], [5, None], [5, None]]
```

The reason is that replicating a list with `*` doesn't create copies, it only creates references to the existing objects. The `*3` creates a list containing 3 references to the same list of length two. Changes to one row will show in all rows, which is almost certainly not what you want.

The suggested approach is to create a list of the desired length first and then fill in each element with a newly created list:

```
A = [None] * 3
for i in range(3):
    A[i] = [None] * 2
```

This generates a list containing 3 different lists of length two. You can also use a list comprehension:

```
w, h = 2, 3
A = [[None] * w for i in range(h)]
```

Or, you can use an extension that provides a matrix datatype; NumPy is the best known.

2.5.7 How do I apply a method to a sequence of objects?

Use a list comprehension:

```
result = [obj.method() for obj in mylist]
```

2.5.8 Why does a_tuple[i] += ["item"] raise an exception when the addition works?

This is because of a combination of the fact that augmented assignment operators are *assignment* operators, and the difference between mutable and immutable objects in Python.

This discussion applies in general when augmented assignment operators are applied to elements of a tuple that point to mutable objects, but we'll use a `list` and `+=` as our exemplar.

If you wrote:

```
>>> a_tuple = (1, 2)
>>> a_tuple[0] += 1
Traceback (most recent call last):
   ...
TypeError: 'tuple' object does not support item assignment
```

The reason for the exception should be immediately clear: `1` is added to the object `a_tuple[0]` points to (`1`), producing the result object, `2`, but when we attempt to assign the result of the computation, `2`, to element `0` of the tuple, we get an error because we can't change what an element of a tuple points to.

Under the covers, what this augmented assignment statement is doing is approximately this:

```
>>> result = a_tuple[0] + 1
>>> a_tuple[0] = result
Traceback (most recent call last):
  ...
TypeError: 'tuple' object does not support item assignment
```

It is the assignment part of the operation that produces the error, since a tuple is immutable.

When you write something like:

```
>>> a_tuple = (['foo'], 'bar')
>>> a_tuple[0] += ['item']
Traceback (most recent call last):
  ...
TypeError: 'tuple' object does not support item assignment
```

The exception is a bit more surprising, and even more surprising is the fact that even though there was an error, the append worked:

```
>>> a_tuple[0]
['foo', 'item']
```

To see why this happens, you need to know that (a) if an object implements an `__iadd__` magic method, it gets called when the `+=` augmented assignment is executed, and its return value is what gets used in the assignment statement; and (b) for lists, `__iadd__` is equivalent to calling `extend` on the list and returning the list. That's why we say that for lists, `+=` is a «shorthand» for `list.extend`:

```
>>> a_list = []
>>> a_list += [1]
>>> a_list
[1]
```

This is equivalent to:

```
>>> result = a_list.__iadd__([1])
>>> a_list = result
```

The object pointed to by a_list has been mutated, and the pointer to the mutated object is assigned back to `a_list`. The end result of the assignment is a no-op, since it is a pointer to the same object that `a_list` was previously pointing to, but the assignment still happens.

Thus, in our tuple example what is happening is equivalent to:

```
>>> result = a_tuple[0].__iadd__(['item'])
>>> a_tuple[0] = result
Traceback (most recent call last):
  ...
TypeError: 'tuple' object does not support item assignment
```

The `__iadd__` succeeds, and thus the list is extended, but even though `result` points to the same object that `a_tuple[0]` already points to, that final assignment still results in an error, because tuples are immutable.

2.5.9 I want to do a complicated sort: can you do a Schwartzian Transform in Python?

The technique, attributed to Randal Schwartz of the Perl community, sorts the elements of a list by a metric which maps each element to its «sort value». In Python, use the `key` argument for the `list.sort()` method:

```
Isorted = L[:]
Isorted.sort(key=lambda s: int(s[10:15]))
```

2.5.10 How can I sort one list by values from another list?

Merge them into an iterator of tuples, sort the resulting list, and then pick out the element you want.

```
>>> list1 = ["what", "I'm", "sorting", "by"]
>>> list2 = ["something", "else", "to", "sort"]
>>> pairs = zip(list1, list2)
>>> pairs = sorted(pairs)
>>> pairs
[("I'm", 'else'), ('by', 'sort'), ('sorting', 'to'), ('what', 'something')]
>>> result = [x[1] for x in pairs]
>>> result
['else', 'sort', 'to', 'something']
```

An alternative for the last step is:

```
>>> result = []
>>> for p in pairs: result.append(p[1])
```

If you find this more legible, you might prefer to use this instead of the final list comprehension. However, it is almost twice as slow for long lists. Why? First, the `append()` operation has to reallocate memory, and while it uses some tricks to avoid doing that each time, it still has to do it occasionally, and that costs quite a bit. Second, the expression «result.append» requires an extra attribute lookup, and third, there's a speed reduction from having to make all those function calls.

2.6 Objects

2.6.1 What is a class?

A class is the particular object type created by executing a class statement. Class objects are used as templates to create instance objects, which embody both the data (attributes) and code (methods) specific to a datatype.

A class can be based on one or more other classes, called its base class(es). It then inherits the attributes and methods of its base classes. This allows an object model to be successively refined by inheritance. You might have a generic `Mailbox` class that provides basic accessor methods for a mailbox, and subclasses such as `MboxMailbox`, `MaildirMailbox`, `OutlookMailbox` that handle various specific mailbox formats.

2.6.2 What is a method?

A method is a function on some object `x` that you normally call as `x.name(arguments...)`. Methods are defined as functions inside the class definition:

```
class C:
    def meth(self, arg):
        return arg * 2 + self.attribute
```

2.6.3 What is self?

Self is merely a conventional name for the first argument of a method. A method defined as `meth(self, a, b, c)` should be called as `x.meth(a, b, c)` for some instance `x` of the class in which the definition occurs; the called method will think it is called as `meth(x, a, b, c)`.

See also *Why must "self" be used explicitly in method definitions and calls?*.

2.6.4 How do I check if an object is an instance of a given class or of a subclass of it?

Use the built-in function `isinstance(obj, cls)`. You can check if an object is an instance of any of a number of classes by providing a tuple instead of a single class, e.g. `isinstance(obj, (class1, class2, ...))`, and can also check whether an object is one of Python's built-in types, e.g. `isinstance(obj, str)` or `isinstance(obj, (int, float, complex))`.

Note that most programs do not use `isinstance()` on user-defined classes very often. If you are developing the classes yourself, a more proper object-oriented style is to define methods on the classes that encapsulate a particular behaviour, instead of checking the object's class and doing a different thing based on what class it is. For example, if you have a function that does something:

```
def search(obj):
    if isinstance(obj, Mailbox):
        ...  # code to search a mailbox
    elif isinstance(obj, Document):
        ...  # code to search a document
    elif ...
```

A better approach is to define a `search()` method on all the classes and just call it:

```
class Mailbox:
    def search(self):
        ...  # code to search a mailbox

class Document:
    def search(self):
        ...  # code to search a document

obj.search()
```

2.6.5 What is delegation?

Delegation is an object oriented technique (also called a design pattern). Let's say you have an object `x` and want to change the behaviour of just one of its methods. You can create a new class that provides a new implementation of the method you're interested in changing and delegates all other methods to the corresponding method of `x`.

Python programmers can easily implement delegation. For example, the following class implements a class that behaves like a file but converts all written data to uppercase:

```
class UpperOut:

    def __init__(self, outfile):
        self._outfile = outfile

    def write(self, s):
        self._outfile.write(s.upper())

    def __getattr__(self, name):
        return getattr(self._outfile, name)
```

Here the `UpperOut` class redefines the `write()` method to convert the argument string to uppercase before calling the underlying `self._outfile.write()` method. All other methods are delegated to the underlying `self._outfile` object. The delegation is accomplished via the `__getattr__` method; consult the language reference for more information about controlling attribute access.

Note that for more general cases delegation can get trickier. When attributes must be set as well as retrieved, the class must define a `__setattr__()` method too, and it must do so carefully. The basic implementation of `__setattr__()` is roughly equivalent to the following:

```
class X:
    ...
    def __setattr__(self, name, value):
        self.__dict__[name] = value
    ...
```

Most `__setattr__()` implementations must modify `self.__dict__` to store local state for self without causing an infinite recursion.

2.6.6 How do I call a method defined in a base class from a derived class that overrides it?

Use the built-in `super()` function:

```
class Derived(Base):
    def meth(self):
        super(Derived, self).meth()
```

For version prior to 3.0, you may be using classic classes: For a class definition such as `class Derived(Base): ...` you can call method `meth()` defined in `Base` (or one of `Base`'s base classes) as `Base.meth(self, arguments...)`. Here, `Base.meth` is an unbound method, so you need to provide the `self` argument.

2.6.7 How can I organize my code to make it easier to change the base class?

You could define an alias for the base class, assign the real base class to it before your class definition, and use the alias throughout your class. Then all you have to change is the value assigned to the alias. Incidentally, this trick is also handy if you want to decide dynamically (e.g. depending on availability of resources) which base class to use. Example:

```
BaseAlias = <real base class>

class Derived(BaseAlias):
    def meth(self):
        BaseAlias.meth(self)
        ...
```

2.6.8 How do I create static class data and static class methods?

Both static data and static methods (in the sense of C++ or Java) are supported in Python.

For static data, simply define a class attribute. To assign a new value to the attribute, you have to explicitly use the class name in the assignment:

```
class C:
    count = 0   # number of times C.__init__ called

    def __init__(self):
        C.count = C.count + 1

    def getcount(self):
        return C.count  # or return self.count
```

`c.count` also refers to `C.count` for any `c` such that `isinstance(c, C)` holds, unless overridden by `c` itself or by some class on the base-class search path from `c.__class__` back to `C`.

Caution: within a method of C, an assignment like `self.count = 42` creates a new and unrelated instance named «count» in `self`'s own dict. Rebinding of a class-static data name must always specify the class whether inside a method or not:

```
C.count = 314
```

Static methods are possible:

```
class C:
    @staticmethod
    def static(arg1, arg2, arg3):
        # No 'self' parameter!
        ...
```

However, a far more straightforward way to get the effect of a static method is via a simple module-level function:

```
def getcount():
    return C.count
```

If your code is structured so as to define one class (or tightly related class hierarchy) per module, this supplies the desired encapsulation.

2.6.9 How can I overload constructors (or methods) in Python?

This answer actually applies to all methods, but the question usually comes up first in the context of constructors.

In C++ you'd write

```
class C {
    C() { cout << "No arguments\n"; }
    C(int i) { cout << "Argument is " << i << "\n"; }
}
```

In Python you have to write a single constructor that catches all cases using default arguments. For example:

```
class C:
    def __init__(self, i=None):
        if i is None:
            print("No arguments")
        else:
            print("Argument is", i)
```

This is not entirely equivalent, but close enough in practice.

You could also try a variable-length argument list, e.g.

```
def __init__(self, *args):
    ...
```

The same approach works for all method definitions.

2.6.10 I try to use __spam and I get an error about _SomeClassName__spam.

Variable names with double leading underscores are «mangled» to provide a simple but effective way to define class private variables. Any identifier of the form `__spam` (at least two leading underscores, at most one trailing underscore) is textually replaced with `_classname__spam`, where `classname` is the current class name with any leading underscores stripped.

This doesn't guarantee privacy: an outside user can still deliberately access the «_classname__spam» attribute, and private values are visible in the object's `__dict__`. Many Python programmers never bother to use private variable names at all.

2.6.11 My class defines __del__ but it is not called when I delete the object.

There are several possible reasons for this.

The del statement does not necessarily call `__del__()` – it simply decrements the object's reference count, and if this reaches zero `__del__()` is called.

If your data structures contain circular links (e.g. a tree where each child has a parent reference and each parent has a list of children) the reference counts will never go back to zero. Once in a while Python runs an algorithm to detect such cycles, but the garbage collector might run some time after the last reference to your data structure vanishes, so your `__del__()` method may be called at an inconvenient and random time. This is inconvenient if you're trying to reproduce a problem. Worse, the order in which object's `__del__()` methods are executed is arbitrary. You can run `gc.collect()` to force a collection, but there *are* pathological cases where objects will never be collected.

Despite the cycle collector, it's still a good idea to define an explicit `close()` method on objects to be called whenever you're done with them. The `close()` method can then remove attributes that refer to subobjects. Don't call `__del__()` directly – `__del__()` should call `close()` and `close()` should make sure that it can be called more than once for the same object.

Another way to avoid cyclical references is to use the `weakref` module, which allows you to point to objects without incrementing their reference count. Tree data structures, for instance, should use weak references for their parent and sibling references (if they need them!).

Finally, if your `__del__()` method raises an exception, a warning message is printed to `sys.stderr`.

2.6.12 How do I get a list of all instances of a given class?

Python does not keep track of all instances of a class (or of a built-in type). You can program the class's constructor to keep track of all instances by keeping a list of weak references to each instance.

2.6.13 Why does the result of `id()` appear to be not unique?

The `id()` builtin returns an integer that is guaranteed to be unique during the lifetime of the object. Since in CPython, this is the object's memory address, it happens frequently that after an object is deleted from memory, the next freshly created object is allocated at the same position in memory. This is illustrated by this example:

```
>>> id(1000)
13901272
>>> id(2000)
13901272
```

The two ids belong to different integer objects that are created before, and deleted immediately after execution of the `id()` call. To be sure that objects whose id you want to examine are still alive, create another reference to the object:

```
>>> a = 1000; b = 2000
>>> id(a)
13901272
>>> id(b)
13891296
```

2.7 Modules

2.7.1 How do I create a .pyc file?

When a module is imported for the first time (or when the source file has changed since the current compiled file was created) a `.pyc` file containing the compiled code should be created in a `__pycache__` subdirectory of the directory containing the `.py` file. The `.pyc` file will have a filename that starts with the same name as the `.py` file, and ends with `.pyc`, with a middle component that depends on the particular `python` binary that created it. (See **PEP 3147** for details.)

One reason that a `.pyc` file may not be created is a permissions problem with the directory containing the source file, meaning that the `__pycache__` subdirectory cannot be created. This can happen, for example, if you develop as one user but run as another, such as if you are testing with a web server.

Unless the `PYTHONDONTWRITEBYTECODE` environment variable is set, creation of a .pyc file is automatic if you're importing a module and Python has the ability (permissions, free space, etc...) to create a `__pycache__` subdirectory and write the compiled module to that subdirectory.

Running Python on a top level script is not considered an import and no `.pyc` will be created. For example, if you have a top-level module `foo.py` that imports another module `xyz.py`, when you run `foo` (by typing `python foo.py` as a shell command), a `.pyc` will be created for `xyz` because `xyz` is imported, but no `.pyc` file will be created for `foo` since `foo.py` isn't being imported.

If you need to create a `.pyc` file for `foo` – that is, to create a `.pyc` file for a module that is not imported – you can, using the `py_compile` and `compileall` modules.

The `py_compile` module can manually compile any module. One way is to use the `compile()` function in that module interactively:

```
>>> import py_compile
>>> py_compile.compile('foo.py')
```

This will write the `.pyc` to a `__pycache__` subdirectory in the same location as `foo.py` (or you can override that with the optional parameter `cfile`).

You can also automatically compile all files in a directory or directories using the `compileall` module. You can do it from the shell prompt by running `compileall.py` and providing the path of a directory containing Python files to compile:

```
python -m compileall .
```

2.7.2 How do I find the current module name?

A module can find out its own module name by looking at the predefined global variable `__name__`. If this has the value `'__main__'`, the program is running as a script. Many modules that are usually used by importing them also provide a command-line interface or a self-test, and only execute this code after checking `__name__`:

```
def main():
    print('Running test...')
    ...

if __name__ == '__main__':
    main()
```

2.7.3 How can I have modules that mutually import each other?

Suppose you have the following modules:

foo.py:

```
from bar import bar_var
foo_var = 1
```

bar.py:

```
from foo import foo_var
bar_var = 2
```

The problem is that the interpreter will perform the following steps:

- main imports foo
- Empty globals for foo are created
- foo is compiled and starts executing
- foo imports bar
- Empty globals for bar are created
- bar is compiled and starts executing
- bar imports foo (which is a no-op since there already is a module named foo)
- bar.foo_var = foo.foo_var

The last step fails, because Python isn't done with interpreting `foo` yet and the global symbol dictionary for `foo` is still empty.

The same thing happens when you use `import foo`, and then try to access `foo.foo_var` in global code.

There are (at least) three possible workarounds for this problem.

Guido van Rossum recommends avoiding all uses of `from <module> import ...`, and placing all code inside functions. Initializations of global variables and class variables should use constants or built-in functions only. This means everything from an imported module is referenced as `<module>.<name>`.

Jim Roskind suggests performing steps in the following order in each module:

- exports (globals, functions, and classes that don't need imported base classes)
- `import` statements
- active code (including globals that are initialized from imported values).

van Rossum doesn't like this approach much because the imports appear in a strange place, but it does work.

Matthias Urlichs recommends restructuring your code so that the recursive import is not necessary in the first place.

These solutions are not mutually exclusive.

2.7.4 __import__("x.y.z") returns <module "x">; how do I get z?

Consider using the convenience function `import_module()` from `importlib` instead:

```
z = importlib.import_module('x.y.z')
```

2.7.5 When I edit an imported module and reimport it, the changes don't show up. Why does this happen?

For reasons of efficiency as well as consistency, Python only reads the module file on the first time a module is imported. If it didn't, in a program consisting of many modules where each one imports the same basic module, the basic module would be parsed and re-parsed many times. To force re-reading of a changed module, do this:

```
import importlib
import modname
importlib.reload(modname)
```

Warning: this technique is not 100% fool-proof. In particular, modules containing statements like

```
from modname import some_objects
```

will continue to work with the old version of the imported objects. If the module contains class definitions, existing class instances will *not* be updated to use the new class definition. This can result in the following paradoxical behaviour:

```
>>> import importlib
>>> import cls
>>> c = cls.C()                # Create an instance of C
>>> importlib.reload(cls)
<module 'cls' from 'cls.py'>
>>> isinstance(c, cls.C)       # isinstance is false?!?
False
```

The nature of the problem is made clear if you print out the «identity» of the class objects:

```
>>> hex(id(c.__class__))
'0x7352a0'
>>> hex(id(cls.C))
'0x4198d0'
```

CAPÍTULO 3

Design and History FAQ

3.1 Why does Python use indentation for grouping of statements?

Guido van Rossum believes that using indentation for grouping is extremely elegant and contributes a lot to the clarity of the average Python program. Most people learn to love this feature after a while.

Since there are no begin/end brackets there cannot be a disagreement between grouping perceived by the parser and the human reader. Occasionally C programmers will encounter a fragment of code like this:

```
if (x <= y)
        x++;
        y--;
z++;
```

Only the `x++` statement is executed if the condition is true, but the indentation leads you to believe otherwise. Even experienced C programmers will sometimes stare at it a long time wondering why `y` is being decremented even for `x > y`.

Because there are no begin/end brackets, Python is much less prone to coding-style conflicts. In C there are many different ways to place the braces. If you're used to reading and writing code that uses one style, you will feel at least slightly uneasy when reading (or being required to write) another style.

Many coding styles place begin/end brackets on a line by themselves. This makes programs considerably longer and wastes valuable screen space, making it harder to get a good overview of a program. Ideally, a function should fit on one screen (say, 20–30 lines). 20 lines of Python can do a lot more work than 20 lines of C. This is not solely due to the lack of begin/end brackets – the lack of declarations and the high-level data types are also responsible – but the indentation-based syntax certainly helps.

3.2 Why am I getting strange results with simple arithmetic operations?

See the next question.

3.3 Why are floating-point calculations so inaccurate?

Users are often surprised by results like this:

```
>>> 1.2 - 1.0
0.19999999999999996
```

and think it is a bug in Python. It's not. This has little to do with Python, and much more to do with how the underlying platform handles floating-point numbers.

The `float` type in CPython uses a C `double` for storage. A `float` object's value is stored in binary floating-point with a fixed precision (typically 53 bits) and Python uses C operations, which in turn rely on the hardware implementation in the processor, to perform floating-point operations. This means that as far as floating-point operations are concerned, Python behaves like many popular languages including C and Java.

Many numbers that can be written easily in decimal notation cannot be expressed exactly in binary floating-point. For example, after:

```
>>> x = 1.2
```

the value stored for `x` is a (very good) approximation to the decimal value `1.2`, but is not exactly equal to it. On a typical machine, the actual stored value is:

```
1.0011001100110011001100110011001100110011001100110011 (binary)
```

which is exactly:

```
1.1999999999999999555910790149937383830547332763671875 (decimal)
```

The typical precision of 53 bits provides Python floats with 15–16 decimal digits of accuracy.

For a fuller explanation, please see the floating point arithmetic chapter in the Python tutorial.

3.4 Why are Python strings immutable?

There are several advantages.

One is performance: knowing that a string is immutable means we can allocate space for it at creation time, and the storage requirements are fixed and unchanging. This is also one of the reasons for the distinction between tuples and lists.

Another advantage is that strings in Python are considered as «elemental» as numbers. No amount of activity will change the value 8 to anything else, and in Python, no amount of activity will change the string «eight» to anything else.

3.5 Why must "self" be used explicitly in method definitions and calls?

The idea was borrowed from Modula-3. It turns out to be very useful, for a variety of reasons.

First, it's more obvious that you are using a method or instance attribute instead of a local variable. Reading `self.x` or `self.meth()` makes it absolutely clear that an instance variable or method is used even if you don't know the class definition by heart. In C++, you can sort of tell by the lack of a local variable declaration (assuming globals are rare or easily recognizable) – but in Python, there are no local variable declarations, so you'd have to look up the class definition to be sure. Some C++ and Java coding standards call for instance attributes to have an `m_` prefix, so this explicitness is still useful in those languages, too.

Second, it means that no special syntax is necessary if you want to explicitly reference or call the method from a particular class. In C++, if you want to use a method from a base class which is overridden in a derived class, you have to use the `::` operator – in Python you can write `baseclass.methodname(self, <argument list>)`. This is particularly useful for `__init__()` methods, and in general in cases where a derived class method wants to extend the base class method of the same name and thus has to call the base class method somehow.

Finally, for instance variables it solves a syntactic problem with assignment: since local variables in Python are (by definition!) those variables to which a value is assigned in a function body (and that aren't explicitly declared global), there has to be some way to tell the interpreter that an assignment was meant to assign to an instance variable instead of to a local variable, and it should preferably be syntactic (for efficiency reasons). C++ does this through declarations, but Python doesn't have declarations and it would be a pity having to introduce them just for this purpose. Using the explicit `self.var` solves this nicely. Similarly, for using instance variables, having to write `self.var` means that references to unqualified names inside a method don't have to search the instance's directories. To put it another way, local variables and instance variables live in two different namespaces, and you need to tell Python which namespace to use.

3.6 Why can't I use an assignment in an expression?

Many people used to C or Perl complain that they want to use this C idiom:

```
while (line = readline(f)) {
    // do something with line
}
```

where in Python you're forced to write this:

```
while True:
    line = f.readline()
    if not line:
        break
    ...  # do something with line
```

The reason for not allowing assignment in Python expressions is a common, hard-to-find bug in those other languages, caused by this construct:

```
if (x = 0) {
    // error handling
}
else {
    // code that only works for nonzero x
}
```

The error is a simple typo: `x = 0`, which assigns 0 to the variable `x`, was written while the comparison `x == 0` is certainly what was intended.

Many alternatives have been proposed. Most are hacks that save some typing but use arbitrary or cryptic syntax or keywords, and fail the simple criterion for language change proposals: it should intuitively suggest the proper meaning to a human reader who has not yet been introduced to the construct.

An interesting phenomenon is that most experienced Python programmers recognize the `while True` idiom and don't seem to be missing the assignment in expression construct much; it's only newcomers who express a strong desire to add this to the language.

There's an alternative way of spelling this that seems attractive but is generally less robust than the «while True» solution:

```
line = f.readline()
while line:
    ...  # do something with line...
    line = f.readline()
```

The problem with this is that if you change your mind about exactly how you get the next line (e.g. you want to change it into `sys.stdin.readline()`) you have to remember to change two places in your program – the second occurrence is hidden at the bottom of the loop.

The best approach is to use iterators, making it possible to loop through objects using the `for` statement. For example, *file objects* support the iterator protocol, so you can write simply:

```
for line in f:
    ...  # do something with line...
```

3.7 Why does Python use methods for some functionality (e.g. list.index()) but functions for other (e.g. len(list))?

As Guido said:

> (a) For some operations, prefix notation just reads better than postfix – prefix (and infix!) operations have a long tradition in mathematics which likes notations where the visuals help the mathematician thinking about a problem. Compare the easy with which we rewrite a formula like x*(a+b) into x*a + x*b to the clumsiness of doing the same thing using a raw OO notation.
>
> (b) When I read code that says len(x) I *know* that it is asking for the length of something. This tells me two things: the result is an integer, and the argument is some kind of container. To the contrary, when I read x.len(), I have to already know that x is some kind of container implementing an interface or inheriting from a class that has a standard len(). Witness the confusion we occasionally have when a class that is not implementing a mapping has a get() or keys() method, or something that isn't a file has a write() method.
>
> —https://mail.python.org/pipermail/python-3000/2006-November/004643.html

3.8 Why is join() a string method instead of a list or tuple method?

Strings became much more like other standard types starting in Python 1.6, when methods were added which give the same functionality that has always been available using the functions of the string module. Most of these new methods have been widely accepted, but the one which appears to make some programmers feel uncomfortable is:

```
", ".join(['1', '2', '4', '8', '16'])
```

which gives the result:

```
"1, 2, 4, 8, 16"
```

There are two common arguments against this usage.

The first runs along the lines of: «It looks really ugly using a method of a string literal (string constant)», to which the answer is that it might, but a string literal is just a fixed value. If the methods are to be allowed on names bound to strings there is no logical reason to make them unavailable on literals.

The second objection is typically cast as: «I am really telling a sequence to join its members together with a string constant». Sadly, you aren't. For some reason there seems to be much less difficulty with having `split()` as a string method, since in that case it is easy to see that

```
"1, 2, 4, 8, 16".split(", ")
```

is an instruction to a string literal to return the substrings delimited by the given separator (or, by default, arbitrary runs of white space).

`join()` is a string method because in using it you are telling the separator string to iterate over a sequence of strings and insert itself between adjacent elements. This method can be used with any argument which obeys the rules for sequence objects, including any new classes you might define yourself. Similar methods exist for bytes and bytearray objects.

3.9 How fast are exceptions?

A try/except block is extremely efficient if no exceptions are raised. Actually catching an exception is expensive. In versions of Python prior to 2.0 it was common to use this idiom:

```
try:
    value = mydict[key]
except KeyError:
    mydict[key] = getvalue(key)
    value = mydict[key]
```

This only made sense when you expected the dict to have the key almost all the time. If that wasn't the case, you coded it like this:

```
if key in mydict:
    value = mydict[key]
else:
    value = mydict[key] = getvalue(key)
```

For this specific case, you could also use `value = dict.setdefault(key, getvalue(key))`, but only if the `getvalue()` call is cheap enough because it is evaluated in all cases.

3.10 Why isn't there a switch or case statement in Python?

You can do this easily enough with a sequence of `if... elif... elif... else`. There have been some proposals for switch statement syntax, but there is no consensus (yet) on whether and how to do range tests. See **PEP 275** for complete details and the current status.

For cases where you need to choose from a very large number of possibilities, you can create a dictionary mapping case values to functions to call. For example:

```
def function_1(...):
    ...

functions = {'a': function_1,
             'b': function_2,
             'c': self.method_1, ...}

func = functions[value]
func()
```

For calling methods on objects, you can simplify yet further by using the `getattr()` built-in to retrieve methods with a particular name:

```
def visit_a(self, ...):
    ...
...

def dispatch(self, value):
    method_name = 'visit_' + str(value)
    method = getattr(self, method_name)
    method()
```

It's suggested that you use a prefix for the method names, such as `visit_` in this example. Without such a prefix, if values are coming from an untrusted source, an attacker would be able to call any method on your object.

3.11 Can't you emulate threads in the interpreter instead of relying on an OS-specific thread implementation?

Answer 1: Unfortunately, the interpreter pushes at least one C stack frame for each Python stack frame. Also, extensions can call back into Python at almost random moments. Therefore, a complete threads implementation requires thread support for C.

Answer 2: Fortunately, there is Stackless Python, which has a completely redesigned interpreter loop that avoids the C stack.

3.12 Why can't lambda expressions contain statements?

Python lambda expressions cannot contain statements because Python's syntactic framework can't handle statements nested inside expressions. However, in Python, this is not a serious problem. Unlike lambda forms in other languages, where they add functionality, Python lambdas are only a shorthand notation if you're too lazy to define a function.

Functions are already first class objects in Python, and can be declared in a local scope. Therefore the only advantage of using a lambda instead of a locally-defined function is that you don't need to invent a name for the function – but that's just a local variable to which the function object (which is exactly the same type of object that a lambda expression yields) is assigned!

3.13 Can Python be compiled to machine code, C or some other language?

Cython compiles a modified version of Python with optional annotations into C extensions. Nuitka is an up-and-coming compiler of Python into C++ code, aiming to support the full Python language. For compiling to Java you can consider VOC.

3.14 How does Python manage memory?

The details of Python memory management depend on the implementation. The standard implementation of Python, *CPython*, uses reference counting to detect inaccessible objects, and another mechanism to collect reference cycles, periodically executing a cycle detection algorithm which looks for inaccessible cycles and deletes the objects involved. The `gc` module provides functions to perform a garbage collection, obtain debugging statistics, and tune the collector's parameters.

Other implementations (such as Jython or PyPy), however, can rely on a different mechanism such as a full-blown garbage collector. This difference can cause some subtle porting problems if your Python code depends on the behavior of the reference counting implementation.

In some Python implementations, the following code (which is fine in CPython) will probably run out of file descriptors:

```
for file in very_long_list_of_files:
    f = open(file)
    c = f.read(1)
```

Indeed, using CPython's reference counting and destructor scheme, each new assignment to *f* closes the previous file. With a traditional GC, however, those file objects will only get collected (and closed) at varying and possibly long intervals.

If you want to write code that will work with any Python implementation, you should explicitly close the file or use the `with` statement; this will work regardless of memory management scheme:

```
for file in very_long_list_of_files:
    with open(file) as f:
        c = f.read(1)
```

3.15 Why doesn't CPython use a more traditional garbage collection scheme?

For one thing, this is not a C standard feature and hence it's not portable. (Yes, we know about the Boehm GC library. It has bits of assembler code for *most* common platforms, not for all of them, and although it is mostly transparent, it isn't completely transparent; patches are required to get Python to work with it.)

Traditional GC also becomes a problem when Python is embedded into other applications. While in a standalone Python it's fine to replace the standard malloc() and free() with versions provided by the GC library, an application embedding Python may want to have its *own* substitute for malloc() and free(), and may not want Python's. Right now, CPython works with anything that implements malloc() and free() properly.

3.16 Why isn't all memory freed when CPython exits?

Objects referenced from the global namespaces of Python modules are not always deallocated when Python exits. This may happen if there are circular references. There are also certain bits of memory that are allocated by the C library that are impossible to free (e.g. a tool like Purify will complain about these). Python is, however, aggressive about cleaning up memory on exit and does try to destroy every single object.

If you want to force Python to delete certain things on deallocation use the `atexit` module to run a function that will force those deletions.

3.17 Why are there separate tuple and list data types?

Lists and tuples, while similar in many respects, are generally used in fundamentally different ways. Tuples can be thought of as being similar to Pascal records or C structs; they're small collections of related data which may be of different types which are operated on as a group. For example, a Cartesian coordinate is appropriately represented as a tuple of two or three numbers.

Lists, on the other hand, are more like arrays in other languages. They tend to hold a varying number of objects all of which have the same type and which are operated on one-by-one. For example, `os.listdir('.')` returns a list of strings representing the files in the current directory. Functions which operate on this output would generally not break if you added another file or two to the directory.

Tuples are immutable, meaning that once a tuple has been created, you can't replace any of its elements with a new value. Lists are mutable, meaning that you can always change a list's elements. Only immutable elements can be used as dictionary keys, and hence only tuples and not lists can be used as keys.

3.18 How are lists implemented in CPython?

CPython's lists are really variable-length arrays, not Lisp-style linked lists. The implementation uses a contiguous array of references to other objects, and keeps a pointer to this array and the array's length in a list head structure.

This makes indexing a list `a[i]` an operation whose cost is independent of the size of the list or the value of the index.

When items are appended or inserted, the array of references is resized. Some cleverness is applied to improve the performance of appending items repeatedly; when the array must be grown, some extra space is allocated so the next few times don't require an actual resize.

3.19 How are dictionaries implemented in CPython?

CPython's dictionaries are implemented as resizable hash tables. Compared to B-trees, this gives better performance for lookup (the most common operation by far) under most circumstances, and the implementation is simpler.

Dictionaries work by computing a hash code for each key stored in the dictionary using the `hash()` built-in function. The hash code varies widely depending on the key and a per-process seed; for example, «Python» could hash to -539294296 while «python», a string that differs by a single bit, could hash to 1142331976. The hash code is then used to calculate a location in an internal array where the value will be stored. Assuming that you're storing keys that all have different hash values, this means that dictionaries take constant time – O(1), in Big-O notation – to retrieve a key.

3.20 Why must dictionary keys be immutable?

The hash table implementation of dictionaries uses a hash value calculated from the key value to find the key. If the key were a mutable object, its value could change, and thus its hash could also change. But since whoever changes the key object can't tell that it was being used as a dictionary key, it can't move the entry around in the dictionary. Then, when you try to look up the same object in the dictionary it won't be found because its hash value is different. If you tried to look up the old value it wouldn't be found either, because the value of the object found in that hash bin would be different.

If you want a dictionary indexed with a list, simply convert the list to a tuple first; the function `tuple(L)` creates a tuple with the same entries as the list `L`. Tuples are immutable and can therefore be used as dictionary keys.

Some unacceptable solutions that have been proposed:

- Hash lists by their address (object ID). This doesn't work because if you construct a new list with the same value it won't be found; e.g.:

  ```
  mydict = {[1, 2]: '12'}
  print(mydict[[1, 2]])
  ```

  would raise a `KeyError` exception because the id of the `[1, 2]` used in the second line differs from that in the first line. In other words, dictionary keys should be compared using `==`, not using `is`.

- Make a copy when using a list as a key. This doesn't work because the list, being a mutable object, could contain a reference to itself, and then the copying code would run into an infinite loop.

- Allow lists as keys but tell the user not to modify them. This would allow a class of hard-to-track bugs in programs when you forgot or modified a list by accident. It also invalidates an important invariant of dictionaries: every value in `d.keys()` is usable as a key of the dictionary.

- Mark lists as read-only once they are used as a dictionary key. The problem is that it's not just the top-level object that could change its value; you could use a tuple containing a list as a key. Entering anything as a key into a dictionary would require marking all objects reachable from there as read-only – and again, self-referential objects could cause an infinite loop.

There is a trick to get around this if you need to, but use it at your own risk: You can wrap a mutable structure inside a class instance which has both a `__eq__()` and a `__hash__()` method. You must then make sure that the hash value for all such wrapper objects that reside in a dictionary (or other hash based structure), remain fixed while the object is in the dictionary (or other structure).

```
class ListWrapper:
    def __init__(self, the_list):
        self.the_list = the_list

    def __eq__(self, other):
        return self.the_list == other.the_list
```

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```
    def __hash__(self):
        l = self.the_list
        result = 98767 - len(l)*555
        for i, el in enumerate(l):
            try:
                result = result + (hash(el) % 9999999) * 1001 + i
            except Exception:
                result = (result % 7777777) + i * 333
        return result
```

Note that the hash computation is complicated by the possibility that some members of the list may be unhashable and also by the possibility of arithmetic overflow.

Furthermore it must always be the case that if `o1 == o2` (ie `o1.__eq__(o2) is True`) then `hash(o1) == hash(o2)` (ie, `o1.__hash__() == o2.__hash__()`), regardless of whether the object is in a dictionary or not. If you fail to meet these restrictions dictionaries and other hash based structures will misbehave.

In the case of ListWrapper, whenever the wrapper object is in a dictionary the wrapped list must not change to avoid anomalies. Don't do this unless you are prepared to think hard about the requirements and the consequences of not meeting them correctly. Consider yourself warned.

3.21 Why doesn't list.sort() return the sorted list?

In situations where performance matters, making a copy of the list just to sort it would be wasteful. Therefore, `list.sort()` sorts the list in place. In order to remind you of that fact, it does not return the sorted list. This way, you won't be fooled into accidentally overwriting a list when you need a sorted copy but also need to keep the unsorted version around.

If you want to return a new list, use the built-in `sorted()` function instead. This function creates a new list from a provided iterable, sorts it and returns it. For example, here's how to iterate over the keys of a dictionary in sorted order:

```
for key in sorted(mydict):
    ...  # do whatever with mydict[key]...
```

3.22 How do you specify and enforce an interface spec in Python?

An interface specification for a module as provided by languages such as C++ and Java describes the prototypes for the methods and functions of the module. Many feel that compile-time enforcement of interface specifications helps in the construction of large programs.

Python 2.6 adds an `abc` module that lets you define Abstract Base Classes (ABCs). You can then use `isinstance()` and `issubclass()` to check whether an instance or a class implements a particular ABC. The `collections.abc` module defines a set of useful ABCs such as `Iterable`, `Container`, and `MutableMapping`.

For Python, many of the advantages of interface specifications can be obtained by an appropriate test discipline for components. There is also a tool, PyChecker, which can be used to find problems due to subclassing.

A good test suite for a module can both provide a regression test and serve as a module interface specification and a set of examples. Many Python modules can be run as a script to provide a simple «self test.» Even modules which use complex external interfaces can often be tested in isolation using trivial «stub» emulations of the external interface. The `doctest` and `unittest` modules or third-party test frameworks can be used to construct exhaustive test suites that exercise every line of code in a module.

An appropriate testing discipline can help build large complex applications in Python as well as having interface specifications would. In fact, it can be better because an interface specification cannot test certain properties of a program. For example, the `append()` method is expected to add new elements to the end of some internal list; an interface specification cannot test that your `append()` implementation will actually do this correctly, but it's trivial to check this property in a test suite.

Writing test suites is very helpful, and you might want to design your code with an eye to making it easily tested. One increasingly popular technique, test-directed development, calls for writing parts of the test suite first, before you write any of the actual code. Of course Python allows you to be sloppy and not write test cases at all.

3.23 Why is there no goto?

You can use exceptions to provide a «structured goto» that even works across function calls. Many feel that exceptions can conveniently emulate all reasonable uses of the «go» or «goto» constructs of C, Fortran, and other languages. For example:

```
class label(Exception): pass  # declare a label

try:
    ...
    if condition: raise label()  # goto label
    ...
except label:  # where to goto
    pass
...
```

This doesn't allow you to jump into the middle of a loop, but that's usually considered an abuse of goto anyway. Use sparingly.

3.24 Why can't raw strings (r-strings) end with a backslash?

More precisely, they can't end with an odd number of backslashes: the unpaired backslash at the end escapes the closing quote character, leaving an unterminated string.

Raw strings were designed to ease creating input for processors (chiefly regular expression engines) that want to do their own backslash escape processing. Such processors consider an unmatched trailing backslash to be an error anyway, so raw strings disallow that. In return, they allow you to pass on the string quote character by escaping it with a backslash. These rules work well when r-strings are used for their intended purpose.

If you're trying to build Windows pathnames, note that all Windows system calls accept forward slashes too:

```
f = open("/mydir/file.txt")  # works fine!
```

If you're trying to build a pathname for a DOS command, try e.g. one of

```
dir = r"\this\is\my\dos\dir" "\\"
dir = r"\this\is\my\dos\dir\ "[:-1]
dir = "\\this\\is\\my\\dos\\dir\\"
```

3.25 Why doesn't Python have a «with» statement for attribute assignments?

Python has a "with" statement that wraps the execution of a block, calling code on the entrance and exit from the block. Some language have a construct that looks like this:

```
with obj:
    a = 1               # equivalent to obj.a = 1
    total = total + 1   # obj.total = obj.total + 1
```

In Python, such a construct would be ambiguous.

Other languages, such as Object Pascal, Delphi, and C++, use static types, so it's possible to know, in an unambiguous way, what member is being assigned to. This is the main point of static typing – the compiler *always* knows the scope of every variable at compile time.

Python uses dynamic types. It is impossible to know in advance which attribute will be referenced at runtime. Member attributes may be added or removed from objects on the fly. This makes it impossible to know, from a simple reading, what attribute is being referenced: a local one, a global one, or a member attribute?

For instance, take the following incomplete snippet:

```
def foo(a):
    with a:
        print(x)
```

The snippet assumes that «a» must have a member attribute called «x». However, there is nothing in Python that tells the interpreter this. What should happen if «a» is, let us say, an integer? If there is a global variable named «x», will it be used inside the with block? As you see, the dynamic nature of Python makes such choices much harder.

The primary benefit of «with» and similar language features (reduction of code volume) can, however, easily be achieved in Python by assignment. Instead of:

```
function(args).mydict[index][index].a = 21
function(args).mydict[index][index].b = 42
function(args).mydict[index][index].c = 63
```

write this:

```
ref = function(args).mydict[index][index]
ref.a = 21
ref.b = 42
ref.c = 63
```

This also has the side-effect of increasing execution speed because name bindings are resolved at run-time in Python, and the second version only needs to perform the resolution once.

3.26 Why are colons required for the if/while/def/class statements?

The colon is required primarily to enhance readability (one of the results of the experimental ABC language). Consider this:

```
if a == b
    print(a)
```

versus

```
if a == b:
    print(a)
```

Notice how the second one is slightly easier to read. Notice further how a colon sets off the example in this FAQ answer; it's a standard usage in English.

Another minor reason is that the colon makes it easier for editors with syntax highlighting; they can look for colons to decide when indentation needs to be increased instead of having to do a more elaborate parsing of the program text.

3.27 Why does Python allow commas at the end of lists and tuples?

Python lets you add a trailing comma at the end of lists, tuples, and dictionaries:

```
[1, 2, 3,]
('a', 'b', 'c',)
d = {
    "A": [1, 5],
    "B": [6, 7],  # last trailing comma is optional but good style
}
```

There are several reasons to allow this.

When you have a literal value for a list, tuple, or dictionary spread across multiple lines, it's easier to add more elements because you don't have to remember to add a comma to the previous line. The lines can also be reordered without creating a syntax error.

Accidentally omitting the comma can lead to errors that are hard to diagnose. For example:

```
x = [
  "fee",
  "fie"
  "foo",
  "fum"
]
```

This list looks like it has four elements, but it actually contains three: «fee», «fiefoo» and «fum». Always adding the comma avoids this source of error.

Allowing the trailing comma may also make programmatic code generation easier.

CAPÍTULO 4

Library and Extension FAQ

4.1 General Library Questions

4.1.1 How do I find a module or application to perform task X?

Check the Library Reference to see if there's a relevant standard library module. (Eventually you'll learn what's in the standard library and will be able to skip this step.)

For third-party packages, search the Python Package Index or try Google or another Web search engine. Searching for «Python» plus a keyword or two for your topic of interest will usually find something helpful.

4.1.2 Where is the math.py (socket.py, regex.py, etc.) source file?

If you can't find a source file for a module it may be a built-in or dynamically loaded module implemented in C, C++ or other compiled language. In this case you may not have the source file or it may be something like `mathmodule.c`, somewhere in a C source directory (not on the Python Path).

There are (at least) three kinds of modules in Python:

1) modules written in Python (.py);
2) modules written in C and dynamically loaded (.dll, .pyd, .so, .sl, etc);
3) modules written in C and linked with the interpreter; to get a list of these, type:

```
import sys
print(sys.builtin_module_names)
```

4.1.3 How do I make a Python script executable on Unix?

You need to do two things: the script file's mode must be executable and the first line must begin with `#!` followed by the path of the Python interpreter.

The first is done by executing `chmod +x scriptfile` or perhaps `chmod 755 scriptfile`.

The second can be done in a number of ways. The most straightforward way is to write

```
#!/usr/local/bin/python
```

as the very first line of your file, using the pathname for where the Python interpreter is installed on your platform.

If you would like the script to be independent of where the Python interpreter lives, you can use the **env** program. Almost all Unix variants support the following, assuming the Python interpreter is in a directory on the user's `PATH`:

```
#!/usr/bin/env python
```

Don't do this for CGI scripts. The `PATH` variable for CGI scripts is often very minimal, so you need to use the actual absolute pathname of the interpreter.

Occasionally, a user's environment is so full that the **/usr/bin/env** program fails; or there's no env program at all. In that case, you can try the following hack (due to Alex Rezinsky):

```
#! /bin/sh
""":"
exec python $0 ${1+"$@"}
"""
```

The minor disadvantage is that this defines the script's __doc__ string. However, you can fix that by adding

```
__doc__ = """...Whatever..."""
```

4.1.4 Is there a curses/termcap package for Python?

For Unix variants: The standard Python source distribution comes with a curses module in the Modules subdirectory, though it's not compiled by default. (Note that this is not available in the Windows distribution – there is no curses module for Windows.)

The `curses` module supports basic curses features as well as many additional functions from ncurses and SYSV curses such as colour, alternative character set support, pads, and mouse support. This means the module isn't compatible with operating systems that only have BSD curses, but there don't seem to be any currently maintained OSes that fall into this category.

For Windows: use the consolelib module.

4.1.5 Is there an equivalent to C's onexit() in Python?

The `atexit` module provides a register function that is similar to C's `onexit()`.

4.1.6 Why don't my signal handlers work?

The most common problem is that the signal handler is declared with the wrong argument list. It is called as

```
handler(signum, frame)
```

so it should be declared with two arguments:

```
def handler(signum, frame):
    ...
```

4.2 Common tasks

4.2.1 How do I test a Python program or component?

Python comes with two testing frameworks. The `doctest` module finds examples in the docstrings for a module and runs them, comparing the output with the expected output given in the docstring.

The `unittest` module is a fancier testing framework modelled on Java and Smalltalk testing frameworks.

To make testing easier, you should use good modular design in your program. Your program should have almost all functionality encapsulated in either functions or class methods – and this sometimes has the surprising and delightful effect of making the program run faster (because local variable accesses are faster than global accesses). Furthermore the program should avoid depending on mutating global variables, since this makes testing much more difficult to do.

The «global main logic» of your program may be as simple as

```
if __name__ == "__main__":
    main_logic()
```

at the bottom of the main module of your program.

Once your program is organized as a tractable collection of functions and class behaviours you should write test functions that exercise the behaviours. A test suite that automates a sequence of tests can be associated with each module. This sounds like a lot of work, but since Python is so terse and flexible it's surprisingly easy. You can make coding much more pleasant and fun by writing your test functions in parallel with the «production code», since this makes it easy to find bugs and even design flaws earlier.

«Support modules» that are not intended to be the main module of a program may include a self-test of the module.

```
if __name__ == "__main__":
    self_test()
```

Even programs that interact with complex external interfaces may be tested when the external interfaces are unavailable by using «fake» interfaces implemented in Python.

4.2.2 How do I create documentation from doc strings?

The pydoc module can create HTML from the doc strings in your Python source code. An alternative for creating API documentation purely from docstrings is epydoc. Sphinx can also include docstring content.

4.2.3 How do I get a single keypress at a time?

For Unix variants there are several solutions. It's straightforward to do this using curses, but curses is a fairly large module to learn.

4.3 Threads

4.3.1 How do I program using threads?

Be sure to use the threading module and not the _thread module. The threading module builds convenient abstractions on top of the low-level primitives provided by the _thread module.

Aahz has a set of slides from his threading tutorial that are helpful; see http://www.pythoncraft.com/OSCON2001/.

4.3.2 None of my threads seem to run: why?

As soon as the main thread exits, all threads are killed. Your main thread is running too quickly, giving the threads no time to do any work.

A simple fix is to add a sleep to the end of the program that's long enough for all the threads to finish:

```
import threading, time

def thread_task(name, n):
    for i in range(n):
        print(name, i)

for i in range(10):
    T = threading.Thread(target=thread_task, args=(str(i), i))
    T.start()

time.sleep(10)  # <---------------------------!
```

But now (on many platforms) the threads don't run in parallel, but appear to run sequentially, one at a time! The reason is that the OS thread scheduler doesn't start a new thread until the previous thread is blocked.

A simple fix is to add a tiny sleep to the start of the run function:

```
def thread_task(name, n):
    time.sleep(0.001)  # <--------------------!
    for i in range(n):
        print(name, i)

for i in range(10):
    T = threading.Thread(target=thread_task, args=(str(i), i))
    T.start()

time.sleep(10)
```

Instead of trying to guess a good delay value for `time.sleep()`, it's better to use some kind of semaphore mechanism. One idea is to use the `queue` module to create a queue object, let each thread append a token to the queue when it finishes, and let the main thread read as many tokens from the queue as there are threads.

4.3.3 How do I parcel out work among a bunch of worker threads?

The easiest way is to use the new `concurrent.futures` module, especially the `ThreadPoolExecutor` class.

Or, if you want fine control over the dispatching algorithm, you can write your own logic manually. Use the `queue` module to create a queue containing a list of jobs. The `Queue` class maintains a list of objects and has a `.put(obj)` method that adds items to the queue and a `.get()` method to return them. The class will take care of the locking necessary to ensure that each job is handed out exactly once.

Here's a trivial example:

```
import threading, queue, time

# The worker thread gets jobs off the queue.  When the queue is empty, it
# assumes there will be no more work and exits.
# (Realistically workers will run until terminated.)
def worker():
    print('Running worker')
    time.sleep(0.1)
    while True:
        try:
            arg = q.get(block=False)
        except queue.Empty:
            print('Worker', threading.currentThread(), end=' ')
            print('queue empty')
            break
        else:
            print('Worker', threading.currentThread(), end=' ')
            print('running with argument', arg)
            time.sleep(0.5)

# Create queue
q = queue.Queue()

# Start a pool of 5 workers
for i in range(5):
    t = threading.Thread(target=worker, name='worker %i' % (i+1))
    t.start()

# Begin adding work to the queue
for i in range(50):
    q.put(i)

# Give threads time to run
print('Main thread sleeping')
time.sleep(5)
```

When run, this will produce the following output:

```
Running worker
Running worker
Running worker
Running worker
```

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```
Running worker
Main thread sleeping
Worker <Thread(worker 1, started 130283832797456)> running with argument 0
Worker <Thread(worker 2, started 130283824404752)> running with argument 1
Worker <Thread(worker 3, started 130283816012048)> running with argument 2
Worker <Thread(worker 4, started 130283807619344)> running with argument 3
Worker <Thread(worker 5, started 130283799226640)> running with argument 4
Worker <Thread(worker 1, started 130283832797456)> running with argument 5
...
```

Consult the module's documentation for more details; the `Queue` class provides a featureful interface.

4.3.4 What kinds of global value mutation are thread-safe?

A *global interpreter lock* (GIL) is used internally to ensure that only one thread runs in the Python VM at a time. In general, Python offers to switch among threads only between bytecode instructions; how frequently it switches can be set via `sys.setswitchinterval()`. Each bytecode instruction and therefore all the C implementation code reached from each instruction is therefore atomic from the point of view of a Python program.

In theory, this means an exact accounting requires an exact understanding of the PVM bytecode implementation. In practice, it means that operations on shared variables of built-in data types (ints, lists, dicts, etc) that «look atomic» really are.

For example, the following operations are all atomic (L, L1, L2 are lists, D, D1, D2 are dicts, x, y are objects, i, j are ints):

```
L.append(x)
L1.extend(L2)
x = L[i]
x = L.pop()
L1[i:j] = L2
L.sort()
x = y
x.field = y
D[x] = y
D1.update(D2)
D.keys()
```

These aren't:

```
i = i+1
L.append(L[-1])
L[i] = L[j]
D[x] = D[x] + 1
```

Operations that replace other objects may invoke those other objects" `__del__()` method when their reference count reaches zero, and that can affect things. This is especially true for the mass updates to dictionaries and lists. When in doubt, use a mutex!

4.3.5 Can't we get rid of the Global Interpreter Lock?

The *global interpreter lock* (GIL) is often seen as a hindrance to Python's deployment on high-end multiprocessor server machines, because a multi-threaded Python program effectively only uses one CPU, due to the insistence that (almost) all Python code can only run while the GIL is held.

Back in the days of Python 1.5, Greg Stein actually implemented a comprehensive patch set (the «free threading» patches) that removed the GIL and replaced it with fine-grained locking. Adam Olsen recently did a similar experiment in his python-safethread project. Unfortunately, both experiments exhibited a sharp drop in single-thread performance (at least 30% slower), due to the amount of fine-grained locking necessary to compensate for the removal of the GIL.

This doesn't mean that you can't make good use of Python on multi-CPU machines! You just have to be creative with dividing the work up between multiple *processes* rather than multiple *threads*. The `ProcessPoolExecutor` class in the new `concurrent.futures` module provides an easy way of doing so; the `multiprocessing` module provides a lower-level API in case you want more control over dispatching of tasks.

Judicious use of C extensions will also help; if you use a C extension to perform a time-consuming task, the extension can release the GIL while the thread of execution is in the C code and allow other threads to get some work done. Some standard library modules such as `zlib` and `hashlib` already do this.

It has been suggested that the GIL should be a per-interpreter-state lock rather than truly global; interpreters then wouldn't be able to share objects. Unfortunately, this isn't likely to happen either. It would be a tremendous amount of work, because many object implementations currently have global state. For example, small integers and short strings are cached; these caches would have to be moved to the interpreter state. Other object types have their own free list; these free lists would have to be moved to the interpreter state. And so on.

And I doubt that it can even be done in finite time, because the same problem exists for 3rd party extensions. It is likely that 3rd party extensions are being written at a faster rate than you can convert them to store all their global state in the interpreter state.

And finally, once you have multiple interpreters not sharing any state, what have you gained over running each interpreter in a separate process?

4.4 Input and Output

4.4.1 How do I delete a file? (And other file questions...)

Use `os.remove(filename)` or `os.unlink(filename)`; for documentation, see the `os` module. The two functions are identical; `unlink()` is simply the name of the Unix system call for this function.

To remove a directory, use `os.rmdir()`; use `os.mkdir()` to create one. `os.makedirs(path)` will create any intermediate directories in `path` that don't exist. `os.removedirs(path)` will remove intermediate directories as long as they're empty; if you want to delete an entire directory tree and its contents, use `shutil.rmtree()`.

To rename a file, use `os.rename(old_path, new_path)`.

To truncate a file, open it using `f = open(filename, "rb+")`, and use `f.truncate(offset)`; offset defaults to the current seek position. There's also `os.ftruncate(fd, offset)` for files opened with `os.open()`, where *fd* is the file descriptor (a small integer).

The `shutil` module also contains a number of functions to work on files including `copyfile()`, `copytree()`, and `rmtree()`.

4.4.2 How do I copy a file?

The `shutil` module contains a `copyfile()` function. Note that on MacOS 9 it doesn't copy the resource fork and Finder info.

4.4.3 How do I read (or write) binary data?

To read or write complex binary data formats, it's best to use the `struct` module. It allows you to take a string containing binary data (usually numbers) and convert it to Python objects; and vice versa.

For example, the following code reads two 2-byte integers and one 4-byte integer in big-endian format from a file:

```
import struct

with open(filename, "rb") as f:
    s = f.read(8)
    x, y, z = struct.unpack(">hhl", s)
```

The ">" in the format string forces big-endian data; the letter "h" reads one «short integer» (2 bytes), and "l" reads one «long integer» (4 bytes) from the string.

For data that is more regular (e.g. a homogeneous list of ints or floats), you can also use the `array` module.

Nota: To read and write binary data, it is mandatory to open the file in binary mode (here, passing `"rb"` to `open()`). If you use `"r"` instead (the default), the file will be open in text mode and `f.read()` will return `str` objects rather than `bytes` objects.

4.4.4 I can't seem to use os.read() on a pipe created with os.popen(); why?

`os.read()` is a low-level function which takes a file descriptor, a small integer representing the opened file. `os.popen()` creates a high-level file object, the same type returned by the built-in `open()` function. Thus, to read *n* bytes from a pipe *p* created with `os.popen()`, you need to use `p.read(n)`.

4.4.5 How do I access the serial (RS232) port?

For Win32, POSIX (Linux, BSD, etc.), Jython:

> http://pyserial.sourceforge.net

For Unix, see a Usenet post by Mitch Chapman:

> https://groups.google.com/groups?selm=34A04430.CF9@ohioee.com

4.4.6 Why doesn't closing sys.stdout (stdin, stderr) really close it?

Python *file objects* are a high-level layer of abstraction on low-level C file descriptors.

For most file objects you create in Python via the built-in `open()` function, `f.close()` marks the Python file object as being closed from Python's point of view, and also arranges to close the underlying C file descriptor. This also happens automatically in `f`'s destructor, when `f` becomes garbage.

But stdin, stdout and stderr are treated specially by Python, because of the special status also given to them by C. Running `sys.stdout.close()` marks the Python-level file object as being closed, but does *not* close the associated C file descriptor.

To close the underlying C file descriptor for one of these three, you should first be sure that's what you really want to do (e.g., you may confuse extension modules trying to do I/O). If it is, use `os.close()`:

```
os.close(stdin.fileno())
os.close(stdout.fileno())
os.close(stderr.fileno())
```

Or you can use the numeric constants 0, 1 and 2, respectively.

4.5 Network/Internet Programming

4.5.1 What WWW tools are there for Python?

See the chapters titled internet and netdata in the Library Reference Manual. Python has many modules that will help you build server-side and client-side web systems.

A summary of available frameworks is maintained by Paul Boddie at https://wiki.python.org/moin/WebProgramming.

Cameron Laird maintains a useful set of pages about Python web technologies at http://phaseit.net/claird/comp.lang.python/web_python.

4.5.2 How can I mimic CGI form submission (METHOD=POST)?

I would like to retrieve web pages that are the result of POSTing a form. Is there existing code that would let me do this easily?

Yes. Here's a simple example that uses urllib.request:

```
#!/usr/local/bin/python

import urllib.request

# build the query string
qs = "First=Josephine&MI=Q&Last=Public"

# connect and send the server a path
req = urllib.request.urlopen('http://www.some-server.out-there'
                             '/cgi-bin/some-cgi-script', data=qs)
with req:
    msg, hdrs = req.read(), req.info()
```

Note that in general for percent-encoded POST operations, query strings must be quoted using `urllib.parse.urlencode()`. For example, to send `name=Guy Steele, Jr.`:

```
>>> import urllib.parse
>>> urllib.parse.urlencode({'name': 'Guy Steele, Jr.'})
'name=Guy+Steele%2C+Jr.'
```

Ver también:

urllib-howto for extensive examples.

4.5.3 What module should I use to help with generating HTML?

You can find a collection of useful links on the Web Programming wiki page.

4.5.4 How do I send mail from a Python script?

Use the standard library module `smtplib`.

Here's a very simple interactive mail sender that uses it. This method will work on any host that supports an SMTP listener.

```
import sys, smtplib

fromaddr = input("From: ")
toaddrs  = input("To: ").split(',')
print("Enter message, end with ^D:")
msg = ''
while True:
    line = sys.stdin.readline()
    if not line:
        break
    msg += line

# The actual mail send
server = smtplib.SMTP('localhost')
server.sendmail(fromaddr, toaddrs, msg)
server.quit()
```

A Unix-only alternative uses sendmail. The location of the sendmail program varies between systems; sometimes it is `/usr/lib/sendmail`, sometimes `/usr/sbin/sendmail`. The sendmail manual page will help you out. Here's some sample code:

```
import os

SENDMAIL = "/usr/sbin/sendmail"  # sendmail location
p = os.popen("%s -t -i" % SENDMAIL, "w")
p.write("To: receiver@example.com\n")
p.write("Subject: test\n")
p.write("\n")  # blank line separating headers from body
p.write("Some text\n")
p.write("some more text\n")
sts = p.close()
if sts != 0:
    print("Sendmail exit status", sts)
```

4.5.5 How do I avoid blocking in the connect() method of a socket?

The `select` module is commonly used to help with asynchronous I/O on sockets.

To prevent the TCP connect from blocking, you can set the socket to non-blocking mode. Then when you do the `connect()`, you will either connect immediately (unlikely) or get an exception that contains the error number as `.errno`. `errno.EINPROGRESS` indicates that the connection is in progress, but hasn't finished yet. Different OSes will return different values, so you're going to have to check what's returned on your system.

You can use the `connect_ex()` method to avoid creating an exception. It will just return the errno value. To poll, you can call `connect_ex()` again later – `0` or `errno.EISCONN` indicate that you're connected – or you can pass this socket to select to check if it's writable.

Nota: The `asyncore` module presents a framework-like approach to the problem of writing non-blocking networking code. The third-party Twisted library is a popular and feature-rich alternative.

4.6 Databases

4.6.1 Are there any interfaces to database packages in Python?

Yes.

Interfaces to disk-based hashes such as `DBM` and `GDBM` are also included with standard Python. There is also the `sqlite3` module, which provides a lightweight disk-based relational database.

Support for most relational databases is available. See the DatabaseProgramming wiki page for details.

4.6.2 How do you implement persistent objects in Python?

The `pickle` library module solves this in a very general way (though you still can't store things like open files, sockets or windows), and the `shelve` library module uses pickle and (g)dbm to create persistent mappings containing arbitrary Python objects.

4.7 Mathematics and Numerics

4.7.1 How do I generate random numbers in Python?

The standard module `random` implements a random number generator. Usage is simple:

```
import random
random.random()
```

This returns a random floating point number in the range [0, 1).

There are also many other specialized generators in this module, such as:

- `randrange(a, b)` chooses an integer in the range [a, b).
- `uniform(a, b)` chooses a floating point number in the range [a, b).
- `normalvariate(mean, sdev)` samples the normal (Gaussian) distribution.

Some higher-level functions operate on sequences directly, such as:

- `choice(S)` chooses random element from a given sequence
- `shuffle(L)` shuffles a list in-place, i.e. permutes it randomly

There's also a `Random` class you can instantiate to create independent multiple random number generators.

CAPÍTULO 5

Extending/Embedding FAQ

5.1 Can I create my own functions in C?

Yes, you can create built-in modules containing functions, variables, exceptions and even new types in C. This is explained in the document extending-index.

Most intermediate or advanced Python books will also cover this topic.

5.2 Can I create my own functions in C++?

Yes, using the C compatibility features found in C++. Place `extern "C" { ... }` around the Python include files and put `extern "C"` before each function that is going to be called by the Python interpreter. Global or static C++ objects with constructors are probably not a good idea.

5.3 Writing C is hard; are there any alternatives?

There are a number of alternatives to writing your own C extensions, depending on what you're trying to do.

Cython and its relative Pyrex are compilers that accept a slightly modified form of Python and generate the corresponding C code. Cython and Pyrex make it possible to write an extension without having to learn Python's C API.

If you need to interface to some C or C++ library for which no Python extension currently exists, you can try wrapping the library's data types and functions with a tool such as SWIG. SIP, CXX Boost, or Weave are also alternatives for wrapping C++ libraries.

5.4 How can I execute arbitrary Python statements from C?

The highest-level function to do this is `PyRun_SimpleString()` which takes a single string argument to be executed in the context of the module `__main__` and returns `0` for success and `-1` when an exception occurred (including `SyntaxError`). If you want more control, use `PyRun_String()`; see the source for `PyRun_SimpleString()` in `Python/pythonrun.c`.

5.5 How can I evaluate an arbitrary Python expression from C?

Call the function `PyRun_String()` from the previous question with the start symbol `Py_eval_input`; it parses an expression, evaluates it and returns its value.

5.6 How do I extract C values from a Python object?

That depends on the object's type. If it's a tuple, `PyTuple_Size()` returns its length and `PyTuple_GetItem()` returns the item at a specified index. Lists have similar functions, `PyListSize()` and `PyList_GetItem()`.

For bytes, `PyBytes_Size()` returns its length and `PyBytes_AsStringAndSize()` provides a pointer to its value and its length. Note that Python bytes objects may contain null bytes so C's `strlen()` should not be used.

To test the type of an object, first make sure it isn't `NULL`, and then use `PyBytes_Check()`, `PyTuple_Check()`, `PyList_Check()`, etc.

There is also a high-level API to Python objects which is provided by the so-called "abstract" interface – read `Include/abstract.h` for further details. It allows interfacing with any kind of Python sequence using calls like `PySequence_Length()`, `PySequence_GetItem()`, etc. as well as many other useful protocols such as numbers (`PyNumber_Index()` et al.) and mappings in the PyMapping APIs.

5.7 How do I use Py_BuildValue() to create a tuple of arbitrary length?

You can't. Use `PyTuple_Pack()` instead.

5.8 How do I call an object's method from C?

The `PyObject_CallMethod()` function can be used to call an arbitrary method of an object. The parameters are the object, the name of the method to call, a format string like that used with `Py_BuildValue()`, and the argument values:

```
PyObject *
PyObject_CallMethod(PyObject *object, const char *method_name,
                    const char *arg_format, ...);
```

This works for any object that has methods – whether built-in or user-defined. You are responsible for eventually `Py_DECREF()`"ing the return value.

To call, e.g., a file object's «seek» method with arguments 10, 0 (assuming the file object pointer is «f»):

```
res = PyObject_CallMethod(f, "seek", "(ii)", 10, 0);
if (res == NULL) {
        ... an exception occurred ...
}
else {
        Py_DECREF(res);
}
```

Note that since `PyObject_CallObject()` *always* wants a tuple for the argument list, to call a function without arguments, pass «()» for the format, and to call a function with one argument, surround the argument in parentheses, e.g. «(i)».

5.9 How do I catch the output from PyErr_Print() (or anything that prints to stdout/stderr)?

In Python code, define an object that supports the `write()` method. Assign this object to `sys.stdout` and `sys.stderr`. Call print_error, or just allow the standard traceback mechanism to work. Then, the output will go wherever your `write()` method sends it.

The easiest way to do this is to use the `io.StringIO` class:

```
>>> import io, sys
>>> sys.stdout = io.StringIO()
>>> print('foo')
>>> print('hello world!')
>>> sys.stderr.write(sys.stdout.getvalue())
foo
hello world!
```

A custom object to do the same would look like this:

```
>>> import io, sys
>>> class StdoutCatcher(io.TextIOBase):
...     def __init__(self):
...         self.data = []
...     def write(self, stuff):
...         self.data.append(stuff)
...
>>> import sys
>>> sys.stdout = StdoutCatcher()
>>> print('foo')
>>> print('hello world!')
>>> sys.stderr.write(''.join(sys.stdout.data))
foo
hello world!
```

5.10 How do I access a module written in Python from C?

You can get a pointer to the module object as follows:

```
module = PyImport_ImportModule("<modulename>");
```

If the module hasn't been imported yet (i.e. it is not yet present in `sys.modules`), this initializes the module; otherwise it simply returns the value of `sys.modules["<modulename>"]`. Note that it doesn't enter the module into any namespace – it only ensures it has been initialized and is stored in `sys.modules`.

You can then access the module's attributes (i.e. any name defined in the module) as follows:

```
attr = PyObject_GetAttrString(module, "<attrname>");
```

Calling `PyObject_SetAttrString()` to assign to variables in the module also works.

5.11 How do I interface to C++ objects from Python?

Depending on your requirements, there are many approaches. To do this manually, begin by reading the «Extending and Embedding» document. Realize that for the Python run-time system, there isn't a whole lot of difference between C and C++ – so the strategy of building a new Python type around a C structure (pointer) type will also work for C++ objects.

For C++ libraries, see *Writing C is hard; are there any alternatives?*.

5.12 I added a module using the Setup file and the make fails; why?

Setup must end in a newline, if there is no newline there, the build process fails. (Fixing this requires some ugly shell script hackery, and this bug is so minor that it doesn't seem worth the effort.)

5.13 How do I debug an extension?

When using GDB with dynamically loaded extensions, you can't set a breakpoint in your extension until your extension is loaded.

In your `.gdbinit` file (or interactively), add the command:

```
br _PyImport_LoadDynamicModule
```

Then, when you run GDB:

```
$ gdb /local/bin/python
gdb) run myscript.py
gdb) continue # repeat until your extension is loaded
gdb) finish   # so that your extension is loaded
gdb) br myfunction.c:50
gdb) continue
```

5.14 I want to compile a Python module on my Linux system, but some files are missing. Why?

Most packaged versions of Python don't include the `/usr/lib/python2.x/config/` directory, which contains various files required for compiling Python extensions.

For Red Hat, install the python-devel RPM to get the necessary files.

For Debian, run `apt-get install python-dev`.

5.15 How do I tell «incomplete input» from «invalid input»?

Sometimes you want to emulate the Python interactive interpreter's behavior, where it gives you a continuation prompt when the input is incomplete (e.g. you typed the start of an «if» statement or you didn't close your parentheses or triple string quotes), but it gives you a syntax error message immediately when the input is invalid.

In Python you can use the `codeop` module, which approximates the parser's behavior sufficiently. IDLE uses this, for example.

The easiest way to do it in C is to call `PyRun_InteractiveLoop()` (perhaps in a separate thread) and let the Python interpreter handle the input for you. You can also set the `PyOS_ReadlineFunctionPointer()` to point at your custom input function. See `Modules/readline.c` and `Parser/myreadline.c` for more hints.

However sometimes you have to run the embedded Python interpreter in the same thread as your rest application and you can't allow the `PyRun_InteractiveLoop()` to stop while waiting for user input. The one solution then is to call `PyParser_ParseString()` and test for `e.error` equal to `E_EOF`, which means the input is incomplete. Here's a sample code fragment, untested, inspired by code from Alex Farber:

```
#define PY_SSIZE_T_CLEAN
#include <Python.h>
#include <node.h>
#include <errcode.h>
#include <grammar.h>
#include <parsetok.h>
#include <compile.h>

int testcomplete(char *code)
  /* code should end in \n */
  /* return -1 for error, 0 for incomplete, 1 for complete */
{
  node *n;
  perrdetail e;

  n = PyParser_ParseString(code, &_PyParser_Grammar,
                           Py_file_input, &e);
  if (n == NULL) {
    if (e.error == E_EOF)
      return 0;
    return -1;
  }

  PyNode_Free(n);
  return 1;
}
```

Another solution is trying to compile the received string with `Py_CompileString()`. If it compiles without errors, try to execute the returned code object by calling `PyEval_EvalCode()`. Otherwise save the input for later. If the compilation fails, find out if it's an error or just more input is required - by extracting the message string from the exception tuple and comparing it to the string «unexpected EOF while parsing». Here is a complete example using the GNU readline library (you may want to ignore **SIGINT** while calling readline()):

```
#include <stdio.h>
#include <readline.h>

#define PY_SSIZE_T_CLEAN
#include <Python.h>
#include <object.h>
#include <compile.h>
#include <eval.h>

int main (int argc, char* argv[])
{
  int i, j, done = 0;                          /* lengths of line, code */
  char ps1[] = ">>> ";
  char ps2[] = "... ";
  char *prompt = ps1;
  char *msg, *line, *code = NULL;
  PyObject *src, *glb, *loc;
  PyObject *exc, *val, *trb, *obj, *dum;

  Py_Initialize ();
  loc = PyDict_New ();
  glb = PyDict_New ();
  PyDict_SetItemString (glb, "__builtins__", PyEval_GetBuiltins ());

  while (!done)
  {
    line = readline (prompt);

    if (NULL == line)                          /* Ctrl-D pressed */
    {
      done = 1;
    }
    else
    {
      i = strlen (line);

      if (i > 0)
        add_history (line);                    /* save non-empty lines */

      if (NULL == code)                        /* nothing in code yet */
        j = 0;
      else
        j = strlen (code);

      code = realloc (code, i + j + 2);
      if (NULL == code)                        /* out of memory */
        exit (1);

      if (0 == j)                              /* code was empty, so */
        code[0] = '\0';                        /* keep strncat happy */

      strncat (code, line, i);                 /* append line to code */
```

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```
    code[i + j] = '\n';                   /* append '\n' to code */
    code[i + j + 1] = '\0';

    src = Py_CompileString (code, "<stdin>", Py_single_input);

    if (NULL != src)                      /* compiled just fine - */
    {
      if (ps1  == prompt ||               /* ">>> " or */
          '\n' == code[i + j - 1])        /* "... " and double '\n' */
      {                                            /* so execute it */
        dum = PyEval_EvalCode (src, glb, loc);
        Py_XDECREF (dum);
        Py_XDECREF (src);
        free (code);
        code = NULL;
        if (PyErr_Occurred ())
          PyErr_Print ();
        prompt = ps1;
      }
    }                                     /* syntax error or E_EOF? */
    else if (PyErr_ExceptionMatches (PyExc_SyntaxError))
    {
      PyErr_Fetch (&exc, &val, &trb);        /* clears exception! */

      if (PyArg_ParseTuple (val, "sO", &msg, &obj) &&
          !strcmp (msg, "unexpected EOF while parsing")) /* E_EOF */
      {
        Py_XDECREF (exc);
        Py_XDECREF (val);
        Py_XDECREF (trb);
        prompt = ps2;
      }
      else                                /* some other syntax error */
      {
        PyErr_Restore (exc, val, trb);
        PyErr_Print ();
        free (code);
        code = NULL;
        prompt = ps1;
      }
    }
    else                                  /* some non-syntax error */
    {
      PyErr_Print ();
      free (code);
      code = NULL;
      prompt = ps1;
    }

    free (line);
  }
}

Py_XDECREF(glb);
Py_XDECREF(loc);
Py_Finalize();
exit(0);
```

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```
}
```

5.16 How do I find undefined g++ symbols __builtin_new or __pure_virtual?

To dynamically load g++ extension modules, you must recompile Python, relink it using g++ (change LINKCC in the Python Modules Makefile), and link your extension module using g++ (e.g., `g++ -shared -o mymodule.so mymodule.o`).

5.17 Can I create an object class with some methods implemented in C and others in Python (e.g. through inheritance)?

Yes, you can inherit from built-in classes such as `int`, `list`, `dict`, etc.

The Boost Python Library (BPL, http://www.boost.org/libs/python/doc/index.html) provides a way of doing this from C++ (i.e. you can inherit from an extension class written in C++ using the BPL).

CAPÍTULO 6

Python on Windows FAQ

6.1 How do I run a Python program under Windows?

This is not necessarily a straightforward question. If you are already familiar with running programs from the Windows command line then everything will seem obvious; otherwise, you might need a little more guidance.

Unless you use some sort of integrated development environment, you will end up *typing* Windows commands into what is variously referred to as a «DOS window» or «Command prompt window». Usually you can create such a window from your search bar by searching for `cmd`. You should be able to recognize when you have started such a window because you will see a Windows «command prompt», which usually looks like this:

```
C:\>
```

The letter may be different, and there might be other things after it, so you might just as easily see something like:

```
D:\YourName\Projects\Python>
```

depending on how your computer has been set up and what else you have recently done with it. Once you have started such a window, you are well on the way to running Python programs.

You need to realize that your Python scripts have to be processed by another program called the Python *interpreter*. The interpreter reads your script, compiles it into bytecodes, and then executes the bytecodes to run your program. So, how do you arrange for the interpreter to handle your Python?

First, you need to make sure that your command window recognises the word «py» as an instruction to start the interpreter. If you have opened a command window, you should try entering the command `py` and hitting return:

```
C:\Users\YourName> py
```

You should then see something like:

```
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on␣
↪win32
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

You have started the interpreter in «interactive mode». That means you can enter Python statements or expressions interactively and have them executed or evaluated while you wait. This is one of Python's strongest features. Check it by entering a few expressions of your choice and seeing the results:

```
>>> print("Hello")
Hello
>>> "Hello" * 3
'HelloHelloHello'
```

Many people use the interactive mode as a convenient yet highly programmable calculator. When you want to end your interactive Python session, call the `exit()` function or hold the `Ctrl` key down while you enter a `Z`, then hit the «`Enter`» key to get back to your Windows command prompt.

You may also find that you have a Start-menu entry such as *Start ‣ Programs ‣ Python 3.x ‣ Python (command line)* that results in you seeing the `>>>` prompt in a new window. If so, the window will disappear after you call the `exit()` function or enter the `Ctrl-Z` character; Windows is running a single «python» command in the window, and closes it when you terminate the interpreter.

Now that we know the `py` command is recognized, you can give your Python script to it. You'll have to give either an absolute or a relative path to the Python script. Let's say your Python script is located in your desktop and is named `hello.py`, and your command prompt is nicely opened in your home directory so you're seeing something similar to:

```
C:\Users\YourName>
```

So now you'll ask the `py` command to give your script to Python by typing `py` followed by your script path:

```
C:\Users\YourName> py Desktop\hello.py
hello
```

6.2 How do I make Python scripts executable?

On Windows, the standard Python installer already associates the .py extension with a file type (Python.File) and gives that file type an open command that runs the interpreter (`D:\Program Files\Python\python.exe "%1" %*`). This is enough to make scripts executable from the command prompt as "foo.py". If you'd rather be able to execute the script by simple typing "foo" with no extension you need to add .py to the PATHEXT environment variable.

6.3 Why does Python sometimes take so long to start?

Usually Python starts very quickly on Windows, but occasionally there are bug reports that Python suddenly begins to take a long time to start up. This is made even more puzzling because Python will work fine on other Windows systems which appear to be configured identically.

The problem may be caused by a misconfiguration of virus checking software on the problem machine. Some virus scanners have been known to introduce startup overhead of two orders of magnitude when the scanner is configured to monitor all reads from the filesystem. Try checking the configuration of virus scanning software on your systems to ensure that they are indeed configured identically. McAfee, when configured to scan all file system read activity, is a particular offender.

6.4 How do I make an executable from a Python script?

See cx_Freeze for a distutils extension that allows you to create console and GUI executables from Python code. py2exe, the most popular extension for building Python 2.x-based executables, does not yet support Python 3 but a version that does is in development.

6.5 Is a `*.pyd` file the same as a DLL?

Yes, .pyd files are dll's, but there are a few differences. If you have a DLL named `foo.pyd`, then it must have a function `PyInit_foo()`. You can then write Python «import foo», and Python will search for foo.pyd (as well as foo.py, foo.pyc) and if it finds it, will attempt to call `PyInit_foo()` to initialize it. You do not link your .exe with foo.lib, as that would cause Windows to require the DLL to be present.

Note that the search path for foo.pyd is PYTHONPATH, not the same as the path that Windows uses to search for foo.dll. Also, foo.pyd need not be present to run your program, whereas if you linked your program with a dll, the dll is required. Of course, foo.pyd is required if you want to say `import foo`. In a DLL, linkage is declared in the source code with `__declspec(dllexport)`. In a .pyd, linkage is defined in a list of available functions.

6.6 How can I embed Python into a Windows application?

Embedding the Python interpreter in a Windows app can be summarized as follows:

1. Do _not_ build Python into your .exe file directly. On Windows, Python must be a DLL to handle importing modules that are themselves DLL's. (This is the first key undocumented fact.) Instead, link to `pythonNN.dll`; it is typically installed in `C:\Windows\System`. *NN* is the Python version, a number such as «33» for Python 3.3.

   You can link to Python in two different ways. Load-time linking means linking against `pythonNN.lib`, while run-time linking means linking against `pythonNN.dll`. (General note: `pythonNN.lib` is the so-called «import lib» corresponding to `pythonNN.dll`. It merely defines symbols for the linker.)

   Run-time linking greatly simplifies link options; everything happens at run time. Your code must load `pythonNN.dll` using the Windows `LoadLibraryEx()` routine. The code must also use access routines and data in `pythonNN.dll` (that is, Python's C API's) using pointers obtained by the Windows `GetProcAddress()` routine. Macros can make using these pointers transparent to any C code that calls routines in Python's C API.

   Borland note: convert `pythonNN.lib` to OMF format using Coff2Omf.exe first.

2. If you use SWIG, it is easy to create a Python «extension module» that will make the app's data and methods available to Python. SWIG will handle just about all the grungy details for you. The result is C code that you link *into* your .exe file (!) You do _not_ have to create a DLL file, and this also simplifies linking.

3. SWIG will create an init function (a C function) whose name depends on the name of the extension module. For example, if the name of the module is leo, the init function will be called initleo(). If you use SWIG shadow classes, as you should, the init function will be called initleoc(). This initializes a mostly hidden helper class used by the shadow class.

   The reason you can link the C code in step 2 into your .exe file is that calling the initialization function is equivalent to importing the module into Python! (This is the second key undocumented fact.)

4. In short, you can use the following code to initialize the Python interpreter with your extension module.

```
#include "python.h"
...
Py_Initialize();  // Initialize Python.
initmyAppc();  // Initialize (import) the helper class.
PyRun_SimpleString("import myApp");  // Import the shadow class.
```

5. There are two problems with Python's C API which will become apparent if you use a compiler other than MSVC, the compiler used to build pythonNN.dll.

   Problem 1: The so-called «Very High Level» functions that take FILE * arguments will not work in a multi-compiler environment because each compiler's notion of a struct FILE will be different. From an implementation standpoint these are very _low_ level functions.

   Problem 2: SWIG generates the following code when generating wrappers to void functions:

   ```
   Py_INCREF(Py_None);
   _resultobj = Py_None;
   return _resultobj;
   ```

   Alas, Py_None is a macro that expands to a reference to a complex data structure called _Py_NoneStruct inside pythonNN.dll. Again, this code will fail in a mult-compiler environment. Replace such code by:

   ```
   return Py_BuildValue("");
   ```

   It may be possible to use SWIG's `%typemap` command to make the change automatically, though I have not been able to get this to work (I'm a complete SWIG newbie).

6. Using a Python shell script to put up a Python interpreter window from inside your Windows app is not a good idea; the resulting window will be independent of your app's windowing system. Rather, you (or the wxPythonWindow class) should create a «native» interpreter window. It is easy to connect that window to the Python interpreter. You can redirect Python's i/o to _any_ object that supports read and write, so all you need is a Python object (defined in your extension module) that contains read() and write() methods.

6.7 How do I keep editors from inserting tabs into my Python source?

The FAQ does not recommend using tabs, and the Python style guide, **PEP 8**, recommends 4 spaces for distributed Python code; this is also the Emacs python-mode default.

Under any editor, mixing tabs and spaces is a bad idea. MSVC is no different in this respect, and is easily configured to use spaces: Take *Tools ‣ Options ‣ Tabs*, and for file type «Default» set «Tab size» and «Indent size» to 4, and select the «Insert spaces» radio button.

Python raises `IndentationError` or `TabError` if mixed tabs and spaces are causing problems in leading whitespace. You may also run the `tabnanny` module to check a directory tree in batch mode.

6.8 How do I check for a keypress without blocking?

Use the msvcrt module. This is a standard Windows-specific extension module. It defines a function `kbhit()` which checks whether a keyboard hit is present, and `getch()` which gets one character without echoing it.

CAPÍTULO 7

Graphic User Interface FAQ

7.1 General GUI Questions

7.2 What platform-independent GUI toolkits exist for Python?

Depending on what platform(s) you are aiming at, there are several. Some of them haven't been ported to Python 3 yet. At least *Tkinter* and *Qt* are known to be Python 3-compatible.

7.2.1 Tkinter

Standard builds of Python include an object-oriented interface to the Tcl/Tk widget set, called tkinter. This is probably the easiest to install (since it comes included with most binary distributions of Python) and use. For more info about Tk, including pointers to the source, see the Tcl/Tk home page. Tcl/Tk is fully portable to the Mac OS X, Windows, and Unix platforms.

7.2.2 wxWidgets

wxWidgets (https://www.wxwidgets.org) is a free, portable GUI class library written in C++ that provides a native look and feel on a number of platforms, with Windows, Mac OS X, GTK, X11, all listed as current stable targets. Language bindings are available for a number of languages including Python, Perl, Ruby, etc.

wxPython is the Python binding for wxwidgets. While it often lags slightly behind the official wxWidgets releases, it also offers a number of features via pure Python extensions that are not available in other language bindings. There is an active wxPython user and developer community.

Both wxWidgets and wxPython are free, open source, software with permissive licences that allow their use in commercial products as well as in freeware or shareware.

7.2.3 Qt

There are bindings available for the Qt toolkit (using either PyQt or PySide) and for KDE (PyKDE4). PyQt is currently more mature than PySide, but you must buy a PyQt license from Riverbank Computing if you want to write proprietary applications. PySide is free for all applications.

Qt 4.5 upwards is licensed under the LGPL license; also, commercial licenses are available from The Qt Company.

7.2.4 Gtk+

The GObject introspection bindings for Python allow you to write GTK+ 3 applications. There is also a Python GTK+ 3 Tutorial.

The older PyGtk bindings for the Gtk+ 2 toolkit have been implemented by James Henstridge; see <http://www.pygtk.org>.

7.2.5 Kivy

Kivy is a cross-platform GUI library supporting both desktop operating systems (Windows, macOS, Linux) and mobile devices (Android, iOS). It is written in Python and Cython, and can use a range of windowing backends.

Kivy is free and open source software distributed under the MIT license.

7.2.6 FLTK

Python bindings for the FLTK toolkit, a simple yet powerful and mature cross-platform windowing system, are available from the PyFLTK project.

7.2.7 OpenGL

For OpenGL bindings, see PyOpenGL.

7.3 What platform-specific GUI toolkits exist for Python?

By installing the PyObjc Objective-C bridge, Python programs can use Mac OS X's Cocoa libraries.

Pythonwin by Mark Hammond includes an interface to the Microsoft Foundation Classes and a Python programming environment that's written mostly in Python using the MFC classes.

7.4 Tkinter questions

7.4.1 How do I freeze Tkinter applications?

Freeze is a tool to create stand-alone applications. When freezing Tkinter applications, the applications will not be truly stand-alone, as the application will still need the Tcl and Tk libraries.

One solution is to ship the application with the Tcl and Tk libraries, and point to them at run-time using the `TCL_LIBRARY` and `TK_LIBRARY` environment variables.

To get truly stand-alone applications, the Tcl scripts that form the library have to be integrated into the application as well. One tool supporting that is SAM (stand-alone modules), which is part of the Tix distribution (http://tix.sourceforge.net/).

Build Tix with SAM enabled, perform the appropriate call to `Tclsam_init()`, etc. inside Python's `Modules/tkappinit.c`, and link with libtclsam and libtksam (you might include the Tix libraries as well).

7.4.2 Can I have Tk events handled while waiting for I/O?

On platforms other than Windows, yes, and you don't even need threads! But you'll have to restructure your I/O code a bit. Tk has the equivalent of Xt's `XtAddInput()` call, which allows you to register a callback function which will be called from the Tk mainloop when I/O is possible on a file descriptor. See tkinter-file-handlers.

7.4.3 I can't get key bindings to work in Tkinter: why?

An often-heard complaint is that event handlers bound to events with the `bind()` method don't get handled even when the appropriate key is pressed.

The most common cause is that the widget to which the binding applies doesn't have «keyboard focus». Check out the Tk documentation for the focus command. Usually a widget is given the keyboard focus by clicking in it (but not for labels; see the takefocus option).

CAPÍTULO 8

«Why is Python Installed on my Computer?» FAQ

8.1 What is Python?

Python is a programming language. It's used for many different applications. It's used in some high schools and colleges as an introductory programming language because Python is easy to learn, but it's also used by professional software developers at places such as Google, NASA, and Lucasfilm Ltd.

If you wish to learn more about Python, start with the Beginner's Guide to Python.

8.2 Why is Python installed on my machine?

If you find Python installed on your system but don't remember installing it, there are several possible ways it could have gotten there.

- Perhaps another user on the computer wanted to learn programming and installed it; you'll have to figure out who's been using the machine and might have installed it.
- A third-party application installed on the machine might have been written in Python and included a Python installation. There are many such applications, from GUI programs to network servers and administrative scripts.
- Some Windows machines also have Python installed. At this writing we're aware of computers from Hewlett-Packard and Compaq that include Python. Apparently some of HP/Compaq's administrative tools are written in Python.
- Many Unix-compatible operating systems, such as Mac OS X and some Linux distributions, have Python installed by default; it's included in the base installation.

8.3 Can I delete Python?

That depends on where Python came from.

If someone installed it deliberately, you can remove it without hurting anything. On Windows, use the Add/Remove Programs icon in the Control Panel.

If Python was installed by a third-party application, you can also remove it, but that application will no longer work. You should use that application's uninstaller rather than removing Python directly.

If Python came with your operating system, removing it is not recommended. If you remove it, whatever tools were written in Python will no longer run, and some of them might be important to you. Reinstalling the whole system would then be required to fix things again.

APÉNDICE A

Glosario

>>> El prompt en el shell interactivo de Python por omisión. Frecuentemente vistos en ejemplos de código que pueden ser ejecutados interactivamente en el intérprete.

... The default Python prompt of the interactive shell when entering the 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 Una herramienta que intenta convertir código de Python 2.x a Python 3.x arreglando la mayoría de las incompatibilidades que pueden ser detectadas analizando el código y recorriendo el árbol de análisis sintáctico.

2to3 está disponible en la biblioteca estándar como `lib2to3`; un punto de entrada independiente es provisto como `Tools/scripts/2to3`. Vea 2to3-reference.

clase base abstracta Las clases base abstractas (ABC, por sus siglas en inglés *Abstract Base Class*) complementan al *duck-typing* brindando un forma de definir interfaces con técnicas como `hasattr()` que serían confusas o sutilmente erróneas (por ejemplo con magic methods). Las ABC introduce subclases virtuales, las cuales son clases que no heredan desde una clase pero aún así son reconocidas por `isinstance()` y `issubclass()`; vea la documentación del módulo `abc`. Python viene con muchas ABC incorporadas para las estructuras de datos(en el módulo `collections.abc`), números (en el módulo `numbers`) , flujos de datos (en el módulo `io`) , buscadores y cargadores de importaciones (en el módulo `importlib.abc`) . Puede crear sus propios ABCs con el módulo `abc`.

anotación Una etiqueta asociada a una variable, atributo de clase, parámetro de función o valor de retorno, usado por convención como un *type hint*.

Las anotaciones de variables no pueden ser accedidas en tiempo de ejecución, pero las anotaciones de variables globales, atributos de clase, y funciones son almacenadas en el atributo especial `__annotations__` de módulos, clases y funciones, respectivamente.

Vea *variable annotation*, *function annotation*, **PEP 484** y **PEP 526**, los cuales describen esta funcionalidad.

argumento Un valor pasado a una *function* (o *method*) cuando se llama a la función. Hay dos clases de argumentos:

- *argumento nombrado*: es un argumento precedido por un identificador (por ejemplo, `nombre=`) en una llamada a una función o pasado como valor en un diccionario precedido por `**`. Por ejemplo `3` y `5` son argumentos nombrados en las llamadas a `complex()`:

```
complex(real=3, imag=5)
complex(**{'real': 3, 'imag': 5})
```

- *argumento posicional* son aquellos que no son nombrados. Los argumentos posicionales deben aparecer al principio de una lista de argumentos o ser pasados como elementos de un *iterable* precedido por `*`. Por ejemplo, `3` y `5` son argumentos posicionales en las siguientes llamadas:

```
complex(3, 5)
complex(*(3, 5))
```

Los argumentos son asignados a las variables locales en el cuerpo de la función. Vea en la sección calls las reglas que rigen estas asignaciones. Sintácticamente, cualquier expresión puede ser usada para representar un argumento; el valor evaluado es asignado a la variable local.

Vea también el *parameter* en el glosario, la pregunta frecuente *la diferencia entre argumentos y parámetros*, y **PEP 362**.

administrador asincrónico de contexto Un objeto que controla el entorno visible en un sentencia `async with` al definir los métodos `__aenter__()` `__aexit__()`. Introducido por **PEP 492**.

generador asincrónico Una función que retorna un *asynchronous generator iterator*. Es similar a una función corrutina definida con `async def` excepto que contiene expresiones `yield` para producir series de variables usadas en un ciclo `async for`.

Usualmente se refiere a una función generadora asincrónica, pero puede referirse a un *iterador generador asincrónico* en ciertos contextos. En aquellos casos en los que el significado no está claro, usar los términos completos evita la ambigüedad.

Una función generadora asincrónica puede contener expresiones `await` así como sentencias `async for`, y `async with`.

iterador generador asincrónico Un objeto creado por una función *asynchronous generator*.

Este es un *asynchronous iterator* el cual cuando es llamado usa el método `__anext__()` retornando un objeto aguardable el cual ejecutará el cuerpo de la función generadora asincrónica hasta la siguiente expresión `yield`.

Cada `yield` suspende temporalmente el procesamiento, recordando el estado local de ejecución (incluyendo a las variables locales y las sentencias *try* pendientes). Cuando el *iterador del generador asincrónico* vuelve efectivamente con otro aguardable retornado por el método `__anext__()`, retoma donde lo dejó. Vea **PEP 492** y **PEP 525**.

iterable asincrónico Un objeto, que puede ser usado en una sentencia `async for`. Debe retornar un *asynchronous iterator* de su método `__aiter__()`. Introducido por **PEP 492**.

iterador asincrónico Un objeto que implementa los métodos meth:*__aiter__* y `__anext__()`. `__anext__` debe retornar un objeto *awaitable*. `async for` resuelve los esperables retornados por un método de iterador asincrónico `__anext__()` hasta que lanza una excepción `StopAsyncIteration`. Introducido por **PEP 492**.

atributo Un valor asociado a un objeto que es referencias por el nombre usado expresiones de punto. Por ejemplo, si un objeto *o* tiene un atributo *a* sería referenciado como *o.a*.

aguardable Es un objeto que puede ser usado en una expresión `await`. Puede ser una *coroutine* o un objeto con un método `__await__()`. Vea también pep:*492*.

BDFL Sigla de Benevolent Dictator For Life, Benevolente dictador vitalicio, es decir Guido van Rossum, el creador de Python.

archivo binario Un *file object* capaz de leer y escribir *objetos tipo binarios*. Ejemplos de archivos binarios son los abiertos en modo binario (`'rb'`, `'wb'` o `'rb+'`), `sys.stdin.buffer`, `sys.stdout.buffer`, e instancias de `io.BytesIO` y de `gzip.GzipFile`.

Vea también *text file* para un objeto archivo capaz de leer y escribir objetos `str`.

objetos tipo binarios Un objeto que soporta bufferobjects y puede exportar un buffer C-*contiguous*. Esto incluye todas los objetos `bytes`, `bytearray`, y `array.array`, así como muchos objetos comunes `memoryview`. Los objetos tipo binarios pueden ser usados para varias operaciones que usan datos binarios; éstas incluyen compresión, salvar a archivos binarios, y enviarlos a través de un socket.

Algunas operaciones necesitan que los datos binarios sean mutables. La documentación frecuentemente se refiere a éstos como «objetos tipo binario de lectura y escritura». Ejemplos de objetos de buffer mutables incluyen a `bytearray` y `memoryview` de la `bytearray`. Otras operaciones que requieren datos binarios almacenados en objetos inmutables («objetos tipo binario de sólo lectura»); ejemplos de éstos incluyen `bytes` y `memoryview` del objeto `bytes`.

bytecode El código fuente Python es compilado en bytecode, la representación interna de un programa python en el intérprete CPython. El bytecode también es guardado en caché en los archivos *.pyc* de tal forma que ejecutar el mismo archivo es más fácil la segunda vez (la recompilación desde el código fuente a bytecode puede ser evitada). Este «lenguaje intermedio» deberá corren en una *virtual machine* que ejecute el código de máquina correspondiente a cada bytecode. Note que los bytecodes no tienen como requisito trabajar en las diversas máquina virtuales de Python, ni de ser estable entre versiones Python.

Una lista de las instrucciones en bytecode está disponible en la documentación de el módulo dis.

clase Una plantilla para crear objetos definidos por el usuario. Las definiciones de clase normalmente contienen definiciones de métodos que operan una instancia de la clase.

variable de clase Una variable definida en una clase y prevista para ser modificada sólo a nivel de clase (es decir, no en una instancia de la clase).

coerción La conversión implícita de una instancia de un tipo en otra durante una operación que involucra dos argumentos del mismo tipo. Por ejemplo, `int(3.15)` convierte el número de punto flotante al entero `3`, pero en `3 + 4.5`, cada argumento es de un tipo diferente (uno entero, otro flotante), y ambos deben ser convertidos al mismo tipo antes de que puedan ser sumados o emitiría un `TypeError`. Sin coerción, todos los argumentos, incluso de tipos compatibles, deberían ser normalizados al mismo tipo por el programador, por ejemplo `float(3)+4.5` en lugar de `3+4.5`.

número complejo Una extensión del sistema familiar de número reales en el cual los números son expresados como la suma de una parte real y una parte imaginaria. Los números imaginarios son múltiplos de la unidad imaginaria (la raíz cuadrada de `-1`), usualmente escrita como `i` en matemáticas o `j` en ingeniería. Python tiene soporte incorporado para números complejos, los cuales son escritos con la notación mencionada al final.; la parte imaginaria es escrita con un sufijo `j`, por ejemplo, `3+1j`. Para tener acceso a los equivalentes complejos del módulo `math` module, use :mod:'cmath. El uso de números complejos es matemática bastante avanzada. Si no le parecen necesarios, puede ignorarlos sin inconvenientes.

administrador de contextos Un objeto que controla el entorno en la sentencia `with` definiendo `__enter__()` y `__exit__()` methods. Vea **PEP 343**.

context variable A variable which can have different values depending on its context. This is similar to Thread-Local Storage in which each execution thread may have a different value for a variable. However, with context variables, there may be several contexts in one execution thread and the main usage for context variables is to keep track of variables in concurrent asynchronous tasks. See `contextvars`.

contiguo Un buffer es considerado contiguo con precisión si es *C-contíguo* o *Fortran contiguo*. Los buffers cero dimensionales con C y Fortran contiguos. En los arreglos unidimensionales, los ítems deben ser dispuestos en memoria uno siguiente al otro, ordenados por índices que comienzan en cero. En arreglos unidimensionales C-contíguos, el último índice varía más velozmente en el orden de las direcciones de memoria. Sin embargo, en arreglos Fortran contiguos, el primer índice vería más rápidamente.

corrutina Coroutines are a more generalized form of subroutines. Subroutines are entered at one point and exited at another point. Coroutines can be entered, exited, and resumed at many different points. They can be implemented with the `async def` statement. See also **PEP 492**.

función corrutina Un función que retorna un objeto *coroutine* . Una función corrutina puede ser definida con la sentencia `async def`, y puede contener las palabras claves `await`, `async for`, y `async with`. Las mismas son introducidas en **PEP 492**.

CPython La implementación canónica del lenguaje de programación Python, como se distribuye en python.org. El término «CPython» es usado cuando es necesario distinguir esta implementación de otras como Jython o IronPython.

decorador Una función que retorna otra función, usualmente aplicada como una función de transformación empleando la sintaxis `@envoltorio`. Ejemplos comunes de decoradores son `classmethod()` y func:*staticmethod*.

La sintaxis del decorador es meramente azúcar sintáctico, las definiciones de las siguientes dos funciones son semánticamente equivalentes:

```
def f(...):
    ...
f = staticmethod(f)

@staticmethod
def f(...):
    ...
```

El mismo concepto existe para clases, pero son menos usadas. Vea la documentación de function definitions y class definitions para mayor detalle sobre decoradores.

descriptor Cualquier objeto que define los métodos `__get__()`, `__set__()`, o `__delete__()`. Cuando un atributo de clase es un descriptor, su conducta enlazada especial es disparada durante la búsqueda del atributo. Normalmente, usando *a.b* para consultar, establecer o borrar un atributo busca el objeto llamado *b* en el diccionario de clase de *a*, pero si *b* es un descriptor, el respectivo método descriptor es llamado. Entender descriptores es clave para lograr una comprensión profunda de Python porque son la base de muchas de las capacidades incluyendo funciones, métodos, propiedades, métodos de clase, métodos estáticos, y referencia a súper clases.

Para más información sobre métodos descriptores, vea descriptors.

diccionario Un arreglo asociativo, con claves arbitrarias que son asociadas a valores. Las claves pueden ser cualquier objeto con los métodos `__hash__()` y `__eq__()` . Son llamadas hash en Perl.

vista de diccionario Los objetos retornados por los métodos `dict.keys()`, `dict.values()`, y `dict.items()` son llamados vistas de diccionarios. Proveen una vista dinámica de las entradas de un diccionario, lo que significa que cuando el diccionario cambia, la vista refleja éstos cambios. Para forzar a la vista de diccionario a convertirse en una lista completa, use `list(dictview)`. Vea dict-views.

docstring Una cadena de caracteres literal que aparece como la primera expresión en una clase, función o módulo. Aunque es ignorada cuando se ejecuta, es reconocida por el compilador y puesta en el atributo `__doc__` de la clase, función o módulo comprendida. Como está disponible mediante introspección, es el lugar canónico para ubicar la documentación del objeto.

tipado de pato Un estilo de programación que no revisa el tipo del objeto para determinar si tiene la interfaz correcta; en vez de ello, el método o atributo es simplemente llamado o usado («Si se ve como un pato y grazna como un pato, debe ser un pato»). Enfatizando las interfaces en vez de hacerlo con los tipos específicos, un código bien diseñado pues tener mayor flexibilidad permitiendo la sustitución polimórfica. El tipado de pato *duck-typing* evita usar pruebas llamando a `type()` o `isinstance()`. (Nota: si embargo, el tipado de pato puede ser complementado con *abstract base classes*. En su lugar, generalmente emplea `hasattr()` tests o *EAFP*.

EAFP Del inglés «Easier to ask for forgiveness than permission», es más fácil pedir perdón que pedir permiso. Este estilo de codificación común en Python asume la existencia de claves o atributos válidos y atrapa las excepciones si esta suposición resulta falsa. Este estilo rápido y limpio está caracterizado por muchas sentencias `try` y `except`. Esta técnica contrasta con estilo *LBYL* usual en otros lenguajes como C.

expresión Una construcción sintáctica que puede ser evaluada, hasta dar un valor. En otras palabras, una expresión es una acumulación de elementos de expresión tales como literales, nombres, accesos a atributos, operadores o llamadas a funciones, todos ellos retornando valor. A diferencia de otros lenguajes, no toda la sintaxis del lenguaje son expresiones. También hay *statement*s que no pueden ser usadas como expresiones, como la `while`. Las asignaciones también son sentencias, no expresiones.

módulo de extensión Un módulo escrito en C o C++, usando la API para C de Python para interactuar con el núcleo y el código del usuario.

f-string Son llamadas «f-strings» las cadenas literales que usan el prefijo `'f'` o `'F'`, que es una abreviatura para cadenas literales formateadas. Vea también **PEP 498**.

objeto archivo Un objeto que expone una API orientada a archivos (con métodos como `read()` o `write()`) al objeto subyacente. Dependiendo de la forma en la que fue creado, un objeto archivo, puede mediar el acceso a un archivo real en el disco u otro tipo de dispositivo de almacenamiento o de comunicación (por ejemplo, entrada/salida estándar, buffer de memoria, sockets, pipes, etc.). Los objetos archivo son también denominados *objetos tipo archivo* o *flujos*.

Existen tres categorías de objetos archivo: crudos *raw* *archivos binarios*, con buffer *archivos binarios* y *archivos de texto*. Sus interfaces son definidas en el módulo `io`. La forma canónica de crear objetos archivo es usando la función `open()`.

objetos tipo archivo Un sinónimo de *file object*.

buscador Un objeto que trata de encontrar el *loader* para el módulo que está siendo importado.

Desde la versión 3.3 de Python, existen dos tipos de buscadores: *meta buscadores de ruta* para usar con `sys.meta_path`, y *buscadores de entradas de rutas* para usar con `sys.path_hooks`.

Vea **PEP 302**, **PEP 420** y **PEP 451** para mayores detalles.

división entera Una división matemática que se redondea hacia el entero menor más cercano. El operador de la división entera es `//`. Por ejemplo, la expresión `11 // 4` evalúa `2` a diferencia del `2.75` retornado por la verdadera división de números flotantes. Note que `(-11) // 4` es `-3` porque es `-2.75` redondeado *para abajo*. Ver **PEP 238**.

función Una serie de sentencias que retornan un valor al que las llama. También se le puede pasar cero o más *argumentos* los cuales pueden ser usados en la ejecución de la misma. Vea también *parameter*, *method*, y la sección function.

anotación de función Una *annotation* del parámetro de una función o un valor de retorno.

Las anotaciones de funciones son usadas frecuentemente para type hint's , por ejemplo, se espera que una función tome dos argumentos de clase :class:'int y también se espera que devuelva dos valores `int`:

```
def sum_two_numbers(a: int, b: int) -> int:
   return a + b
```

La sintaxis de las anotaciones de funciones son explicadas en la sección function.

Vea *variable annotation* y **PEP 484**, que describen esta funcionalidad.

__future__ Un pseudo-módulo que los programadores pueden usar para habilitar nuevas capacidades del lenguaje que no son compatibles con el intérprete actual.

Al importar el módulo `__future__` y evaluar sus variables, puede verse cuándo las nuevas capacidades fueron agregadas por primera vez al lenguaje y cuando se quedaron establecidas por defecto:

```
>>> import __future__
>>> __future__.division
_Feature((2, 2, 0, 'alpha', 2), (3, 0, 0, 'alpha', 0), 8192)
```

recolección de basura El proceso de liberar la memoria de lo que ya no está en uso. Python realiza recolección de basura (*garbage collection*) llevando la cuenta de las referencias, y el recogedor de basura cíclico es capaz de detectar y romper las referencias cíclicas. El recogedor de basura puede ser controlado mediante el módulo `gc` .

generador Una función que retorna un *generator iterator*. Luce como una función normal excepto que contiene la expresión `yield` para producir series de valores utilizables en un bucle for o que pueden ser obtenidas una por una con la función `next()`.

Usualmente se refiere a una función generadora, pero puede referirse a un *iterador generador* en ciertos contextos. En aquellos casos en los que el significado no está claro, usar los términos completos evita la ambigüedad.

iterador generador Un objeto creado por una función *generator*.

Cada `yield` suspende temporalmente el procesamiento, recordando el estado de ejecución local (incluyendo las variables locales y las sentencias try pendientes). Cuando el «iterador generado» vuelve, retoma donde ha dejado, a diferencia de lo que ocurre con las funciones que comienzan nuevamente con cada invocación.

expresión generadora Una expresión que retorna un iterador. Luce como una expresión normal seguida por la cláusula `for` definiendo así una variable de bucle, un rango y una cláusula opcional `if`. La expresión combinada genera valores para la función contenedora:

```
>>> sum(i*i for i in range(10))         # sum of squares 0, 1, 4, ... 81
285
```

función genérica Una función compuesta de muchas funciones que implementan la misma operación para diferentes tipos. Qué implementación deberá ser usada durante la llamada a la misma es determinado por el algoritmo de despacho.

Vea también la entrada de glosario *single dispatch*, el decorador `functools.singledispatch()`, y **PEP 443**.

GIL Vea *global interpreter lock*.

bloqueo global del intérprete Mecanismo empleado por el intérprete *CPython* para asegurar que sólo un hilo ejecute el *bytecode* Python por vez. Esto simplifica la implementación de CPython haciendo que el modelo de objetos (incluyendo algunos críticos como `dict`) están implícitamente a salvo de acceso concurrente. Bloqueando el intérprete completo se simplifica hacerlo multi-hilos, a costa de mucho del paralelismo ofrecido por las máquinas con múltiples procesadores.

Sin embargo, algunos módulos de extensión, tanto estándar como de terceros, están diseñados para liberar el GIL cuando se realizan tareas computacionalmente intensivas como la compresión o el hashing. Además, el GIL siempre es liberado cuando se hace entrada/salida.

Esfuerzos previos hechos para crear un intérprete «sin hilos» (uno que bloquee los datos compartidos con una granularidad mucho más fina) no han sido exitosos debido a que el rendimiento sufrió para el caso más común de un solo procesador. Se cree que superar este problema de rendimiento haría la implementación mucho más compleja y por tanto, más costosa de mantener.

hash-based pyc Un archivo cache de bytecode que usa el hash en vez de usar el tiempo de la última modificación del archivo fuente correspondiente para determinar su validez. Vea pyc-invalidation.

hashable Un objeto es *hashable* si tiene un valor de hash que nunca cambiará durante su tiempo de vida (necesita un método `__hash__()`), y puede ser comparado con otro objeto (necesita el método `__eq__()`). Los objetos hashables que se comparan iguales deben tener el mismo número hash.

La hashabilidad hace a un objeto empleable como clave de un diccionario y miembro de un set, porque éstas estructuras de datos usan los valores de hash internamente.

Most of Python's immutable built-in objects are hashable; mutable containers (such as lists or dictionaries) are not; immutable containers (such as tuples and frozensets) are only hashable if their elements are hashable. 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 El entorno integrado de desarrollo de Python, o «Integrated Development Environment for Python». IDLE es un editor básico y un entorno de intérprete que se incluye con la distribución estándar de Python.

inmutable Un objeto con un valor fijo. Los objetos inmutables son números, cadenas y tuplas. Éstos objetos no pueden ser alterados. Un nuevo objeto debe ser creado si un valor diferente ha de ser guardado. Juegan un rol importante en lugares donde es necesario un valor de hash constante, por ejemplo como claves de un diccionario.

ruta de importación Una lista de las ubicaciones (o *entradas de ruta*) que son revisadas por *path based finder* al importar módulos. Durante la importación, ésta lista de localizaciones usualmente viene de `sys.path`, pero para los subpaquetes también puede incluir al atributo `__path__` del paquete padre.

importar El proceso mediante el cual el código Python dentro de un módulo se hace alcanzable desde otro código Python en otro módulo.

importador Un objeto que buscan y lee un módulo; un objeto que es tanto *finder* como *loader*.

interactivo Python tiene un intérprete interactivo, lo que significa que puede ingresar sentencias y expresiones en el prompt del intérprete, ejecutarlos de inmediato y ver sus resultados. Sólo ejecute `python` sin argumentos (podría seleccionarlo desde el menú principal de su computadora). Es una forma muy potente de probar nuevas ideas o inspeccionar módulos y paquetes (recuerde `help(x)`).

interpretado Python es un lenguaje interpretado, a diferencia de uno compilado, a pesar de que la distinción puede ser difusa debido al compilador a bytecode. Esto significa que los archivos fuente pueden ser corridos directamente, sin crear explícitamente un ejecutable que es corrido luego. Los lenguajes interpretados típicamente tienen ciclos de desarrollo y depuración más cortos que los compilados, sin embargo sus programas suelen correr más lentamente. Vea también *interactive*.

apagado del intérprete Cuando se le solicita apagarse, el intérprete Python ingresa a un fase especial en la cual gradualmente libera todos los recursos reservados, como módulos y varias estructuras internas críticas. También hace varias llamadas al *recolector de basura*. Esto puede disparar la ejecución de código de destructores definidos por el usuario o «weakref callbacks». El código ejecutado durante la fase de apagado puede encontrar varias excepciones debido a que los recursos que necesita pueden no funcionar más (ejemplos comunes son los módulos de bibliotecas o los artefactos de advertencias «warnings machinery»)

La principal razón para el apagado del intérpreter es que el módulo `__main__` o el script que estaba corriendo termine su ejecución.

iterable Un objeto capaz de retornar sus miembros uno por vez. Ejemplos de iterables son todos los tipos de secuencias (como `list`, `str`, y `tuple`) y algunos de tipos no secuenciales, como `dict`, *objeto archivo*, y objetos de cualquier clase que defina con los métodos `__iter__()` o con un método `__getitem__()` que implementen la semántica de *Sequence*.

Los iterables pueden ser usados en el bucle `for` y en muchos otros sitios donde una secuencia es necesaria (`zip()`, `map()`, …). Cuando un objeto iterable es pasado como argumento a la función incorporada `iter()`, retorna un iterador para el objeto. Este iterador pasa así el conjunto de valores. Cuando se usan iterables, normalmente no es necesario llamar a la función `iter()` o tratar con los objetos iteradores usted mismo. La sentencia `for` lo hace automáticamente por usted, creando un variable temporal sin nombre para mantener el iterador mientras dura el bucle. Vea también *iterator*, *sequence*, y *generator*.

iterador Un objeto que representa un flujo de datos. Llamadas repetidas al método `__next__()` del iterador (o al pasar la función incorporada `next()`) retorna ítems sucesivos del flujo. Cuando no hay más datos disponibles, una excepción `StopIteration` es disparada. En este momento, el objeto iterador está exhausto y cualquier llamada posterior al método `__next__()` sólo dispara otra vez `StopIteration`. Los iteradores necesitan tener un método:meth:*__iter__* que retorna el objeto iterador mismo así cada iterador es también un iterable y puede ser usado en casi todos los lugares donde los iterables son aceptados. Una excepción importante es el código que intenta múltiples pases de iteración. Un objeto contenedor (como la `list`) produce un nuevo iterador cada vez que las pasa a una función `iter()` o la usa en un blucle `for`. Intentar ésto con un iterador simplemente retornaría el mismo objeto iterador exhausto usado en previas iteraciones, haciéndolo aparecer como un contenedor vacío.

Puede encontrar más información en typeiter.

función clave Una función clave o una función de colación es un invocable que retorna un valor usado para el ordenamiento o clasificación. Por ejemplo, `locale.strxfrm()` es usada para producir claves de ordenamiento que se adaptan a las convenciones específicas de ordenamiento de un locale.

Cierta cantidad de herramientas de Python aceptan funciones clave para controlar como los elementos son ordenados o agrupados. Incluyendo a `min()`, `max()`, `sorted()`, `list.sort()`, `heapq.merge()`, `heapq.nsmallest()`, `heapq.nlargest()`, y `itertools.groupby()`.

Hay varias formas de crear una función clave. Por ejemplo, el método `str.lower()` puede servir como función clave para ordenamientos que no distingan mayúsculas de minúsculas. Como alternativa, una función clave puede ser realizada con una expresión `lambda` como `lambda r: (r[0], r[2])`. También, el módulo `operator` provee tres constructores de funciones clave: `attrgetter()`, `itemgetter()`, y `methodcaller()`. Vea en Sorting HOW TO ejemplos de cómo crear y usar funciones clave.

argumento nombrado Vea *argument*.

lambda Una función anónima de una línea consistente en un sola *expression* que es evaluada cuando la función es llamada. La sintaxis para crear una función lambda es `lambda [parameters]: expression`

LBYL Del inglés «Look before you leap», «mira antes de saltar». Es un estilo de codificación que prueba explícitamente las condiciones previas antes de hacer llamadas o búsquedas. Este estilo contrasta con la manera *EAFP* y está caracterizado por la presencia de muchas sentencias `if`.

En entornos multi-hilos, el método LBYL tiene el riesgo de introducir condiciones de carrera entre los hilos que están «mirando» y los que están «saltando». Por ejemplo, el código, *if key in mapping: return mapping[key]‘* puede fallar si otro hilo remueve *key* de *mapping* después del test, pero antes de retornar el valor. Este problema puede ser resuelto usando bloqueos o empleando el método EAFP.

lista Es una *sequence* Python incorporada. A pesar de su nombre es más similar a un arreglo en otros lenguajes que a una lista enlazada porque el acceso a los elementos es O(1).

comprensión de listas Una forma compacta de procesar todos o parte de los elementos en una secuencia y retornar una lista como resultado. `result = ['{:#04x}'.format(x) for x in range(256) if x % 2 == 0]` genera una lista de cadenas conteniendo números hexadecimales (0x..) entre 0 y 255. La cláusula `if` es opcional. Si es omitida, todos los elementos en `range(256)` son procesados.

cargador Un objeto que carga un módulo. Debe definir el método llamado `load_module()`. Un cargador es normalmente retornados por un *finder*. Vea **PEP 302** para detalles y `importlib.abc.Loader` para una *abstract base class*.

método mágico Una manera informal de llamar a un *special method*.

mapeado Un objeto contenedor que permite recupero de claves arbitrarias y que implementa los métodos especificados en la `Mapping` o `MutableMapping` abstract base classes. Por ejemplo, `dict`, `collections.defaultdict`, `collections.OrderedDict` y `collections.Counter`.

meta buscadores de ruta Un *finder* retornado por una búsqueda de `sys.meta_path`. Los meta buscadores de ruta están relacionados a *buscadores de entradas de rutas*, pero son algo diferente.

Vea en `importlib.abc.MetaPathFinder` los métodos que los meta buscadores de ruta implementan.

metaclase La clase de una clase. Las definiciones de clases crean nombres de clase, un diccionario de clase, y una lista de clases base. Las metaclases son responsables de tomar estos tres argumentos y crear la clase. La mayoría de los objetos de un lenguaje de programación orientado a objetos provienen de una implementación por defecto. Lo que hace a Python especial que es posible crear metaclases a medida. La mayoría de los usuario nunca necesitarán esta herramienta, pero cuando la necesidad surge, las metaclases pueden brindar soluciones poderosas y elegantes. Han sido usadas para loggear acceso de atributos, agregar seguridad a hilos, rastrear la creación de objetos, implementar singletons, y muchas otras tareas.

Más información hallará en metaclasses.

método Una función que es definida dentro del cuerpo de una clase. Si es llamada como un atributo de una instancia de otra clase, el método tomará el objeto instanciado como su primer *argument* (el cual es usualmente denominado *self*). Vea *function* y *nested scope*.

orden de resolución de métodos Orden de resolución de métodos es el orden en el cual una clase base es buscada por un miembro durante la búsqueda. Mire en The Python 2.3 Method Resolution Order los detalles del algoritmo usado por el intérprete Python desde la versión 2.3.

módulo Un objeto que sirve como unidad de organización del código Python. Los módulos tienen espacios de nombres conteniendo objetos Python arbitrarios. Los módulos son cargados en Python por el proceso de *importing*.

Vea también *package*.

especificador de módulo Un espacio de nombres que contiene la información relacionada a la importación usada al leer un módulo. Una instancia de `importlib.machinery.ModuleSpec`.

MRO Vea *method resolution order*.

mutable Los objetos mutables pueden cambiar su valor pero mantener su `id()`. Vea también *immutable*.

tupla nombrada The term «named tuple» applies to any type or class that inherits from tuple and whose indexable elements are also accessible using named attributes. The type or class may have other features as well.

Several built-in types are named tuples, including the values returned by `time.localtime()` and `os.stat()`. Another example is `sys.float_info`:

```
>>> sys.float_info[1]                   # indexed access
1024
>>> sys.float_info.max_exp              # named field access
1024
>>> isinstance(sys.float_info, tuple)   # kind of tuple
True
```

Some named tuples are built-in types (such as the above examples). Alternatively, a named tuple can be created from a regular class definition that inherits from `tuple` and that defines named fields. Such a class can be written by hand or it can be created with the factory function `collections.namedtuple()`. The latter technique also adds some extra methods that may not be found in hand-written or built-in named tuples.

espacio de nombres El lugar donde la variable es almacenada. Los espacios de nombres son implementados como diccionarios. Hay espacio de nombre local, global, e incorporado así como espacios de nombres anidados en objetos (en métodos). Los espacios de nombres soportan modularidad previniendo conflictos de nombramiento. Por ejemplo, las funciones `builtins.open` y `os.open()` se distinguen por su espacio de nombres. Los espacios de nombres también ayuda a la legibilidad y mantenibilidad dejando claro qué módulo implementa una función. Por ejemplo, escribiendo `random.seed()` o `itertools.islice()` queda claro que éstas funciones están implementadas en los módulos `random` y `itertools`, respectivamente.

paquete de espacios de nombres Un **PEP 420** *package* que sirve sólo para contener subpaquetes. Los paquetes de espacios de nombres pueden no tener representación física, y específicamente se diferencian de los *regular package* porque no tienen un archivo `__init__.py`.

Vea también *module*.

alcances anidados La habilidad de referirse a una variable dentro de una definición encerrada. Por ejemplo, una función definida dentro de otra función puede referir a variables en la función externa. Note que los alcances anidados por defecto sólo funcionan para referencia y no para asignación. Las variables locales leen y escriben sólo en el alcance más interno. De manera semejante, las variables globales pueden leer y escribir en el espacio de nombres global. Con `nonlocal` se puede escribir en alcances exteriores.

clase de nuevo estilo Vieja denominación usada para el estilo de clases ahora empleado en todos los objetos de clase. En versiones más tempranas de Python, sólo las nuevas clases podían usar capacidades nuevas y versátiles de Python como `__slots__`, descriptores, propiedades, `__getattribute__()`, métodos de clase y métodos estáticos.

objeto Cualquier dato con estado (atributo o valor) y comportamiento definido (métodos). También es la más básica clase base para cualquier *new-style class*.

paquete Un *module* Python que puede contener submódulos o recursivamente, subpaquetes. Técnicamente, un paquete es un módulo Python con un atributo `__path__`.

Vea también *regular package* y *namespace package*.

parámetro Una entidad nombrada en una definición de una *function* (o método) que especifica un *argument* (o en algunos casos, varios argumentos) que la función puede aceptar. Existen cinco tipos de argumentos:

- *posicional o nombrado*: especifica un argumento que puede ser pasado tanto como *posicional* o como *nombrado*. Este es el tipo por defecto de parámetro, como *foo* y *bar* en el siguiente ejemplo:

```
def func(foo, bar=None): ...
```

- *sólo posicional*: especifica un argumento que puede ser pasado sólo por posición. Python no tiene una sintaxis específica para los parámetros que son sólo por posición. Sin embargo, algunas funciones tienen parámetros sólo por posición (por ejemplo `abs()`).

- *sólo nombrado*: especifica un argumento que sólo puede ser pasado por nombre. Los parámetros sólo por nombre pueden ser definidos incluyendo un parámetro posicional de una sola variable o un mero `` *` `` antes de ellos en la lista de parámetros en la definición de la función, como *kw_only1* y *kw_only2* en el ejemplo siguiente:

```
def func(arg, *, kw_only1, kw_only2): ...
```

- *variable posicional*: especifica una secuencia arbitraria de argumentos posicionales que pueden ser brindados (además de cualquier argumento posicional aceptado por otros parámetros). Este parámetro puede ser definido anteponiendo al nombre del parámetro `*`, como a *args* en el siguiente ejemplo:

```
def func(*args, **kwargs): ...
```

- *variable nombrado*: especifica que arbitrariamente muchos argumentos nombrados pueden ser brindados (además de cualquier argumento nombrado ya aceptado por cualquier otro parámetro). Este parámetro puede ser definido anteponiendo al nombre del parámetro con `**`, como *kwargs* en el ejemplo más arriba.

Los parámetros puede especificar tanto argumentos opcionales como requeridos, así como valores por defecto para algunos argumentos opcionales.

Vea también el glosario de *argument*, la pregunta respondida en *la diferencia entre argumentos y parámetros*, la clase `inspect.Parameter`, la sección function , y **PEP 362**.

entrada de ruta Una ubicación única en el *import path* que el *path based finder* consulta para encontrar los módulos a importar.

buscador de entradas de ruta Un *finder* retornado por un invocable en `sys.path_hooks` (esto es, un *path entry hook*) que sabe cómo localizar módulos dada una *path entry*.

Vea en `importlib.abc.PathEntryFinder` los métodos que los buscadores de entradas de paths implementan.

gancho a entrada de ruta Un invocable en la lista `sys.path_hook` que retorna un *path entry finder* si éste sabe cómo encontrar módulos en un *path entry* específico.

buscador basado en ruta Uno de los *meta buscadores de ruta* por defecto que busca un *import path* para los módulos.

objeto tipo ruta Un objeto que representa una ruta del sistema de archivos. Un objeto tipo ruta puede ser tanto una `str` como un `bytes` representando una ruta, o un objeto que implementa el protocolo `os.PathLike`. Un objeto que soporta el protocolo `os.PathLike` puede ser convertido a ruta del sistema de archivo de clase `str` o `bytes` usando la función `os.fspath()`; `os.fsdecode()` `os.fsencode()` pueden emplearse para garantizar que retorne respectivamente `str` o `bytes`. Introducido por **PEP 519**.

PEP Propuesta de mejora de Python, del inglés «Python Enhancement Proposal». Un PEP es un documento de diseño que brinda información a la comunidad Python, o describe una nueva capacidad para Python, sus procesos o entorno. Los PEPs deberían dar una especificación técnica concisa y una fundamentación para las capacidades propuestas.

Los PEPs tienen como propósito ser los mecanismos primarios para proponer nuevas y mayores capacidad, para recoger la opinión de la comunidad sobre un tema, y para documentar las decisiones de diseño que se han hecho en Python. El autor del PEP es el responsable de lograr consenso con la comunidad y documentar las opiniones disidentes.

Vea **PEP 1**.

porción Un conjunto de archivos en un único directorio (posiblemente guardo en un archivo comprimido zip) que contribuye a un espacio de nombres de paquete, como está definido en **PEP 420**.

argumento posicional Vea *argument*.

API provisoria Una API provisoria es aquella que deliberadamente fue excluida de las garantías de compatibilidad hacia atrás de la biblioteca estándar. Aunque no se esperan cambios fundamentales en dichas interfaces, como están marcadas como provisionales, los cambios incompatibles hacia atrás (incluso remover la misma interfaz) podrían ocurrir si los desarrolladores principales lo estiman. Estos cambios no se hacen gratuitamente – solo ocurrirán si fallas fundamentales y serias son descubiertas que no fueron vistas antes de la inclusión de la API.

Incluso para APIs provisorias, los cambios incompatibles hacia atrás son vistos como una «solución de último recurso» - se intentará todo para encontrar una solución compatible hacia atrás para los problemas identificados.

Este proceso permite que la biblioteca estándar continúe evolucionando con el tiempo, sin bloquearse por errores de diseño problemáticos por períodos extensos de tiempo. Vea :pep'241' para más detalles.

paquete provisorio Vea *provisional API*.

Python 3000 Apodo para la fecha de lanzamiento de Python 3.x (acuñada en un tiempo cuando llegar a la versión 3 era algo distante en el futuro.) También se lo abrevió como «Py3k».

Pythónico Una idea o pieza de código que sigue ajustadamente la convenciones idiomáticas comunes del lenguaje Python, en vez de implementar código usando conceptos comunes a otros lenguajes. Por ejemplo, una convención común en Python es hacer bucles sobre todos los elementos de un iterable con la sentencia `for`. Muchos otros lenguajes no tienen este tipo de construcción, así que los que no están familiarizados con Python podrían usar contadores numéricos:

```
for i in range(len(food)):
    print(food[i])
```

En contraste, un método Pythónico más limpio:

```
for piece in food:
    print(piece)
```

nombre calificado Un nombre con puntos mostrando la ruta desde el alcance global del módulo a la clase, función o método definido en dicho módulo, como se define en **PEP 3155**. Para las funciones o clases de más alto nivel, el nombre calificado es el igual al nombre del objeto:

```
>>> class C:
...     class D:
...         def meth(self):
...             pass
...
>>> C.__qualname__
'C'
>>> C.D.__qualname__
```

(continué en la próxima página)

(proviene de la página anterior)

```
'C.D'
>>> C.D.meth.__qualname__
'C.D.meth'
```

Cuando es usado para referirse a los módulos, *nombre completamente calificado* significa la ruta con puntos completo al módulo, incluyendo cualquier paquete padre, por ejemplo, *email.mime.text*':

```
>>> import email.mime.text
>>> email.mime.text.__name__
'email.mime.text'
```

contador de referencias El número de referencias a un objeto. Cuando el contador de referencias de un objeto cae hasta cero, éste es desalojable. En conteo de referencias no suele ser visible en el código de Python, pero es un elemento clave para la implementación de *CPython*. El módulo `sys` define la `getrefcount()` que los programadores pueden emplear para retornar el conteo de referencias de un objeto en particular.

paquete regular Un *package* tradicional, como aquellos con un directorio conteniendo el archivo `__init__.py`.

Vea también *namespace package*.

__slots__ Es una declaración dentro de una clase que ahorra memoria pre declarando espacio para las atributos de la instancia y eliminando diccionarios de la instancia. Aunque es popular, esta técnica es algo dificultosa de lograr correctamente y es mejor reservarla para los casos raros en los que existen grandes cantidades de instancias en aplicaciones con uso crítico de memoria.

secuencia Un *iterable* que logra un acceso eficiente a los elementos usando índices enteros a través del método especial `__getitem__()` y que define un método `__len__()` que devuelve la longitud de la secuencia. Algunas de las secuencias incorporadas son `list`, `str`, `tuple`, y `bytes`. Observe que `dict` también soporta `__getitem__()` y `__len__()`, pero es considerada un mapeo más que una secuencia porque las búsquedas son por claves arbitraria *immutable* y no por enteros.

La clase base abstracta `collections.abc.Sequence` define una interfaz mucho más rica que va más allá de sólo `__getitem__()` y `__len__()`, agregando `count()`, `index()`, `__contains__()`, y `__reversed__()`. Los tipos que implementan esta interfaz expandida pueden ser registrados explícitamente usando `register()`.

despacho único Una forma de despacho de una *generic function* donde la implementación es elegida a partir del tipo de un sólo argumento.

rebanada Un objeto que contiene una porción de una *sequence*. Una rebanada es creada usando la notación de suscripto, `[]` con dos puntos entre los números cuando se ponen varios, como en `nombre_variable[1:3:5]`. La notación con corchete (suscrito) usa internamente objetos `slice`.

método especial Un método que es llamado implícitamente por Python cuando ejecuta ciertas operaciones en un tipo, como la adición. Estos métodos tienen nombres que comienzan y terminan con doble barra baja. Los métodos especiales están documentados en specialnames.

sentencia Una sentencia es parte de un conjunto (un «bloque» de código). Una sentencia tanto es una *expression* como alguna de las varias sintaxis usando una palabra clave, como `if`, `while` o `for`.

codificación de texto Un códec que codifica las cadenas Unicode a bytes.

archivo de texto Un *file object* capaz de leer y escribir objetos `str`. Frecuentemente, un archivo de texto también accede a un flujo de datos binario y maneja automáticamente el *text encoding*. Ejemplos de archivos de texto que son abiertos en modo texto (`'r'` o `'w'`), `sys.stdin`, `sys.stdout`, y las instancias de `io.StringIO`.

Vea también *binary file* por objeto de archivos capaces de leer y escribir *objeto tipo binario*.

cadena con triple comilla Una cadena que está enmarcada por tres instancias de comillas (») o apostrofes ("). Aunque no brindan ninguna funcionalidad que no está disponible usando cadenas con comillas simple, son útiles por varias razones. Permiten incluir comillas simples o dobles sin escapar dentro de las cadenas y pueden abarcar múltiples líneas sin el uso de caracteres de continuación, haciéndolas particularmente útiles para escribir docstrings.

tipo El tipo de un objeto Python determina qué tipo de objeto es; cada objeto tiene un tipo. El tipo de un objeto puede ser accedido por su atributo `__class__` o puede ser conseguido usando `type(obj)`.

alias de tipos Un sinónimo para un tipo, creado al asignar un tipo a un identificador.

Los alias de tipos son útiles para simplificar los *indicadores de tipo*. Por ejemplo:

```
from typing import List, Tuple

def remove_gray_shades(
        colors: List[Tuple[int, int, int]]) -> List[Tuple[int, int, int]]:
    pass
```

podría ser más legible así:

```
from typing import List, Tuple

Color = Tuple[int, int, int]

def remove_gray_shades(colors: List[Color]) -> List[Color]:
    pass
```

Vea `typing` y **PEP 484**, que describen esta funcionalidad.

indicador de tipo Una *annotation* que especifica el tipo esperado para una variable, un atributo de clase, un parámetro para una función o un valor de retorno.

Los indicadores de tipo son opcionales y no son obligados por Python pero son útiles para las herramientas de análisis de tipos estático, y ayuda a las IDE en el completado del código y la refactorización.

Los indicadores de tipo de las variables globales, atributos de clase, y funciones, no de variables locales, pueden ser accedidos usando `typing.get_type_hints()`.

Vea `typing` y **PEP 484**, que describen esta funcionalidad.

saltos de líneas universales Una manera de interpretar flujos de texto en la cual son reconocidos como finales de línea todas siguientes formas: la convención de Unix para fin de línea `'\n'`, la convención de Windows `'\r\n'`, y la vieja convención de Macintosh `'\r'`. Vea **PEP 278** y **PEP 3116**, además de:func:*bytes.splitlines* para usos adicionales.

anotación de variable Una *annotation* de una variable o un atributo de clase.

Cuando se anota una variable o un atributo de clase, la asignación es opcional:

```
class C:
    field: 'annotation'
```

Las anotaciones de variables son frecuentemente usadas para *type hints*: por ejemplo, se espera que esta variable tenga valores de clase `int`:

```
count: int = 0
```

La sintaxis de la anotación de variables está explicada en la sección annassign.

Vea *function annotation*, **PEP 484** y **PEP 526**, los cuales describen esta funcionalidad.

entorno virtual Un entorno cooperativamente aislado de ejecución que permite a los usuarios de Python y a las aplicaciones instalar y actualizar paquetes de distribución de Python sin interferir con el comportamiento de otras aplicaciones de Python en el mismo sistema.

Vea también `venv`.

máquina virtual Una computadora definida enteramente por software. La máquina virtual de Python ejecuta el *bytecode* generado por el compilador de bytecode.

Zen de Python Un listado de los principios de diseño y la filosofía de Python que son útiles para entender y usar el lenguaje. El listado puede encontrarse ingresando «`import this`» en la consola interactiva.

APÉNDICE B

Acerca de estos documentos

Estos documentos son generados por reStructuredText desarrollado por Sphinx, un procesador de documentos específicamente escrito para la documentación de Python.

El desarrollo de la documentación y su cadena de herramientas es un esfuerzo enteramente voluntario, al igual que Python. Si tu quieres contribuir, por favor revisa la página reporting-bugs para más información de cómo hacerlo. Los nuevos voluntarios son siempre bienvenidos!

Agradecemos a:

- Fred L. Drake, Jr., el creador original de la documentación del conjunto de herramientas de Python y escritor de gran parte del contenido;
- el proyecto Docutils para creación de reStructuredText y el juego de Utilidades de Documentación;
- Fredrik Lundh por su proyecto Referencia Alternativa de Python para la cual Sphinx tuvo muchas ideas.

B.1 Contribuidores de la documentación de Python

Muchas personas han contribuido para el lenguaje de Python, la librería estándar de Python, y la documentación de Python. Revisa Misc/ACKS la distribución de Python para una lista parcial de contribuidores.

Es solamente con la aportación y contribuciones de la comunidad de Python que Python tiene tan fantástica documentación – Muchas gracias!

APÉNDICE C

History and License

C.1 History of the software

Python was created in the early 1990s by Guido van Rossum at Stichting Mathematisch Centrum (CWI, see https://www.cwi.nl/) in the Netherlands as a successor of a language called ABC. Guido remains Python's principal author, although it includes many contributions from others.

In 1995, Guido continued his work on Python at the Corporation for National Research Initiatives (CNRI, see https://www.cnri.reston.va.us/) in Reston, Virginia where he released several versions of the software.

In May 2000, Guido and the Python core development team moved to BeOpen.com to form the BeOpen PythonLabs team. In October of the same year, the PythonLabs team moved to Digital Creations (now Zope Corporation; see https://www.zope.org/). In 2001, the Python Software Foundation (PSF, see https://www.python.org/psf/) was formed, a non-profit organization created specifically to own Python-related Intellectual Property. Zope Corporation is a sponsoring member of the PSF.

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C.3.1 Mersenne Twister

The `_random` module includes code based on a download from http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/MT2002/emt19937ar.html. The following are the verbatim comments from the original code:

```
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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C.3.2 Sockets

The `socket` module uses the functions, `getaddrinfo()`, and `getnameinfo()`, which are coded in separate source files from the WIDE Project, http://www.wide.ad.jp/.

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C.3.3 Asynchronous socket services

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C.3.4 Cookie management

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- Arguments more compliant with Python standard
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C.3.10 SipHash24

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Original location:
   https://github.com/majek/csiphash/

Solution inspired by code from:
   Samuel Neves (supercop/crypto_auth/siphash24/little)
   djb (supercop/crypto_auth/siphash24/little2)
   Jean-Philippe Aumasson (https://131002.net/siphash/siphash24.c)
```

C.3.11 strtod and dtoa

The file `Python/dtoa.c`, which supplies C functions dtoa and strtod for conversion of C doubles to and from strings, is derived from the file of the same name by David M. Gay, currently available from http://www.netlib.org/fp/. The original file, as retrieved on March 16, 2009, contains the following copyright and licensing notice:

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C.3.12 OpenSSL

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