
Installing Python Modules

Release 3.1.5

Guido van Rossum
Fred L. Drake, Jr., editor

April 09, 2012

Python Software Foundation
Email: docs@python.org

CONTENTS

1	Introduction	3
1.1	Best case: trivial installation	3
1.2	The new standard: Distutils	3
2	Standard Build and Install	5
2.1	Platform variations	5
2.2	Splitting the job up	5
2.3	How building works	6
2.4	How installation works	6
3	Alternate Installation	9
3.1	Alternate installation: the home scheme	9
3.2	Alternate installation: Unix (the prefix scheme)	9
3.3	Alternate installation: Windows (the prefix scheme)	10
4	Custom Installation	13
4.1	Modifying Python's Search Path	14
5	Distutils Configuration Files	17
5.1	Location and names of config files	17
5.2	Syntax of config files	18
6	Building Extensions: Tips and Tricks	19
6.1	Tweaking compiler/linker flags	19
6.2	Using non-Microsoft compilers on Windows	20
A	Glossary	23
B	About these documents	31
B.1	Contributors to the Python Documentation	31
C	History and License	33
C.1	History of the software	33
C.2	Terms and conditions for accessing or otherwise using Python	34
C.3	Licenses and Acknowledgements for Incorporated Software	36
D	Copyright	49
	Index	51

Author Greg Ward

Release 3.1

Date April 09, 2012

Abstract

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.

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 *Distributing Python Modules* (in *Distributing Python Modules*) manual.

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` 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 anyways).

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

```
python 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.

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:

```
python setup.py install
```

On Unix, you'd run this command from a shell prompt; on Windows, you have to open a command prompt window ("DOS box") and do it there; on Mac OS X, you open a **Terminal** window to get a shell prompt.

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 ("DOS box"), 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=/tmp/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	Notes
Unix (pure)	<code>prefix/lib/pythonX.Y/site-packages</code>	<code>usr/local/lib/pythonX.Y/site-packages</code>	(1)
Unix (non-pure)	<code>exec-prefix/lib/pythonX.Y/site-packages</code>	<code>usr/local/lib/pythonX.Y/site-packages</code>	(1)
Windows	<code>prefix\Lib\site-packages</code>	<code>C:\PythonXY\Lib\site-packages</code>	(2)

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'
```

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.

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.

3.1 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=~
```

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	Override option
pure module distribution	home/lib/python	<code>--install-purelib</code>
non-pure module distribution	home/lib/python	<code>--install-platlib</code>
scripts	home/bin	<code>--install-scripts</code>
data	home/share	<code>--install-data</code>

3.2 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 “home scheme” comes first. 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	Override option
pure module distribution	prefix/lib/pythonX.Y/site-packages	<code>--install-purelib</code>
non-pure module distribution	exec-prefix/lib/pythonX.Y/site-packages	<code>--install-platlib</code>
scripts	prefix/bin	<code>--install-scripts</code>
data	prefix/share	<code>--install-data</code>

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.)

3.3 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. Files are installed as follows:

Type of file	Installation Directory	Override option
pure module distribution	prefix	<i>--install-purelib</i>
non-pure module distribution	prefix	<i>--install-platlib</i>
scripts	prefix\Scripts	<i>--install-scripts</i>
data	prefix\Data	<i>--install-data</i>

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*.

You probably noticed the column of “override options” in the tables describing the alternate installation schemes above. Those options are how you define a custom installation scheme. 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.)

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, pure modules and non-pure modules (i.e., modules from a non-pure distribution). For example:

```
python setup.py install --install-purelib=Site --install-platlib=Site
```

The specified installation directories are relative to `prefix`. Of course, you also have to ensure that these directories are in Python's module search path, such as by putting a `.pth` file in `prefix`. 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.

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.

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/pythonver/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)

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 `getpuid()` 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.

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 `.cpp` 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.

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

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:

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

and for Cygwin in no-cygwin mode³ 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://www.emmestech.com/software/pexports-0.43/download_pexports.html).

```
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`.

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 - Automated Python 2 to 3 code translation* (in *The Python Library Reference*).

abstract base class Abstract Base Classes (abbreviated ABCs) complement *duck-typing* by providing a way to define interfaces when other techniques like `hasattr()` would be clumsy. Python comes with many built-in ABCs for data structures (in the `collections` module), numbers (in the `numbers` module), and streams (in the `io` module). You can create your own ABC with the `abc` module.

argument A value passed to a function or method, assigned to a named local variable in the function body. A function or method may have both positional arguments and keyword arguments in its definition. Positional and keyword arguments may be variable-length: `*` accepts or passes (if in the function definition or call) several positional arguments in a list, while `**` does the same for keyword arguments in a dictionary.

Any expression may be used within the argument list, and the evaluated value is passed to the local variable.

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.

bytecode Python source code is compiled into bytecode, the internal representation of a Python program in the 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.

A list of bytecode instructions can be found in the documentation for *the dis module* (in *The Python Library Reference*).

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* (in *The Python Language Reference*) and *class definitions* (in *The Python Language Reference*) 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 *Implementing Descriptors* (in *The Python Language Reference*).

dictionary An associative array, where arbitrary keys are mapped to values. The keys can be any object with `__hash__()` function 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 *LYBL* 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 *statements* 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 other 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 a method named `find_module()`. See [PEP 302](#) 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 *argument* and *method*.

__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 a generator. 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, 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.

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

iterator 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 *Iterator Types* (in *The Python Library Reference*).

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* (in) for examples of how to create and use key functions.

keyword argument Arguments which are preceded with a `variable_name=` in the call. The variable name designates the local name in the function to which the value is assigned. `**` is used to accept or pass a dictionary of keyword arguments. 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.

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 (such as `dict`) which supports arbitrary key lookups using the special method `__getitem__()`. Mappings also support `__len__()`, `__iter__()`, and `__contains__()`.

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 *Customizing class creation* (in *The Python Language Reference*).

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*.

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.izip()` makes it clear that those functions are implemented by the `random` and `itertools` modules, respectively.

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, `__getattr__()`, 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*.

positional argument The arguments assigned to local names inside a function or method, determined by the order in which they were given in the call. `*` is used to either accept multiple positional arguments (when in the definition), or pass several arguments as a list to a function. See *argument*.

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)
```

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.

`__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.

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 *Special method names* (in *The Python Language Reference*).

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

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)`.

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 *Dictionary view objects* (in *The Python Library Reference*).

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.

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 takes place on the docs@python.org mailing list. We're always looking for volunteers wanting to help with the docs, so feel free to send a mail there!

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.

See *Reporting Bugs* for information how to report bugs in this documentation, or Python itself.

B.1 Contributors to the Python Documentation

This section lists people who have contributed in some way to the Python documentation. It is probably not complete – if you feel that you or anyone else should be on this list, please let us know (send email to docs@python.org), and we'll be glad to correct the problem.

Aahz, Michael Abbott, Steve Alexander, Jim Ahlstrom, Fred Allen, A. Amoroso, Pehr Anderson, Oliver Andrich, Heidi Annexstad, Jesús Cea Avi3n, Manuel Balsera, Daniel Barclay, Chris Barker, Don Bashford, Anthony Baxter, Alexander Belopolsky, Bennett Benson, Jonathan Black, Robin Boerdijk, Michal Bozon, Aaron Brancotti, Georg Brandl, Keith Briggs, Ian Bruntlett, Lee Busby, Lorenzo M. Catucci, Carl Cerecke, Mauro Cicognini, Gilles Civario, Mike Clarkson, Steve Clift, Dave Cole, Matthew Cowles, Jeremy Craven, Andrew Dalke, Ben Darnell, L. Peter Deutsch, Robert Donohue, Fred L. Drake, Jr., Jacques Ducasse, Josip Dzolong, Jeff Epler, Michael Ernst, Blame Andy Eskilsson, Carey Evans, Martijn Faassen, Carl Feynman, Dan Finnie, Hern3n Mart3nez Foffani, Stefan Franke, Jim Fulton, Peter Funk, Lele Gaifax, Matthew Gallagher, Gabriel Genellina, Ben Gertzfield, Nadim Ghaznavi, Jonathan Giddy, Matt Giuca, Shelley Gooch, Nathaniel Gray, Grant Griffin, Thomas Guettler, Anders Hammarquist, Mark Hammond, Harald Hanche-Olsen, Manus Hand, Gerhard H3ring, Travis B. Hartwell, Tim Hatch, Janko Hauser, Thomas Heller, Bernhard Herzog, Magnus L. Hetland, Konrad Hinsin, Stefan Hoffmeister, Albert Hofkamp, Gregor HOFFleit, Steve Holden, Thomas Holenstein, Gerrit Holl, Rob Hooft, Brian Hooper, Randall Hopper, Michael Hudson, Eric Huss, Jeremy Hylton, Roger Irwin, Jack Jansen, Philip H. Jensen, Pedro Diaz Jimenez, Kent Johnson, Lucas de Jonge, Andreas Jung, Robert Kern, Jim Kerr, Jan Kim, Greg Kochanski, Guido Kollerie, Peter A. Koren, Daniel Koza, Andrew M. Kuchling, Dave Kuhlman, Erno Kuusela, Ross Lagerwall, Thomas Lamb, Detlef Lannert, Piers Lauder, Glyph Lefkowitz, Robert Lehmann, Marc-Andr3 Lemberg, Ross Light, Ulf A. Lindgren, Everett Lipman, Mirko Liss, Martin von L3wis, Fredrik Lundh, Jeff MacDonald, John Machin, Andrew MacIntyre, Vladimir Marangozov, Vincent Marchetti, Westley Mart3nez, Laura Matson, Daniel May, Rebecca McCreary, Doug Mennella, Paolo Milani, Skip Montanaro, Paul Moore, Ross Moore, Sjoerd Mullender, Dale Nagata, Michal Nowikowski, Ng Pheng Siong, Koray Oner, Tomas Oppelstrup, Denis S. Otkidach, Zooko O'Whielacronx, Shriphani Palakodety, William

Park, Joonas Paalasmaa, Harri Pasanen, Bo Peng, Tim Peters, Benjamin Peterson, Christopher Petrilli, Justin D. Pettit, Chris Phoenix, François Pinard, Paul Prescod, Eric S. Raymond, Edward K. Ream, Terry J. Reedy, Sean Reifschneider, Bernhard Reiter, Armin Rigo, Wes Rishel, Armin Ronacher, Jim Roskind, Guido van Rossum, Donald Wallace Rouse II, Mark Russell, Nick Russo, Chris Ryland, Constantina S., Hugh Sasse, Bob Savage, Scott Schram, Neil Schemenauer, Barry Scott, Joakim Sernbrant, Justin Sheehy, Charlie Shepherd, SilentGhost, Michael Simcich, Ionel Simionescu, Michael Sloan, Gregory P. Smith, Roy Smith, Clay Spence, Nicholas Spies, Tage Stabell-Kulo, Frank Stajano, Anthony Starks, Greg Stein, Peter Stoehr, Mark Summerfield, Reuben Sumner, Kalle Svensson, Jim Tittsler, David Turner, Ville Vainio, Martijn Vries, Charles G. Waldman, Greg Ward, Barry Warsaw, Corran Webster, Glyn Webster, Bob Weiner, Eddy Welbourne, Jeff Wheeler, Mats Wichmann, Gerry Wiener, Timothy Wild, Collin Winter, Blake Winton, Dan Wolfe, Steven Work, Thomas Wouters, Ka-Ping Yee, Rory Yorke, Moshe Zadka, Milan Zamazal, Cheng Zhang, Trent Nelson, Michael Foord.

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

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.

All Python releases are Open Source (see <http://www.opensource.org/> for the Open Source Definition). Historically, most, but not all, Python releases have also been GPL-compatible; the table below summarizes the various releases.

Release	Derived from	Year	Owner	GPL compatible?
0.9.0 thru 1.2	n/a	1991-1995	CWI	yes
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
2.2	2.1.1	2001	PSF	yes
2.1.2	2.1.1	2002	PSF	yes
2.1.3	2.1.2	2002	PSF	yes
2.2.1	2.2	2002	PSF	yes
2.2.2	2.2.1	2002	PSF	yes
2.2.3	2.2.2	2002-2003	PSF	yes
2.3	2.2.2	2002-2003	PSF	yes
2.3.1	2.3	2002-2003	PSF	yes
2.3.2	2.3.1	2003	PSF	yes
2.3.3	2.3.2	2003	PSF	yes
2.3.4	2.3.3	2004	PSF	yes
2.3.5	2.3.4	2005	PSF	yes
2.4	2.3	2004	PSF	yes

Continued on next page

Table C.1 – continued from previous page

2.4.1	2.4	2005	PSF	yes
2.4.2	2.4.1	2005	PSF	yes
2.4.3	2.4.2	2006	PSF	yes
2.4.4	2.4.3	2006	PSF	yes
2.5	2.4	2006	PSF	yes
2.5.1	2.5	2007	PSF	yes
2.6	2.5	2008	PSF	yes
2.6.1	2.6	2008	PSF	yes
2.6.2	2.6.1	2009	PSF	yes
2.6.3	2.6.2	2009	PSF	yes
2.6.4	2.6.3	2009	PSF	yes
3.0	2.6	2008	PSF	yes
3.0.1	3.0	2009	PSF	yes
3.1	3.0.1	2009	PSF	yes
3.1.1	3.1	2009	PSF	yes

Note: GPL-compatible doesn’t mean that we’re distributing Python under the GPL. All Python licenses, unlike the GPL, let you distribute a modified version without making your changes open source. The GPL-compatible licenses make it possible to combine Python with other software that is released under the GPL; the others don’t.

Thanks to the many outside volunteers who have worked under Guido’s direction to make these releases possible.

C.2 Terms and conditions for accessing or otherwise using Python

PSF LICENSE AGREEMENT FOR PYTHON 3.1.5

1. This LICENSE AGREEMENT is between the Python Software Foundation (“PSF”), and the Individual or Organization (“Licensee”) accessing and otherwise using Python 3.1.5 software in source or binary form and its associated documentation.
2. Subject to the terms and conditions of this License Agreement, PSF hereby grants Licensee a nonexclusive, royalty-free, world-wide license to reproduce, analyze, test, perform and/or display publicly, prepare derivative works, distribute, and otherwise use Python 3.1.5 alone or in any derivative version, provided, however, that PSF’s License Agreement and PSF’s notice of copyright, i.e., “Copyright © 2001-2010 Python Software Foundation; All Rights Reserved” are retained in Python 3.1.5 alone or in any derivative version prepared by Licensee.
3. In the event Licensee prepares a derivative work that is based on or incorporates Python 3.1.5 or any part thereof, and wants to make the derivative work available to others as provided herein, then Licensee hereby agrees to include in any such work a brief summary of the changes made to Python 3.1.5.
4. PSF is making Python 3.1.5 available to Licensee on an “AS IS” basis. PSF MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED. BY WAY OF EXAMPLE, BUT NOT LIMITATION, PSF MAKES NO AND DISCLAIMS ANY REPRESENTATION OR WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OR THAT THE USE OF PYTHON 3.1.5 WILL NOT INFRINGE ANY THIRD PARTY RIGHTS.
5. PSF SHALL NOT BE LIABLE TO LICENSEE OR ANY OTHER USERS OF PYTHON 3.1.5 FOR ANY INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES OR LOSS AS A RESULT OF MODIFYING, DISTRIBUTING, OR OTHERWISE USING PYTHON 3.1.5, OR ANY DERIVATIVE THEREOF, EVEN IF ADVISED OF THE POSSIBILITY THEREOF.
6. This License Agreement will automatically terminate upon a material breach of its terms and conditions.

7. Nothing in this License Agreement shall be deemed to create any relationship of agency, partnership, or joint venture between PSF and Licensee. This License Agreement does not grant permission to use PSF trademarks or trade name in a trademark sense to endorse or promote products or services of Licensee, or any third party.
8. By copying, installing or otherwise using Python 3.1.5, Licensee agrees to be bound by the terms and conditions of this License Agreement.

BEOPEN.COM LICENSE AGREEMENT FOR PYTHON 2.0

BEOPEN PYTHON OPEN SOURCE LICENSE AGREEMENT VERSION 1

1. This LICENSE AGREEMENT is between BeOpen.com (“BeOpen”), having an office at 160 Saratoga Avenue, Santa Clara, CA 95051, and the Individual or Organization (“Licensee”) accessing and otherwise using this software in source or binary form and its associated documentation (“the Software”).
2. Subject to the terms and conditions of this BeOpen Python License Agreement, BeOpen hereby grants Licensee a non-exclusive, royalty-free, world-wide license to reproduce, analyze, test, perform and/or display publicly, prepare derivative works, distribute, and otherwise use the Software alone or in any derivative version, provided, however, that the BeOpen Python License is retained in the Software, alone or in any derivative version prepared by Licensee.
3. BeOpen is making the Software available to Licensee on an “AS IS” basis. BEOPEN MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED. BY WAY OF EXAMPLE, BUT NOT LIMITATION, BEOPEN MAKES NO AND DISCLAIMS ANY REPRESENTATION OR WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OR THAT THE USE OF THE SOFTWARE WILL NOT INFRINGE ANY THIRD PARTY RIGHTS.
4. BEOPEN SHALL NOT BE LIABLE TO LICENSEE OR ANY OTHER USERS OF THE SOFTWARE FOR ANY INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES OR LOSS AS A RESULT OF USING, MODIFYING OR DISTRIBUTING THE SOFTWARE, OR ANY DERIVATIVE THEREOF, EVEN IF ADVISED OF THE POSSIBILITY THEREOF.
5. This License Agreement will automatically terminate upon a material breach of its terms and conditions.
6. This License Agreement shall be governed by and interpreted in all respects by the law of the State of California, excluding conflict of law provisions. Nothing in this License Agreement shall be deemed to create any relationship of agency, partnership, or joint venture between BeOpen and Licensee. This License Agreement does not grant permission to use BeOpen trademarks or trade names in a trademark sense to endorse or promote products or services of Licensee, or any third party. As an exception, the “BeOpen Python” logos available at <http://www.pythonlabs.com/logos.html> may be used according to the permissions granted on that web page.
7. By copying, installing or otherwise using the software, Licensee agrees to be bound by the terms and conditions of this License Agreement.

CNRI LICENSE AGREEMENT FOR PYTHON 1.6.1

1. This LICENSE AGREEMENT is between the Corporation for National Research Initiatives, having an office at 1895 Preston White Drive, Reston, VA 20191 (“CNRI”), and the Individual or Organization (“Licensee”) accessing and otherwise using Python 1.6.1 software in source or binary form and its associated documentation.
2. Subject to the terms and conditions of this License Agreement, CNRI hereby grants Licensee a nonexclusive, royalty-free, world-wide license to reproduce, analyze, test, perform and/or display publicly, prepare derivative works, distribute, and otherwise use Python 1.6.1 alone or in any derivative version, provided, however, that CNRI’s License Agreement and CNRI’s notice of copyright, i.e., “Copyright © 1995-2001 Corporation for National Research Initiatives; All Rights Reserved” are retained in Python 1.6.1 alone or in any derivative version prepared by Licensee. Alternately, in lieu of CNRI’s License Agreement, Licensee may substitute the following text (omitting the quotes): “Python 1.6.1 is made available subject to the terms and conditions in CNRI’s License Agreement. This Agreement together with Python 1.6.1 may be located on the Internet using the following unique, persistent identifier (known as a handle): 1895.22/1013. This Agreement may also be obtained from a proxy server on the Internet using the following URL: <http://hdl.handle.net/1895.22/1013>.”

3. In the event Licensee prepares a derivative work that is based on or incorporates Python 1.6.1 or any part thereof, and wants to make the derivative work available to others as provided herein, then Licensee hereby agrees to include in any such work a brief summary of the changes made to Python 1.6.1.
4. CNRI is making Python 1.6.1 available to Licensee on an “AS IS” basis. CNRI MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED. BY WAY OF EXAMPLE, BUT NOT LIMITATION, CNRI MAKES NO AND DISCLAIMS ANY REPRESENTATION OR WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OR THAT THE USE OF PYTHON 1.6.1 WILL NOT INFRINGE ANY THIRD PARTY RIGHTS.
5. CNRI SHALL NOT BE LIABLE TO LICENSEE OR ANY OTHER USERS OF PYTHON 1.6.1 FOR ANY INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES OR LOSS AS A RESULT OF MODIFYING, DISTRIBUTING, OR OTHERWISE USING PYTHON 1.6.1, OR ANY DERIVATIVE THEREOF, EVEN IF ADVISED OF THE POSSIBILITY THEREOF.
6. This License Agreement will automatically terminate upon a material breach of its terms and conditions.
7. This License Agreement shall be governed by the federal intellectual property law of the United States, including without limitation the federal copyright law, and, to the extent such U.S. federal law does not apply, by the law of the Commonwealth of Virginia, excluding Virginia’s conflict of law provisions. Notwithstanding the foregoing, with regard to derivative works based on Python 1.6.1 that incorporate non-separable material that was previously distributed under the GNU General Public License (GPL), the law of the Commonwealth of Virginia shall govern this License Agreement only as to issues arising under or with respect to Paragraphs 4, 5, and 7 of this License Agreement. Nothing in this License Agreement shall be deemed to create any relationship of agency, partnership, or joint venture between CNRI and Licensee. This License Agreement does not grant permission to use CNRI trademarks or trade name in a trademark sense to endorse or promote products or services of Licensee, or any third party.
8. By clicking on the “ACCEPT” button where indicated, or by copying, installing or otherwise using Python 1.6.1, Licensee agrees to be bound by the terms and conditions of this License Agreement.

ACCEPT

CWI LICENSE AGREEMENT FOR PYTHON 0.9.0 THROUGH 1.2

Copyright © 1991 - 1995, Stichting Mathematisch Centrum Amsterdam, The Netherlands. All rights reserved.

Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Stichting Mathematisch Centrum or CWI not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

STICHTING MATHEMATISCH CENTRUM DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO EVENT SHALL STICHTING MATHEMATISCH CENTRUM BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

C.3 Licenses and Acknowledgements for Incorporated Software

This section is an incomplete, but growing list of licenses and acknowledgements for third-party software incorporated in the Python distribution.

C.3.1 Mersenne Twister

The `_random` module includes code based on a download from <http://www.math.keio.ac.jp/matsumoto/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)`.

Copyright (C) 1997 - 2002, Makoto Matsumoto and Takuji Nishimura,
All rights reserved.

Redistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions
are met:

1. Redistributions of source code must retain the above copyright
notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright
notice, this list of conditions and the following disclaimer in the
documentation and/or other materials provided with the distribution.
3. The names of its contributors may not be used to endorse or promote
products derived from this software without specific prior written
permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS
"AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT
LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR
A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR
CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL,
EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO,
PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR
PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF
LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING
NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS
SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Any feedback is very welcome.
<http://www.math.keio.ac.jp/matsumoto/emt.html>
email: matsumoto@math.keio.ac.jp

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/>.

Copyright (C) 1995, 1996, 1997, and 1998 WIDE Project.
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of the project nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE PROJECT AND CONTRIBUTORS ``AS IS'' AND GAI_ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE PROJECT OR CONTRIBUTORS BE LIABLE FOR GAI_ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON GAI_ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN GAI_ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

C.3.3 Floating point exception control

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

```
-----
/                               Copyright (c) 1996.                               \
|           The Regents of the University of California.           |
|               All rights reserved.               |
|
|  Permission to use, copy, modify, and distribute this software for  |
|  any purpose without fee is hereby granted, provided that this en- |
|  tire notice is included in all copies of any software which is or |
|  includes a copy or modification of this software and in all      |
|  copies of the supporting documentation for such software.         |
|
|  This work was produced at the University of California, Lawrence  |
|  Livermore National Laboratory under contract no. W-7405-ENG-48   |
|  between the U.S. Department of Energy and The Regents of the    |
|  University of California for the operation of UC LLNL.           |
|
|                               DISCLAIMER                               |
|
|  This software was prepared as an account of work sponsored by an  |
|  agency of the United States Government. Neither the United States |
|  Government nor the University of California nor any of their em-  |
|  ployees, makes any warranty, express or implied, or assumes any  |
|  liability or responsibility for the accuracy, completeness, or    |
|  usefulness of any information, apparatus, product, or process    |
|  disclosed, or represents that its use would not infringe         |
|  privately-owned rights. Reference herein to any specific commer-
```

```
| cial products, process, or service by trade name, trademark, |
| manufacturer, or otherwise, does not necessarily constitute or |
| imply its endorsement, recommendation, or favoring by the United |
| States Government or the University of California. The views and |
| opinions of authors expressed herein do not necessarily state or |
| reflect those of the United States Government or the University |
| of California, and shall not be used for advertising or product |
| \ endorsement purposes. /
```

C.3.4 Asynchronous socket services

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

Copyright 1996 by Sam Rushing

All Rights Reserved

Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Sam Rushing not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

SAM RUSHING DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO EVENT SHALL SAM RUSHING BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

C.3.5 Cookie management

The `http.cookies` module contains the following notice:

Copyright 2000 by Timothy O'Malley <timo@alum.mit.edu>

All Rights Reserved

Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Timothy O'Malley not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

Timothy O'Malley DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS

SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO EVENT SHALL Timothy O'Malley BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

C.3.6 Execution tracing

The trace module contains the following notice:

```
portions copyright 2001, Autonomous Zones Industries, Inc., all rights...
err... reserved and offered to the public under the terms of the
Python 2.2 license.
Author: Zooko O'Whielacronx
http://zooko.com/
mailto:zooko@zooko.com
```

```
Copyright 2000, Mojam Media, Inc., all rights reserved.
Author: Skip Montanaro
```

```
Copyright 1999, Bioreason, Inc., all rights reserved.
Author: Andrew Dalke
```

```
Copyright 1995-1997, Automatrix, Inc., all rights reserved.
Author: Skip Montanaro
```

```
Copyright 1991-1995, Stichting Mathematisch Centrum, all rights reserved.
```

Permission to use, copy, modify, and distribute this Python software and its associated documentation for any purpose without fee is hereby granted, provided that the above copyright notice appears in all copies, and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of neither Automatrix, Bioreason or Mojam Media be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

C.3.7 UUencode and UUdecode functions

The uu module contains the following notice:

```
Copyright 1994 by Lance Ellinghouse
Cathedral City, California Republic, United States of America.
All Rights Reserved
```

Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Lance Ellinghouse not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

LANCE ELLINGHOUSE DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO EVENT SHALL LANCE ELLINGHOUSE CENTRUM BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

Modified by Jack Jansen, CWI, July 1995:

- Use binascii module to do the actual line-by-line conversion between ascii and binary. This results in a 1000-fold speedup. The C version is still 5 times faster, though.
- Arguments more compliant with Python standard

C.3.8 XML Remote Procedure Calls

The `xmlrpc.client` module contains the following notice:

The XML-RPC client interface is

Copyright (c) 1999-2002 by Secret Labs AB
Copyright (c) 1999-2002 by Fredrik Lundh

By obtaining, using, and/or copying this software and/or its associated documentation, you agree that you have read, understood, and will comply with the following terms and conditions:

Permission to use, copy, modify, and distribute this software and its associated documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appears in all copies, and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Secret Labs AB or the author not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

SECRET LABS AB AND THE AUTHOR DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS. IN NO EVENT SHALL SECRET LABS AB OR THE AUTHOR BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

C.3.9 test_epoll

The `test_epoll` contains the following notice:

Copyright (c) 2001-2006 Twisted Matrix Laboratories.

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the

"Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

C.3.10 Select kqueue

The select and contains the following notice for the kqueue interface:

Copyright (c) 2000 Doug White, 2006 James Knight, 2007 Christian Heimes
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

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:

```
/*****  
 *  
 */
```

```

* The author of this software is David M. Gay.
*
* Copyright (c) 1991, 2000, 2001 by Lucent Technologies.
*
* Permission to use, copy, modify, and distribute this software for any
* purpose without fee is hereby granted, provided that this entire notice
* is included in all copies of any software which is or includes a copy
* or modification of this software and in all copies of the supporting
* documentation for such software.
*
* THIS SOFTWARE IS BEING PROVIDED "AS IS", WITHOUT ANY EXPRESS OR IMPLIED
* WARRANTY. IN PARTICULAR, NEITHER THE AUTHOR NOR LUCENT MAKES ANY
* REPRESENTATION OR WARRANTY OF ANY KIND CONCERNING THE MERCHANTABILITY
* OF THIS SOFTWARE OR ITS FITNESS FOR ANY PARTICULAR PURPOSE.
*
*****/

```

C.3.12 OpenSSL

The modules `hashlib`, `posix`, `ssl`, `crypt` use the OpenSSL library for added performance if made available by the operating system. Additionally, the Windows installers for Python include a copy of the OpenSSL libraries, so we include a copy of the OpenSSL license here:

```

LICENSE ISSUES
=====

```

The OpenSSL toolkit stays under a dual license, i.e. both the conditions of the OpenSSL License and the original SSLeay license apply to the toolkit. See below for the actual license texts. Actually both licenses are BSD-style Open Source licenses. In case of any license issues related to OpenSSL please contact openssl-core@openssl.org.

```

OpenSSL License
-----

```

```

/* =====
* Copyright (c) 1998-2008 The OpenSSL Project. All rights reserved.
*
* Redistribution and use in source and binary forms, with or without
* modification, are permitted provided that the following conditions
* are met:
*
* 1. Redistributions of source code must retain the above copyright
* notice, this list of conditions and the following disclaimer.
*
* 2. Redistributions in binary form must reproduce the above copyright
* notice, this list of conditions and the following disclaimer in
* the documentation and/or other materials provided with the
* distribution.
*
* 3. All advertising materials mentioning features or use of this
* software must display the following acknowledgment:
* "This product includes software developed by the OpenSSL Project
* for use in the OpenSSL Toolkit. (http://www.openssl.org/)"

```

```
*
* 4. The names "OpenSSL Toolkit" and "OpenSSL Project" must not be used to
*    endorse or promote products derived from this software without
*    prior written permission. For written permission, please contact
*    openssl-core@openssl.org.
*
* 5. Products derived from this software may not be called "OpenSSL"
*    nor may "OpenSSL" appear in their names without prior written
*    permission of the OpenSSL Project.
*
* 6. Redistributions of any form whatsoever must retain the following
*    acknowledgment:
*    "This product includes software developed by the OpenSSL Project
*    for use in the OpenSSL Toolkit (http://www.openssl.org/)"
*
* THIS SOFTWARE IS PROVIDED BY THE OpenSSL PROJECT ``AS IS'' AND ANY
* EXPRESSED OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR
* PURPOSE ARE DISCLAIMED.  IN NO EVENT SHALL THE OpenSSL PROJECT OR
* ITS CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,
* SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT
* NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES;
* LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
* HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT,
* STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE)
* ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED
* OF THE POSSIBILITY OF SUCH DAMAGE.
* =====
*
* This product includes cryptographic software written by Eric Young
* (eay@cryptsoft.com).  This product includes software written by Tim
* Hudson (tjh@cryptsoft.com).
*
*/
```

Original SSLeay License

```
-----
/* Copyright (C) 1995-1998 Eric Young (eay@cryptsoft.com)
 * All rights reserved.
 *
 * This package is an SSL implementation written
 * by Eric Young (eay@cryptsoft.com).
 * The implementation was written so as to conform with Netscapes SSL.
 *
 * This library is free for commercial and non-commercial use as long as
 * the following conditions are aheared to.  The following conditions
 * apply to all code found in this distribution, be it the RC4, RSA,
 * lhash, DES, etc., code; not just the SSL code.  The SSL documentation
 * included with this distribution is covered by the same copyright terms
 * except that the holder is Tim Hudson (tjh@cryptsoft.com).
 *
 * Copyright remains Eric Young's, and as such any Copyright notices in
 * the code are not to be removed.
```



```

* If this package is used in a product, Eric Young should be given attribution
* as the author of the parts of the library used.
* This can be in the form of a textual message at program startup or
* in documentation (online or textual) provided with the package.
*
* Redistribution and use in source and binary forms, with or without
* modification, are permitted provided that the following conditions
* are met:
* 1. Redistributions of source code must retain the copyright
*   notice, this list of conditions and the following disclaimer.
* 2. Redistributions in binary form must reproduce the above copyright
*   notice, this list of conditions and the following disclaimer in the
*   documentation and/or other materials provided with the distribution.
* 3. All advertising materials mentioning features or use of this software
*   must display the following acknowledgement:
*   "This product includes cryptographic software written by
*   Eric Young (eay@cryptsoft.com)"
*   The word 'cryptographic' can be left out if the routines from the library
*   being used are not cryptographic related :-).
* 4. If you include any Windows specific code (or a derivative thereof) from
*   the apps directory (application code) you must include an acknowledgement:
*   "This product includes software written by Tim Hudson (tjh@cryptsoft.com)"
*
* THIS SOFTWARE IS PROVIDED BY ERIC YOUNG ``AS IS'' AND
* ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
* ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE
* FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL
* DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS
* OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
* HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT
* LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY
* OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF
* SUCH DAMAGE.
*
* The licence and distribution terms for any publically available version or
* derivative of this code cannot be changed. i.e. this code cannot simply be
* copied and put under another distribution licence
* [including the GNU Public Licence.]
*/

```

C.3.13 expat

The pyexpat extension is built using an included copy of the expat sources unless the build is configured `--with-system-expat`:

Copyright (c) 1998, 1999, 2000 Thai Open Source Software Center Ltd
and Clark Cooper

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to

permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

C.3.14 libffi

The `_ctypes` extension is built using an included copy of the libffi sources unless the build is configured `--with-system-libffi`:

Copyright (c) 1996–2008 Red Hat, Inc and others.

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the ‘Software’), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED ‘AS IS’, WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

C.3.15 zlib

The `zlib` extension is built using an included copy of the `zlib` sources unless the `zlib` version found on the system is too old to be used for the build:

Copyright (C) 1995–2010 Jean-loup Gailly and Mark Adler

This software is provided ‘as-is’, without any express or implied warranty. In no event will the authors be held liable for any damages arising from the use of this software.

Permission is granted to anyone to use this software for any purpose,

including commercial applications, and to alter it and redistribute it freely, subject to the following restrictions:

1. The origin of this software must not be misrepresented; you must not claim that you wrote the original software. If you use this software in a product, an acknowledgment in the product documentation would be appreciated but is not required.
2. Altered source versions must be plainly marked as such, and must not be misrepresented as being the original software.
3. This notice may not be removed or altered from any source distribution.

Jean-loup Gailly
jloup@gzip.org

Mark Adler
madler@alumni.caltech.edu

COPYRIGHT

Python and this documentation is:

Copyright © 2001-2010 Python Software Foundation. All rights reserved.

Copyright © 2000 BeOpen.com. All rights reserved.

Copyright © 1995-2000 Corporation for National Research Initiatives. All rights reserved.

Copyright © 1991-1995 Stichting Mathematisch Centrum. All rights reserved.

See *History and License* for complete license and permissions information.

INDEX

Symbols

..., 23
__future__, 25
__slots__, 28
>>>, 23
2to3, 23

A

abstract base class, 23
argument, 23
attribute, 23

B

BDFL, 23
bytecode, 23

C

CFLAGS, 20
class, 23
coercion, 23
complex number, 24
context manager, 24
CPython, 24

D

decorator, 24
descriptor, 24
dictionary, 24
docstring, 24
duck-typing, 24

E

EAFP, 24
environment variable
 CFLAGS, 20
 HOME, 17, 18
 HOMEDRIVE, 18
 HOMEPATH, 18
 PYTHONHOME, 15
 PYTHONPATH, 15
 USERPROFILE, 18

expression, 25
extension module, 25

F

file object, 25
file-like object, 25
finder, 25
floor division, 25
function, 25

G

garbage collection, 25
generator, 25
generator expression, 25
GIL, 25
global interpreter lock, 25

H

hashable, 26
HOME, 17, 18
HOMEDRIVE, 18
HOMEPATH, 18

I

IDLE, 26
immutable, 26
importer, 26
interactive, 26
interpreted, 26
iterable, 26
iterator, 26

K

key function, 27
keyword argument, 27

L

lambda, 27
LBYL, 27
list, 27
list comprehension, 27

loader, [27](#)

M

mapping, [27](#)

metaclass, [27](#)

method, [27](#)

mutable, [27](#)

N

named tuple, [27](#)

namespace, [28](#)

nested scope, [28](#)

new-style class, [28](#)

O

object, [28](#)

P

positional argument, [28](#)

Python 3000, [28](#)

Python Enhancement Proposals

 PEP 238, [25](#)

 PEP 302, [25](#), [27](#)

 PEP 343, [24](#)

PYTHONHOME, [15](#)

Pythonic, [28](#)

PYTHONPATH, [15](#)

R

reference count, [28](#)

S

sequence, [28](#)

slice, [28](#)

special method, [29](#)

statement, [29](#)

T

triple-quoted string, [29](#)

type, [29](#)

U

USERPROFILE, [18](#)

V

view, [29](#)

virtual machine, [29](#)

Z

Zen of Python, [29](#)