Installing Python Modules

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This document describes the Python Distribution Utilities ("Distutils") from the end-user's point-of-view, describing how to extend the capabilities of a standard Python installation by building and installing third-party Python modules and extensions.

Note: This guide only covers the basic tools for installing extensions that are provided as part of this version of Python. Third party tools offer easier to use and more secure alternatives. Refer to the quick recommendations section in the Python Packaging User Guide for more information.

CHAPTER

ONE

INTRODUCTION

Although Python's extensive standard library covers many programming needs, there often comes a time when you need to add some new functionality to your Python installation in the form of third-party modules. This might be necessary to support your own programming, or to support an application that you want to use and that happens to be written in Python.

In the past, there has been little support for adding third-party modules to an existing Python installation. With the introduction of the Python Distribution Utilities (Distutils for short) in Python 2.0, this changed.

This document is aimed primarily at the people who need to install third-party Python modules: end-users and system administrators who just need to get some Python application running, and existing Python programmers who want to add some new goodies to their toolbox. You don't need to know Python to read this document; there will be some brief forays into using Python's interactive mode to explore your installation, but that's it. If you're looking for information on how to distribute your own Python modules so that others may use them, see the *distutils-index* manual. *debug-setup-script* may also be of interest.

1.1 Best case: trivial installation

In the best case, someone will have prepared a special version of the module distribution you want to install that is targeted specifically at your platform and is installed just like any other software on your platform. For example, the module developer might make an executable installer available for Windows users, an RPM package for users of RPM-based Linux systems (Red Hat, SuSE, Mandrake, and many others), a Debian package for users of Debian-based Linux systems, and so forth.

In that case, you would download the installer appropriate to your platform and do the obvious thing with it: run it if it's an executable installer, `rpm --install` it if it's an RPM, etc. You don't need to run Python or a setup script, you don't need to compile anything—you might not even need to read any instructions (although it's always a good idea to do so anyway).

Of course, things will not always be that easy. You might be interested in a module distribution that doesn't have an easy-to-use installer for your platform. In that case, you'll have to start with the source distribution released by the module's author/maintainer. Installing from a source distribution is not too hard, as long as the modules are packaged in the standard way. The bulk of this document is about building and installing modules from standard source distributions.

1.2 The new standard: Distutils

If you download a module source distribution, you can tell pretty quickly if it was packaged and distributed in the standard way, i.e. using the Distutils. First, the distribution's name and version number will be featured prominently in the name of the downloaded archive, e.g. `foo-1.0.tar.gz` or `widget-0.9.7.zip`. Next, the archive will unpack into a similarly-named directory: `foo-1.0` or `widget-0.9.7`. Additionally, the distribution will contain a

setup script `setup.py`, and a file named `README.txt` or possibly just `README`, which should explain that building and installing the module distribution is a simple matter of running one command from a terminal:

```
python setup.py install
```

For Windows, this command should be run from a command prompt window (*Start* → *Accessories*):

```
setup.py install
```

If all these things are true, then you already know how to build and install the modules you've just downloaded: Run the command above. Unless you need to install things in a non-standard way or customize the build process, you don't really need this manual. Or rather, the above command is everything you need to get out of this manual.

CHAPTER

TWO

STANDARD BUILD AND INSTALL

As described in section *The new standard: Distutils*, building and installing a module distribution using the Distutils is usually one simple command to run from a terminal:

```
python setup.py install
```

2.1 Platform variations

You should always run the setup command from the distribution root directory, i.e. the top-level subdirectory that the module source distribution unpacks into. For example, if you've just downloaded a module source distribution `foo-1.0.tar.gz` onto a Unix system, the normal thing to do is:

```
gunzip -c foo-1.0.tar.gz | tar xf -    # unpacks into directory foo-1.0
cd foo-1.0
python setup.py install
```

On Windows, you'd probably download `foo-1.0.zip`. If you downloaded the archive file to `C:\Temp`, then it would unpack into `C:\Temp\foo-1.0`; you can use either a archive manipulator with a graphical user interface (such as WinZip) or a command-line tool (such as **unzip** or **pkunzip**) to unpack the archive. Then, open a command prompt window and run:

```
cd c:\Temp\foo-1.0
python setup.py install
```

2.2 Splitting the job up

Running `setup.py install` builds and installs all modules in one run. If you prefer to work incrementally—especially useful if you want to customize the build process, or if things are going wrong—you can use the setup script to do one thing at a time. This is particularly helpful when the build and install will be done by different users—for example, you might want to build a module distribution and hand it off to a system administrator for installation (or do it yourself, with super-user privileges).

For example, you can build everything in one step, and then install everything in a second step, by invoking the setup script twice:

```
python setup.py build
python setup.py install
```

If you do this, you will notice that running the **install** command first runs the **build** command, which—in this case—quickly notices that it has nothing to do, since everything in the `build` directory is up-to-date.

You may not need this ability to break things down often if all you do is install modules downloaded off the 'net, but it's very handy for more advanced tasks. If you get into distributing your own Python modules and extensions, you'll run lots of individual Distutils commands on their own.

2.3 How building works

As implied above, the **build** command is responsible for putting the files to install into a *build directory*. By default, this is `build` under the distribution root; if you're excessively concerned with speed, or want to keep the source tree pristine, you can change the build directory with the `--build-base` option. For example:

```
python setup.py build --build-base=/path/to/pybuild/foo-1.0
```

(Or you could do this permanently with a directive in your system or personal Distutils configuration file; see section *Distutils Configuration Files*.) Normally, this isn't necessary.

The default layout for the build tree is as follows:

```
--- build/ --- lib/
or
--- build/ --- lib.<plat>/
               temp.<plat>/
```

where `<plat>` expands to a brief description of the current OS/hardware platform and Python version. The first form, with just a `lib` directory, is used for "pure module distributions"—that is, module distributions that include only pure Python modules. If a module distribution contains any extensions (modules written in C/C++), then the second form, with two `<plat>` directories, is used. In that case, the `temp.plat` directory holds temporary files generated by the compile/link process that don't actually get installed. In either case, the `lib` (or `lib.plat`) directory contains all Python modules (pure Python and extensions) that will be installed.

In the future, more directories will be added to handle Python scripts, documentation, binary executables, and whatever else is needed to handle the job of installing Python modules and applications.

2.4 How installation works

After the **build** command runs (whether you run it explicitly, or the **install** command does it for you), the work of the **install** command is relatively simple: all it has to do is copy everything under `build/lib` (or `build/lib.plat`) to your chosen installation directory.

If you don't choose an installation directory—i.e., if you just run `setup.py install`—then the **install** command installs to the standard location for third-party Python modules. This location varies by platform and by how you built/installed Python itself. On Unix (and Mac OS X, which is also Unix-based), it also depends on whether the module distribution being installed is pure Python or contains extensions ("non-pure"):

Platform	Standard installation location	Default value
Unix (pure)	*prefix*/lib/python*X.Y*/site-packages	/usr/local/lib/python*X.Y*/site-packa
Unix (non-pure)	*exec-prefix*/lib/python*X.Y*/site-packages	/usr/local/lib/python*X.Y*/site-packa
Windows	*prefix*\Lib\site-packages	C:\Python*XY*\Lib\site-packages

Notes:

1. Most Linux distributions include Python as a standard part of the system, so *prefix* and *exec-prefix* are usually both `/usr` on Linux. If you build Python yourself on Linux (or any Unix-like system), the default *prefix* and *exec-prefix* are `/usr/local`.
2. The default installation directory on Windows was `C:\Program Files\Python` under Python 1.6a1, 1.5.2, and earlier.

prefix and *exec-prefix* stand for the directories that Python is installed to, and where it finds its libraries at run-time. They are always the same under Windows, and very often the same under Unix and Mac OS X. You can find out what your Python installation uses for *prefix* and *exec-prefix* by running Python in interactive mode and typing a few simple commands. Under Unix, just type `python` at the shell prompt. Under Windows, choose *Start → Programs → Python X.Y → Python (command line)*. Once the interpreter is started, you type Python code at the prompt. For example, on my Linux system, I type the three Python statements shown below, and get the output as shown, to find out my *prefix* and *exec-prefix*:

```
Python 2.4 (#26, Aug  7 2004, 17:19:02)
Type "help", "copyright", "credits" or "license" for more information.
>>> import sys
>>> sys.prefix
'/usr'
>>> sys.exec_prefix
'/usr'
```

A few other placeholders are used in this document: *X.Y* stands for the version of Python, for example `3.2`; *abiflags* will be replaced by the value of `sys.abiflags` or the empty string for platforms which don't define ABI flags; *distname* will be replaced by the name of the module distribution being installed. Dots and capitalization are important in the paths; for example, a value that uses `python3.2` on UNIX will typically use `Python32` on Windows.

If you don't want to install modules to the standard location, or if you don't have permission to write there, then you need to read about alternate installations in section *Alternate Installation*. If you want to customize your installation directories more heavily, see section *Custom Installation* on custom installations.

CHAPTER

THREE

ALTERNATE INSTALLATION

Often, it is necessary or desirable to install modules to a location other than the standard location for third-party Python modules. For example, on a Unix system you might not have permission to write to the standard third-party module directory. Or you might wish to try out a module before making it a standard part of your local Python installation. This is especially true when upgrading a distribution already present: you want to make sure your existing base of scripts still works with the new version before actually upgrading.

The Distutils **install** command is designed to make installing module distributions to an alternate location simple and painless. The basic idea is that you supply a base directory for the installation, and the **install** command picks a set of directories (called an *installation scheme*) under this base directory in which to install files. The details differ across platforms, so read whichever of the following sections applies to you.

Note that the various alternate installation schemes are mutually exclusive: you can pass `--user`, or `--home`, or `--prefix` and `--exec-prefix`, or `--install-base` and `--install-platbase`, but you can't mix from these groups.

3.1 Alternate installation: the user scheme

This scheme is designed to be the most convenient solution for users that don't have write permission to the global site-packages directory or don't want to install into it. It is enabled with a simple option:

```
python setup.py install --user
```

Files will be installed into subdirectories of `site.USER_BASE` (written as *`userbase`* hereafter). This scheme installs pure Python modules and extension modules in the same location (also known as `site.USER_SITE`). Here are the values for UNIX, including Mac OS X:

Type of file	Installation directory
modules	*`userbase`*`/lib/python`*`X.Y`*`/site-packages`
scripts	*`userbase`*`/bin`
data	*`userbase`*
C headers	*`userbase`*`/include/python`*`X.Yabiflags`*`/`*`distname`*

And here are the values used on Windows:

Type of file	Installation directory
modules	*`userbase`*`\Python`*`XY`*`\site-packages`
scripts	*`userbase`*`\Scripts`
data	*`userbase`*
C headers	*`userbase`*`\Python`*`XY`*`\Include\`*`distname`*

The advantage of using this scheme compared to the other ones described below is that the user site-packages directory is under normal conditions always included in `sys.path` (see `site` for more information), which means that there is no additional step to perform after running the `setup.py` script to finalize the installation.

The **build_ext** command also has a `--user` option to add *userbase*`/include` to the compiler search path for header files and *userbase*`/lib` to the compiler search path for libraries as well as to the runtime search path for shared C libraries (rpath).

3.2 Alternate installation: the home scheme

The idea behind the "home scheme" is that you build and maintain a personal stash of Python modules. This scheme's name is derived from the idea of a "home" directory on Unix, since it's not unusual for a Unix user to make their home directory have a layout similar to `/usr/` or `/usr/local/`. This scheme can be used by anyone, regardless of the operating system they are installing for.

Installing a new module distribution is as simple as

```
python setup.py install --home=<dir>
```

where you can supply any directory you like for the *--home* option. On Unix, lazy typists can just type a tilde (~); the **install** command will expand this to your home directory:

```
python setup.py install --home=~
```

To make Python find the distributions installed with this scheme, you may have to *modify Python's search path* or edit `sitecustomize` (see `site`) to call `site.addsitedir()` or edit `sys.path`.

The *--home* option defines the installation base directory. Files are installed to the following directories under the installation base as follows:

Type of file	Installation directory
modules	*home*`/lib/python`
scripts	*home*`/bin`
data	*home*
C headers	*home*`/include/python/`*distname*

(Mentally replace slashes with backslashes if you're on Windows.)

3.3 Alternate installation: Unix (the prefix scheme)

The "prefix scheme" is useful when you wish to use one Python installation to perform the build/install (i.e., to run the setup script), but install modules into the third-party module directory of a different Python installation (or something that looks like a different Python installation). If this sounds a trifle unusual, it is—that's why the user and home schemes come before. However, there are at least two known cases where the prefix scheme will be useful.

First, consider that many Linux distributions put Python in `/usr`, rather than the more traditional `/usr/local`. This is entirely appropriate, since in those cases Python is part of "the system" rather than a local add-on. However, if you are installing Python modules from source, you probably want them to go in `/usr/local/lib/python2.`*X* rather than `/usr/lib/python2.`*X*. This can be done with

```
/usr/bin/python setup.py install --prefix=/usr/local
```

Another possibility is a network filesystem where the name used to write to a remote directory is different from the name used to read it: for example, the Python interpreter accessed as `/usr/local/bin/python` might search for modules in `/usr/local/lib/python2.`*X*, but those modules would have to be installed to, say, `/mnt/`*@server*`/export/lib/python2.`*X*. This could be done with

```
/usr/local/bin/python setup.py install --prefix=/mnt/@server/export
```

In either case, the *--prefix* option defines the installation base, and the *--exec-prefix* option defines the platform-specific installation base, which is used for platform-specific files. (Currently, this just means non-pure

module distributions, but could be expanded to C libraries, binary executables, etc.) If *--exec-prefix* is not supplied, it defaults to *--prefix*. Files are installed as follows:

Type of file	Installation directory
Python modules	*prefix*/lib/python*X.Y*/site-packages
extension modules	*exec-prefix*/lib/python*X.Y*/site-packages
scripts	*prefix*/bin
data	*prefix*
C headers	*prefix*/include/python*X.Yabiflags*/*distname*

There is no requirement that *--prefix* or *--exec-prefix* actually point to an alternate Python installation; if the directories listed above do not already exist, they are created at installation time.

Incidentally, the real reason the prefix scheme is important is simply that a standard Unix installation uses the prefix scheme, but with *--prefix* and *--exec-prefix* supplied by Python itself as `sys.prefix` and `sys.exec_prefix`. Thus, you might think you'll never use the prefix scheme, but every time you run `python setup.py install` without any other options, you're using it.

Note that installing extensions to an alternate Python installation has no effect on how those extensions are built: in particular, the Python header files (`Python.h` and friends) installed with the Python interpreter used to run the setup script will be used in compiling extensions. It is your responsibility to ensure that the interpreter used to run extensions installed in this way is compatible with the interpreter used to build them. The best way to do this is to ensure that the two interpreters are the same version of Python (possibly different builds, or possibly copies of the same build). (Of course, if your *--prefix* and *--exec-prefix* don't even point to an alternate Python installation, this is immaterial.)

3.4 Alternate installation: Windows (the prefix scheme)

Windows has no concept of a user's home directory, and since the standard Python installation under Windows is simpler than under Unix, the *--prefix* option has traditionally been used to install additional packages in separate locations on Windows.

```
python setup.py install --prefix="\Temp\Python"
```

to install modules to the `\Temp\Python` directory on the current drive.

The installation base is defined by the *--prefix* option; the *--exec-prefix* option is not supported under Windows, which means that pure Python modules and extension modules are installed into the same location. Files are installed as follows:

Type of file	Installation directory
modules	*prefix*\Lib\site-packages
scripts	*prefix*\Scripts
data	*prefix*
C headers	*prefix*\Include*distname*

CHAPTER

FOUR

CUSTOM INSTALLATION

Sometimes, the alternate installation schemes described in section *Alternate Installation* just don't do what you want. You might want to tweak just one or two directories while keeping everything under the same base directory, or you might want to completely redefine the installation scheme. In either case, you're creating a *custom installation scheme*.

To create a custom installation scheme, you start with one of the alternate schemes and override some of the installation directories used for the various types of files, using these options:

Type of file	Override option
Python modules	`--install-purelib`
extension modules	`--install-platlib`
all modules	`--install-lib`
scripts	`--install-scripts`
data	`--install-data`
C headers	`--install-headers`

These override options can be relative, absolute, or explicitly defined in terms of one of the installation base directories. (There are two installation base directories, and they are normally the same— they only differ when you use the Unix "prefix scheme" and supply different `--prefix` and `--exec-prefix` options; using `--install-lib` will override values computed or given for `--install-purelib` and `--install-platlib`, and is recommended for schemes that don't make a difference between Python and extension modules.)

For example, say you're installing a module distribution to your home directory under Unix—but you want scripts to go in `~/scripts` rather than `~/bin`. As you might expect, you can override this directory with the *`--install-scripts`* option; in this case, it makes most sense to supply a relative path, which will be interpreted relative to the installation base directory (your home directory, in this case):

```
python setup.py install --home=~ --install-scripts=scripts
```

Another Unix example: suppose your Python installation was built and installed with a prefix of `/usr/local/python`, so under a standard installation scripts will wind up in `/usr/local/python/bin`. If you want them in `/usr/local/bin` instead, you would supply this absolute directory for the *`--install-scripts`* option:

```
python setup.py install --install-scripts=/usr/local/bin
```

(This performs an installation using the "prefix scheme," where the prefix is whatever your Python interpreter was installed with— `/usr/local/python` in this case.)

If you maintain Python on Windows, you might want third-party modules to live in a subdirectory of *`prefix`*, rather than right in *`prefix`* itself. This is almost as easy as customizing the script installation directory —you just have to remember that there are two types of modules to worry about, Python and extension modules, which can conveniently be both controlled by one option:

```
python setup.py install --install-lib=Site
```

The specified installation directory is relative to *prefix*. Of course, you also have to ensure that this directory is in Python's module search path, such as by putting a `.pth` file in a site directory (see `site`). See section *Modifying Python's Search Path* to find out how to modify Python's search path.

If you want to define an entire installation scheme, you just have to supply all of the installation directory options. The recommended way to do this is to supply relative paths; for example, if you want to maintain all Python module-related files under `python` in your home directory, and you want a separate directory for each platform that you use your home directory from, you might define the following installation scheme:

```
python setup.py install --home=~ \
                        --install-purelib=python/lib \
                        --install-platlib=python/lib.$PLAT \
                        --install-scripts=python/scripts
                        --install-data=python/data
```

or, equivalently,

```
python setup.py install --home=~/python \
                        --install-purelib=lib \
                        --install-platlib='lib.$PLAT' \
                        --install-scripts=scripts
                        --install-data=data
```

`$PLAT` is not (necessarily) an environment variable—it will be expanded by the Distutils as it parses your command line options, just as it does when parsing your configuration file(s).

Obviously, specifying the entire installation scheme every time you install a new module distribution would be very tedious. Thus, you can put these options into your Distutils config file (see section *Distutils Configuration Files*):

```
[install]
install-base=$HOME
install-purelib=python/lib
install-platlib=python/lib.$PLAT
install-scripts=python/scripts
install-data=python/data
```

or, equivalently,

```
[install]
install-base=$HOME/python
install-purelib=lib
install-platlib=lib.$PLAT
install-scripts=scripts
install-data=data
```

Note that these two are *not* equivalent if you supply a different installation base directory when you run the setup script. For example,

```
python setup.py install --install-base=/tmp
```

would install pure modules to `/tmp/python/lib` in the first case, and to `/tmp/lib` in the second case. (For the second case, you probably want to supply an installation base of `/tmp/python`.)

You probably noticed the use of `$HOME` and `$PLAT` in the sample configuration file input. These are Distutils configuration variables, which bear a strong resemblance to environment variables. In fact, you can use environment variables in config files on platforms that have such a notion but the Distutils additionally define a few extra variables that may not be in your environment, such as `$PLAT`. (And of course, on systems that don't have environment variables, such as Mac OS 9, the configuration variables supplied by the Distutils are the only ones you can use.) See section *Distutils Configuration Files* for details.

Note: When a *virtual environment* is activated, any options that change the installation path will be ignored from all distutils configuration files to prevent inadvertently installing projects outside of the virtual environment.

4.1 Modifying Python's Search Path

When the Python interpreter executes an `import` statement, it searches for both Python code and extension modules along a search path. A default value for the path is configured into the Python binary when the interpreter is built. You can determine the path by importing the `sys` module and printing the value of `sys.path`.

```
$ python
Python 2.2 (#11, Oct  3 2002, 13:31:27)
[GCC 2.96 20000731 (Red Hat Linux 7.3 2.96-112)] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import sys
>>> sys.path
['', '/usr/local/lib/python2.3', '/usr/local/lib/python2.3/plat-linux2',
 '/usr/local/lib/python2.3/lib-tk', '/usr/local/lib/python2.3/lib-dynload',
 '/usr/local/lib/python2.3/site-packages']
>>>
```

The null string in `sys.path` represents the current working directory.

The expected convention for locally installed packages is to put them in the `.../site-packages/` directory, but you may want to install Python modules into some arbitrary directory. For example, your site may have a convention of keeping all software related to the web server under `/www`. Add-on Python modules might then belong in `/www/python`, and in order to import them, this directory must be added to `sys.path`. There are several different ways to add the directory.

The most convenient way is to add a path configuration file to a directory that's already on Python's path, usually to the `.../site-packages/` directory. Path configuration files have an extension of `.pth`, and each line must contain a single path that will be appended to `sys.path`. (Because the new paths are appended to `sys.path`, modules in the added directories will not override standard modules. This means you can't use this mechanism for installing fixed versions of standard modules.)

Paths can be absolute or relative, in which case they're relative to the directory containing the `.pth` file. See the documentation of the `site` module for more information.

A slightly less convenient way is to edit the `site.py` file in Python's standard library, and modify `sys.path`. `site.py` is automatically imported when the Python interpreter is executed, unless the *-S* switch is supplied to suppress this behaviour. So you could simply edit `site.py` and add two lines to it:

```
import sys
sys.path.append('/www/python/')
```

However, if you reinstall the same major version of Python (perhaps when upgrading from 2.2 to 2.2.2, for example) `site.py` will be overwritten by the stock version. You'd have to remember that it was modified and save a copy before doing the installation.

There are two environment variables that can modify `sys.path`. `PYTHONHOME` sets an alternate value for the prefix of the Python installation. For example, if `PYTHONHOME` is set to `/www/python`, the search path will be set to `['', '/www/python/lib/pythonX.Y/', '/www/python/lib/pythonX.Y/plat-linux2', ...]`.

The `PYTHONPATH` variable can be set to a list of paths that will be added to the beginning of `sys.path`. For example, if `PYTHONPATH` is set to `/www/python:/opt/py`, the search path will begin with `['/www/python', '/opt/py']`. (Note that directories must exist in order to be added to `sys.path`; the `site` module removes paths that don't exist.)

Finally, `sys.path` is just a regular Python list, so any Python application can modify it by adding or removing entries.

CHAPTER

FIVE

DISTUTILS CONFIGURATION FILES

As mentioned above, you can use Distutils configuration files to record personal or site preferences for any Distutils options. That is, any option to any command can be stored in one of two or three (depending on your platform) configuration files, which will be consulted before the command-line is parsed. This means that configuration files will override default values, and the command-line will in turn override configuration files. Furthermore, if multiple configuration files apply, values from "earlier" files are overridden by "later" files.

5.1 Location and names of config files

The names and locations of the configuration files vary slightly across platforms. On Unix and Mac OS X, the three configuration files (in the order they are processed) are:

Type of file	Location and filename	Notes
system	*prefix*/lib/python*ver*/distutils/distutils.cfg	(1)
personal	$HOME/.pydistutils.cfg	(2)
local	setup.cfg	(3)

And on Windows, the configuration files are:

Type of file	Location and filename	Notes
system	*prefix*\Lib\distutils\distutils.cfg	(4)
personal	%HOME%\pydistutils.cfg	(5)
local	setup.cfg	(3)

On all platforms, the "personal" file can be temporarily disabled by passing the *–no-user-cfg* option.

Notes:

1. Strictly speaking, the system-wide configuration file lives in the directory where the Distutils are installed; under Python 1.6 and later on Unix, this is as shown. For Python 1.5.2, the Distutils will normally be installed to *prefix*/lib/python1.5/site-packages/distutils, so the system configuration file should be put there under Python 1.5.2.
2. On Unix, if the HOME environment variable is not defined, the user's home directory will be determined with the getpwuid() function from the standard pwd module. This is done by the os.path.expanduser() function used by Distutils.
3. I.e., in the current directory (usually the location of the setup script).
4. (See also note (1).) Under Python 1.6 and later, Python's default "installation prefix" is C:\Python, so the system configuration file is normally C:\Python\Lib\distutils\distutils.cfg. Under Python 1.5.2, the default prefix was C:\Program Files\Python, and the Distutils were not part of the standard library—so the system configuration file would be C:\Program Files\Python\distutils\distutils.cfg in a standard Python 1.5.2 installation under Windows.

5. On Windows, if the HOME environment variable is not defined, USERPROFILE then HOMEDRIVE and HOMEPATH will be tried. This is done by the os.path.expanduser() function used by Distutils.

5.2 Syntax of config files

The Distutils configuration files all have the same syntax. The config files are grouped into sections. There is one section for each Distutils command, plus a global section for global options that affect every command. Each section consists of one option per line, specified as option=value.

For example, the following is a complete config file that just forces all commands to run quietly by default:

```
[global]
verbose=0
```

If this is installed as the system config file, it will affect all processing of any Python module distribution by any user on the current system. If it is installed as your personal config file (on systems that support them), it will affect only module distributions processed by you. And if it is used as the setup.cfg for a particular module distribution, it affects only that distribution.

You could override the default "build base" directory and make the **build*** commands always forcibly rebuild all files with the following:

```
[build]
build-base=blib
force=1
```

which corresponds to the command-line arguments

```
python setup.py build --build-base=blib --force
```

except that including the **build** command on the command-line means that command will be run. Including a particular command in config files has no such implication; it only means that if the command is run, the options in the config file will apply. (Or if other commands that derive values from it are run, they will use the values in the config file.)

You can find out the complete list of options for any command using the *--help* option, e.g.:

```
python setup.py build --help
```

and you can find out the complete list of global options by using *--help* without a command:

```
python setup.py --help
```

See also the "Reference" section of the "Distributing Python Modules" manual.

CHAPTER

SIX

BUILDING EXTENSIONS: TIPS AND TRICKS

Whenever possible, the Distutils try to use the configuration information made available by the Python interpreter used to run the `setup.py` script. For example, the same compiler and linker flags used to compile Python will also be used for compiling extensions. Usually this will work well, but in complicated situations this might be inappropriate. This section discusses how to override the usual Distutils behaviour.

6.1 Tweaking compiler/linker flags

Compiling a Python extension written in C or C++ will sometimes require specifying custom flags for the compiler and linker in order to use a particular library or produce a special kind of object code. This is especially true if the extension hasn't been tested on your platform, or if you're trying to cross-compile Python.

In the most general case, the extension author might have foreseen that compiling the extensions would be complicated, and provided a `Setup` file for you to edit. This will likely only be done if the module distribution contains many separate extension modules, or if they often require elaborate sets of compiler flags in order to work.

A `Setup` file, if present, is parsed in order to get a list of extensions to build. Each line in a `Setup` describes a single module. Lines have the following structure:

```
module ... [sourcefile ...] [cpparg ...] [library ...]
```

Let's examine each of the fields in turn.

- *module* is the name of the extension module to be built, and should be a valid Python identifier. You can't just change this in order to rename a module (edits to the source code would also be needed), so this should be left alone.
- *sourcefile* is anything that's likely to be a source code file, at least judging by the filename. Filenames ending in `.c` are assumed to be written in C, filenames ending in `.C`, `.cc`, and `.c++` are assumed to be C++, and filenames ending in `.m` or `.mm` are assumed to be in Objective C.
- *cpparg* is an argument for the C preprocessor, and is anything starting with *`-I`*, *`-D`*, *`-U`* or *`-C`*.
- *library* is anything ending in `.a` or beginning with *`-l`* or *`-L`*.

If a particular platform requires a special library on your platform, you can add it by editing the `Setup` file and running `python setup.py build`. For example, if the module defined by the line

```
foo foomodule.c
```

must be linked with the math library `libm.a` on your platform, simply add *`-lm`* to the line:

```
foo foomodule.c -lm
```

Arbitrary switches intended for the compiler or the linker can be supplied with the *`-Xcompiler arg`* and *`-Xlinker arg`* options:

```
foo foomodule.c -Xcompiler -o32 -Xlinker -shared -lm
```

The next option after *-Xcompiler* and *-Xlinker* will be appended to the proper command line, so in the above example the compiler will be passed the *-o32* option, and the linker will be passed *-shared*. If a compiler option requires an argument, you'll have to supply multiple *-Xcompiler* options; for example, to pass `-x c++` the `Setup` file would have to contain `-Xcompiler -x -Xcompiler c++`.

Compiler flags can also be supplied through setting the `CFLAGS` environment variable. If set, the contents of `CFLAGS` will be added to the compiler flags specified in the `Setup` file.

6.2 Using non-Microsoft compilers on Windows

6.2.1 Borland/CodeGear C++

This subsection describes the necessary steps to use Distutils with the Borland C++ compiler version 5.5. First you have to know that Borland's object file format (OMF) is different from the format used by the Python version you can download from the Python or ActiveState Web site. (Python is built with Microsoft Visual C++, which uses COFF as the object file format.) For this reason you have to convert Python's library `python25.lib` into the Borland format. You can do this as follows:

```
coff2omf python25.lib python25_bcpp.lib
```

The `coff2omf` program comes with the Borland compiler. The file `python25.lib` is in the `Libs` directory of your Python installation. If your extension uses other libraries (zlib, ...) you have to convert them too.

The converted files have to reside in the same directories as the normal libraries.

How does Distutils manage to use these libraries with their changed names? If the extension needs a library (eg. `foo`) Distutils checks first if it finds a library with suffix `_bcpp` (eg. `foo_bcpp.lib`) and then uses this library. In the case it doesn't find such a special library it uses the default name (`foo.lib`.) [1]

To let Distutils compile your extension with Borland C++ you now have to type:

```
python setup.py build --compiler=bcpp
```

If you want to use the Borland C++ compiler as the default, you could specify this in your personal or system-wide configuration file for Distutils (see section *Distutils Configuration Files*.)

See also:

C++Builder Compiler Information about the free C++ compiler from Borland, including links to the download pages.

Creating Python Extensions Using Borland's Free Compiler Document describing how to use Borland's free command-line C++ compiler to build Python.

6.2.2 GNU C / Cygwin / MinGW

This section describes the necessary steps to use Distutils with the GNU C/C++ compilers in their Cygwin and MinGW distributions. [2] For a Python interpreter that was built with Cygwin, everything should work without any of these following steps.

Not all extensions can be built with MinGW or Cygwin, but many can. Extensions most likely to not work are those that use C++ or depend on Microsoft Visual C extensions.

To let Distutils compile your extension with Cygwin you have to type:

[1] This also means you could replace all existing COFF-libraries with OMF-libraries of the same name.
[2] Check http://sources.redhat.com/cygwin/ and http://www.mingw.org/ for more information

```
python setup.py build --compiler=cygwin
```

and for Cygwin in no-cygwin mode [3] or for MinGW type:

```
python setup.py build --compiler=mingw32
```

If you want to use any of these options/compilers as default, you should consider writing it in your personal or system-wide configuration file for Distutils (see section *Distutils Configuration Files*.)

Older Versions of Python and MinGW

The following instructions only apply if you're using a version of Python inferior to 2.4.1 with a MinGW inferior to 3.0.0 (with binutils-2.13.90-20030111-1).

These compilers require some special libraries. This task is more complex than for Borland's C++, because there is no program to convert the library. First you have to create a list of symbols which the Python DLL exports. (You can find a good program for this task at http://sourceforge.net/projects/mingw/files/MinGW/Extension/pexports/).

```
pexports python25.dll >python25.def
```

The location of an installed `python25.dll` will depend on the installation options and the version and language of Windows. In a "just for me" installation, it will appear in the root of the installation directory. In a shared installation, it will be located in the system directory.

Then you can create from these information an import library for gcc.

```
/cygwin/bin/dlltool --dllname python25.dll --def python25.def --output-lib libpython25.a
```

The resulting library has to be placed in the same directory as `python25.lib`. (Should be the `libs` directory under your Python installation directory.)

If your extension uses other libraries (zlib,...) you might have to convert them too. The converted files have to reside in the same directories as the normal libraries do.

See also:

Building Python modules on MS Windows platform with MinGW Information about building the required libraries for the MinGW environment.

[3] Then you have no POSIX emulation available, but you also don't need `cygwin1.dll`.

APPENDIX

A

GLOSSARY

>>> The default Python prompt of the interactive shell. Often seen for code examples which can be executed interactively in the interpreter.

... The default Python prompt of the interactive shell when entering code for an indented code block or within a pair of matching left and right delimiters (parentheses, square brackets or curly braces).

2to3 A tool that tries to convert Python 2.x code to Python 3.x code by handling most of the incompatibilities which can be detected by parsing the source and traversing the parse tree.

2to3 is available in the standard library as `lib2to3`; a standalone entry point is provided as `Tools/scripts/2to3`. See *2to3-reference*.

abstract base class Abstract base classes complement *duck-typing* by providing a way to define interfaces when other techniques like `hasattr()` would be clumsy or subtly wrong (for example with *magic methods*). ABCs introduce virtual subclasses, which are classes that don't inherit from a class but are still recognized by `isinstance()` and `issubclass()`; see the `abc` module documentation. Python comes with many built-in ABCs for data structures (in the `collections.abc` module), numbers (in the `numbers` module), streams (in the `io` module), import finders and loaders (in the `importlib.abc` module). You can create your own ABCs with the `abc` module.

argument A value passed to a *function* (or *method*) when calling the function. There are two kinds of argument:

- *keyword argument*: an argument preceded by an identifier (e.g. `name=`) in a function call or passed as a value in a dictionary preceded by `**`. For example, `3` and `5` are both keyword arguments in the following calls to `complex()`:

  ```
  complex(real=3, imag=5)
  complex(**{'real': 3, 'imag': 5})
  ```

- *positional argument*: an argument that is not a keyword argument. Positional arguments can appear at the beginning of an argument list and/or be passed as elements of an *iterable* preceded by `*`. For example, `3` and `5` are both positional arguments in the following calls:

  ```
  complex(3, 5)
  complex(*(3, 5))
  ```

Arguments are assigned to the named local variables in a function body. See the *calls* section for the rules governing this assignment. Syntactically, any expression can be used to represent an argument; the evaluated value is assigned to the local variable.

See also the *parameter* glossary entry, the FAQ question on *the difference between arguments and parameters*, and **PEP 362**.

attribute A value associated with an object which is referenced by name using dotted expressions. For example, if an object *o* has an attribute *a* it would be referenced as *o.a*.

BDFL Benevolent Dictator For Life, a.k.a. Guido van Rossum, Python's creator.

binary file A *file object* able to read and write *bytes-like objects*.

See also:

A *text file* reads and writes `str` objects.

bytes-like object An object that supports the *bufferobjects*, like `bytes`, `bytearray` or `memoryview`. Bytes-like objects can be used for various operations that expect binary data, such as compression, saving to a binary file or sending over a socket. Some operations need the binary data to be mutable, in which case not all bytes-like objects can apply.

bytecode Python source code is compiled into bytecode, the internal representation of a Python program in the CPython interpreter. The bytecode is also cached in `.pyc` and `.pyo` files so that executing the same file is faster the second time (recompilation from source to bytecode can be avoided). This "intermediate language" is said to run on a *virtual machine* that executes the machine code corresponding to each bytecode. Do note that bytecodes are not expected to work between different Python virtual machines, nor to be stable between Python releases.

A list of bytecode instructions can be found in the documentation for *the dis module*.

class A template for creating user-defined objects. Class definitions normally contain method definitions which operate on instances of the class.

coercion The implicit conversion of an instance of one type to another during an operation which involves two arguments of the same type. For example, `int(3.15)` converts the floating point number to the integer `3`, but in `3+4.5`, each argument is of a different type (one int, one float), and both must be converted to the same type before they can be added or it will raise a `TypeError`. Without coercion, all arguments of even compatible types would have to be normalized to the same value by the programmer, e.g., `float(3)+4.5` rather than just `3+4.5`.

complex number An extension of the familiar real number system in which all numbers are expressed as a sum of a real part and an imaginary part. Imaginary numbers are real multiples of the imaginary unit (the square root of `-1`), often written `i` in mathematics or `j` in engineering. Python has built-in support for complex numbers, which are written with this latter notation; the imaginary part is written with a `j` suffix, e.g., `3+1j`. To get access to complex equivalents of the `math` module, use `cmath`. Use of complex numbers is a fairly advanced mathematical feature. If you're not aware of a need for them, it's almost certain you can safely ignore them.

context manager An object which controls the environment seen in a `with` statement by defining `__enter__()` and `__exit__()` methods. See **PEP 343**.

CPython The canonical implementation of the Python programming language, as distributed on python.org. The term "CPython" is used when necessary to distinguish this implementation from others such as Jython or IronPython.

decorator A function returning another function, usually applied as a function transformation using the `@wrapper` syntax. Common examples for decorators are `classmethod()` and `staticmethod()`.

The decorator syntax is merely syntactic sugar, the following two function definitions are semantically equivalent:

```
def f(...):
    ...
f = staticmethod(f)

@staticmethod
def f(...):
    ...
```

The same concept exists for classes, but is less commonly used there. See the documentation for *function definitions* and *class definitions* for more about decorators.

descriptor Any object which defines the methods `__get__()`, `__set__()`, or `__delete__()`. When a class attribute is a descriptor, its special binding behavior is triggered upon attribute lookup. Normally, using *a.b* to get, set or delete an attribute looks up the object named *b* in the class dictionary for *a*, but if *b* is a descriptor, the respective descriptor method gets called. Understanding descriptors is a key to a deep understanding of Python because they are the basis for many features including functions, methods, properties, class methods, static methods, and reference to super classes.

For more information about descriptors' methods, see *descriptors*.

dictionary An associative array, where arbitrary keys are mapped to values. The keys can be any object with `__hash__()` and `__eq__()` methods. Called a hash in Perl.

docstring A string literal which appears as the first expression in a class, function or module. While ignored when the suite is executed, it is recognized by the compiler and put into the `__doc__` attribute of the enclosing class, function or module. Since it is available via introspection, it is the canonical place for documentation of the object.

duck-typing A programming style which does not look at an object's type to determine if it has the right interface; instead, the method or attribute is simply called or used ("If it looks like a duck and quacks like a duck, it must be a duck.") By emphasizing interfaces rather than specific types, well-designed code improves its flexibility by allowing polymorphic substitution. Duck-typing avoids tests using `type()` or `isinstance()`. (Note, however, that duck-typing can be complemented with *abstract base classes*.) Instead, it typically employs `hasattr()` tests or *EAFP* programming.

EAFP Easier to ask for forgiveness than permission. This common Python coding style assumes the existence of valid keys or attributes and catches exceptions if the assumption proves false. This clean and fast style is characterized by the presence of many `try` and `except` statements. The technique contrasts with the *LBYL* style common to many other languages such as C.

expression A piece of syntax which can be evaluated to some value. In other words, an expression is an accumulation of expression elements like literals, names, attribute access, operators or function calls which all return a value. In contrast to many other languages, not all language constructs are expressions. There are also *statement*s which cannot be used as expressions, such as `if`. Assignments are also statements, not expressions.

extension module A module written in C or C++, using Python's C API to interact with the core and with user code.

file object An object exposing a file-oriented API (with methods such as `read()` or `write()`) to an underlying resource. Depending on the way it was created, a file object can mediate access to a real on-disk file or to another type of storage or communication device (for example standard input/output, in-memory buffers, sockets, pipes, etc.). File objects are also called *file-like objects* or *streams*.

There are actually three categories of file objects: raw *binary files*, buffered *binary files* and *text files*. Their interfaces are defined in the `io` module. The canonical way to create a file object is by using the `open()` function.

file-like object A synonym for *file object*.

finder An object that tries to find the *loader* for a module. It must implement either a method named `find_loader()` or a method named `find_module()`. See **PEP 302** and **PEP 420** for details and `importlib.abc.Finder` for an *abstract base class*.

floor division Mathematical division that rounds down to nearest integer. The floor division operator is `//`. For example, the expression `11 // 4` evaluates to `2` in contrast to the `2.75` returned by float true division. Note that `(-11) // 4` is `-3` because that is `-2.75` rounded *downward*. See **PEP 238**.

function A series of statements which returns some value to a caller. It can also be passed zero or more *arguments* which may be used in the execution of the body. See also *parameter*, *method*, and the *function* section.

function annotation An arbitrary metadata value associated with a function parameter or return value. Its syntax is explained in section *function*. Annotations may be accessed via the `__annotations__` special attribute of a function object.

Python itself does not assign any particular meaning to function annotations. They are intended to be interpreted by third-party libraries or tools. See **PEP 3107**, which describes some of their potential uses.

__future__ A pseudo-module which programmers can use to enable new language features which are not compatible with the current interpreter.

By importing the `__future__` module and evaluating its variables, you can see when a new feature was first added to the language and when it becomes the default:

```
>>> import __future__
>>> __future__.division
_Feature((2, 2, 0, 'alpha', 2), (3, 0, 0, 'alpha', 0), 8192)
```

garbage collection The process of freeing memory when it is not used anymore. Python performs garbage collection via reference counting and a cyclic garbage collector that is able to detect and break reference cycles.

generator A function which returns an iterator. It looks like a normal function except that it contains `yield` statements for producing a series a values usable in a for-loop or that can be retrieved one at a time with the `next()` function. Each `yield` temporarily suspends processing, remembering the location execution state (including local variables and pending try-statements). When the generator resumes, it picks-up where it left-off (in contrast to functions which start fresh on every invocation).

generator expression An expression that returns an iterator. It looks like a normal expression followed by a `for` expression defining a loop variable, range, and an optional `if` expression. The combined expression generates values for an enclosing function:

```
>>> sum(i*i for i in range(10))         # sum of squares 0, 1, 4, ... 81
285
```

GIL See *global interpreter lock*.

global interpreter lock The mechanism used by the *CPython* interpreter to assure that only one thread executes Python *bytecode* at a time. This simplifies the CPython implementation by making the object model (including critical built-in types such as `dict`) implicitly safe against concurrent access. Locking the entire interpreter makes it easier for the interpreter to be multi-threaded, at the expense of much of the parallelism afforded by multi-processor machines.

However, some extension modules, either standard or third-party, are designed so as to release the GIL when doing computationally-intensive tasks such as compression or hashing. Also, the GIL is always released when doing I/O.

Past efforts to create a "free-threaded" interpreter (one which locks shared data at a much finer granularity) have not been successful because performance suffered in the common single-processor case. It is believed that overcoming this performance issue would make the implementation much more complicated and therefore costlier to maintain.

hashable An object is *hashable* if it has a hash value which never changes during its lifetime (it needs a `__hash__()` method), and can be compared to other objects (it needs an `__eq__()` method). Hashable objects which compare equal must have the same hash value.

Hashability makes an object usable as a dictionary key and a set member, because these data structures use the hash value internally.

All of Python's immutable built-in objects are hashable, while no mutable containers (such as lists or dictionaries) are. Objects which are instances of user-defined classes are hashable by default; they all compare unequal (except with themselves), and their hash value is their `id()`.

IDLE An Integrated Development Environment for Python. IDLE is a basic editor and interpreter environment which ships with the standard distribution of Python.

immutable An object with a fixed value. Immutable objects include numbers, strings and tuples. Such an object cannot be altered. A new object has to be created if a different value has to be stored. They play an important role in places where a constant hash value is needed, for example as a key in a dictionary.

import path A list of locations (or *path entries*) that are searched by the *path based finder* for modules to import. During import, this list of locations usually comes from `sys.path`, but for subpackages it may also come from the parent package's `__path__` attribute.

importing The process by which Python code in one module is made available to Python code in another module.

importer An object that both finds and loads a module; both a *finder* and *loader* object.

interactive Python has an interactive interpreter which means you can enter statements and expressions at the interpreter prompt, immediately execute them and see their results. Just launch `python` with no arguments (possibly by selecting it from your computer's main menu). It is a very powerful way to test out new ideas or inspect modules and packages (remember `help(x)`).

interpreted Python is an interpreted language, as opposed to a compiled one, though the distinction can be blurry because of the presence of the bytecode compiler. This means that source files can be run directly without explicitly creating an executable which is then run. Interpreted languages typically have a shorter development/debug cycle than compiled ones, though their programs generally also run more slowly. See also *interactive*.

iterable An object capable of returning its members one at a time. Examples of iterables include all sequence types (such as `list`, `str`, and `tuple`) and some non-sequence types like `dict`, *file objects*, and objects of any classes you define with an `__iter__()` or `__getitem__()` method. Iterables can be used in a `for` loop and in many other places where a sequence is needed (`zip()`, `map()`, ...). When an iterable object is passed as an argument to the built-in function `iter()`, it returns an iterator for the object. This iterator is good for one pass over the set of values. When using iterables, it is usually not necessary to call `iter()` or deal with iterator objects yourself. The `for` statement does that automatically for you, creating a temporary unnamed variable to hold the iterator for the duration of the loop. See also *iterator*, *sequence*, and *generator*.

iterator An object representing a stream of data. Repeated calls to the iterator's `__next__()` method (or passing it to the built-in function `next()`) return successive items in the stream. When no more data are available a `StopIteration` exception is raised instead. At this point, the iterator object is exhausted and any further calls to its `__next__()` method just raise `StopIteration` again. Iterators are required to have an `__iter__()` method that returns the iterator object itself so every iterator is also iterable and may be used in most places where other iterables are accepted. One notable exception is code which attempts multiple iteration passes. A container object (such as a `list`) produces a fresh new iterator each time you pass it to the `iter()` function or use it in a `for` loop. Attempting this with an iterator will just return the same exhausted iterator object used in the previous iteration pass, making it appear like an empty container.

More information can be found in *typeiter*.

key function A key function or collation function is a callable that returns a value used for sorting or ordering. For example, `locale.strxfrm()` is used to produce a sort key that is aware of locale specific sort conventions.

A number of tools in Python accept key functions to control how elements are ordered or grouped. They include `min()`, `max()`, `sorted()`, `list.sort()`, `heapq.nsmallest()`, `heapq.nlargest()`, and `itertools.groupby()`.

There are several ways to create a key function. For example. the `str.lower()` method can serve as a key function for case insensitive sorts. Alternatively, an ad-hoc key function can be built from a `lambda` expression such as `lambda r: (r[0], r[2])`. Also, the `operator` module provides three key function constructors: `attrgetter()`, `itemgetter()`, and `methodcaller()`. See the *Sorting HOW TO* for examples of how to create and use key functions.

keyword argument See *argument*.

lambda An anonymous inline function consisting of a single *expression* which is evaluated when the function is called. The syntax to create a lambda function is `lambda [arguments]: expression`

LBYL Look before you leap. This coding style explicitly tests for pre-conditions before making calls or lookups. This style contrasts with the *EAFP* approach and is characterized by the presence of many `if` statements.

In a multi-threaded environment, the LBYL approach can risk introducing a race condition between "the looking" and "the leaping". For example, the code, `if key in mapping: return mapping[key]` can fail if another thread removes *key* from *mapping* after the test, but before the lookup. This issue can be solved with locks or by using the EAFP approach.

list A built-in Python *sequence*. Despite its name it is more akin to an array in other languages than to a linked list since access to elements are O(1).

list comprehension A compact way to process all or part of the elements in a sequence and return a list with the results. `result = ['{:#04x}'.format(x) for x in range(256) if x % 2 == 0]` generates a list of strings containing even hex numbers (0x..) in the range from 0 to 255. The `if` clause is optional. If omitted, all elements in `range(256)` are processed.

loader An object that loads a module. It must define a method named `load_module()`. A loader is typically returned by a *finder*. See **PEP 302** for details and `importlib.abc.Loader` for an *abstract base class*.

mapping A container object that supports arbitrary key lookups and implements the methods specified in the `Mapping` or `MutableMapping` *abstract base classes*. Examples include `dict`, `collections.defaultdict`, `collections.OrderedDict` and `collections.Counter`.

meta path finder A finder returned by a search of `sys.meta_path`. Meta path finders are related to, but different from *path entry finders*.

metaclass The class of a class. Class definitions create a class name, a class dictionary, and a list of base classes. The metaclass is responsible for taking those three arguments and creating the class. Most object oriented programming languages provide a default implementation. What makes Python special is that it is possible to create custom metaclasses. Most users never need this tool, but when the need arises, metaclasses can provide powerful, elegant solutions. They have been used for logging attribute access, adding thread-safety, tracking object creation, implementing singletons, and many other tasks.

More information can be found in *metaclasses*.

method A function which is defined inside a class body. If called as an attribute of an instance of that class, the method will get the instance object as its first *argument* (which is usually called `self`). See *function* and *nested scope*.

method resolution order Method Resolution Order is the order in which base classes are searched for a member during lookup. See The Python 2.3 Method Resolution Order.

module An object that serves as an organizational unit of Python code. Modules have a namespace containing arbitrary Python objects. Modules are loaded into Python by the process of *importing*.

See also *package*.

MRO See *method resolution order*.

mutable Mutable objects can change their value but keep their `id()`. See also *immutable*.

named tuple Any tuple-like class whose indexable elements are also accessible using named attributes (for example, `time.localtime()` returns a tuple-like object where the *year* is accessible either with an index such as `t[0]` or with a named attribute like `t.tm_year`).

A named tuple can be a built-in type such as `time.struct_time`, or it can be created with a regular class definition. A full featured named tuple can also be created with the factory function `collections.namedtuple()`. The latter approach automatically provides extra features such as a self-documenting representation like `Employee(name='jones', title='programmer')`.

namespace The place where a variable is stored. Namespaces are implemented as dictionaries. There are the local, global and built-in namespaces as well as nested namespaces in objects (in methods). Namespaces support

modularity by preventing naming conflicts. For instance, the functions `builtins.open` and `os.open()` are distinguished by their namespaces. Namespaces also aid readability and maintainability by making it clear which module implements a function. For instance, writing `random.seed()` or `itertools.islice()` makes it clear that those functions are implemented by the `random` and `itertools` modules, respectively.

namespace package A **PEP 420** *package* which serves only as a container for subpackages. Namespace packages may have no physical representation, and specifically are not like a *regular package* because they have no `__init__.py` file.

See also *module*.

nested scope The ability to refer to a variable in an enclosing definition. For instance, a function defined inside another function can refer to variables in the outer function. Note that nested scopes by default work only for reference and not for assignment. Local variables both read and write in the innermost scope. Likewise, global variables read and write to the global namespace. The `nonlocal` allows writing to outer scopes.

new-style class Old name for the flavor of classes now used for all class objects. In earlier Python versions, only new-style classes could use Python's newer, versatile features like `__slots__`, descriptors, properties, `__getattribute__()`, class methods, and static methods.

object Any data with state (attributes or value) and defined behavior (methods). Also the ultimate base class of any *new-style class*.

package A Python *module* which can contain submodules or recursively, subpackages. Technically, a package is a Python module with an `__path__` attribute.

See also *regular package* and *namespace package*.

parameter A named entity in a *function* (or method) definition that specifies an *argument* (or in some cases, arguments) that the function can accept. There are five kinds of parameter:

- *positional-or-keyword*: specifies an argument that can be passed either *positionally* or as a *keyword argument*. This is the default kind of parameter, for example *foo* and *bar* in the following:

  ```
  def func(foo, bar=None): ...
  ```

- *positional-only*: specifies an argument that can be supplied only by position. Python has no syntax for defining positional-only parameters. However, some built-in functions have positional-only parameters (e.g. `abs()`).

- *keyword-only*: specifies an argument that can be supplied only by keyword. Keyword-only parameters can be defined by including a single var-positional parameter or bare `*` in the parameter list of the function definition before them, for example *kw_only1* and *kw_only2* in the following:

  ```
  def func(arg, *, kw_only1, kw_only2): ...
  ```

- *var-positional*: specifies that an arbitrary sequence of positional arguments can be provided (in addition to any positional arguments already accepted by other parameters). Such a parameter can be defined by prepending the parameter name with `*`, for example *args* in the following:

  ```
  def func(*args, **kwargs): ...
  ```

- *var-keyword*: specifies that arbitrarily many keyword arguments can be provided (in addition to any keyword arguments already accepted by other parameters). Such a parameter can be defined by prepending the parameter name with `**`, for example *kwargs* in the example above.

Parameters can specify both optional and required arguments, as well as default values for some optional arguments.

See also the *argument* glossary entry, the FAQ question on *the difference between arguments and parameters*, the `inspect.Parameter` class, the *function* section, and **PEP 362**.

path entry A single location on the *import path* which the *path based finder* consults to find modules for importing.

path entry finder A *finder* returned by a callable on `sys.path_hooks` (i.e. a *path entry hook*) which knows how to locate modules given a *path entry*.

path entry hook A callable on the `sys.path_hook` list which returns a *path entry finder* if it knows how to find modules on a specific *path entry*.

path based finder One of the default *meta path finders* which searches an *import path* for modules.

portion A set of files in a single directory (possibly stored in a zip file) that contribute to a namespace package, as defined in **PEP 420**.

positional argument See *argument*.

provisional package A provisional package is one which has been deliberately excluded from the standard library's backwards compatibility guarantees. While major changes to such packages are not expected, as long as they are marked provisional, backwards incompatible changes (up to and including removal of the package) may occur if deemed necessary by core developers. Such changes will not be made gratuitously – they will occur only if serious flaws are uncovered that were missed prior to the inclusion of the package.

This process allows the standard library to continue to evolve over time, without locking in problematic design errors for extended periods of time. See **PEP 411** for more details.

Python 3000 Nickname for the Python 3.x release line (coined long ago when the release of version 3 was something in the distant future.) This is also abbreviated "Py3k".

Pythonic An idea or piece of code which closely follows the most common idioms of the Python language, rather than implementing code using concepts common to other languages. For example, a common idiom in Python is to loop over all elements of an iterable using a `for` statement. Many other languages don't have this type of construct, so people unfamiliar with Python sometimes use a numerical counter instead:

```
for i in range(len(food)):
    print(food[i])
```

As opposed to the cleaner, Pythonic method:

```
for piece in food:
    print(piece)
```

qualified name A dotted name showing the "path" from a module's global scope to a class, function or method defined in that module, as defined in **PEP 3155**. For top-level functions and classes, the qualified name is the same as the object's name:

```
>>> class C:
...     class D:
...         def meth(self):
...             pass
...
>>> C.__qualname__
'C'
>>> C.D.__qualname__
'C.D'
>>> C.D.meth.__qualname__
'C.D.meth'
```

When used to refer to modules, the *fully qualified name* means the entire dotted path to the module, including any parent packages, e.g. `email.mime.text`:

```
>>> import email.mime.text
>>> email.mime.text.__name__
'email.mime.text'
```

reference count The number of references to an object. When the reference count of an object drops to zero, it is deallocated. Reference counting is generally not visible to Python code, but it is a key element of the *CPython* implementation. The `sys` module defines a `getrefcount()` function that programmers can call to return the reference count for a particular object.

regular package A traditional *package*, such as a directory containing an `__init__.py` file.

See also *namespace package*.

__slots__ A declaration inside a class that saves memory by pre-declaring space for instance attributes and eliminating instance dictionaries. Though popular, the technique is somewhat tricky to get right and is best reserved for rare cases where there are large numbers of instances in a memory-critical application.

sequence An *iterable* which supports efficient element access using integer indices via the `__getitem__()` special method and defines a `__len__()` method that returns the length of the sequence. Some built-in sequence types are `list`, `str`, `tuple`, and `bytes`. Note that `dict` also supports `__getitem__()` and `__len__()`, but is considered a mapping rather than a sequence because the lookups use arbitrary *immutable* keys rather than integers.

The `collections.abc.Sequence` abstract base class defines a much richer interface that goes beyond just `__getitem__()` and `__len__()`, adding `count()`, `index()`, `__contains__()`, and `__reversed__()`. Types that implement this expanded interface can be registered explicitly using `register()`.

slice An object usually containing a portion of a *sequence*. A slice is created using the subscript notation, `[]` with colons between numbers when several are given, such as in `variable_name[1:3:5]`. The bracket (subscript) notation uses `slice` objects internally.

special method A method that is called implicitly by Python to execute a certain operation on a type, such as addition. Such methods have names starting and ending with double underscores. Special methods are documented in *specialnames*.

statement A statement is part of a suite (a "block" of code). A statement is either an *expression* or one of several constructs with a keyword, such as `if`, `while` or `for`.

struct sequence A tuple with named elements. Struct sequences expose an interface similar to *named tuple* in that elements can either be accessed either by index or as an attribute. However, they do not have any of the named tuple methods like `_make()` or `_asdict()`. Examples of struct sequences include `sys.float_info` and the return value of `os.stat()`.

text file A *file object* able to read and write `str` objects. Often, a text file actually accesses a byte-oriented datastream and handles the text encoding automatically.

See also:

A *binary file* reads and write `bytes` objects.

triple-quoted string A string which is bound by three instances of either a quotation mark (") or an apostrophe ('). While they don't provide any functionality not available with single-quoted strings, they are useful for a number of reasons. They allow you to include unescaped single and double quotes within a string and they can span multiple lines without the use of the continuation character, making them especially useful when writing docstrings.

type The type of a Python object determines what kind of object it is; every object has a type. An object's type is accessible as its `__class__` attribute or can be retrieved with `type(obj)`.

universal newlines A manner of interpreting text streams in which all of the following are recognized as ending a line: the Unix end-of-line convention `'\n'`, the Windows convention `'\r\n'`, and the old Macintosh convention `'\r'`. See **PEP 278** and **PEP 3116**, as well as `str.splitlines()` for an additional use.

view The objects returned from `dict.keys()`, `dict.values()`, and `dict.items()` are called dictionary views. They are lazy sequences that will see changes in the underlying dictionary. To force the dictionary view to become a full list use `list(dictview)`. See *dict-views*.

virtual machine A computer defined entirely in software. Python's virtual machine executes the *bytecode* emitted by the bytecode compiler.

Zen of Python Listing of Python design principles and philosophies that are helpful in understanding and using the language. The listing can be found by typing "`import this`" at the interactive prompt.

APPENDIX

B

ABOUT THESE DOCUMENTS

These documents are generated from reStructuredText sources by Sphinx, a document processor specifically written for the Python documentation.

Development of the documentation and its toolchain is an entirely volunteer effort, just like Python itself. If you want to contribute, please take a look at the *reporting-bugs* page for information on how to do so. New volunteers are always welcome!

Many thanks go to:

- Fred L. Drake, Jr., the creator of the original Python documentation toolset and writer of much of the content;
- the Docutils project for creating reStructuredText and the Docutils suite;
- Fredrik Lundh for his Alternative Python Reference project from which Sphinx got many good ideas.

B.1 Contributors to the Python Documentation

Many people have contributed to the Python language, the Python standard library, and the Python documentation. See Misc/ACKS in the Python source distribution for a partial list of contributors.

It is only with the input and contributions of the Python community that Python has such wonderful documentation – Thank You!

APPENDIX

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 http://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 http://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 http://www.zope.com/). In 2001, the Python Software Foundation (PSF, see http://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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1.3 thru 1.5.2	1.2	1995-1999	CNRI	yes
1.6	1.5.2	2000	CNRI	no
2.0	1.6	2000	BeOpen.com	no
1.6.1	1.6	2001	CNRI	no
2.1	2.0+1.6.1	2001	PSF	no
2.0.1	2.0+1.6.1	2001	PSF	yes
2.1.1	2.1+2.0.1	2001	PSF	yes
2.1.2	2.1.1	2002	PSF	yes
2.1.3	2.1.2	2002	PSF	yes
2.2 and above	2.1.1	2001-now	PSF	yes

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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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http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/emt.html
email: m-mat @ math.sci.hiroshima-u.ac.jp (remove space)
```

C.3.2 Sockets

The `socket` module uses the functions, `getaddrinfo()`, and `getnameinfo()`, which are coded in separate source files from the WIDE Project, http://www.wide.ad.jp/.

```
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```

C.3.3 Floating point exception control

The source for the `fpectl` module includes the following notice:

```
  ----------------------------------------------------------------------
 /                      Copyright (c) 1996.                             \
```

```
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  ------------------------------------------------------------------------
```

C.3.4 Asynchronous socket services

The `asynchat` and `asyncore` modules contain the following notice:

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```

C.3.5 Cookie management

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```

C.3.6 Execution tracing

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Modified by Jack Jansen, CWI, July 1995:
- Use binascii module to do the actual line-by-line conversion
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- Arguments more compliant with Python standard
```

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C.3.11 strtod and dtoa

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