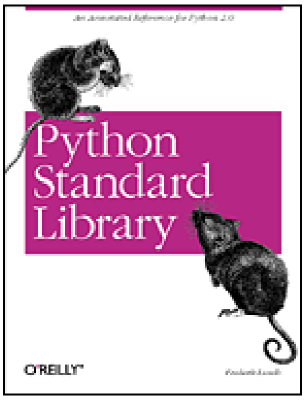
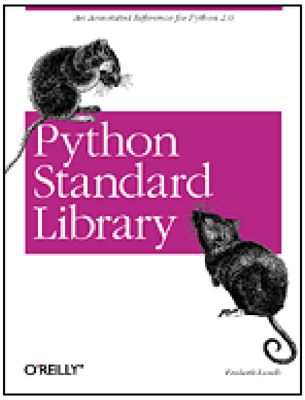


Python Standard Library

By Fredrik Lundh

Publisher : O'Reilly
Pub Date : May 2001
ISBN : 0-596-00096-0
Pages : 300

Python Standard Library, an essential guide for serious Python programmers, delivers accurate, author-tested documentation of all the modules in the Python Standard Library, along with over 300 annotated example scripts using the modules. This version of the book covers all the new modules and related information for Python 2.0, the first major release of Python in four years.



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Preface

> *"We'd like to pretend that 'Fredrik' is a role, but even hundreds of volunteers couldn't possibly keep up. No, 'Fredrik' is the result of crossing an http server with a spam filter with an emacs whatsit and some other stuff besides."*
>
> —Gordon McMillan, June 1998

The Python 2.0 distribution comes with an extensive standard library, comprised of over 200 modules. This book briefly describes each module and provides one or more sample scripts showing how to use it. All in all, this book contains 360 sample scripts.

About This Book

> *"Those people who have nothing better to do than post on the Internet all day long are rarely the ones who have the most insights."*
>
> —Jakob Nielsen, December 1998

Since I first stumbled upon Python some five years ago, I've spent hundreds of hours answering questions on the `comp.lang.python` newsgroup. Maybe someone found a module that might be exactly what he wanted, but he couldn't really figure out how to use it. Maybe someone had picked the wrong module for the task. Or maybe someone tried to reinvent the wheel. Often, a short sample script could be much more helpful than a pointer to the reference documentation.

After posting a couple of scripts each week, for a number of years, you end up with a rather large collection of potentially useful scripts. What you'll find in this book are the best parts from over 3,000 newsgroup messages. You'll also find hundreds of new scripts added to make sure every little nook and cranny of standard library has been fully covered.

I've worked hard to make the scripts both understandable and adaptable. I've intentionally kept the annotations as short as possible. If you want more background, there's plenty of reference material shipped with most Python distributions. In this book, the emphasis is on the code.

Comments, suggestions, and bug reports are welcome. Send them to fredrik@pythonware.com. I read all mail as soon as it arrives, but it might take a while until I get around to answering.

For updates, addenda, and other information related to this book, point your web browser to http://www.pythonware.com/people/fredrik/librarybook.htm

What About Tkinter?

This book covers the entire standard library, except the (optional) Tkinter user-interface library. There are several reasons for this, mostly related to time, space, and the fact that I'm working on several other Tkinter documentation projects.

For current status on these projects, see http://www.pythonware.com/people/fredrik/tkinterbook.htm.

Production Details

This book was written in DocBook SGML. I used a variety of tools, including Secret Labs' PythonWorks, Excosoft Documentor, James Clark's Jade DSSSL processor, Norm Walsh's DocBook stylesheets, and a bunch of Python scripts, of course.

Thanks to my referees: Tim Peters, Guido van Rossum, David Ascher, Mark Lutz, and Rael Dornfest, and the PythonWare crew: Matthew Ellis, Håkan Karlsson, and Rune Uhlin.

Thanks to Lenny Muellner, who turned my SGML files into the book you see before you, and to Christien Shangraw, who pulled all the different text and code files together for the book and the CD-ROM (view CD-ROM content online at http://examples.oreilly.com/pythonsl).

Conventions Used in This Book

The following typographic conventions appear in this book:

Italic

Is used for filenames and command names. It is also used to define terms the first time they appear.

`Constant Width`

Is used in examples and in regular text to show methods, modules, operators, functions, statements, and attributes.

About the Examples

Unless otherwise noted, all examples run under Python 1.5.2 and Python 2.0. I've tried not to depend on internal details, and I expect most scripts to work with upcoming 2.x versions as well.

The examples have been tested on Windows, Solaris, and Linux. Except for a few scripts that depend on platform-specific modules, the examples should work right out of the box on most other platforms as well. (If you find something that doesn't work as expected, let me know!)

All code is copyrighted. Of course, you're free to use one or more modules in your own programs, just don't forget where you got them.

Most script files are named after the module they're using, followed by the string "`-example-`" and a unique "serial number." Note that the scripts sometimes appear out of order; it's done this way on purpose, to match the filenames used in an earlier version of this book, *(the eff-bot guide to) The Standard Python Library*.

You'll find copies of all scripts on the CD provided with this book (see http://examples.oreilly.com/pythonsl). For updates and more information, see http://www.pythonware.com/people/fredrik/librarybook.htm. That page also explains what you need to know to decrypt and unpack the archive.

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Chapter 1. Core Modules

"Since the functions in the C runtime library are not part of the Win32 API, we believe the number of applications that will be affected by this bug to be very limited."

—Microsoft, January 1999

1.1 Introduction

Python's standard library covers a wide range of modules. It includes everything from modules that are as much a part of the Python language as the types and statements defined by the language specification, to obscure modules that are probably useful only to a small number of programs.

This chapter describes a number of fundamental standard library modules. Any larger Python program is likely to use most of these modules, either directly or indirectly.

1.1.1 Built-in Functions and Exceptions

The following two modules are even more basic than all other modules combined: the `__builtin__` module, which defines built-in functions (like `len`, `int`, and `range`), and the `exceptions` module, which defines all built-in exceptions.

Python imports both modules when it starts up, and makes their content available for all programs.

1.1.2 Operating System Interface Modules

There are a number of modules modeled after the POSIX standard API and the standard C library that provide platform-independent interfaces to the underlying operating system.

The modules in this group include `os`, which provides file and process operations, `os.path`, which offers a platform-independent way to pull apart and put together filenames, and `time`, which provides functions to work with dates and times.

To some extent, networking and thread support modules could also belong in this group, but they are not supported by all Python implementations.

1.1.3 Type Support Modules

Several built-in types have support modules in the standard library. The `string` module implements commonly used string operations, the `math` module provides math operations and constants, and the `cmath` module does the same for complex numbers.

1.1.4 Regular Expressions

The `re` module provides regular expressions support for Python. Regular expressions are string patterns written in a special syntax, which can be used to match strings and extract substrings.

1.1.5 Language Support Modules

`sys` gives you access to various interpreter variables, such as the module search path, and the interpreter version. `operator` provides functional equivalents to many built-in operators. `copy` allows you to copy objects. And finally, `gc` gives you more control over the garbage collector facilities in Python 2.0.

1.2 The _ _builtin_ _ Module

This module contains built-in functions that are automatically available in all Python modules. You usually don't have to import this module; Python does that for you when necessary.

1.2.1 Calling a Function with Arguments from a Tuple or Dictionary

Python allows you to build function argument lists on the fly. Just put all the arguments in a tuple, and call the built-in `apply` function, as illustrated in Example 1-1.

Example 1-1. Using the apply Function

```
File: builtin-apply-example-1.py

def function(a, b):
    print a, b

apply(function, ("whither", "canada?"))
apply(function, (1, 2 + 3))

whither canada?
1 5
```

To pass keyword arguments to a function, you can use a dictionary as the third argument to `apply`, as shown in Example 1-2.

Example 1-2. Using the apply Function to Pass Keyword Arguments

```
File: builtin-apply-example-2.py

def function(a, b):
    print a, b

apply(function, ("crunchy", "frog"))
apply(function, ("crunchy",), {"b": "frog"})
apply(function, (), {"a": "crunchy", "b": "frog"})

crunchy frog
crunchy frog
crunchy frog
```

One common use for `apply` is to pass constructor arguments from a subclass on to the base class, especially if the constructor takes a lot of arguments. See Example 1-3.

Example 1-3. Using the apply Function to Call Base Class Constructors

```
File: builtin-apply-example-3.py
```

```
class Rectangle:
    def _ _init_ _(self, color="white", width=10, height=10):
        print "create a", color, self, "sized", width, "x", height

class RoundedRectangle(Rectangle):
    def _ _init_ _(self, **kw):
        apply(Rectangle._ _init_ _, (self,), kw)

rect = Rectangle(color="green", height=100, width=100)
rect = RoundedRectangle(color="blue", height=20)
```

```
create a green <Rectangle instance at 8c8260> sized 100 x 100
create a blue <RoundedRectangle instance at 8c84c0> sized 10 x 20
```

Python 2.0 provides an alternate syntax. Instead of `apply`, you can use an ordinary function call, and use `*` to mark the tuple, and `**` to mark the dictionary.

The following two statements are equivalent:

```
result = function(*args, **kwargs)
result = apply(function, args, kwargs)
```

1.2.2 Loading and Reloading Modules

If you've written a Python program larger than just a few lines, you know that the `import` statement is used to import external modules (you can also use the `from-import` version). What you might not know already is that `import` delegates the actual work to a built-in function called `_ _import_ _`.

The trick is that you can call this function directly. This can be handy if you have the module name in a string variable, as in Example 1-4, which imports all modules whose names end with "`-plugin`":

Example 1-4. Using the _ _import_ _ Function to Load Named Modules

```
File: builtin-import-example-1.py

import glob, os

modules = []

for module_file in glob.glob("*-plugin.py"):
    try:
        module_name, ext = os.path.splitext(os.path.basename(module_file))
        module = _ _import_ _(module_name)
        modules.append(module)
    except ImportError:
        pass # ignore broken modules

# say hello to all modules
for module in modules:
    module.hello()
```

```
example-plugin says hello
```

Note that the plug-in modules have hyphens. This means that you cannot import such a module using the ordinary `import` command, since you cannot have hyphens in Python identifiers.

Example 1-5 shows the plug-in used in Example 1-4.

Example 1-5. A Sample Plug-in

```
File: example-plugin.py

def hello():
    print "example-plugin says hello"
```

Example 1-6 shows how to get a function object, given that the module and function name are strings.

Example 1-6. Using the _ _import_ _ Function to Get a Named Function

```
File: builtin-import-example-2.py

def getfunctionbyname(module_name, function_name):
    module = _ _import_ _(module_name)
    return getattr(module, function_name)

print repr(getfunctionbyname("dumbdbm", "open"))
```

```
<function open at 794fa0>
```

You can also use this function to implement lazy module loading. In Example 1-7, the `string` module is imported when it is first used.

Example 1-7. Using the _ _import_ _ Function to Implement Lazy Import

```
File: builtin-import-example-3.py

class LazyImport:
    def _ _init_ _(self, module_name):
        self.module_name = module_name
        self.module = None
    def _ _getattr_ _(self, name):
        if self.module is None:
            self.module = _ _import_ _(self.module_name)
        return getattr(self.module, name)

string = LazyImport("string")

print string.lowercase
```

```
abcdefghijklmnopqrstuvwxyz
```

Python provides some basic support for reloading modules that you've already imported. Example 1-8 loads the *hello.py* file three times.

Example 1-8. Using the reload Function

```
File: builtin-reload-example-1.py
```

```
import hello
reload(hello)
reload(hello)

hello again, and welcome to the show
hello again, and welcome to the show
hello again, and welcome to the show
```

`reload` uses the module name associated with the module object, not the variable name. Even if you've renamed the original module, `reload` can still find it.

Note that when you reload a module, it is recompiled, and the new module replaces the old one in the module dictionary. However, if you have created instances of classes defined in that module, those instances will still use the old implementation.

Likewise, if you've used `from-import` to create references to module members in other modules, those references will not be updated.

1.2.3 Looking in Namespaces

The `dir` function returns a list of all members of a given module, class, instance, or other type. It's probably most useful when you're working with an interactive Python interpreter, but can also come in handy in other situations. Example 1-9 shows the `dir` function in use.

Example 1-9. Using the dir Function

```
File: builtin-dir-example-1.py

def dump(value):
    print value, "=>", dir(value)

import sys

dump(0)
dump(1.0)
dump(0.0j) # complex number
dump([]) # list
dump({}) # dictionary
dump("string")
dump(len) # function
dump(sys) # module

0 => []
1.0 => []
0j => ['conjugate', 'imag', 'real']
[] => ['append', 'count', 'extend', 'index', 'insert',
    'pop', 'remove', 'reverse', 'sort']
{} => ['clear', 'copy', 'get', 'has_key', 'items',
    'keys', 'update', 'values']
string => []
<built-in function len> => ['_ _doc_ _', '_ _name_ _', '_ _self_ _']
<module 'sys' (built-in)> => ['_ _doc_ _', '_ _name_ _',
    '_ _stderr_ _', '_ _stdin_ _', '_ _stdout_ _', 'argv',
```

```
    'builtin_module_names', 'copyright', 'dllhandle',
    'exc_info', 'exc_type', 'exec_prefix', 'executable',
...
```

In Example 1-10, the getmember function returns all class-level attributes and methods defined by a given class.

Example 1-10. Using the dir Function to Find All Members of a Class

```
File: builtin-dir-example-2.py

class A:
    def a(self):
        pass
    def b(self):
        pass

class B(A):
    def c(self):
        pass
    def d(self):
        pass

def getmembers(klass, members=None):
    # get a list of all class members, ordered by class
    if members is None:
        members = []
    for k in klass.__bases__:
        getmembers(k, members)
    for m in dir(klass):
        if m not in members:
            members.append(m)
    return members

print getmembers(A)
print getmembers(B)
print getmembers(IOError)

['__doc__', '__module__', 'a', 'b']
['__doc__', '__module__', 'a', 'b', 'c', 'd']
['__doc__', '__getitem__', '__init__', '__module__', '__str__']
```

Note that the getmembers function returns an ordered list. The earlier a name appears in the list, the higher up in the class hierarchy it's defined. If order doesn't matter, you can use a dictionary to collect the names instead of a list.

The vars function is similar, but it returns a dictionary containing the current value for each member. If you use vars without an argument, it returns a dictionary containing what's visible in the current local namespace, as shown in Example 1-11.

Example 1-11. Using the vars Function

```
File: builtin-vars-example-1.py
```

```
book = "library2"
pages = 250
scripts = 350


print "the %(book)s book contains more than %(scripts)s scripts" % vars()
```

```
the library book contains more than 350 scripts
```

1.2.4 Checking an Object's Type

Python is a dynamically typed language, which means that a given variable can be bound to values of different types on different occasions. In the following example, the same function is called with an integer, a floating point value, and a string:

```
def function(value):
    print value
function(1)
function(1.0)
function("one")
```

The `type` function (shown in Example 1-12) allows you to check what type a variable has. This function returns a *type descriptor*, which is a unique object for each type provided by the Python interpreter.

Example 1-12. Using the type Function

```
File: builtin-type-example-1.py

def dump(value):
    print type(value), value

dump(1)
dump(1.0)
dump("one")
```

```
<type 'int'> 1
<type 'float'> 1.0
<type 'string'> one
```

Each type has a single corresponding type object, which means that you can use the `is` operator (object identity) to do type testing (as shown in Example 1-13).

Example 1-13. Using the type Function with Filenames and File Objects

```
File: builtin-type-example-2.py

def load(file):
    if isinstance(file, type("")):
        file = open(file, "rb")
    return file.read()

print len(load("samples/sample.jpg")), "bytes"
print len(load(open("samples/sample.jpg", "rb"))), "bytes"
```

```
4672 bytes
4672 bytes
```

The `callable` function, shown in Example 1-14, checks if an object can be called (either directly or via `apply`). It returns true for functions, methods, lambda expressions, classes, and class instances that define the `_ _call_ _` method.

Example 1-14. Using the callable Function

```
File: builtin-callable-example-1.py

def dump(function):
    if callable(function):
        print function, "is callable"
    else:
        print function, "is *not* callable"

class A:
    def method(self, value):
        return value

class B(A):
    def _ _call_ _(self, value):
        return value

a = A()
b = B()

dump(0) # simple objects
dump("string")
dump(callable)
dump(dump) # function

dump(A) # classes
dump(B)
dump(B.method)

dump(a) # instances
dump(b)
dump(b.method)

0 is *not* callable
string is *not* callable
<built-in function callable> is callable
<function dump at 8ca320> is callable
A is callable
B is callable
<unbound method A.method> is callable
<A instance at 8caa10> is *not* callable
<B instance at 8cab00> is callable
<method A.method of B instance at 8cab00> is callable
```

Note that the class objects (*A* and *B*) are both callable; if you call them, they create new objects. However, instances of class *A* are not callable, since that class doesn't have a `_ _call_ _` method.

You'll find functions to check if an object is of any of the built-in number, sequence, or dictionary types in the `operator` module. However, since it's easy to create a class that implements (for example, the basic sequence methods), it's usually a bad idea to use explicit type testing on such objects.

Things get even more complicated when it comes to classes and instances. Python doesn't treat classes as types per se; instead, all classes belong to a special class type, and all class instances belong to a special instance type.

This means that you cannot use `type` to test if an instance belongs to a given class; all instances have the same type! To solve this, you can use the `isinstance` function, which checks if an object is an instance of a given class (or of a subclass to it). Example 1-15 illustrates the `isinstance` function.

Example 1-15. Using the isinstance Function

```
File: builtin-isinstance-example-1.py

class A:
    pass

class B:
    pass

class C(A):
    pass

class D(A, B):
    pass

def dump(object):
    print object, "=>",
    if isinstance(object, A):
        print "A",
    if isinstance(object, B):
        print "B",
    if isinstance(object, C):
        print "C",
    if isinstance(object, D):
        print "D",
    print

a = A()
b = B()
c = C()
d = D()

dump(a)
dump(b)
dump(c)
dump(d)
dump(0)
dump("string")

<A instance at 8ca6d0> => A
<B instance at 8ca750> => B
<C instance at 8ca780> => A C
```

```
<D instance at 8ca7b0> => A B D
0 =>
string =>
```

The `issubclass` function is similar, but it instead checks whether a class object is the same as a given class, or is a subclass of it. The `issubclass` function is shown in Example 1-16.

Note that while `isinstance` accepts any kind of object, the `issubclass` function raises a *TypeError* exception if you use it on something that is not a class object.

Example 1-16. Using the issubclass Function

```
File: builtin-issubclass-example-1.py

class A:
    pass

class B:
    pass

class C(A):
    pass

class D(A, B):
    pass

def dump(object):
    print object, "=>",
    if issubclass(object, A):
        print "A",
    if issubclass(object, B):
        print "B",
    if issubclass(object, C):
        print "C",
    if issubclass(object, D):
        print "D",
    print

dump(A)
dump(B)
dump(C)
dump(D)
dump(0)
dump("string")
```

```
A => A
B => B
C => A C
D => A B D
0 =>
Traceback (innermost last):
  File "builtin-issubclass-example-1.py", line 29, in ?
  File "builtin-issubclass-example-1.py", line 15, in dump
TypeError: arguments must be classes
```

1.2.5 Evaluating Python Expressions

Python provides several ways to interact with the interpreter from within a program. For example, the `eval` function evaluates a string as if it were a Python expression. You can pass it a literal, simple expression, or use built-in functions, as shown in Example 1-17.

Example 1-17. Using the eval Function

```
File: builtin-eval-example-1.py

def dump(expression):
    result = eval(expression)
    print expression, "=>", result, type(result)

dump("1")
dump("1.0")
dump("'string'")
dump("1.0 + 2.0")
dump("'*' * 10")
dump("len('world')")

1 => 1 <type 'int'>
1.0 => 1.0 <type 'float'>
'string' => string <type 'string'>
1.0 + 2.0 => 3.0 <type 'float'>
'*' * 10 => ********** <type 'string'>
len('world') => 5 <type 'int'>
```

If you cannot trust the source from which you got the string, you may get into trouble using `eval`. For example, someone might use the built-in `_ _import_ _` function to load the `os` module, and then remove files on your disk (as shown in Example 1-18).

Example 1-18. Using the eval Function to Execute Arbitrary Commands

```
File: builtin-eval-example-2.py

print eval("_ _import_ _('os').getcwd()")
print eval("_ _import_ _('os').remove('file')")

/home/fredrik/librarybook
Traceback (innermost last):
 File "builtin-eval-example-2", line 2, in ?
 File "<string>", line 0, in ?
os.error: (2, 'No such file or directory')
```

Note that you get an *os.error* exception, which means that *Python actually tried to remove the file!*

Luckily, there's a way around this problem. You can pass a second argument to `eval`, which should contain a dictionary defining the namespace in which the expression is evaluated. Let's pass in an empty namespace:

```
>>> print eval("_ _import_ _('os').remove('file')", {})
Traceback (innermost last):
  File "<stdin>", line 1, in ?
  File "<string>", line 0, in ?
```

```
os.error: (2, 'No such file or directory')
```

Hmm. We still end up with an *os.error* exception.

The reason for this is that Python looks in the dictionary before it evaluates the code, and if it doesn't find a variable named `_ _builtins_ _` in there (note the plural form), it adds one:

```
>>> namespace = {}
>>> print eval("_ _import_ _('os').remove('file')", namespace)
Traceback (innermost last):
  File "<stdin>", line 1, in ?
  File "<string>", line 0, in ?
os.error: (2, 'No such file or directory')
>>> namespace.keys()
['_ _builtins_ _']
```

If you print the contents of the namespace variable, you'll find that they contain the full set of built-in functions.

The solution to this little dilemma isn't far away: since Python doesn't add this item if it is already there, simply add a dummy item called `_ _builtins_ _` to the namespace before calling `eval`, as shown in Example 1-19.

Example 1-19. Using the eval Function to Evaluate Arbitrary Strings Safely

```
File: builtin-eval-example-3.py

print eval("_ _import_ _('os').getcwd()", {})
print eval("_ _import_ _('os').remove('file')", {"_ _builtins_ _": {}})

/home/fredrik/librarybook
Traceback (innermost last):
  File "builtin-eval-example-3.py", line 2, in ?
  File "<string>", line 0, in ?
NameError: _ _import_ _
```

Note that this doesn't protect you from CPU or memory-resource attacks (for example, something like `eval("'*'*1000000*2*2*2*2*2*2*2*2*2")` will most likely cause your program to run out of memory after a while).

1.2.6 Compiling and Executing Code

The `eval` function only works for simple expressions. To handle larger blocks of code, use the `compile` and `exec` functions (as demonstrated in Example 1-20).

Example 1-20. Using the compile Function to Check Syntax

```
File: builtin-compile-example-1.py

NAME = "script.py"

BODY = """
prnt 'owl-stretching time'
```

```
"""

try:
    compile(BODY, NAME, "exec")
except SyntaxError, v:
    print "syntax error:", v, "in", NAME

# syntax error: invalid syntax in script.py
```

When successful, the `compile` function returns a code object, which you can execute with the `exec` statement, as in Example 1-21.

Example 1-21. Compiling and Executing Compiled Code

```
File: builtin-compile-example-2.py

BODY = """
print 'the ant, an introduction'
"""

code = compile(BODY, "<script>", "exec")

print code

exec code

<code object ? at 8c6be0, file "<script>", line 0>
the ant, an introduction
```

To generate code on the fly, use the class shown in the Example 1-22. Use the `write` method to add statements, and the methods `indent` and `dedent` to add structure. The class will take care of the rest.

Example 1-22. A Simple Code Generator Tool

```
File: builtin-compile-example-3.py

import sys, string

class CodeGeneratorBackend:
    "Simple code generator for Python"

    def begin(self, tab="\t"):
        self.code = []
        self.tab = tab
        self.level = 0

    def end(self):
        self.code.append("") # make sure there's a newline at the end
        return compile(string.join(self.code, "\n"), "<code>", "exec")

    def write(self, string):
        self.code.append(self.tab * self.level + string)

    def indent(self):
```

```
        self.level = self.level + 1
        # in 2.0 and later, this can be written as: self.level += 1

    def dedent(self):
        if self.level == 0:
            raise SyntaxError, "internal error in code generator"
        self.level = self.level - 1
        # or: self.level -= 1

#
# try it out!

c = CodeGeneratorBackend()
c.begin()
c.write("for i in range(5):")
c.indent()
c.write("print 'code generation made easy!'")
c.dedent()
exec c.end()

code generation made easy!
code generation made easy!
code generation made easy!
code generation made easy!
code generation made easy!
```

Python also provides a function called `execfile`, a shortcut for loading code from a file, compiling it, and executing it. Example 1-23 shows how to use and emulate this function.

Example 1-23. Using the execfile Function

```
File: builtin-execfile-example-1.py

execfile("hello.py")

def EXECFILE(filename, locals=None, globals=None):
    exec compile(open(filename).read(), filename, "exec") in locals, globals

EXECFILE("hello.py")

hello again, and welcome to the show
hello again, and welcome to the show
```

The contents of the *hello.py* file used Example 1-23 are shown in Example 1-24.

Example 1-24. The hello.py Script

```
File: hello.py

print "hello again, and welcome to the show"
```

1.2.7 Overloading Functions from the _ _builtin_ _ Module

Since Python does not look among the built-in functions until *after* it has checked the local and module namespace, there may be situations in which you need to explicitly refer to the `__builtin__` module. For instance, the script in Example 1-25 overloads the `open` function with a version that opens an ordinary file and checks that it starts with a "magic" string. To be able to use the original `open` function, the script explicitly refers to the function using the module name.

Example 1-25. Explicitly Accessing Functions in the __builtin__ Module

```
File: builtin-open-example-1.py

def open(filename, mode="rb"):
    import __builtin__
    file = __builtin__.open(filename, mode)
    if file.read(5) not in("GIF87", "GIF89"):
        raise IOError, "not a GIF file"
    file.seek(0)
    return file

fp = open("samples/sample.gif")
print len(fp.read()), "bytes"

fp = open("samples/sample.jpg")
print len(fp.read()), "bytes"

3565 bytes
Traceback (innermost last):
  File "builtin-open-example-1.py", line 12, in ?
  File "builtin-open-example-1.py", line 5, in open
IOError: not a GIF file
```

1.3 The exceptions Module

The `exceptions` module provides the standard exception hierarchy. It's automatically imported when Python starts, and the exceptions are added to the `__builtin__` module. In other words, you usually don't need to import this module.

This is a Python module in 1.5.2, and a built-in module in 2.0 and later.

The following standard exceptions are defined by this module:

- *Exception* is used as a base class for all exceptions. It's strongly recommended (but not yet required) that user exceptions are derived from this class too.
- *SystemExit(Exception)* is raised by the `sys.exit` function. If it propagates to the top level without being caught by a `try-except` clause, the interpreter is terminated without a traceback message.
- *StandardError(Exception)* is used as a base class for all standard exceptions (except *SystemExit*, that is).
- *KeyboardInterrupt(StandardError)* is raised when the user presses Control-C (or any other interrupt key). Note that this may cause strange errors if you use "catch all" `try-except` statements.
- *ImportError(StandardError)* is raised when Python fails to import a module.
- *EnvironmentError* is used as a base class for exceptions that can be caused by the interpreter's environment (that is, they're usually not caused by bugs in the program).
- *IOError(EnvironmentError)* is used to flag I/O-related errors.
- *OSError(EnvironmentError)* is used to flag errors by the `os` module.
- *WindowsError(OSError)* is used to flag Windows-specific errors from the `os` module.
- *NameError(StandardError)* is raised when Python fails to find a global or local name.
- *UnboundLocalError(NameError)* is raised if your program attempts to access a local variable before it has been assigned a value. This exception is only used in 2.0 and later; earlier versions raise a plain *NameError* exception instead.
- *AttributeError(StandardError)* is raised when Python fails to find (or assign to) an instance attribute, a method, a module function, or any other qualified name.
- *SyntaxError(StandardError)* is raised when the compiler stumbles upon a syntax error.
- (2.0 and later) *IndentationError(SyntaxError)* is raised for syntax errors caused by bad indentation. This exception is only used in 2.0 and later; earlier versions raise a plain *SyntaxError* exception instead.
- (2.0 and later) *TabError(IndentationError)* is raised by the interpreter when the *-tt* option is used to check for inconsistent indentation. This exception is only used in 2.0 and later; earlier versions raise a plain *SyntaxError* exception instead.
- *TypeError(StandardError)* is raised when an operation cannot be applied to an object of the given type.

- *AssertionError(StandardError)* is raised when an `assert` statement fails (if the expression is false, that is).
- *LookupError(StandardError)* is used as a base class for exceptions raised when a sequence or dictionary type doesn't contain a given index or key.
- *IndexError(LookupError)* is raised by sequence objects when the given index doesn't exist.
- *KeyError(LookupError)* is raised by dictionary objects when the given key doesn't exist.
- *ArithmeticError(StandardError)* is used as a base class for exceptions that are math-related.
- *OverflowError(ArithmeticError)* is raised when an operations overflows (for example, when an integer is too large to fit in the given type).
- *ZeroDivisionError(ArithmeticError)* is raised when you try to divide a number by zero.
- *FloatingPointError(ArithmeticError)* is raised when a floating point operation fails.
- *ValueError(StandardError)* is raised if an argument has the right type, but an invalid value.
- (2.0 and later) *UnicodeError(ValueError)* is raised for type problems related to the Unicode string type. This is only used in 2.0 and later.
- *RuntimeError(StandardError)* is used for various run-time problems, including attempts to get outside the box when running in restricted mode, unexpected hardware problems, etc.
- *NotImplementedError(RuntimeError)* can be used to flag functions that hasn't been implemented yet, or methods that should be overridden.
- *SystemError(StandardError)* is raised if the interpreter messes up, and knows about it. The exception value contains a more detailed description (usually something cryptic, like "`eval_code2: NULL globals`" or so). I cannot recall ever seeing this exception in over five years of full-time Python programming, but maybe that's just me.
- *MemoryError(StandardError)* is raised when the interpreter runs out of memory. Note that this only happens when the underlying memory allocation routines complain; you can often send your poor computer into a mindless swapping frenzy before that happens.

You can create your own exception classes. Just inherit from the built-in *Exception* class (or a proper standard exception), and override the constructor and/or `_ _str_ _` method as necessary. Example 1-26 shows the `exceptions` module.

Example 1-26. Using the exceptions Module

```
File: exceptions-example-1.py

# python imports this module by itself, so the following
# line isn't really needed
# import exceptions

class HTTPError(Exception):
    # indicates an HTTP protocol error
    def _ _init_ _(self, url, errcode, errmsg):
        self.url = url
        self.errcode = errcode
        self.errmsg = errmsg
```

```
    def _ _str_ _(self):
        return (
            "<HTTPError for %s: %s %s>" %
            (self.url, self.errcode, self.errmsg)
            )

try:
    raise HTTPError("http://www.python.org/foo", 200, "Not Found")
except HTTPError, error:
    print "url", "=>", error.url
    print "errcode", "=>", error.errcode
    print "errmsg", "=>", error.errmsg
    raise # reraise exception
```

```
url => http://www.python.org/foo
errcode => 200
errmsg => Not Found
Traceback (innermost last):
  File "exceptions-example-1", line 16, in ?
HTTPError: <HTTPError for http://www.python.org/foo: 200 Not Found>
```

1.4 The os Module

The os module provides a unified interface to many operating system functions.

Most of the functions in this module are implemented by platform-specific modules, such as posix or nt. The os module automatically loads the right implementation module when it is first imported.

1.4.1 Working with Files

The built-in open function lets you create, open, and modify files, as shown in Example 1-27. This module adds those extra functions you need to rename and remove files.

Example 1-27. Using the os Module to Rename and Remove Files

```
File: os-example-3.py

import os
import string

def replace(file, search_for, replace_with):
    # replace strings in a text file

    back = os.path.splitext(file)[0] + ".bak"
    temp = os.path.splitext(file)[0] + ".tmp"

    try:
        # remove old temp file, if any
        os.remove(temp)
    except os.error:
        pass

    fi = open(file)
    fo = open(temp, "w")

    for s in fi.readlines():
        fo.write(string.replace(s, search_for, replace_with))

    fi.close()
    fo.close()

    try:
        # remove old backup file, if any
        os.remove(back)
    except os.error:
        pass

    # rename original to backup...
    os.rename(file, back)

    # ...and temporary to original
```

```
    os.rename(temp, file)

#
# try it out!

file = "samples/sample.txt"

replace(file, "hello", "tjena")
replace(file, "tjena", "hello")
```

1.4.2 Working with Directories

The `os` module also contains many functions that work on entire directories.

The `listdir` function returns a list of all filenames in a given directory, as shown in Example 1-28. The current and parent directory markers used on Unix and Windows (. and ..) are not included in this list.

Example 1-28. Using the os Module to List the Files in a Directory

```
File: os-example-5.py

import os

for file in os.listdir("samples"):
    print file

sample.au
sample.jpg
sample.wav
...
```

The `getcwd` and `chdir` functions are used to get and set the current directory, as shown in Example 1-29.

Example 1-29. Using the os Module to Change the Working Directory

```
File: os-example-4.py

import os

# where are we?
cwd = os.getcwd()
print "1", cwd

# go down
os.chdir("samples")
print "2", os.getcwd()

# go back up
os.chdir(os.pardir)
print "3", os.getcwd()

1 /ematter/librarybook
2 /ematter/librarybook/samples
```

The makedirs and removedirs functions are used to create and remove directory hierarchies, as shown in Example 1-30.

Example 1-30. Using the os Module to Create and Remove Multiple Directory Levels

```
File: os-example-6.py

import os

os.makedirs("test/multiple/levels")

fp = open("test/multiple/levels/file", "w")
fp.write("inspector praline")
fp.close()

# remove the file
os.remove("test/multiple/levels/file")

# and all empty directories above it
os.removedirs("test/multiple/levels")
```

Note that removedirs removes all empty directories along the given path, starting with the last directory in the given pathname. In contrast, the mkdir and rmdir functions can only handle a single directory level, as shown in Example 1-31.

Example 1-31. Using the os Module to Create and Remove Directories

```
File: os-example-7.py

import os

os.mkdir("test")
os.rmdir("test")

os.rmdir("samples") # this will fail

Traceback (innermost last):
  File "os-example-7", line 6, in ?
OSError: [Errno 41] Directory not empty: 'samples'
```

To remove non-empty directories, you can use the rmtree function in the shutil module.

1.4.3 Working with File Attributes

The stat function fetches information about an existing file, as demonstrated in Example 1-32. It returns a 9-tuple which contains the size, inode change timestamp, modification timestamp, and access privileges.

Example 1-32. Using the os Module to Get Information About a File

```
File: os-example-1.py

import os
import time

file = "samples/sample.jpg"

def dump(st):
    mode, ino, dev, nlink, uid, gid, size, atime, mtime, ctime = st
    print "- size:", size, "bytes"
    print "- owner:", uid, gid
    print "- created:", time.ctime(ctime)
    print "- last accessed:", time.ctime(atime)
    print "- last modified:", time.ctime(mtime)
    print "- mode:", oct(mode)
    print "- inode/dev:", ino, dev

#
# get stats for a filename

st = os.stat(file)

print "stat", file
dump(st)
print

#
# get stats for an open file

fp = open(file)

st = os.fstat(fp.fileno())

print "fstat", file
dump(st)
```

```
stat samples/sample.jpg
- size: 4762 bytes
- owner: 0 0
- created: Tue Sep 07 22:45:58 1999
- last accessed: Sun Sep 19 00:00:00 1999
- last modified: Sun May 19 01:42:16 1996
- mode: 0100666
- inode/dev: 0 2

fstat samples/sample.jpg
- size: 4762 bytes
- owner: 0 0
- created: Tue Sep 07 22:45:58 1999
- last accessed: Sun Sep 19 00:00:00 1999
- last modified: Sun May 19 01:42:16 1996
- mode: 0100666
- inode/dev: 0 0
```

Some fields don't make sense on non-Unix platforms; for example, the (`inode`, `dev`) tuple provides a unique identity for each file on Unix, but may contain arbitrary data on other platforms.

The `stat` module contains a number of useful constants and helper functions for dealing with the members of the stat tuple. Some of these are shown in the examples that follow.

You can modify the mode and time fields using the `chmod` and `utime` functions, as shown in Example 1-33.

Example 1-33. Using the os Module to Change a File's Privileges and Timestamps

```
File: os-example-2.py

import os
import stat, time

infile = "samples/sample.jpg"
outfile = "out.jpg"

# copy contents
fi = open(infile, "rb")
fo = open(outfile, "wb")

while 1:
    s = fi.read(10000)
    if not s:
        break
    fo.write(s)

fi.close()
fo.close()

# copy mode and timestamp
st = os.stat(infile)
os.chmod(outfile, stat.S_IMODE(st[stat.ST_MODE]))
os.utime(outfile, (st[stat.ST_ATIME], st[stat.ST_MTIME]))

print "original", "=>"
print "mode", oct(stat.S_IMODE(st[stat.ST_MODE]))
print "atime", time.ctime(st[stat.ST_ATIME])
print "mtime", time.ctime(st[stat.ST_MTIME])

print "copy", "=>"
st = os.stat(outfile)
print "mode", oct(stat.S_IMODE(st[stat.ST_MODE]))
print "atime", time.ctime(st[stat.ST_ATIME])
print "mtime", time.ctime(st[stat.ST_MTIME])

original =>
mode 0666
atime Thu Oct 14 15:15:50 1999
mtime Mon Nov 13 15:42:36 1995
copy =>
mode 0666
atime Thu Oct 14 15:15:50 1999
mtime Mon Nov 13 15:42:36 1995
```

1.4.4 Working with Processes

The system function runs a new command under the current process, and waits for it to finish, as shown in Example 1-34.

Example 1-34. Using the os Module to Run an Operating System Command

```
File: os-example-8.py

import os

if os.name == "nt":
    command = "dir"
else:
    command = "ls -l"

os.system(command)

-rwxrw-r--   1 effbot  effbot        76 Oct  9 14:17 README
-rwxrw-r--   1 effbot  effbot      1727 Oct  7 19:00 SimpleAsyncHTTP.py
-rwxrw-r--   1 effbot  effbot       314 Oct  7 20:29 aifc-example-1.py
-rwxrw-r--   1 effbot  effbot       259 Oct  7 20:38 anydbm-example-1.py
...
```

The command is run via the operating system's standard shell, and returns the shell's exit status. Under Windows 95/98, the shell is usually `command.com`, whose exit status is always 0.

> Since `os.system` passes the command on to the shell as is, it can be dangerous to use if you don't check the arguments carefully (consider running `os.system("viewer %s" % file)` with the file variable set to "`sample.jpg; rm -rf $HOME`"). When unsure, it's usually better to use `exec` or `spawn` instead (explained later).

The exec function starts a new process, replacing the current one ("go to process," in other words). In Example 1-35, note that the "goodbye" message is never printed.

Example 1-35. Using the os Module to Start a New Process

```
File: os-exec-example-1.py

import os
import sys

program = "python"
arguments = ["hello.py"]

print os.execvp(program, (program,) +  tuple(arguments))
print "goodbye"

hello again, and welcome to the show
```

Python provides a whole bunch of `exec` functions, with slightly varying behaviors. Example 1-35 uses `execvp`, which searches for the program along the standard path, passes the contents of the second argument tuple as individual arguments to that program, and runs it with the current set of environment variables. See the *Python Library Reference* for more information on the other seven ways to call this function.

Under Unix, you can call other programs from the current one by combining `exec` with two other functions, `fork` and `wait`, as shown in Example 1-36. The `fork` function makes a copy of the current process, and the `wait` function waits for a child process to finish.

Example 1-36. Using the os Module to Run Another Program (Unix)

```
File: os-exec-example-2.py

import os
import sys

def run(program, *args):
    pid = os.fork()
    if not pid:
        os.execvp(program, (program,) +  args)
    return os.wait()[0]

run("python", "hello.py")

print "goodbye"
```

```
hello again, and welcome to the show
goodbye
```

The `fork` returns zero in the new process (the return from `fork` is the first thing that happens in that process!), and a non-zero process identifier in the original process. Or in other words, "`not pid`" is true only if we're in the new process.

The `fork` and `wait` functions are not available on Windows, but you can use the `spawn` function instead, as shown in Example 1-37. Unfortunately, there's no standard version of `spawn` that searches for an executable along the path, so you have to do that yourself.

Example 1-37. Using the os Module to Run Another Program (Windows)

```
File: os-spawn-example-1.py

import os
import string

def run(program, *args):
    # find executable
    for path in string.split(os.environ["PATH"], os.pathsep):
        file = os.path.join(path, program) + ".exe"
        try:
            return os.spawnv(os.P_WAIT, file, (file,) + args)
        except os.error:
            pass
    raise os.error, "cannot find executable"

run("python", "hello.py")

print "goodbye"
```

```
hello again, and welcome to the show
goodbye
```

You can also use spawn to run other programs in the background. Example 1-38 adds an optional mode argument to the run function; when set to os.P_NOWAIT, the script doesn't wait for the other program to finish. The default flag value os.P_WAIT tells spawn to wait until the new process is finished.

Other flags include os.P_OVERLAY, which makes spawn behave like exec, and os.P_DETACH, which runs the new process in the background, detached from both console and keyboard.

Example 1-38. Using the os Module to Run Another Program in the Background (Windows)

```
File: os-spawn-example-2.py

import os
import string

def run(program, *args, **kw):
    # find executable
    mode = kw.get("mode", os.P_WAIT)
    for path in string.split(os.environ["PATH"], os.pathsep):
        file = os.path.join(path, program) + ".exe"
        try:
            return os.spawnv(mode, file, (file,) + args)
        except os.error:
            pass
    raise os.error, "cannot find executable"

run("python", "hello.py", mode=os.P_NOWAIT)
print "goodbye"
```

```
goodbye
hello again, and welcome to the show
```

Example 1-39 provides a spawn method that works on either platform.

Example 1-39. Using Either spawn or fork/exec to Run Another Program

```
File: os-spawn-example-3.py

import os
import string

if os.name in ("nt", "dos"):
    exefile = ".exe"
else:
    exefile = ""

def spawn(program, *args):
    try:
        # possible 2.0 shortcut!
        return os.spawnvp(program, (program,) + args)
    except AttributeError:
        pass
```

```
    try:
        spawnv = os.spawnv
    except AttributeError:

        # assume it's unix
        pid = os.fork()
        if not pid:
            os.execvp(program, (program,) + args)
        return os.wait()[0]
    else:
        # got spawnv but no spawnp: go look for an executable
        for path in string.split(os.environ["PATH"], os.pathsep):
            file = os.path.join(path, program) + exefile
            try:
                return spawnv(os.P_WAIT, file, (file,) + args)
            except os.error:
                pass
        raise IOError, "cannot find executable"

#
# try it out!

spawn("python", "hello.py")

print "goodbye"
```

```
hello again, and welcome to the show
goodbye
```

Example 1-39 first attempts to call a function named `spawnvp`. If that doesn't exist (it doesn't, in 2.0 and earlier), the function looks for a function named `spawnv` and searches the path all by itself. As a last resort, it falls back on `exec` and `fork`.

1.4.5 Working with Daemon Processes

On Unix, you can also use `fork` to turn the current process into a background process (a "daemon"). Basically, you need to fork off a copy of the current process, and terminate the original process, as shown in Example 1-40.

Example 1-40. Using the os Module to Run as Daemon (Unix)

```
File: os-example-14.py

import os
import time

pid = os.fork()
if pid:
    os._exit(0) # kill original

print "daemon started"
time.sleep(10)
print "daemon terminated"
```

It takes a bit more work to create a real daemon, however. First, call `setpgrp` to make the new process a "process group leader." Otherwise, signals sent to a (by that time) unrelated process group might cause problems in your daemon:

```
os.setpgrp()
```

It's also a good idea to remove the user mode mask, to make sure files created by the daemon actually get the mode flags specified by the program:

```
os.umask(0)
```

Then, you should redirect the *stdout/stderr* files, instead of just closing them (if you don't do this, you may get unexpected exceptions the day some of your code tries to write something to the console via *stdout* or *stderr*).

```
class NullDevice:
    def write(self, s):
        pass
sys.stdin.close()
sys.stdout = NullDevice()
sys.stderr = NullDevice()
```

In other words, while Python's `print` and C's `printf/fprintf` won't crash your program if the devices have been disconnected, `sys.stdout.write()` happily throws an *IOError* exception when the application runs as a daemon. But your program works just fine when running in the foreground...

By the way, the `_exit` function used in the previous examples terminates the current process. In contrast to `sys.exit`, this works also if the caller happens to catch the *SystemExit* exception, as shown in Example 1-41.

Example 1-41. Using the os Module to Exit the Current Process

```
File: os-example-9.py

import os
import sys

try:
    sys.exit(1)
except SystemExit, value:
    print "caught exit(%s)" % value

try:
    os._exit(2)
except SystemExit, value:
    print "caught exit(%s)" % value

print "bye!"

caught exit(1)
```

1.5 The os.path Module

The `os.path` module contains functions that deal with long filenames (pathnames) in various ways. To use this module, import the `os` module, and access this module as `os.path`.

1.5.1 Working with Filenames

The `os.path` module contains a number of functions that deal with long filenames in a platform independent way. In other words, you won't have to deal with forward and backward slashes, colons, and whatnot. Let's look at Example 1-42.

Example 1-42. Using the os.path Module to Handle Filename

```
File: os-path-example-1.py

import os

filename = "my/little/pony"

print "using", os.name, "..."
print "split", "=>", os.path.split(filename)
print "splitext", "=>", os.path.splitext(filename)
print "dirname", "=>", os.path.dirname(filename)
print "basename", "=>", os.path.basename(filename)
print "join", "=>", os.path.join(os.path.dirname(filename),
                                 os.path.basename(filename))

using nt ...
split => ('my/little', 'pony')
splitext => ('my/little/pony', '')
dirname => my/little
basename => pony
join => my/little\pony
```

Note that `split` only splits off a single item.

The `os.path` module also contains a number of functions that allow you to quickly figure out what a filename represents, as shown in Example 1-43.

Example 1-43. Using the os.path Module to Check What a Filename Represents

```
File: os-path-example-2.py

import os

FILES = (
    os.curdir,
    "/",
```

```
    "file",
    "/file",
    "samples",
    "samples/sample.jpg",
    "directory/file",
    "../directory/file",
    "/directory/file"
    )

for file in FILES:
    print file, "=>",
    if os.path.exists(file):
        print "EXISTS",
    if os.path.isabs(file):
        print "ISABS",
    if os.path.isdir(file):
        print "ISDIR",
    if os.path.isfile(file):
        print "ISFILE",
    if os.path.islink(file):
        print "ISLINK",
    if os.path.ismount(file):
        print "ISMOUNT",
    print
```

```
. => EXISTS ISDIR
/ => EXISTS ISABS ISDIR ISMOUNT
file =>
/file => ISABS
samples => EXISTS ISDIR
samples/sample.jpg => EXISTS ISFILE
directory/file =>
../directory/file =>
/directory/file => ISABS
```

The `expanduser` function treats a username shortcut in the same way as most modern Unix shells (it doesn't work well on Windows), as shown in Example 1-44.

Example 1-44. Using the os.path Module to Insert the Username into a Filename

```
File: os-path-expanduser-example-1.py

import os

print os.path.expanduser("~/.pythonrc")

# /home/effbot/.pythonrc
```

The `expandvars` function inserts environment variables into a filename, as shown in Example 1-45.

Example 1-45. Using the os.path Module to Insert Variables into a Filename

```
File: os-path-expandvars-example-1.py
```

```
import os

os.environ["USER"] = "user"

print os.path.expandvars("/home/$USER/config")
print os.path.expandvars("$USER/folders")

/home/user/config
user/folders
```

1.5.2 Traversing a Filesystem

The `walk` function helps you find all files in a directory tree (as Example 1-46 demonstrates). It takes a directory name, a callback function, and a data object that is passed on to the callback.

Example 1-46. Using the os.path Module to Traverse a Filesystem

```
File: os-path-walk-example-1.py

import os

def callback(arg, directory, files):
    for file in files:
        print os.path.join(directory, file), repr(arg)

os.path.walk(".", callback, "secret message")

./aifc-example-1.py 'secret message'
./anydbm-example-1.py 'secret message'
./array-example-1.py 'secret message'
...
./samples 'secret message'
./samples/sample.jpg 'secret message'
./samples/sample.txt 'secret message'
./samples/sample.zip 'secret message'
./samples/articles 'secret message'
./samples/articles/article-1.txt 'secret message'
./samples/articles/article-2.txt 'secret message'
...
```

The `walk` function has a somewhat obscure user interface (maybe it's just me, but I can never remember the order of the arguments). The `index` function in Example 1-47 returns a list of filenames instead, which lets you use a straightforward `for-in` loop to process the files.

Example 1-47. Using os.listdir to Traverse a Filesystem

```
File: os-path-walk-example-2.py

import os

def index(directory):
    # like os.listdir, but traverses directory trees
    stack = [directory]
```

```
    files = []
    while stack:
        directory = stack.pop()
        for file in os.listdir(directory):
            fullname = os.path.join(directory, file)
            files.append(fullname)
            if os.path.isdir(fullname) and not os.path.islink(fullname):
                stack.append(fullname)
    return files

for file in index("."):
    print file
```

```
.\aifc-example-1.py
.\anydbm-example-1.py
.\array-example-1.py
...
```

If you don't want to list all files (for performance or memory reasons), Example 1-48 uses a different approach. Here, the *DirectoryWalker* class behaves like a sequence object, returning one file at a time:

Example 1-48. Using DirectoryWalker to Traverse a Filesystem

```
File: os-path-walk-example-3.py

import os

class DirectoryWalker:
    # a forward iterator that traverses a directory tree

    def _ _init_ _(self, directory):
        self.stack = [directory]
        self.files = []
        self.index = 0

    def _ _getitem_ _(self, index):
        while 1:
            try:
                file = self.files[self.index]
                self.index = self.index + 1
            except IndexError:
                # pop next directory from stack
                self.directory = self.stack.pop()
                self.files = os.listdir(self.directory)
                self.index = 0
            else:
                # got a filename
                fullname = os.path.join(self.directory, file)
                if os.path.isdir(fullname) and not os.path.islink(fullname):
                    self.stack.append(fullname)
                return fullname

for file in DirectoryWalker("."):
    print file
```

```
.\aifc-example-1.py
.\anydbm-example-1.py
.\array-example-1.py
...
```

Note the *DirectoryWalker* class doesn't check the index passed to the `__getitem__` method. This means that it won't work properly if you access the sequence members out of order.

Finally, if you're interested in the file sizes or timestamps, Example 1-49 demonstrates a version of the class that returns both the filename and the tuple returned from `os.stat`. This version saves one or two `stat` calls for each file (both `os.path.isdir` and `os.path.islink` uses `stat`), and runs quite a bit faster on some platforms.

Example 1-49. Using DirectoryStatWalker to Traverse a Filesystem

```
File: os-path-walk-example-4.py

import os, stat

class DirectoryStatWalker:
    # a forward iterator that traverses a directory tree, and
    # returns the filename and additional file information

    def __init__(self, directory):
        self.stack = [directory]
        self.files = []
        self.index = 0

    def __getitem__(self, index):
        while 1:
            try:
                file = self.files[self.index]
                self.index = self.index + 1
            except IndexError:
                # pop next directory from stack
                self.directory = self.stack.pop()
                self.files = os.listdir(self.directory)
                self.index = 0
            else:
                # got a filename
                fullname = os.path.join(self.directory, file)
                st = os.stat(fullname)
                mode = st[stat.ST_MODE]
                if stat.S_ISDIR(mode) and not stat.S_ISLNK(mode):
                    self.stack.append(fullname)
                return fullname, st

for file, st in DirectoryStatWalker("."):
    print file, st[stat.ST_SIZE]

.\aifc-example-1.py 336
.\anydbm-example-1.py 244
.\array-example-1.py 526
```

1.6 The stat Module

The `stat` module, shown in Example 1-50, contains a number of constants and test functions that can be used with the `os.stat` function.

Example 1-50. Using the stat Module

```
File: stat-example-1.py

import stat
import os, time

st = os.stat("samples/sample.txt")

print "mode", "=>", oct(stat.S_IMODE(st[stat.ST_MODE]))

print "type", "=>",
if stat.S_ISDIR(st[stat.ST_MODE]):
    print "DIRECTORY",
if stat.S_ISREG(st[stat.ST_MODE]):
    print "REGULAR",
if stat.S_ISLNK(st[stat.ST_MODE]):
    print "LINK",
print

print "size", "=>", st[stat.ST_SIZE]

print "last accessed", "=>", time.ctime(st[stat.ST_ATIME])
print "last modified", "=>", time.ctime(st[stat.ST_MTIME])
print "inode changed", "=>", time.ctime(st[stat.ST_CTIME])

mode => 0664
type => REGULAR
size => 305
last accessed => Sun Oct 10 22:12:30 1999
last modified => Sun Oct 10 18:39:37 1999
inode changed => Sun Oct 10 15:26:38 1999
```

1.7 The string Module

The `string` module contains a number of functions to process standard Python strings, as shown in Example 1-51.

Example 1-51. Using the string Module

```
File: string-example-1.py

import string

text = "Monty Python's Flying Circus"

print "upper", "=>", string.upper(text)
print "lower", "=>", string.lower(text)
print "split", "=>", string.split(text)
print "join", "=>", string.join(string.split(text), "+")
print "replace", "=>", string.replace(text, "Python", "Java")
print "find", "=>", string.find(text, "Python"), string.find(text, "Java")
print "count", "=>", string.count(text, "n")

upper => MONTY PYTHON'S FLYING CIRCUS
lower => monty python's flying circus
split => ['Monty', "Python's", 'Flying', 'Circus']
join => Monty+Python's+Flying+Circus
replace => Monty Java's Flying Circus
find => 6 -1
count => 3
```

In Python 1.5.2 and earlier, the `string` module uses functions from the `strop` implementation module where possible.

In Python 1.6 and later, most string operations are made available as string methods as well, as shown in Example 1-52. Many of the functions in the `string` module are simply wrapper functions that call the corresponding string method.

Example 1-52. Using string Methods Instead of string Module Functions

```
File: string-example-2.py

text = "Monty Python's Flying Circus"

print "upper", "=>", text.upper()
print "lower", "=>", text.lower()
print "split", "=>", text.split()
print "join", "=>", "+".join(text.split())
print "replace", "=>", text.replace("Python", "Perl")
print "find", "=>", text.find("Python"), text.find("Perl")
print "count", "=>", text.count("n")
```

```
upper => MONTY PYTHON'S FLYING CIRCUS
lower => monty python's flying circus
split => ['Monty', "Python's", 'Flying', 'Circus']
join => Monty+Python's+Flying+Circus
replace => Monty Perl's Flying Circus
find => 6 -1
count => 3
```

In addition to the string-manipulation capabilities offered by `string`, the module also contains a number of functions that convert strings to other types (as Example 1-53 demonstrates).

Example 1-53. Using the string Module to Convert Strings to Numbers

```
File: string-example-3.py

import string

print int("4711"),
print string.atoi("4711"),
print string.atoi("11147", 8), # octal
print string.atoi("1267", 16), # hexadecimal
print string.atoi("3mv", 36) # whatever...

print string.atoi("4711", 0),
print string.atoi("04711", 0),
print string.atoi("0x4711", 0)

print float("4711"),
print string.atof("1"),
print string.atof("1.23e5")
```

```
4711 4711 4711 4711 4711
4711 2505 18193
4711.0 1.0 123000.0
```

In most cases (especially if you're using 1.6 or later), you can use the `int` and `float` functions instead of their `string` module counterparts.

The `atoi` function takes an optional second argument, which specifices the number base. If the base is 0, the function looks at the first few characters before attempting to interpret the value: if "0x," the base is set to 16 (hexadecimal), and if "0," the base is set to 8 (octal). The default is base 10 (decimal), just as if you hadn't provided an extra argument.

In 1.6 and later, `int` also accepts a second argument, just like `atoi`. Unlike the string versions, `int` and `float` accept Unicode strings.

1.8 The re Module

> *"Some people, when confronted with a problem, think 'I know, I'll use regular expressions.' Now they have two problems."*
>
> —Jamie Zawinski, on *comp.lang.emacs*

The re module provides a set of powerful regular expression facilities, which allows you to quickly check whether a given string *matches* a given pattern (using the match function), or *contains* such a pattern (using the search function). A regular expression is a string pattern written in a compact (and quite cryptic) syntax.

The match function attempts to match a pattern against the beginning of the given string, as shown in Example 1-54. If the pattern matches anything at all (including an empty string, if the pattern allows that!), match returns a *match object*. The group method can be used to find out what matched.

Example 1-54. Using the re Module to Match Strings

```
File: re-example-1.py

import re

text = "The Attila the Hun Show"

# a single character
m = re.match(".", text)
if m: print repr("."), "=>", repr(m.group(0))

# any string of characters
m = re.match(".*", text)
if m: print repr(".*"), "=>", repr(m.group(0))

# a string of letters (at least one)
m = re.match("\w+", text)
if m: print repr("\w+"), "=>", repr(m.group(0))

# a string of digits
m = re.match("\d+", text)
if m: print repr("\d+"), "=>", repr(m.group(0))

 '.' => 'T'
'.*' => 'The Attila the Hun Show'
'\\w+' => 'The'
```

You can use parentheses to mark regions in the pattern. If the pattern matched, the group method can be used to extract the contents of these regions, as shown in Example 1-55. group(1) returns the contents of the first group, group(2) returns the contents of the second, and so on. If you pass several group numbers to the group function, it returns a tuple.

Example 1-55. Using the re Module to Extract Matching Substrings

```
File: re-example-2.py

import re

text ="10/15/99"

m = re.match("(\d{2})/(\d{2})/(\d{2,4})", text)
if m:
    print m.group(1, 2, 3)

('10', '15', '99')
```

The search function searches for the pattern inside the string, as shown in Example 1-56. It basically tries the pattern at every possible character position, starting from the left, and returns a match object as soon it has found a match. If the pattern doesn't match anywhere, it returns *None*.

Example 1-56. Using the re Module to Search for Substrings

```
File: re-example-3.py

import re

text = "Example 3: There is 1 date 10/25/95 in here!"

m = re.search("(\d{1,2})/(\d{1,2})/(\d{2,4})", text)

print m.group(1), m.group(2), m.group(3)

month, day, year = m.group(1, 2, 3)
print month, day, year

date = m.group(0)
print date

10 25 95
10 25 95
10/25/95
```

The sub function used in Example 1-57 can be used to replace patterns with another string.

Example 1-57. Using the re Module to Replace Substrings

```
File: re-example-4.py

import re

text = "you're no fun anymore..."

# literal replace (string.replace is faster)
print re.sub("fun", "entertaining", text)

# collapse all non-letter sequences to a single dash
print re.sub("[^\w]+", "-", text)
```

```
# convert all words to beeps
print re.sub("\S+", "-BEEP-", text)

you're no entertaining anymore...
you-re-no-fun-anymore-
-BEEP- -BEEP- -BEEP- -BEEP-
```

You can also use `sub` to replace patterns via a `callback` function. Example 1-58 shows how to precompile patterns.

Example 1-58. Using the re Module to Replace Substrings via the callback Function

```
File: re-example-5.py

import re
import string

text = "a line of text\\012another line of text\\012etc..."

def octal(match):
    # replace octal code with corresponding ASCII character
    return chr(string.atoi(match.group(1), 8))

octal_pattern = re.compile(r"\\(\d\d\d)")

print text
print octal_pattern.sub(octal, text)

a line of text\012another line of text\012etc...
a line of text
another line of text
etc...
```

If you don't compile, the `re` module caches compiled versions for you, so you usually don't have to compile regular expressions in small scripts. In Python 1.5.2, the cache holds 20 patterns. In 2.0, the cache size has been increased to 100 patterns.

Finally, Example 1-59 matches a string against a list of patterns. The list of patterns are combined into a single pattern, and precompiled to save time.

Example 1-59. Using the re Module to Match Against One of Many Patterns

```
File: re-example-6.py

import re, string

def combined_pattern(patterns):
    p = re.compile(
        string.join(map(lambda x: "("+x+")", patterns), "|")
        )
    def fixup(v, m=p.match, r=range(0,len(patterns))):
        try:
            regs = m(v).regs
        except AttributeError:
```

```
            return None # no match, so m.regs will fail
        else:
            for i in r:
                if regs[i+1] != (-1, -1):
                    return i
    return fixup

#
# try it out!

patterns = [
    r"\d+",
    r"abc\d{2,4}",
    r"p\w+"
]

p = combined_pattern(patterns)

print p("129391")
print p("abc800")
print p("abc1600")
print p("python")
print p("perl")
print p("tcl")
```

```
0
1
1
2
2
None
```

1.9 The math Module

The `math` module implements a number of mathematical operations for floating-point numbers. The functions are generally thin wrappers around the platform C library functions of the same name, so results may vary slightly across platforms in normal cases, or vary a lot in exceptional cases. Example 1-60 demonstrates the use of the `math` module.

Example 1-60. Using the math Module

```
File: math-example-1.py

import math

print "e", "=>", math.e
print "pi", "=>", math.pi
print "hypot", "=>", math.hypot(3.0, 4.0)

# and many others...

e => 2.71828182846
pi => 3.14159265359
hypot => 5.0
```

See the *Python Library Reference* for a full list of functions.

1.10 The cmath Module

The `cmath` module shown in Example 1-61 contains a number of mathematical operations for complex numbers.

Example 1-61. Using the cmath Module

```
File: cmath-example-1.py

import cmath

print "pi", "=>", cmath.pi
print "sqrt(-1)", "=>", cmath.sqrt(-1)

pi => 3.14159265359
sqrt(-1) => 1j
```

See the *Python Library Reference* for a full list of functions.

1.11 The operator Module

The `operator` module provides a "functional" interface to the standard operators in Python. The functions in this module can be used instead of some `lambda` constructs, when processing data with functions like `map` and `filter`. They are also quite popular among people who like to write obscure code, for obvious reasons. The `operator` module is demonstrated in Example 1-62.

Example 1-62. Using the operator Module

```
File: operator-example-1.py

import operator

sequence = 1, 2, 4

print "add", "=>", reduce(operator.add, sequence)
print "sub", "=>", reduce(operator.sub, sequence)
print "mul", "=>", reduce(operator.mul, sequence)
print "concat", "=>", operator.concat("spam", "egg")
print "repeat", "=>", operator.repeat("spam", 5)
print "getitem", "=>", operator.getitem(sequence, 2)
print "indexOf", "=>", operator.indexOf(sequence, 2)
print "sequenceIncludes", "=>", operator.sequenceIncludes(sequence, 3)

add => 7
sub => -5
mul => 8
concat => spamegg
repeat => spamspamspamspamspam

getitem => 4
indexOf => 1
sequenceIncludes => 0
```

Example 1-63 shows some `operator` functions that can be used to check object types.

Example 1-63. Using the operator Module for Type Checking

```
File: operator-example-2.py

import operator
import UserList

def dump(data):
    print type(data), "=>",
    if operator.isCallable(data):
        print "CALLABLE",
    if operator.isMappingType(data):
        print "MAPPING",
    if operator.isNumberType(data):
```

```
        print "NUMBER",
    if operator.isSequenceType(data):
        print "SEQUENCE",
    print

dump(0)
dump("string")
dump("string"[0])
dump([1, 2, 3])
dump((1, 2, 3))
dump({"a": 1})
dump(len) # function
dump(UserList) # module
dump(UserList.UserList) # class
dump(UserList.UserList()) # instance
```

```
<type 'int'> => NUMBER
<type 'string'> => SEQUENCE
<type 'string'> => SEQUENCE
<type 'list'> => SEQUENCE
<type 'tuple'> => SEQUENCE
<type 'dictionary'> => MAPPING
<type 'builtin_function_or_method'> => CALLABLE
<type 'module'> =>
<type 'class'> => CALLABLE
<type 'instance'> => MAPPING NUMBER SEQUENCE
```

Note that the `operator` module doesn't handle object instances in a normal fashion. Be careful when you use the `isNumberType`, `isMappingType`, and `isSequenceType` functions. It's easy to make your code less flexible than it has to be.

Also, note that a string sequence member (a character) is also a sequence. If you're writing a recursive function that uses `isSequenceType` to traverse an object tree, you better not pass it an ordinary string (or anything containing one).

1.12 The copy Module

The `copy` module contains two functions that are used to copy objects, as shown in Example 1-64.

`copy(object) => object` creates a "shallow" copy of the given object. In this context, shallow means that the object itself is copied, but if the object is a container, the members will still refer to the original member objects.

Example 1-64. Using the copy Module to Copy Objects

```
File: copy-example-1.py

import copy

a = [[1],[2],[3]]
b = copy.copy(a)

print "before", "=>"
print a
print b

# modify original
a[0][0] = 0
a[1] = None

print "after", "=>"
print a
print b

before =>
[[1], [2], [3]]
[[1], [2], [3]]
after =>
[[0], None, [3]]
[[0], [2], [3]]
```

You can also make shallow copies of lists using the [:] syntax (full slice), and you can make copies of dictionaries using the `copy` method.

In contrast, `deepcopy(object) => object` creates a "deep" copy of the given object, as shown in Example 1-65. If the object is a container, all members are copied as well, recursively.

Example 1-65. Using the copy Module to Copy Collections

```
File: copy-example-2.py

import copy

a = [[1],[2],[3]]
b = copy.deepcopy(a)
```

```
print "before", "=>"
print a
print b

# modify original
a[0][0] = 0
a[1] = None

print "after", "=>"
print a
print b
```

```
before =>
[[1], [2], [3]]
[[1], [2], [3]]
after =>
[[0], None, [3]]
[[1], [2], [3]]
```

1.13 The sys Module

The sys module provides a number of functions and variables that can be used to manipulate different parts of the Python runtime environment.

1.13.1 Working with Command-line Arguments

The argv list contains the arguments that were passed to the script, when the interpreter was started, as shown in Example 1-66. The first item contains the name of the script itself.

Example 1-66. Using the sys Module to Get Script Arguments

```
File: sys-argv-example-1.py

import sys

print "script name is", sys.argv[0]

if len(sys.argv) > 1:
    print "there are", len(sys.argv)-1, "arguments:"
    for arg in sys.argv[1:]:
        print arg
else:
    print "there are no arguments!"

script name is sys-argv-example-1.py
there are no arguments!
```

If you read the script from standard input (like "python < sys-argv-example-1.py"), the script name is set to an empty string. If you pass in the program as a string (using the -c option), the script name is set to "-c."

1.13.2 Working with Modules

The path list contains a list of directory names in which Python looks for extension modules (Python source modules, compiled modules, or binary extensions). When you start Python, this list is initialized from a mixture of built-in rules, the contents of the PYTHONPATH environment variable, and the registry contents (on Windows). But since it's an ordinary list, you can also manipulate it from within the program, as Example 1-67 shows.

Example 1-67. Using the sys Module to Manipulate the Module Search Path

```
File: sys-path-example-1.py

import sys

print "path has", len(sys.path), "members"
```

```
# add the sample directory to the path
sys.path.insert(0, "samples")
import sample

# nuke the path
sys.path = []
import random # oops!

path has 7 members
this is the sample module!
Traceback (innermost last):
  File "sys-path-example-1.py", line 11, in ?
    import random # oops!
ImportError: No module named random
```

Example 1-68 demonstrates the `builtin_module_names` list, which contains the names of all modules built into the Python interpreter.

Example 1-68. Using the sys Module to Find Built-in Modules

```
File: sys-builtin-module-names-example-1.py

import sys

def dump(module):
    print module, "=>",
    if module in sys.builtin_module_names:
        print "<BUILTIN>"
    else:
        module = _ _import_ _(module)
        print module._ _file_ _

dump("os")
dump("sys")
dump("string")
dump("strop")
dump("zlib")

os => C:\python\lib\os.pyc
sys => <BUILTIN>
string => C:\python\lib\string.pyc
strop => <BUILTIN>
zlib => C:\python\zlib.pyd
```

The `modules` dictionary contains all loaded modules. The `import` statement checks this dictionary before it actually loads something from disk.

As you can see from Example 1-69, Python loads quite a bunch of modules before handing control over to your script.

Example 1-69. Using the sys Module to Find Imported Modules

```
File: sys-modules-example-1.py
```

```
import sys

print sys.modules.keys()

['os.path', 'os', 'exceptions', '_ _main_ _', 'ntpath', 'strop', 'nt',
'sys', '_ _builtin_ _', 'site', 'signal', 'UserDict', 'string', 'stat']
```

1.13.3 Working with Reference Counts

The `getrefcount` function (shown in Example 1-70) returns the reference count for a given object—that is, the number of places where this variable is used. Python keeps track of this value, and when it drops to 0, the object is destroyed.

Example 1-70. Using the sys Module to Find the Reference Count

```
File: sys-getrefcount-example-1.py

import sys

variable = 1234

print sys.getrefcount(0)
print sys.getrefcount(variable)
print sys.getrefcount(None)

50
3
192
```

Note that this value is always larger than the actual count, since the function itself hangs on to the object while determining the value.

1.13.4 Checking the Host Platform

Example 1-71 shows the `platform` variable, which contains the name of the host platform.

Example 1-71. Using the sys Module to Find the Current Platform

```
File: sys-platform-example-1.py

import sys

#
# emulate "import os.path" (sort of)...

if sys.platform == "win32":
    import ntpath
    pathmodule = ntpath
elif sys.platform == "mac":
    import macpath
    pathmodule = macpath
else:
```

```
    # assume it's a posix platform
    import posixpath
    pathmodule = posixpath

print pathmodule
```

Typical platform names are `win32` for Windows 9X/NT and `mac` for Macintosh. For Unix systems, the platform name is usually derived from the output of the "`uname -r`" command, such as `irix6`, `linux2`, or `sunos5` (Solaris).

1.13.5 Tracing the Program

The `setprofiler` function allows you to install a profiling function. This is called every time a function or method is called, at every return (explicit or implied), and for each exception. Let's look at Example 1-72.

Example 1-72. Using the sys Module to Install a Profiler Function

```
File: sys-setprofiler-example-1.py

import sys

def test(n):
    j = 0
    for i in range(n):
        j = j + i
    return n

def profiler(frame, event, arg):
    print event, frame.f_code.co_name, frame.f_lineno, "->", arg

# profiler is activated on the next call, return, or exception
sys.setprofile(profiler)

# profile this function call
test(1)

# disable profiler
sys.setprofile(None)

# don't profile this call
test(2)

call test 3 -> None
return test 7 -> 1
```

The `profile` module provides a complete profiler framework, based on this function.

The `settrace` function in Example 1-73 is similar, but the `trace` function is called for each new line:

Example 1-73. Using the sys Module to Install a trace Function

```
File: sys-settrace-example-1.py
```

```
import sys

def test(n):
    j = 0
    for i in range(n):
        j = j + i
    return n

def tracer(frame, event, arg):
    print event, frame.f_code.co_name, frame.f_lineno, "->", arg
    return tracer

# tracer is activated on the next call, return, or exception
sys.settrace(tracer)

# trace this function call
test(1)

# disable tracing
sys.settrace(None)

# don't trace this call
test(2)

call test 3 -> None
line test 3 -> None
line test 4 -> None
line test 5 -> None
line test 5 -> None
line test 6 -> None
line test 5 -> None
line test 7 -> None
return test 7 -> 1
```

The pdb module provides a complete debugger framework, based on the tracing facilities offered by this function.

1.13.6 Working with Standard Input and Output

The stdin, stdout, and stderr variables contain stream objects corresponding to the standard I/O streams. You can access them directly if you need better control over the output than print can give you. You can also *replace* them, if you want to redirect output and input to some other device, or process them in some non-standard way, as shown in Example 1-74.

Example 1-74. Using the sys Module to Redirect Output

```
File: sys-stdout-example-1.py

import sys
import string

class Redirect:

    def _ _init_ _(self, stdout):
```

```
        self.stdout = stdout

    def write(self, s):
        self.stdout.write(string.lower(s))

# redirect standard output (including the print statement)
old_stdout = sys.stdout
sys.stdout = Redirect(sys.stdout)

print "HEJA SVERIGE",
print "FRISKT HUM\303\226R"

# restore standard output
sys.stdout = old_stdout

print "M\303\205\303\205\303\205\303\205L!"
```

```
heja sverige friskt hum\303\266r
M\303\205\303\205\303\205\303\205L!
```

An object that implements the `write` method is all it takes to redirect output.

(Unless it's a C type instance, that is: Python uses an integer attribute called `softspace` to control spacing, and adds it to the object if it isn't there. You don't have to bother if you're using Python objects, but if you need to redirect to a C type, you should make sure that type supports the `softspace` attribute.)

1.13.7 Exiting the Program

When you reach the end of the main program, the interpreter is automatically terminated. If you need to exit in midflight, you can call the `sys.exit` function, which takes an optional integer value that is returned to the calling program. It is demonstrated in Example 1-75.

Example 1-75. Using the sys Module to Exit the Program

```
File: sys-exit-example-1.py

import sys

print "hello"

sys.exit(1)

print "there"
```

```
hello
```

It may not be obvious, but `sys.exit` doesn't exit at once. Instead, it raises a *SystemExit* exception. This means that you can trap calls to `sys.exit` in your main program, as Example 1-76 shows.

Example 1-76. Catching the sys.exit Call

```
File: sys-exit-example-2.py
```

```
import sys

print "hello"

try:
    sys.exit(1)
except SystemExit:
    pass

print "there"

hello
there
```

If you want to clean things up after yourself, you can install an "exit handler," which is a function that is automatically called on the way out. This is shown in Example 1-77.

Example 1-77. Catching the sys.exit Call Another Way

```
File: sys-exitfunc-example-1.py

import sys

def exitfunc():
    print "world"

sys.exitfunc = exitfunc

print "hello"
sys.exit(1)
print "there" # never printed

hello
world
```

In Python 2.0, you can use the `atexit` module to register more than one exit handler.

1.14 The atexit Module

(2.0 only) The `atexit` module allows you to register one or more functions that are called when the interpreter is terminated.

To register a function, simply call the `register` function, as shown in Example 1-78. You can also add one or more extra arguments, which are passed as arguments to the `exit` function.

Example 1-78. Using the atexit Module

```
File: atexit-example-1.py

import atexit

def exit(*args):
    print "exit", args

# register two exit handler
atexit.register(exit)
atexit.register(exit, 1)
atexit.register(exit, "hello", "world")

exit ('hello', 'world')
exit (1,)
exit ()
```

This module is a straightforward wrapper for the `sys.exitfunc` hook.

1.15 The time Module

The `time` module provides a number of functions that deal with dates and the time within a day. It's a thin layer on top of the C runtime library.

A given date and time can either be represented as a floating-point value (the number of seconds since a reference date, usually January 1, 1970), or as a time tuple.

1.15.1 Getting the Current Time

Example 1-79 shows how you can use the `time` module to get the current time.

Example 1-79. Using the time Module to Get the Current Time

```
File: time-example-1.py

import time

now = time.time()

print now, "seconds since", time.gmtime(0)[:6]
print
print "or in other words:"
print "- local time:", time.localtime(now)
print "- utc:", time.gmtime(now)

937758359.77 seconds since (1970, 1, 1, 0, 0, 0)

or in other words:
- local time: (1999, 9, 19, 18, 25, 59, 6, 262, 1)
- utc: (1999, 9, 19, 16, 25, 59, 6, 262, 0)
```

The tuple returned by `localtime` and `gmtime` contains the year, month, day, hour, minute, second, day of the week, day of the year, daylight savings flag. The year number is four digits, the day of week begins with 0 for Monday, and January 1 is day number 1.

1.15.2 Converting Time Values to Strings

You can of course use standard string-formatting operators to convert a time tuple to a string, but the `time` module also provides a number of standard conversion functions, as Example 1-80 illustrates.

Example 1-80. Using the time Module to Format Dates and Times

```
File: time-example-2.py

import time
```

```
now = time.localtime(time.time())

print time.asctime(now)
print time.strftime("%y/%m/%d %H:%M", now)
print time.strftime("%a %b %d", now)
print time.strftime("%c", now)
print time.strftime("%I %p", now)
print time.strftime("%Y-%m-%d %H:%M:%S %Z", now)

# do it by hand...
year, month, day, hour, minute, second, weekday, yearday, daylight = now
print "%04d-%02d-%02d" % (year, month, day)
print "%02d:%02d:%02d" % (hour, minute, second)
print ("MON", "TUE", "WED", "THU", "FRI", "SAT", "SUN")[weekday], yearday
```

```
Sun Oct 10 21:39:24 1999
99/10/10 21:39
Sun Oct 10
Sun Oct 10 21:39:24 1999
09 PM
1999-10-10 21:39:24 CEST
1999-10-10
21:39:24
SUN 283
```

1.15.3 Converting Strings to Time Values

On some platforms, the `time` module contains a `strptime` function, which is pretty much the opposite of `strftime`. Given a string and a pattern, it returns the corresponding time tuple, as shown in Example 1-81.

Example 1-81. Using the time.strptime Function to Parse Dates and Times

```
File: time-example-6.py

import time

# make sure we have a strptime function!
try:
    strptime = time.strptime
except AttributeError:
    from strptime import strptime

print strptime("31 Nov 00", "%d %b %y")
print strptime("1 Jan 70 1:30pm", "%d %b %y %I:%M%p")
```

The `time.strptime` function is currently only made available by Python if it's provided by the platform's C libraries. For platforms that don't have a standard implementation (this includes Windows), Example 1-82 offers a partial replacement.

Example 1-82. A strptime Implementation

```
File: strptime.py
```

```
import re
import string

MONTHS = ["Jan", "Feb", "Mar", "Apr", "May", "Jun", "Jul", "Aug",
          "Sep", "Oct", "Nov", "Dec"]

SPEC = {
    # map formatting code to a regular expression fragment
    "%a": "(?P<weekday>[a-z]+)",
    "%A": "(?P<weekday>[a-z]+)",
    "%b": "(?P<month>[a-z]+)",
    "%B": "(?P<month>[a-z]+)",
    "%C": "(?P<century>\d\d?)",
    "%d": "(?P<day>\d\d?)",
    "%D": "(?P<month>\d\d?)/(?P<day>\d\d?)/(?P<year>\d\d)",
    "%e": "(?P<day>\d\d?)",
    "%h": "(?P<month>[a-z]+)",
    "%H": "(?P<hour>\d\d?)",
    "%I": "(?P<hour12>\d\d?)",
    "%j": "(?P<yearday>\d\d?\d?)",
    "%m": "(?P<month>\d\d?)",
    "%M": "(?P<minute>\d\d?)",
    "%p": "(?P<ampm12>am|pm)",
    "%R": "(?P<hour>\d\d?):(?P<minute>\d\d?)",
    "%S": "(?P<second>\d\d?)",
    "%T": "(?P<hour>\d\d?):(?P<minute>\d\d?):(?P<second>\d\d?)",
    "%U": "(?P<week>\d\d)",
    "%w": "(?P<weekday>\d)",
    "%W": "(?P<weekday>\d\d)",
    "%y": "(?P<year>\d\d)",
    "%Y": "(?P<year>\d\d\d\d)",
    "%%": "%"
}

class TimeParser:
    def _ _init_ _(self, format):
        # convert strptime format string to regular expression
        format = string.join(re.split("(?:\s|%t|%n)+", format))
        pattern = []
        try:
            for spec in re.findall("%\w|%%|.", format):
                if spec[0] == "%":
                    spec = SPEC[spec]
                pattern.append(spec)
        except KeyError:
            raise ValueError, "unknown specificer: %s" % spec
        self.pattern = re.compile("(?i)" + string.join(pattern, ""))
    def match(self, daytime):
        # match time string
        match = self.pattern.match(daytime)
        if not match:
            raise ValueError, "format mismatch"
        get = match.groupdict().get
        tm = [0] * 9
        # extract date elements
        y = get("year")
```

```
        if y:
            y = int(y)
            if y < 68:
                y = 2000 + y
            elif y < 100:
                y = 1900 + y
            tm[0] = y
        m = get("month")
        if m:
            if m in MONTHS:
                m = MONTHS.index(m) + 1
            tm[1] = int(m)
        d = get("day")
        if d: tm[2] = int(d)
        # extract time elements
        h = get("hour")
        if h:
            tm[3] = int(h)
        else:
            h = get("hour12")
            if h:
                h = int(h)
                if string.lower(get("ampm12", "")) == "pm":
                    h = h + 12
                tm[3] = h
        m = get("minute")
        if m: tm[4] = int(m)
        s = get("second")
        if s: tm[5] = int(s)
        # ignore weekday/yearday for now
        return tuple(tm)

def strptime(string, format="%a %b %d %H:%M:%S %Y"):
    return TimeParser(format).match(string)

if _ _name_ _ == "_ _main_ _":
    # try it out
    import time
    print strptime("2000-12-20 01:02:03", "%Y-%m-%d %H:%M:%S")
    print strptime(time.ctime(time.time()))

(2000, 12, 20, 1, 2, 3, 0, 0, 0)
(2000, 11, 15, 12, 30, 45, 0, 0, 0)
```

1.15.4 Converting Time Values

Converting a time tuple back to a time value is pretty easy, at least as long as we're talking about local time. Just pass the time tuple to the `mktime` function, as shown in Example 1-83.

Example 1-83. Using the time Module to Convert a Local Time Tuple to a Time Integer

```
File: time-example-3.py

import time
```

```
t0 = time.time()
tm = time.localtime(t0)

print tm

print t0
print time.mktime(tm)

(1999, 9, 9, 0, 11, 8, 3, 252, 1)
936828668.16
936828668.0
```

Unfortunately, there's no function in the 1.5.2 standard library that converts UTC time tuples *back* to time values (neither in Python nor in the underlying C libraries). Example 1-84 provides a Python implementation of such a function, called `timegm`.

Example 1-84. Converting a UTC Time Tuple to a Time Integer

```
File: time-example-4.py

import time

def _d(y, m, d, days=(0,31,59,90,120,151,181,212,243,273,304,334,365)):
    # map a date to the number of days from a reference point
    return (((y - 1901)*1461)/4 + days[m-1] + d +
        ((m > 2 and not y % 4 and (y % 100 or not y % 400)) and 1))

def timegm(tm, epoch=_d(1970,1,1)):
    year, month, day, h, m, s = tm[:6]
    assert year >= 1970
    assert 1 <= month <= 12
    return (_d(year, month, day) - epoch)*86400 + h*3600 + m*60 + s

t0 = time.time()
tm = time.gmtime(t0)

print tm

print t0
print timegm(tm)

(1999, 9, 8, 22, 12, 12, 2, 251, 0)
936828732.48
936828732
```

In 1.6 and later, a similar function is available in the `calendar` module, as `calendar.timegm`.

1.15.5 Timing Things

The `time` module can be used to time the execution of a Python program, as Example 1-85 demonstrates. You can measure either "wall time" (real world time), or "process time" (amount of CPU time the process has consumed, thus far).

Example 1-85. Using the time Module to Benchmark an Algorithm

```
File: time-example-5.py

import time

def procedure():
    time.sleep(2.5)

# measure process time
t0 = time.clock()
procedure()
print time.clock() - t0, "seconds process time"

# measure wall time
t0 = time.time()
procedure()
print time.time() - t0, "seconds wall time"

0.0 seconds process time
2.50903499126 seconds wall time
```

Not all systems can measure the true process time. On such systems (including Windows), `clock` usually measures the wall time since the program was started.

The process time has limited precision. On many systems, it wraps around after just over 30 minutes.

Also, see the `timing` module, which measures the wall time between two events.

1.16 The types Module

The `types` module contains type objects for all object types defined by the standard interpreter, as Example 1-86 demonstrates. All objects of the same type share a single type object. You can use `is` to test if an object has a given type.

Example 1-86. Using the types Module

```
File: types-example-1.py

import types

def check(object):
    print object,

    if type(object) is types.IntType:
        print "INTEGER",
    if type(object) is types.FloatType:
        print "FLOAT",
    if type(object) is types.StringType:
        print "STRING",
    if type(object) is types.ClassType:
        print "CLASS",
    if type(object) is types.InstanceType:
        print "INSTANCE",
    print

check(0)
check(0.0)
check("0")

class A:
    pass

class B:
    pass

check(A)
check(B)

a = A()
b = B()

check(a)
check(b)

0 INTEGER
0.0 FLOAT
0 STRING
A CLASS
B CLASS
```

```
<A instance at 796960> INSTANCE
<B instance at 796990> INSTANCE
```

Note that all classes have the same type, as do all instances. To test what class hierarchy a class or an instance belongs to, use the built-in `issubclass` and `isinstance` functions.

The `types` module destroys the current exception state when it is first imported. In other words, don't import it (or *any* module that imports it!) from within an exception handler.

1.17 The gc Module

(Optional, 2.0 and later) The `gc` module provides an interface to the built-in cyclic garbage collector.

Python uses reference counting to keep track of when to get rid of objects; as soon as the last reference to an object goes away, the object is destroyed.

Starting with Version 2.0, Python also provides a cyclic garbage collector, which runs at regular intervals. This collector looks for data structures that point to themselves, and attempts to break the cycles. Example 1-87 shows this.

You can use the `gc.collect` function to force full collection. This function returns the number of objects destroyed by the collector.

Example 1-87. Using the gc Module to Collect Cyclic Garbage

```
File: gc-example-1.py

import gc

# create a simple object that links to itself
class Node:

    def _ _init_ _(self, name):
        self.name = name
        self.parent = None
        self.children = []

    def addchild(self, node):
        node.parent = self
        self.children.append(node)

    def _ _repr_ _(self):
        return "<Node %s at %x>" % (repr(self.name), id(self))

# set up a self-referencing structure
root = Node("monty")

root.addchild(Node("eric"))
root.addchild(Node("john"))
root.addchild(Node("michael"))

# remove our only reference
del root

print gc.collect(), "unreachable objects"
print gc.collect(), "unreachable objects"

12 unreachable objects
0 unreachable objects
```

If you're sure that your program doesn't create any self-referencing data structures, you can use the `gc.disable` function to disable collection. After calling this function, Python 2.0 works exactly like 1.5.2 and earlier.

Chapter 2. More Standard Modules

"Now, imagine that your friend kept complaining that she didn't want to visit you since she found it too hard to climb up the drain pipe, and you kept telling her to use the friggin' stairs like everyone else..."

—eff-bot, June 1998

2.1 Overview

This chapter describes a number of modules that are used in many Python programs. It's perfectly possible to write large Python programs without using them, but they can help you save a lot of time and effort.

2.1.1 Files and Streams

The `fileinput` module makes it easy to write different kinds of text filters. This module provides a wrapper class, which lets you use a simple `for-in` statement to loop over the contents of one or more text files.

The `StringIO` module (and the `cStringIO` variant) implements an in-memory file object. You can use `StringIO` objects in many places where Python expects an ordinary file object.

2.1.2 Type Wrappers

`UserDict`, `UserList`, and `UserString` are thin wrappers on top of the corresponding built-in types. Unlike the built-in types, these wrappers can be subclassed. This can come in handy if you need a class that works almost like a built-in type, but has one or more extra methods.

2.1.3 Random Numbers

The `random` module provides a number of different random number generators. The `whrandom` module is similar, but it also allows you to create multiple generator objects.

2.1.4 Digests and Encryption Algorithms

The `md5` and `sha` modules are used to calculate cryptographically strong message signatures (so-called "message digests").

The `crypt` module implements a DES-style one-way encryption. This module is usually only available on Unix systems.

The `rotor` module provides simple two-way encryption.

2.2 The fileinput Module

The `fileinput` module allows you to loop over the contents of one or more text files, as shown in Example 2-1.

Example 2-1. Using the fileinput Module to Loop Over a Text File

```
File: fileinput-example-1.py

import fileinput
import sys

for line in fileinput.input("samples/sample.txt"):
    sys.stdout.write("-> ")
    sys.stdout.write(line)

-> We will perhaps eventually be writing only small
-> modules which are identified by name as they are
-> used to build larger ones, so that devices like
-> indentation, rather than delimiters, might become
-> feasible for expressing local structure in the
-> source language.
->      -- Donald E. Knuth, December 1974
```

The `fileinput` module also allows you to get metainformation about the current line. This includes `isfirstline`, `filename`, and `lineno`, as Example 2-2 shows.

Example 2-2. Using the fileinput Module to Process Multiple Files

```
File: fileinput-example-2.py

import fileinput
import glob
import string, sys

for line in fileinput.input(glob.glob("samples/*.txt")):
    if fileinput.isfirstline(): # first in a file?
        sys.stderr.write("-- reading %s --\n" % fileinput.filename())
    sys.stdout.write(str(fileinput.lineno()) + " " + string.upper(line))

-- reading samples\sample.txt --
1 WE WILL PERHAPS EVENTUALLY BE WRITING ONLY SMALL
2 MODULES WHICH ARE IDENTIFIED BY NAME AS THEY ARE
3 USED TO BUILD LARGER ONES, SO THAT DEVICES LIKE
4 INDENTATION, RATHER THAN DELIMITERS, MIGHT BECOME
5 FEASIBLE FOR EXPRESSING LOCAL STRUCTURE IN THE
6 SOURCE LANGUAGE.
7    -- DONALD E. KNUTH, DECEMBER 1974
```

Processing text files in place is also easy. Just call the `input` function with the `inplace` keyword argument set to 1, and the module takes care of the rest. Example 2-3 demonstrates this.

Example 2-3. Using the fileinput Module to Convert CRLF to LF

```
File: fileinput-example-3.py

import fileinput, sys

for line in fileinput.input(inplace=1):
    # convert Windows/DOS text files to Unix files
    if line[-2:] == "\r\n":
        line = line[:-2] + "\n"
    sys.stdout.write(line)
```

2.3 The shutil Module

The shutil utility module contains some functions for copying files and directories. The copy function used in Example 2-4 copies a file in pretty much the same way as the Unix cp command.

Example 2-4. Using the shutil Module to Copy Files

```
File: shutil-example-1.py

import shutil
import os

for file in os.listdir("."):
    if os.path.splitext(file)[1] == ".py":
        print file
        shutil.copy(file, os.path.join("backup", file))

aifc-example-1.py
anydbm-example-1.py
array-example-1.py
...
```

The copytree function copies an entire directory tree (same as cp -r), and rmtree removes an entire tree (same as rm -r). These functions are illustrated in Example 2-5.

Example 2-5. Using the shutil Module to Copy and Remove Directory Trees

```
File: shutil-example-2.py

import shutil
import os

SOURCE = "samples"
BACKUP = "samples-bak"

# create a backup directory
shutil.copytree(SOURCE, BACKUP)

print os.listdir(BACKUP)

# remove it
shutil.rmtree(BACKUP)

print os.listdir(BACKUP)

['sample.wav', 'sample.jpg', 'sample.au', 'sample.msg', 'sample.tgz',
...
Traceback (most recent call last):
 File "shutil-example-2.py", line 17, in ?
   print os.listdir(BACKUP)
```

```
os.error: No such file or directory
```

2.4 The tempfile Module

The `tempfile` module in Example 2-6 allows you to quickly come up with unique names to use for temporary files.

Example 2-6. Using the tempfile Module to Create Filenames for Temporary Files

```
File: tempfile-example-1.py

import tempfile
import os

tempfile = tempfile.mktemp()

print "tempfile", "=>", tempfile

file = open(tempfile, "w+b")
file.write("*" * 1000)
file.seek(0)
print len(file.read()), "bytes"
file.close()

try:
    # must remove file when done
    os.remove(tempfile)
except OSError:
    pass

tempfile => C:\TEMP\~160-1
1000 bytes
```

The `TemporaryFile` function picks a suitable name and opens the file, as shown in Example 2-7. It also makes sure that the file is removed when it's closed. (On Unix, you can remove an open file and have it disappear when the file is closed. On other platforms, this is done via a special wrapper class.)

Example 2-7. Using the tempfile Module to Open Temporary Files

```
File: tempfile-example-2.py

import tempfile

file = tempfile.TemporaryFile()

for i in range(100):
    file.write("*" * 100)

file.close() # removes the file!
```

2.5 The StringIO Module

The `stringio` module shown in Example 2-8 implements an in-memory file object. This object can be used as input or output to most functions that expect a standard file object.

Example 2-8. Using the StringIO Module to Read from a Static File

```
File: stringio-example-1.py

import StringIO

MESSAGE = "That man is depriving a village somewhere of a computer scientist."

file = StringIO.StringIO(MESSAGE)

print file.read()

That man is depriving a village somewhere of a computer scientist.
```

The StringIO class implements memory file versions of all methods available for built-in file objects, plus a `getvalue` method that returns the internal string value. Example 2-9 demonstrates this method.

Example 2-9. Using the StringIO Module to Write to a Memory File

```
File: stringio-example-2.py

import StringIO

file = StringIO.StringIO()
file.write("This man is no ordinary man. ")
file.write("This is Mr. F. G. Superman.")

print file.getvalue()

This man is no ordinary man. This is Mr. F. G. Superman.
```

StringIO can be used to capture redirected output from the Python interpreter, as shown in Example 2-10.

Example 2-10. Using the StringIO Module to Capture Output

```
File: stringio-example-3.py

import StringIO
import string, sys

stdout = sys.stdout

sys.stdout = file = StringIO.StringIO()
```

```
print """
According to Gbaya folktales, trickery and guile
are the best ways to defeat the python, king of
snakes, which was hatched from a dragon at the
world's start. -- National Geographic, May 1997
"""

sys.stdout = stdout

print string.upper(file.getvalue())
```

```
ACCORDING TO GBAYA FOLKTALES, TRICKERY AND GUILE
ARE THE BEST WAYS TO DEFEAT THE PYTHON, KING OF
SNAKES, WHICH WAS HATCHED FROM A DRAGON AT THE
WORLD'S START. -- NATIONAL GEOGRAPHIC, MAY 1997
```

2.6 The cStringIO Module

The `cStringIO` is an optional module, which contains a faster implementation of the `StringIO` module. It works exactly like the `StringIO` module, but it cannot be subclassed. Example 2-11 shows how `cStringIO` is used.

Example 2-11. Using the cStringIO Module

```
File: cstringio-example-1.py

import cStringIO

MESSAGE = "That man is depriving a village somewhere of a computer scientist."

file = cStringIO.StringIO(MESSAGE)

print file.read()

That man is depriving a village somewhere of a computer scientist.
```

To make your code as fast as possible, but also robust enough to run on older Python installations, you can fall back on the `StringIO` module if `cStringIO` is not available, as Example 2-12 does.

Example 2-12. Falling Back on the StringIO Module

```
File: cstringio-example-2.py

try:
    import cStringIO
    StringIO = cStringIO
except ImportError:
    import StringIO

print StringIO

<module  'StringIO'  (built-in)>
```

2.7 The mmap Module

(New in 2.0) The `mmap` module provides an interface to the operating system's memory mapping functions, as shown in Example 2-13. The mapped region behaves like a string object, but data is read directly from the file.

Example 2-13. Using the mmap Module

```
File: mmap-example-1.py

import mmap
import os

filename = "samples/sample.txt"

file = open(filename, "r+")
size = os.path.getsize(filename)

data = mmap.mmap(file.fileno(), size)

# basics
print data
print len(data), size

# use slicing to read from the file
print repr(data[:10]), repr(data[:10])

# or use the standard file interface
print repr(data.read(10)), repr(data.read(10))

<mmap object at 008A2A10>
302 302
'We will pe' 'We will pe'
'We will pe' 'rhaps even'
```

Under Windows, the file must currently be opened for both reading and writing (`r+`, or `w+`), or the `mmap` call will fail.

Example 2-14 shows that memory mapped regions can be used instead of ordinary strings in many places, including regular expressions and many string operations.

Example 2-14. Using String Functions and Regular Expressions on a Mapped Region

```
File: mmap-example-2.py

import mmap
import os, string, re

def mapfile(filename):
    file = open(filename, "r+")
```

```
    size = os.path.getsize(filename)
    return mmap.mmap(file.fileno(), size)

data = mapfile("samples/sample.txt")

# search
index = data.find("small")
print index, repr(data[index-5:index+15])

# regular expressions work too!
m = re.search("small", data)
print m.start(), m.group()
```

```
43 'only small\015\012modules '
43 small
```

2.8 The UserDict Module

The UserDict module contains a dictionary class that can be subclassed (it's actually a Python wrapper for the built-in dictionary type).

Example 2-15 shows an enhanced dictionary class, which allows dictionaries to be "added" to each other and initialized using the keyword argument syntax.

Example 2-15. Using the UserDict Module

```
File: userdict-example-1.py

import UserDict

class FancyDict(UserDict.UserDict):

    def _ _init_ _(self, data = {}, **kw):
        UserDict.UserDict._ _init_ _(self)
        self.update(data)
        self.update(kw)

    def _ _add_ _(self, other):
        dict = FancyDict(self.data)
        dict.update(b)
        return dict

a = FancyDict(a = 1)
b = FancyDict(b = 2)

print a + b

{'b': 2, 'a': 1}
```

2.9 The UserList Module

The `UserList` module contains a list class that can be subclassed (simply a Python wrapper for the built-in list type).

In Example 2-16, *AutoList* instances work just like ordinary lists, except that they allow you to insert items at the end by assigning to them.

Example 2-16. Using the UserList Module

```
File: userlist-example-1.py

import UserList

class AutoList(UserList.UserList):

    def _ _setitem_ _(self, i, item):
        if i == len(self.data):
            self.data.append(item)
        else:
            self.data[i] = item

list = AutoList()

for i in range(10):
    list[i] = i

print list

[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

2.10 The UserString Module

(New in 2.0) The `UserString` module contains two classes, *UserString* and *MutableString*. The former is a wrapper for the standard string type that can be subclassed, and the latter is a variation that allows you to modify the string in place.

Note that *MutableString* is not very efficient. Most operations are implemented using slicing and string concatenation. If performance is important, use lists of string fragments or the `array` module. Example 2-17 shows the `UserString` module.

Example 2-17. Using the UserString Module

```
File: userstring-example-1.py

import UserString

class MyString(UserString.MutableString):

    def append(self, s):
        self.data = self.data + s

    def insert(self, index, s):
        self.data = self.data[index:] + s + self.data[index:]

    def remove(self, s):
        self.data = self.data.replace(s, "")

file = open("samples/book.txt")
text = file.read()
file.close()

book = MyString(text)

for bird in ["gannet", "robin", "nuthatch"]:
    book.remove(bird)

print book

...
C: The one without the !
P: The one without the -!!! They've ALL got the !! It's a
Standard British Bird, the , it's in all the books!!!
...
```

2.11 The traceback Module

The `traceback` module in Example 2-18 allows you to print exception tracebacks inside your programs, just like the interpreter does when you don't catch an exception yourself.

Example 2-18. Using the traceback Module to Print a Traceback

```
File: traceback-example-1.py

# note! importing the traceback module messes up the
# exception state, so you better do that here and not
# in the exception handler
import traceback

try:
    raise SyntaxError, "example"
except:
    traceback.print_exc()

Traceback (innermost last):
  File "traceback-example-1.py", line 7, in ?
SyntaxError: example
```

Example 2-19 uses the `StringIO` module to put the traceback in a string.

Example 2-19. Using the traceback Module to Copy a Traceback to a String

```
File: traceback-example-2.py

import traceback
import StringIO

try:
    raise IOError, "an i/o error occurred"
except:
    fp = StringIO.StringIO()
    traceback.print_exc(file=fp)
    message = fp.getvalue()

    print "failure! the error was:", repr(message)

failure! the error was: 'Traceback (innermost last):\012  File
"traceback-example-2.py", line 5, in ?\012IOError: an i/o error
occurred\012'
```

To format the traceback in a nonstandard way, use the `extract_tb` function to convert a traceback object to a list of stack entries, as Example 2-20 demonstrates.

Example 2-20. Using the traceback Module to Decode a Traceback Object

```
File: traceback-example-3.py

import traceback
import sys

def function():
    raise IOError, "an i/o error occurred"

try:
    function()
except:
    info = sys.exc_info()
    for file, lineno, function, text in traceback.extract_tb(info[2]):
        print file, "line", lineno, "in", function
        print "=>", repr(text)
    print "** %s: %s" % info[:2]
```

```
traceback-example-3.py line 8 in ?
=> 'function()'
traceback-example-3.py line 5 in function
=> 'raise IOError, "an i/o error occurred"'
** exceptions.IOError: an i/o error occurred
```

2.12 The errno Module

The errno module defines a number of symbolic error codes, such as ENOENT ("no such directory entry") and EPERM ("permission denied"). It also provides a dictionary mapping from platform-dependent numerical error codes to symbolic names. Example 2-21 shows how to use errno.

In most cases, the *IOError* exception provides a 2-tuple with the numerical error code and an explanatory string. If you need to distinguish between different error codes, use the symbolic names where possible.

Example 2-21. Using the errno Module

```
File: errno-example-1.py

import errno

try:
    fp = open("no.such.file")
except IOError, (error, message):
    if error == errno.ENOENT:
        print "no such file"
    elif error == errno.EPERM:
        print "permission denied"
    else:
        print message

no such file
```

Example 2-22 is a bit contrived, but it shows how to use the errorcode dictionary to map from a numerical error code to the symbolic name.

Example 2-22. Using the errorcode Dictionary

```
File: errno-example-2.py

import errno

try:
    fp = open("no.such.file")
except IOError, (error, message):
    print error, repr(message)
    print errno.errorcode[error]

# 2 'No such file or directory'
# ENOENT
```

2.13 The getopt Module

The `getopt` module used in Example 2-23 contains functions to extract command-line options and arguments. It can handle both short and long option formats.

The second argument specifies the short options that should be allowed. A colon (:) after an option name means that option must have an additional argument.

Example 2-23. Using the getopt Module

```
File: getopt-example-1.py

import getopt
import sys

# simulate command-line invocation
sys.argv = ["myscript.py", "-l", "-d", "directory", "filename"]

# process options
opts, args = getopt.getopt(sys.argv[1:], "ld:")

long = 0
directory = None

for o, v in opts:
    if o == "-l":
        long = 1
    elif o == "-d":
        directory = v

print "long", "=", long
print "directory", "=", directory
print "arguments", "=", args

long = 1
directory = directory
arguments = ['filename']
```

To make `getopt` look for long options, as in Example 2-24, pass a list of option descriptors as the third argument. If an option name ends with an equals sign (=), that option must have an additional argument.

Example 2-24. Using the getopt Module to Handle Long Options

```
File: getopt-example-2.py

import getopt
import sys

# simulate command-line invocation
sys.argv = ["myscript.py", "--echo", "--printer", "lp01", "message"]
```

```
opts, args = getopt.getopt(sys.argv[1:], "ep:", ["echo", "printer="])

# process options
echo = 0
printer = None

for o, v in opts:
    if o in ("-e", "--echo"):
        echo = 1
    elif o in ("-p", "--printer"):
        printer = v

print "echo", "=", echo
print "printer", "=", printer
print "arguments", "=", args
```

```
echo = 1
printer = lp01
arguments = ['message']
```

2.14 The getpass Module

The `getpass` module provides a platform-independent way to enter a password in a command-line program, as Example 2-25 shows.

`getpass(prompt)` prints the prompt string, switches off keyboard echo, and reads a password. If the prompt argument is omitted, it prints "`Password:`".

`getuser()` gets the current username, if possible.

Example 2-25. Using the getpass Module

```
File: getpass-example-1.py

import getpass

usr = getpass.getuser()

pwd = getpass.getpass("enter password for user %s: " % usr)

print usr, pwd

enter password for user mulder:
mulder trustno1
```

2.15 The glob Module

The `glob` module generates lists of files matching given patterns, just like the Unix shell.

File patterns are similar to regular expressions, but simpler. An asterisk (`*`) matches zero or more characters, and a question mark (`?`) matches exactly one character. You can also use brackets to indicate character ranges, such as `[0-9]` for a single digit. All other characters match themselves.

`glob(pattern)` returns a list of all files matching a given pattern. The `glob` module is demonstrated in Example 2-26.

Example 2-26. Using the glob Module

```
File: glob-example-1.py

import glob

for file in glob.glob("samples/*.jpg"):
    print file
```

```
samples/sample.jpg
```

Note that `glob` returns full pathnames, unlike the `os.listdir` function. `glob` uses the `fnmatch` module to do the actual pattern matching.

2.16 The fnmatch Module

The `fnmatch` module matches filenames against a pattern, as Example 2-27 shows.

The pattern syntax is the same as that used in Unix shells. An asterisk (`*`) matches zero or more characters, and a question mark (`?`) matches exactly one character. You can also use brackets to indicate character ranges, such as `[0-9]` for a single digit. All other characters match themselves.

Example 2-27. Using the fnmatch Module to Match Files

```
File: fnmatch-example-1.py

import fnmatch
import os

for file in os.listdir("samples"):
    if fnmatch.fnmatch(file, "*.jpg"):
        print file

sample.jpg
```

In Example 2-28, the `translate` function converts a file pattern to a regular expression.

Example 2-28. Using the fnmatch Module to Convert a Pattern to a Regular Expression

```
File: fnmatch-example-2.py

import fnmatch
import os, re

pattern = fnmatch.translate("*.jpg")

for file in os.listdir("samples"):
    if re.match(pattern, file):
        print file

print "(pattern was %s)" % pattern

sample.jpg
(pattern was .*\.jpg$)
```

The `fnmatch` module is used by the `glob` and `find` modules.

2.17 The random Module

"Anyone who considers arithmetical methods of producing random digits is, of course, in a state of sin."

—John von Neumann, 1951

The `random` module contains a number of random number generators.

The basic random number generator (after an algorithm by Wichmann and Hill, 1982) can be accessed in several ways, as Example 2-29 shows.

Example 2-29. Using the random Module to Get Random Numbers

```
File: random-example-1.py

import random

for i in range(5):

    # random float: 0.0 <= number < 1.0
    print random.random(),

    # random float: 10 <= number < 20
    print random.uniform(10, 20),

    # random integer: 100 <= number <= 1000
    print random.randint(100, 1000),

    # random integer: even numbers in 100 <= number < 1000
    print random.randrange(100, 1000, 2)

0.946842713956 19.5910069381 709 172
0.573613195398 16.2758417025 407 120
0.363241598013 16.8079747714 916 580
0.602115173978 18.386796935 531 774
0.526767588533 18.0783794596 223 344
```

Note that the `randint` function can return the upper limit, while the other functions always return values smaller than the upper limit.

Example 2-30 shows how the `choice` function picks a random item from a sequence. It can be used with lists, tuples, or any other sequence (provided it can be accessed in random order, of course).

Example 2-30. Using the random Module for Random Items from a Sequence

```
File: random-example-2.py

import random

# random choice from a list
```

```
for i in range(5):
    print random.choice([1, 2, 3, 5, 9])

2
3
1
9
1
```

In 2.0 and later, the `shuffle` function can be used to shuffle the contents of a list (that is, generate a random permutation of a list in-place). Example 2-31 also shows how to implement that function under 1.5.2 and earlier.

Example 2-31. Using the random Module to Shuffle a Deck of Cards

```
File: random-example-4.py

import random

try:
    # available in 2.0 and later
    shuffle = random.shuffle
except AttributeError:
    def shuffle(x):
        for i in xrange(len(x)-1, 0, -1):
            # pick an element in x[:i+1] with which to exchange x[i]
            j = int(random.random() * (i+1))
            x[i], x[j] = x[j], x[i]

cards = range(52)

shuffle(cards)

myhand = cards[:5]

print myhand

[4, 8, 40, 12, 30]
```

The `random` module also contains random generators with non-uniform distribution. Example 2-32 uses the `gauss` function to generate random numbers with a gaussian distribution.

Example 2-32. Using the random Module for Gaussian Random Numbers

```
File: random-example-3.py

import random

histogram = [0] * 20

# calculate histogram for gaussian
# noise, using average=5, stddev=1
for i in range(1000):
    i = int(random.gauss(5, 1) * 2)
```

```
    histogram[i] = histogram[i] + 1

# print the histogram
m = max(histogram)
for v in histogram:
    print "*" * (v * 50 / m)
```

```
****
**********
*************************
***********************************
************************************************
**************************************************
*************************************
***************************
*************
***
*
```

See the *Python Library Reference* for more information on non-uniform generators.

> The random-number generators provided in the standard library are pseudo-random generators. While this might be good enough for many purposes—including simulations, numerical analysis, and games—it's definitely not good enough for cryptographic use.

2.18 The whrandom Module

The whrandom module, shown in Example 2-33, provides a pseudo-random number generator (based on an algorithm by Wichmann and Hill, 1982). Unless you need several generators that do not share internal state (for example, in a multithreaded application), it's better to use the functions in the random module instead.

Example 2-33. Using the whrandom Module

```
File: whrandom-example-1.py

import whrandom

# same as random
print whrandom.random()
print whrandom.choice([1, 2, 3, 5, 9])
print whrandom.uniform(10, 20)
print whrandom.randint(100, 1000)

0.113412062346
1
16.8778954689
799
```

Example 2-34 shows how to create multiple generators by creating instances of the *whrandom* class.

Example 2-34. Using the whrandom Module to Create Multiple Random Generators

```
File: whrandom-example-2.py

import whrandom

# initialize all generators with the same seed
rand1 = whrandom.whrandom(4,7,11)
rand2 = whrandom.whrandom(4,7,11)
rand3 = whrandom.whrandom(4,7,11)

for i in range(5):
    print rand1.random(), rand2.random(), rand3.random()

0.123993532536 0.123993532536 0.123993532536
0.180951499518 0.180951499518 0.180951499518
0.291924111809 0.291924111809 0.291924111809
0.952048889363 0.952048889363 0.952048889363
0.969794283643 0.969794283643 0.969794283643
```

2.19 The md5 Module

The md5 module is used to calculate message signatures (message digests).

The md5 algorithm calculates a strong 128-bit signature. This means that if two strings are different, it's highly likely that their md5 signatures are different as well. To put it another way, given an md5 digest, it's supposed to be nearly impossible to come up with a string that generates that digest. Example 2-35 demonstrates the md5 module.

Example 2-35. Using the md5 Module

```
File: md5-example-1.py

import md5

hash = md5.new()
hash.update("spam, spam, and eggs")

print repr(hash.digest())

 'L\005J\243\266\355\243u`\305r\203\267\020F\303'
```

Note that the checksum is returned as a binary string. Getting a hexadecimal or base64-encoded string is quite easy, though, as Example 2-36 shows.

Example 2-36. Using the md5 Module to Get a Hexadecimal or Base64-Encoded md5 Value

```
File: md5-example-2.py

import md5
import string
import base64

hash = md5.new()
hash.update("spam, spam, and eggs")

value = hash.digest()
print string.join(map(lambda v: "%02x" % ord(v), value), "")
# in 2.0, the above can be written as
# print hash.hexdigest()

print base64.encodestring(value)

4c054aa3b6eda37560c57283b71046c3
TAVKo7bto3VgxXKDtxBGww==
```

Example 2-37 shows how, among other things, the md5 checksum can be used for challenge-response authentication (but see the note on random numbers later).

Example 2-37. Using the md5 Module for Challenge-Response Authentication

```
File: md5-example-3.py

import md5
import string, random

def getchallenge():
    # generate a 16-byte long random string.  (note that the built-
    # in pseudo-random generator uses a 24-bit seed, so this is not
    # as good as it may seem...)
    challenge = map(lambda i: chr(random.randint(0, 255)), range(16))
    return string.join(challenge, "")

def getresponse(password, challenge):
    # calculate combined digest for password and challenge
    m = md5.new()
    m.update(password)
    m.update(challenge)
    return m.digest()

#
# server/client communication

# 1. client connects.  server issues challenge.

print "client:", "connect"

challenge = getchallenge()

print "server:", repr(challenge)

# 2. client combines password and challenge, and calculates
# the response.

client_response = getresponse("trustno1", challenge)

print "client:", repr(client_response)

# 3. server does the same, and compares the result with the
# client response.  the result is a safe login in which the
# password is never sent across the communication channel.

server_response = getresponse("trustno1", challenge)

if server_response == client_response:
    print "server:", "login ok"
```

```
client: connect
server: '\334\352\227Z#\272\273\212KG\330\265\032>\311o'
client: "l'\305\240-x\245\237\035\225A\254\233\337\225\001"
server: login ok
```

Example 2-38 offers a variation of `md5`, which can be used to sign messages sent over a public network, so that their integrity can be verified at the receiving end.

Example 2-38. Using the md5 Module for Data Integrity Checks

```
File: md5-example-4.py

import md5
import array

class HMAC_MD5:
    # keyed md5 message authentication

    def __init__(self, key):
        if len(key) > 64:
            key = md5.new(key).digest()
        ipad = array.array("B", [0x36] * 64)
        opad = array.array("B", [0x5C] * 64)
        for i in range(len(key)):
            ipad[i] = ipad[i] ^ ord(key[i])
            opad[i] = opad[i] ^ ord(key[i])
        self.ipad = md5.md5(ipad.tostring())
        self.opad = md5.md5(opad.tostring())

    def digest(self, data):
        ipad = self.ipad.copy()
        opad = self.opad.copy()
        ipad.update(data)
        opad.update(ipad.digest())
        return opad.digest()

#
# simulate server end

key = "this should be a well-kept secret"
message = open("samples/sample.txt").read()

signature = HMAC_MD5(key).digest(message)

# (send message and signature across a public network)

#
# simulate client end

key = "this should be a well-kept secret"

client_signature = HMAC_MD5(key).digest(message)

if client_signature == signature:
    print "this is the original message:"
    print
    print message
else:
    print "someone has modified the message!!!"
```

The `copy` method takes a snapshot of the internal object state. This allows you to precalculate partial digests (such as the padded key, in Example 2-38).

For details on this algorithm, see *HMAC-MD5:Keyed-MD5 for Message Authentication* (http://www.research.ibm.com/security/draft-ietf-ipsec-hmac-md5-00.txt) by Krawczyk, et al.

> Don't forget that the built-in pseudo-random number generator isn't really good enough for encryption purposes. Be careful.

2.20 The sha Module

The sha module provides an alternative way to calculate message signatures, as shown in Example 2-39. It's similar to the md5 module, but generates 160-bit signatures instead.

Example 2-39. Using the sha Module

```
File: sha-example-1.py

import sha

hash = sha.new()
hash.update("spam, spam, and eggs")

print repr(hash.digest())
print hash.hexdigest()

'\321\333\003\026I\331\272-j\303\247\240\345\343Tvq\364\346\311'
d1db031649d9ba2d6ac3a7a0e5e3547671f4e6c9
```

See the md5 examples for more ways to use sha signatures.

2.21 The crypt Module

(Optional) The `crypt` module implements one-way DES encryption. Unix systems use this encryption algorithm to store passwords, and this module is really only useful to generate or check such passwords.

Example 2-40 shows how to encrypt a password by calling `crypt.crypt` with the password string, plus a *salt,* which should consist of two random characters. You can now throw away the actual password, and just store the encrypted string.

Example 2-40. Using the crypt Module

```
File: crypt-example-1.py

import crypt

import random, string

def getsalt(chars = string.letters + string.digits):
    # generate a random 2-character 'salt'
    return random.choice(chars) + random.choice(chars)

print crypt.crypt("bananas", getsalt())

'py8UGrijma1j6'
```

To verify a given password, encrypt the new password using the two first characters from the encrypted string as the salt. If the result matches the encrypted string, the password is valid. Example 2-41 uses the `pwd` module to fetch the encrypted password for a given user.

Example 2-41. Using the crypt Module for Authentication

```
File: crypt-example-2.py

import pwd, crypt

def login(user, password):
    "Check if user would be able to log in using password"
    try:
        pw1 = pwd.getpwnam(user)[1]
        pw2 = crypt.crypt(password, pw1[:2])
        return pw1 == pw2
    except KeyError:
        return 0 # no such user

user = raw_input("username:")
password = raw_input("password:")

if login(user, password):
    print "welcome", user
else:
```

```
    print "login failed"
```

For other ways to implement authentication, see the description of the `md5` module.

2.22 The rotor Module

(Optional) The `rotor` module implements a simple encryption algorithm, shown in Example 2-42, which is based on the WWII Enigma engine.

Example 2-42. Using the rotor Module

```
File: rotor-example-1.py

import rotor

SECRET_KEY = "spam"
MESSAGE = "the holy grail"

r = rotor.newrotor(SECRET_KEY)

encoded_message = r.encrypt(MESSAGE)
decoded_message = r.decrypt(encoded_message)

print "original:", repr(MESSAGE)
print "encoded message:", repr(encoded_message)
print "decoded message:", repr(decoded_message)

original: 'the holy grail'
encoded message: '\227\271\244\015\305sw\3340\337\252\237\340U'
decoded message: 'the holy grail'
```

2.23 The zlib Module

(Optional) The `zlib` module provides support for "zlib" compression. (This compression method is also known as "deflate.")

Example 2-43 shows how the `compress` and `decompress` functions take string arguments.

Example 2-43. Using the zlib Module to Compress a String

```
File: zlib-example-1.py

import zlib

MESSAGE = "life of brian"

compressed_message = zlib.compress(MESSAGE)
decompressed_message = zlib.decompress(compressed_message)

print "original:", repr(MESSAGE)
print "compressed message:", repr(compressed_message)
print "decompressed message:", repr(decompressed_message)

original: 'life of brian'
compressed message: 'x\234\313\311LKU\310OSH*\312L\314\003\000!\010\004\302'
decompressed message: 'life of brian'
```

The compression rate varies a lot, depending on the contents of the file, as you can see in Example 2-44.

Example 2-44. Using the zlib Module to Compress a Group of Files

```
File: zlib-example-2.py

import zlib
import glob

for file in glob.glob("samples/*"):

    indata = open(file, "rb").read()
    outdata = zlib.compress(indata, zlib.Z_BEST_COMPRESSION)

    print file, len(indata), "=>", len(outdata),
    print "%d%%" % (len(outdata) * 100 / len(indata))

samples\sample.au 1676 => 1109 66%
samples\sample.gz 42 => 51 121%
samples\sample.htm 186 => 135 72%
samples\sample.ini 246 => 190 77%
samples\sample.jpg 4762 => 4632 97%
samples\sample.msg 450 => 275 61%
samples\sample.sgm 430 => 321 74%
```

```
samples\sample.tar 10240 => 125 1%
samples\sample.tgz 155 => 159 102%
samples\sample.txt 302 => 220 72%
samples\sample.wav 13260 => 10992 82%
```

You can also compress or decompress data on the fly, which Example 2-45 demonstrates.

Example 2-45. Using the zlib Module to Decompress Streams

```
File: zlib-example-3.py

import zlib

encoder = zlib.compressobj()

data = encoder.compress("life")
data = data + encoder.compress(" of ")
data = data + encoder.compress("brian")
data = data + encoder.flush()

print repr(data)
print repr(zlib.decompress(data))
```

```
'x\234\313\311LKU\310OSH*\312L\314\003\000!\010\004\302'
'life of brian'
```

Example 2-46 shows how to make it a bit more convenient to read a compressed file, by wrapping a decoder object in a file-like wrapper.

Example 2-46. Emulating a File Object for Compressed Streams

```
File: zlib-example-4.py

import zlib
import string, StringIO

class ZipInputStream:

    def _ _init_ _(self, file):
        self.file = file
        self._ _rewind()

    def _ _rewind(self):
        self.zip = zlib.decompressobj()
        self.pos = 0 # position in zipped stream
        self.offset = 0 # position in unzipped stream
        self.data = ""

    def _ _fill(self, bytes):
        if self.zip:
            # read until we have enough bytes in the buffer
            while not bytes or len(self.data) < bytes:
                self.file.seek(self.pos)
                data = self.file.read(16384)
```

```
                if not data:
                    self.data = self.data + self.zip.flush()
                    self.zip = None # no more data
                    break
                self.pos = self.pos + len(data)
                self.data = self.data + self.zip.decompress(data)

    def seek(self, offset, whence=0):
        if whence == 0:
            position = offset
        elif whence == 1:
            position = self.offset + offset
        else:
            raise IOError, "Illegal argument"
        if position < self.offset:
            raise IOError, "Cannot seek backwards"

        # skip forward, in 16k blocks
        while position > self.offset:
            if not self.read(min(position - self.offset, 16384)):
                break

    def tell(self):
        return self.offset

    def read(self, bytes = 0):
        self._ _fill(bytes)
        if bytes:
            data = self.data[:bytes]
            self.data = self.data[bytes:]
        else:
            data = self.data
            self.data = ""
        self.offset = self.offset + len(data)
        return data

    def readline(self):
        # make sure we have an entire line
        while self.zip and "\n" not in self.data:
            self._ _fill(len(self.data) + 512)
        i = string.find(self.data, "\n") + 1
        if i <= 0:
            return self.read()
        return self.read(i)

    def readlines(self):
        lines = []
        while 1:
            s = self.readline()
            if not s:
                break
            lines.append(s)
        return lines

#
# try it out
```

```
data = open("samples/sample.txt").read()
data = zlib.compress(data)

file = ZipInputStream(StringIO.StringIO(data))
for line in file.readlines():
    print line[:-1]
```

We will perhaps eventually be writing only small modules which are identified by name as they are used to build larger ones, so that devices like indentation, rather than delimiters, might become feasible for expressing local structure in the source language.
-- Donald E. Knuth, December 1974

2.24 The code Module

The `code` module provides a number of functions that can be used to emulate the behavior of the standard interpreter's interactive mode.

The `compile_command` behaves like the built-in `compile` function, but does some additional tests to make sure you pass it a complete Python statement.

In Example 2-47, we're compiling a program line by line, executing the resulting code objects as soon as we manage to compile. The program looks like this:

```
a = (
  1,
  2,
  3
)
print a
```

Note that the tuple assignment cannot be properly compiled until we've reached the second parenthesis.

Example 2-47. Using the code Module to Compile Statements

```
File: code-example-1.py

import code
import string

#
SCRIPT = [
    "a = (",
    "  1,",
    "  2,",
    "  3 ",
    ")",
    "print a"
]

script = ""

for line in SCRIPT:
    script = script + line + "\n"
    co = code.compile_command(script, "<stdin>", "exec")
    if co:
        # got a complete statement.  execute it!
        print "-"*40
        print script,
        print "-"*40
        exec co
        script = ""

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

```
a = (
  1,
  2,
  3
)
----------------------------------------
----------------------------------------
print a
----------------------------------------
(1, 2, 3)
```

The *InteractiveConsole* class implements an interactive console, much like the one you get when you fire up the Python interpreter in interactive mode.

The console can be either active (it calls a function to get the next line) or passive (you call the `push` method when you have new data). The default is to use the built-in `raw_input` function. Overload the method with the same name if you prefer to use another input function. Example 2-48 shows how to use the `code` module to emulate the interactive interpreter.

Example 2-48. Using the code Module to Emulate the Interactive Interpreter

```
File: code-example-2.py

import code

console = code.InteractiveConsole()
console.interact()
```

```
Python 1.5.2
Copyright 1991-1995 Stichting Mathematisch Centrum, Amsterdam
(InteractiveConsole)
>>> a = (
...     1,
...     2,
...     3
... )
>>> print a
(1, 2, 3)
```

The script in Example 2-49 defines a function called `keyboard`. It allows you to hand control over to the interactive interpreter at any point in your program.

Example 2-49. Using the code Module for Simple Debugging

```
File: code-example-3.py

def keyboard(banner=None):
    import code, sys

    # use exception trick to pick up the current frame
    try:
        raise None
    except:
        frame = sys.exc_info()[2].tb_frame.f_back
```

```
    # evaluate commands in current namespace
    namespace = frame.f_globals.copy()
    namespace.update(frame.f_locals)

    code.interact(banner=banner, local=namespace)

def func():
    print "START"
    a = 10
    keyboard()
    print "END"

func()
```

```
START
Python 1.5.2
Copyright 1991-1995 Stichting Mathematisch Centrum, Amsterdam
(InteractiveConsole)
>>> print a
10
>>> print keyboard
<function keyboard at 9032c8>
^Z
END
```

Chapter 3. Threads and Processes

> *"Well, since you last asked us to stop, this thread has moved from discussing languages suitable for professional programmers via accidental users to computer-phobic users. A few more iterations can make this thread really interesting..."*
>
> —eff-bot, June 1996

3.1 Overview

This chapter describes the thread-support modules provided with the standard Python interpreter. Note that thread support is optional and may not be available in your Python interpreter.

This chapter also covers some modules that allow you to run external processes on Unix and Windows systems.

3.1.1 Threads

When you run a Python program, execution starts at the top of the main module and proceeds downwards. Loops can be used to repeat portions of the program, and function and method calls transfer control to a different part of the program (but only temporarily).

With threads, your program can do several things at one time. Each thread has its own flow of control. While one thread might be reading data from a file, another thread can keep the screen updated.

To keep two threads from accessing the same internal data structure at the same time, Python uses a *global interpreter lock*. Only one thread at a time can execute Python code; Python automatically switches to the next thread after a short period of time, or when a thread does something that may take a while (like waiting for the next byte to arrive over a network socket, or reading data from a file).

The global lock isn't enough to avoid problems in your own programs, though. If multiple threads attempt to access the same data object, it may end up in an inconsistent state. Consider a simple cache:

```
def getitem(key):
    item = cache.get(key)
    if item is None:
        # not in cache; create a new one
        item = create_new_item(key)
 cache[key] = item
    return item
```

If two threads call the `getitem` function just after each other with the same missing key, they're likely to end up calling `create_new_item` twice with the same argument. While this may be okay in many cases, it can cause serious problems in others.

To avoid problems like this, you can use *lock objects* to synchronize threads. A lock object can only be owned by one thread at a time, and can thus be used to make sure that only one thread at a time is executing the code in the `getitem` body.

3.1.2 Processes

On most modern operating systems, each program runs in its own *process*. You usually start a new program/process by entering a command to the shell, or by selecting it in a menu. Python also allows you to start new programs from inside a Python program.

Most process-related functions are defined by the `os` module. See Section 1.4.4 for the full story.

3.2 The threading Module

(Optional) The `threading` module is a higher-level interface for threading, demonstrated in Example 3-1. It's modeled after the Java thread facilities. Like the lower-level `thread` module, it's only available if your interpreter was built with thread support.

To create a new thread, subclass the *Thread* class and define the run method. To run such threads, create one or more instances of that class, and call the `start` method. Each instance's `run` method will execute in its own thread.

Example 3-1. Using the threading Module

```
File: threading-example-1.py

import threading
import time, random

class Counter:
    def _ _init_ _(self):
        self.lock = threading.Lock()
        self.value = 0

    def increment(self):
        self.lock.acquire() # critical section
        self.value = value = self.value + 1
        self.lock.release()
        return value

counter = Counter()

class Worker(threading.Thread):

    def run(self):
        for i in range(10):
            # pretend we're doing something that takes 10–100 ms
            value = counter.increment() # increment global counter
            time.sleep(random.randint(10, 100) / 1000.0)
            print self.getName(), "-- task", i, "finished", value

#
# try it

for i in range(10):
    Worker().start() # start a worker

Thread-1 -- task 0 finished 1
Thread-3 -- task 0 finished 3
Thread-7 -- task 0 finished 8
Thread-1 -- task 1 finished 7
Thread-4 -- task 0 Thread-5 -- task 0 finished 4
finished 5
```

```
Thread-8 -- task 0 Thread-6 -- task 0 finished 9
finished 6
...
Thread-6 -- task 9 finished 98
Thread-4 -- task 9 finished 99
Thread-9 -- task 9 finished 100
```

Example 3-1 also uses *Lock* objects to create a critical section inside the global counter object. If you remove the calls to `acquire` and `release`, it's pretty likely that the counter won't reach 100.

3.3 The Queue Module

The Queue module provides a thread-safe queue implementation, shown in Example 3-2. It provides a convenient way of moving Python objects between different threads.

Example 3-2. Using the Queue Module

```
File: queue-example-1.py

import threading
import Queue
import time, random

WORKERS = 2

class Worker(threading.Thread):

    def _ _init_ _(self, queue):
        self._ _queue = queue
        threading.Thread._ _init_ _(self)

    def run(self):
        while 1:
            item = self._ _queue.get()
            if item is None:
                break # reached end of queue

            # pretend we're doing something that takes 10—100 ms
            time.sleep(random.randint(10, 100) / 1000.0)

            print "task", item, "finished"

#
# try it

queue = Queue.Queue(0)

for i in range(WORKERS):
    Worker(queue).start() # start a worker

for i in range(10):
    queue.put(i)

for i in range(WORKERS):
    queue.put(None) # add end-of-queue markers

task 1 finished
task 0 finished
task 3 finished
task 2 finished
task 4 finished
```

```
task 5 finished
task 7 finished
task 6 finished
task 9 finished
task 8 finished
```

Example 3-3 shows how you can limit the size of the queue. If the producer threads fill the queue, they will block until items are popped off the queue.

Example 3-3. Using the Queue Module with a Maximum Size

```
File: queue-example-2.py

import threading
import Queue

import time, random

WORKERS = 2

class Worker(threading.Thread):

    def _ _init_ _(self, queue):
        self._ _queue = queue
        threading.Thread._ _init_ _(self)

    def run(self):
        while 1:
            item = self._ _queue.get()
            if item is None:
                break # reached end of queue

            # pretend we're doing something that takes 10—100 ms
            time.sleep(random.randint(10, 100) / 1000.0)

            print "task", item, "finished"

#
# run with limited queue

queue = Queue.Queue(3)

for i in range(WORKERS):
    Worker(queue).start() # start a worker

for item in range(10):
    print "push", item
    queue.put(item)

for i in range(WORKERS):
    queue.put(None) # add end-of-queue markers
```

```
push 0
push 1
push 2
```

```
push 3
push 4
push 5
task 0 finished
push 6
task 1 finished
push 7
task 2 finished
push 8
task 3 finished
push 9
task 4 finished
task 6 finished
task 5 finished
task 7 finished
task 9 finished
task 8 finished
```

You can modify the behavior through subclassing. The class in Example 3-4 provides a simple priority queue. It expects all items added to the queue to be tuples, where the first member contains the priority (lower value means higher priority).

Example 3-4. Using the Queue Module to Implement a Priority Queue

```
File: queue-example-3.py

import Queue
import bisect

Empty = Queue.Empty

class PriorityQueue(Queue.Queue):
    "Thread-safe priority queue"

    def _put(self, item):
        # insert in order
        bisect.insort(self.queue, item)

#
# try it

queue = PriorityQueue(0)

# add items out of order
queue.put((20, "second"))
queue.put((10, "first"))
queue.put((30, "third"))

# print queue contents
try:
    while 1:
        print queue.get_nowait()
except Empty:
    pass
```

```
third
second
first
```

Example 3-5 shows a simple stack implementation (last-in, first-out, instead of first-in, first-out).

Example 3-5. Using the Queue Module to Implement a Stack

```
File: queue-example-4.py

import Queue

Empty = Queue.Empty

class Stack(Queue.Queue):
    "Thread-safe stack"

    def _put(self, item):
        # insert at the beginning of queue, not at the end
        self.queue.insert(0, item)

    # method aliases
    push = Queue.Queue.put
    pop = Queue.Queue.get
    pop_nowait = Queue.Queue.get_nowait

#
# try it

stack = Stack(0)

# push items on stack
stack.push("first")
stack.push("second")
stack.push("third")

# print stack contents
try:
    while 1:
        print stack.pop_nowait()
except Empty:
    pass
```

```
third
second
first
```

3.4 The thread Module

(Optional) The `thread` module provides a low-level interface for threading, as shown in Example 3-6. It's only available if your interpreter is built with thread support. New code should use the higher-level interface in the `threading` module instead.

Example 3-6. Using the thread Module

```
File: thread-example-1.py

import thread
import time, random

def worker():
    for i in range(50):
        # pretend we're doing something that takes 10—100 ms
        time.sleep(random.randint(10, 100) / 1000.0)
        print thread.get_ident(), "-- task", i, "finished"

#
# try it out!

for i in range(2):
    thread.start_new_thread(worker, ())

time.sleep(1)

print "goodbye!"

311 -- task 0 finished
265 -- task 0 finished
265 -- task 1 finished
311 -- task 1 finished
...
265 -- task 17 finished
311 -- task 13 finished
265 -- task 18 finished
goodbye!
```

Note that when the main program exits, all threads are killed. The `threading` module doesn't have that problem.

3.5 The commands Module

(Unix only) The `commands` module contains a few convenience functions designed to make it easier to execute external commands under Unix. Example 3-7 demonstrates this module.

Example 3-7. Using the commands Module

```
File: commands-example-1.py

import commands

stat, output = commands.getstatusoutput("ls -lR")

print "status", "=>", stat
print "output", "=>", len(output), "bytes"

status => 0
output => 171046 bytes
```

3.6 The pipes Module

(Unix only) The `pipes` module shown in Example 3-8 contains support functions to create "conversion pipelines." You can create a pipeline consisting of a number of external utilities and use it on one or more files.

Example 3-8. Using the pipes Module

```
File: pipes-example-1.py

import pipes

t = pipes.Template()

# create a pipeline
t.append("sort", "--")
t.append("uniq", "--")

# filter some text
t.copy("samples/sample.txt", "")

Alan Jones (sensible party)
Kevin Phillips-Bong (slightly silly)
Tarquin Fin-tim-lin-bin-whin-bim-lin-bus-stop-F'tang-F'tang-Olé-Biscuitbarrel
```

3.7 The popen2 Module

The popen2 module allows you to run an external command and access stdin and stdout (and possibly also stderr) as individual streams.

In Python 1.5.2 and earlier, this module is only supported on Unix. In 2.0, the functions are also implemented on Windows. Example 3-9 shows you how to sort strings using this module.

Example 3-9. Using the popen2 Module to Sort Strings

```
File: popen2-example-1.py

import popen2, string

fin, fout = popen2.popen2("sort")

fout.write("foo\n")
fout.write("bar\n")
fout.close()

print fin.readline(),
print fin.readline(),
fin.close()

bar
foo
```

Example 3-10 demonstrates how you can use this module to control an existing application.

Example 3-10. Using the popen2 Module to Control gnuchess

```
File: popen2-example-2.py

import popen2
import string

class Chess:
    "Interface class for chesstool-compatible programs"

    def _ _init_ _(self, engine = "gnuchessc"):
        self.fin, self.fout = popen2.popen2(engine)
        s = self.fin.readline()
        if s != "Chess\n":
            raise IOError, "incompatible chess program"

    def move(self, move):
        self.fout.write(move + "\n")
        self.fout.flush()
        my = self.fin.readline()
        if my == "Illegal move":
```

```
            raise ValueError, "illegal move"
        his = self.fin.readline()
        return string.split(his)[2]

    def quit(self):
        self.fout.write("quit\n")
        self.fout.flush()

#
# play a few moves

g = Chess()

print g.move("a2a4")
print g.move("b2b3")

g.quit()
```

```
b8c6
e7e5
```

3.8 The signal Module

The `signal` module is used to install your own signal handlers, as Example 3-11 shows. When the interpreter sees a signal, the signal handler is executed as soon as possible.

Example 3-11. Using the signal Module

```
File: signal-example-1.py

import signal
import time

def handler(signo, frame):
    print "got signal", signo

signal.signal(signal.SIGALRM, handler)

# wake me up in two seconds
signal.alarm(2)

now = time.time()

time.sleep(200)

print "slept for", time.time() - now, "seconds"

got signal 14
slept for 1.99262607098 seconds
```

Chapter 4. Data Representation

"PALO ALTO, Calif.—Intel says its Pentium Pro and new Pentium II chips have a flaw that can cause computers to sometimes make mistakes but said the problems could be fixed easily with rewritten software."

—Reuters telegram

4.1 Overview

This chapter describes a number of modules that can be used to convert between Python objects and other data representations. These modules are often used to read and write foreign file formats and to store or transfer Python variables.

4.1.1 Binary Data

Python provides several support modules that help you decode and encode binary data formats. The `struct` module can convert between binary data structures (like C structs) and Python tuples. The `array` module wraps binary arrays of data (C arrays) into a Python sequence object.

4.1.2 Self-Describing Formats

To pass data between different Python programs, you can `marshal` or `pickle` your data.

The `marshal` module uses a simple self-describing format that supports most built-in datatypes, including code objects. Python uses this format itself to store compiled code on disk (in PYC files).

The `pickle` module provides a more sophisticated format, which supports user-defined classes, self-referencing data structures, and more. This module is available in two versions; the basic `pickle` module is written in Python and is relatively slow, while `cPickle` is written in C and is usually as fast as `marshal`.

4.1.3 Output Formatting

The modules in this group supplement built-in formatting functions like `repr` and the `%` string formatting operator.

The `pprint` module can print almost any Python data structure in a nice, readable way (as readable as it can make things, that is).

The `repr` module provides a replacement for the built-in function with the same name. The version in this module applies tight limits on most things: it doesn't print more than 30 characters from each string, it doesn't print more than a few levels of deeply nested data structures, etc.

4.1.4 Encoded Binary Data

Python supports most common binary encodings, such as `base64`, `binhex` (a Macintosh format), `quoted printable`, and `uu` encoding.

4.2 The array Module

The `array` module implements an efficient array storage type. Arrays are similar to lists, but all items must be of the same primitive type. The type is defined when the array is created.

Examples 4-1 through 4-5 are simple ones. Example 4-1 creates an *array* object and copies the internal buffer to a string through the `tostring` method.

Example 4-1. Using the array Module to Convert Lists of Integers to Strings

```
File: array-example-1.py

import array

a = array.array("B", range(16)) # unsigned char
b = array.array("h", range(16)) # signed short

print a
print repr(a.tostring())

print b
print repr(b.tostring())

array('B', [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15])
'\000\001\002\003\004\005\006\007\010\011\012\013\014\015\016\017'

array('h', [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15])
'\000\000\001\000\002\000\003\000\004\000\005\000\006\000\007\000
\010\000\011\000\012\000\013\000\014\000\015\000\016\000\017\000'
```

The *array* objects can be treated as ordinary lists to some extent, as Example 4-2 shows. You cannot concatenate arrays if they have different type codes, though.

Example 4-2. Using Arrays as Ordinary Sequences

```
File: array-example-2.py

import array

a = array.array("B", [1, 2, 3])

a.append(4)

a = a + a

a = a[2:-2]

print a
print repr(a.tostring())
for i in a:
```

```
    print i,

array('B', [3, 4, 1, 2])
'\003\004\001\002'
3 4 1 2
```

This module also provides a very efficient way to turn raw binary data into a sequence of integers (or floating point values, for that matter), as Example 4-3 demonstrates.

Example 4-3. Using Arrays to Convert Strings to Lists of Integers

```
File: array-example-3.py

import array

a = array.array("i", "fish license") # signed integer

print a
print repr(a.tostring())
print a.tolist()

array('i', [1752394086, 1667853344, 1702063717])
'fish license'
[1752394086, 1667853344, 1702063717]
```

Finally, Example 4-4 shows how to use this module to determine the endianess of the current platform.

Example 4-4. Using the array Module to Determine Platform Endianess

```
File: array-example-4.py

import array

def little_endian():
    return ord(array.array("i",[1]).tostring()[0])

if little_endian():
    print "little-endian platform (intel, alpha)"
else:
    print "big-endian platform (motorola, sparc)"

big-endian platform (motorola, sparc)
```

Python 2.0 and later provides a `sys.byteorder` attribute, which is set to either "`little`" or "`big`," as you can see in Example 4-5.

Example 4-5. Using the sys.byteorder Attribute to Determine Platform Endianess (Python 2.0)

```
File: sys-byteorder-example-1.py

import sys

# 2.0 and later
```

```
if sys.byteorder == "little":
    print "little-endian platform (intel, alpha)"
else:
    print "big-endian platform (motorola, sparc)"
```

```
big-endian platform (motorola, sparc)
```

4.3 The struct Module

The `struct` module shown in Example 4-6 contains functions to convert between binary strings and Python tuples. The `pack` function takes a format string and one or more arguments, and returns a binary string. The `unpack` function takes a string and returns a tuple.

Example 4-6. Using the struct Module

```
File: struct-example-1.py

import struct

# native byteorder
buffer = struct.pack("ihb", 1, 2, 3)
print repr(buffer)
print struct.unpack("ihb", buffer)

# data from a sequence, network byteorder
data = [1, 2, 3]
buffer = apply(struct.pack, ("!ihb",) + tuple(data))
print repr(buffer)
print struct.unpack("!ihb", buffer)

# in 2.0, the apply statement can also be written as:
# buffer = struct.pack("!ihb", *data)

'\001\000\000\000\002\000\003'
(1, 2, 3)
'\000\000\000\001\000\002\003'
(1, 2, 3)
```

4.4 The xdrlib Module

The xdrlib module converts between Python datatypes and Sun's external data representation (XDR), as Example 4-7 illustrates.

Example 4-7. Using the xdrlib Module

```
File: xdrlib-example-1.py

import xdrlib

#
# create a packer and add some data to it

p = xdrlib.Packer()
p.pack_uint(1)
p.pack_string("spam")

data = p.get_buffer()

print "packed:", repr(data)

#
# create an unpacker and use it to decode the data

u = xdrlib.Unpacker(data)

print "unpacked:", u.unpack_uint(), repr(u.unpack_string())

u.done()

packed: '\000\000\000\001\000\000\000\004spam'
unpacked: 1 'spam'
```

The XDR format is used by Sun's remote procedure call (RPC) protocol. Example 4-8 is an incomplete (and rather contrived) example showing how to build an RPC request package.

Example 4-8. Using the xdrlib Module to Send an RPC Call Package

```
File: xdrlib-example-2.py

import xdrlib

# some constants (see the RPC specs for details)
RPC_CALL = 1
RPC_VERSION = 2

MY_PROGRAM_ID = 1234 # assigned by Sun
MY_VERSION_ID = 1000
MY_TIME_PROCEDURE_ID = 9999
```

```
AUTH_NULL = 0

transaction = 1

p = xdrlib.Packer()

# send a Sun RPC call package
p.pack_uint(transaction)
p.pack_enum(RPC_CALL)
p.pack_uint(RPC_VERSION)
p.pack_uint(MY_PROGRAM_ID)
p.pack_uint(MY_VERSION_ID)
p.pack_uint(MY_TIME_PROCEDURE_ID)
p.pack_enum(AUTH_NULL)
p.pack_uint(0)
p.pack_enum(AUTH_NULL)
p.pack_uint(0)

print repr(p.get_buffer())
```

```
'\000\000\000\001\000\000\000\001\000\000\000\002\000\000\004\322
\000\000\003\350\000\000\'\017\000\000\000\000\000\000\000\000\000
\000\000\000\000\000\000\000'
```

4.5 The marshal Module

The `marshal` module is used to serialize data—that is, convert data to and from character strings, so that they can be stored on file or sent over a network. Example 4-9 illustrates this.

The `marshal` module uses a simple self-describing data format. For each data item, the marshalled string contains a type code, followed by one or more type-specific fields. Integers are stored in little-endian order, strings are stored as length fields followed by the strings' contents (which can include null bytes), tuples are stored as length fields followed by the objects that make up each tuple, etc.

Example 4-9. Using the marshal Module to Serialize Data

```
File: marshal-example-1.py

import marshal

value = (
    "this is a string",
    [1, 2, 3, 4],
    ("more tuples", 1.0, 2.3, 4.5),
    "this is yet another string"
    )

data = marshal.dumps(value)

# intermediate format
print type(data), len(data)

print "-"*50
print repr(data)
print "-"*50

print marshal.loads(data)

<type 'string'> 118
--------------------------------------------------
'(\004\000\000\000s\020\000\000\000this is a string
[\004\000\000\000i\001\000\000\000i\002\000\000\000
i\003\000\000\000i\004\000\000\000(\004\000\000\000
s\013\000\000\000more tuplesf\0031.0f\0032.3f\0034.
5s\032\000\000\000this is yet another string'
--------------------------------------------------
('this is a string', [1, 2, 3, 4], ('more tuples',
1.0, 2.3, 4.5), 'this is yet another string')
```

The `marshal` module can also handle code objects (it's used to store precompiled Python modules). Example 4-10 demonstrates.

Example 4-10. Using the marshal Module to Serialize Code

```
File: marshal-example-2.py

import marshal

script = """
print 'hello'
"""

code = compile(script, "<script>", "exec")

data = marshal.dumps(code)

# intermediate format
print type(data), len(data)

print "-"*50
print repr(data)
print "-"*50

exec marshal.loads(data)
```

```
<type 'string'> 81
--------------------------------------------------
'c\000\000\000\000\001\000\000\000s\017\000\000\00
0\177\000\000\177\002\000d\000\000GHd\001\000S(\00
2\000\000\000s\005\000\000\000helloN(\000\000\000\
000(\000\000\000\000s\010\000\000\000<script>s\001
\000\000\000?\002\000s\000\000\000\000'
--------------------------------------------------
hello
```

4.6 The pickle Module

The `pickle` module, shown in Example 4-11, is used to serialize data—that is, convert data to and from character strings, so that they can be stored on file or sent over a network. It's a bit slower than `marshal`, but it can handle class instances, shared elements, and recursive data structures, among other things.

Example 4-11. Using the pickle Module

```
File: pickle-example-1.py

import pickle

value = (
    "this is a string",
    [1, 2, 3, 4],
    ("more tuples", 1.0, 2.3, 4.5),
    "this is yet another string"
    )

data = pickle.dumps(value)

# intermediate format
print type(data), len(data)

print "-"*50
print data
print "-"*50

print pickle.loads(data)
```

```
<type 'string'> 121
--------------------------------------------------
(S'this is a string'
p0
(lp1
I1
aI2
aI3
aI4
a(S'more tuples'
p2
F1.0
F2.3
F4.5
tp3
S'this is yet another string'
p4
tp5
.
--------------------------------------------------
('this is a string', [1, 2, 3, 4], ('more tuples',
```

```
1.0, 2.3, 4.5), 'this is yet another string')
```

On the other hand, pickle cannot handle code objects (but see the copy_reg module for a way to fix this).

By default, pickle uses a text-based format. You can also use a binary format, in which numbers and binary strings are stored in a compact binary format. The binary format usually results in smaller files. This is demonstrated in Example 4-12.

Example 4-12. Using the pickle Module in Binary Mode

```
File: pickle-example-2.py

import pickle
import math

value = (
    "this is a long string" * 100,
    [1.2345678, 2.3456789, 3.4567890] * 100
    )

# text mode
data = pickle.dumps(value)
print type(data), len(data), pickle.loads(data) == value

# binary mode
data = pickle.dumps(value, 1)
print type(data), len(data), pickle.loads(data) == value
```

4.7 The cPickle Module

(Optional) The `cPickle` module shown in Example 4-13 contains a faster reimplementation of the `pickle` module.

Example 4-13. Using the cPickle Module

```
File: cpickle-example-1.py

try:
    import cPickle
    pickle = cPickle
except ImportError:
    import pickle
```

4.8 The copy_reg Module

The copy_reg module provides a registry that you can use to register your own extension types. The pickle and copy modules use this registry to figure out how to process non-standard types.

For example, the standard pickle implementation cannot deal with Python code objects, as shown in the following example:

```
File: copy-reg-example-1.py

import pickle

CODE = """
print 'good evening'
"""

code = compile(CODE, "<string>", "exec")

exec code
exec pickle.loads(pickle.dumps(code))

good evening
Traceback (innermost last):
...
pickle.PicklingError: can't pickle 'code' objects
```

We can work around this by registering a code object handler. Such a handler consists of two parts: a *pickler*, which takes the code object and returns a tuple that can only contain simple datatypes, and an *unpickler*, which takes the contents of such a tuple as its arguments. Example 4-14 demonstrates this.

Example 4-14. Using the copy_reg Module to Enable Pickling of Code Objects

```
File: copy-reg-example-2.py

import copy_reg
import pickle, marshal, types

#
# register a pickle handler for code objects

def code_unpickler(data):
    return marshal.loads(data)

def code_pickler(code):
    return code_unpickler, (marshal.dumps(code),)

copy_reg.pickle(types.CodeType, code_pickler, code_unpickler)

#
# try it out
```

```
CODE = """
print "suppose he's got a pointed stick"
"""

code = compile(CODE, "<string>", "exec")

exec code
exec pickle.loads(pickle.dumps(code))

suppose he's got a pointed stick
suppose he's got a pointed stick
```

If you're transferring the pickled data across a network or to another program, the custom `unpickler` must be available at the receiving end as well.

For the really adventurous, Example 4-15 shows a version that allows you to pickle open file objects.

Example 4-15. Using the copy_reg Module to Enable Pickling of File Objects

```
File: copy-reg-example-3.py

import copy_reg
import pickle, types
import StringIO

#
# register a pickle handler for file objects

def file_unpickler(position, data):
    file = StringIO.StringIO(data)
    file.seek(position)
    return file

def file_pickler(code):
    position = file.tell()
    file.seek(0)
    data = file.read()
    file.seek(position)
    return file_unpickler, (position, data)

copy_reg.pickle(types.FileType, file_pickler, file_unpickler)

#
# try it out

file = open("samples/sample.txt", "rb")

print file.read(120),
print "<here>",
print pickle.loads(pickle.dumps(file)).read()

We will perhaps eventually be writing only small
modules, which are identified by name as they are
used to build larger <here> ones, so that devices like
indentation, rather than delimiters, might become
```

feasible for expressing local structure in the source language.
-- Donald E. Knuth, December 1974

4.9 The pprint Module

The `pprint` module, shown in Example 4-16, is a "pretty printer" for Python data structures. It's useful if you have to print non-trivial data structures to the console.

Example 4-16. Using the pprint Module

```
File: pprint-example-1.py

import pprint

data = (
    "this is a string", [1, 2, 3, 4], ("more tuples",
    1.0, 2.3, 4.5), "this is yet another string"
    )

pprint.pprint(data)

('this is a string',
 [1, 2, 3, 4],
 ('more tuples', 1.0, 2.3, 4.5),
 'this is yet another string')
```

4.10 The repr Module

The `repr` module provides a version of the built-in `repr` function, with limits on most sizes (string lengths, recursion, etc). Example 4-17 shows the module in use.

Example 4-17. Using the repr Module

```
File: repr-example-1.py

# note: this overrides the built-in 'repr' function
from repr import repr

# an annoyingly recursive data structure
data = (
    "X" * 100000,
    )
data = [data]
data.append(data)

print repr(data)

[('XXXXXXXXXXXX...XXXXXXXXXXXXX',), [('XXXXXXXXXXXX...XXXXXXXXXX
XXX',), [('XXXXXXXXXXXX...XXXXXXXXXXXXX',), [('XXXXXXXXXXXX...XX
XXXXXXXXXXX',), [('XXXXXXXXXXXX...XXXXXXXXXXXXX',), [(...), [...
]]]]]]]
```

4.11 The base64 Module

The base64 encoding scheme is used to convert arbitrary binary data to plain text. To do this, the encoder stores each group of three binary bytes as a group of four characters from the following set:

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
0123456789+/
```

In addition, the = character is used for padding at the end of the data stream.

Example 4-18 shows how the encode and decode functions work on file objects.

Example 4-18. Using the base64 Module to Encode Files

```
File: base64-example-1.py

import base64

MESSAGE = "life of brian"

file = open("out.txt", "w")
file.write(MESSAGE)
file.close()

base64.encode(open("out.txt"), open("out.b64", "w"))
base64.decode(open("out.b64"), open("out.txt", "w"))

print "original:", repr(MESSAGE)
print "encoded message:", repr(open("out.b64").read())
print "decoded message:", repr(open("out.txt").read())

original:  'life of brian'
encoded message: 'bGlmZSBvZiBicmlhbg==\012'
decoded message: 'life of brian'
```

Example 4-19 shows the encodestring and decodestring functions converting between strings. The functions are currently implemented as wrappers on top of encode and decode, using StringIO objects for input and output.

Example 4-19. Using the base64 Module to Encode Strings

```
File: base64-example-2.py

import base64

MESSAGE = "life of brian"

data = base64.encodestring(MESSAGE)
```

```
original_data = base64.decodestring(data)

print "original:", repr(MESSAGE)
print "encoded data:", repr(data)
print "decoded data:", repr(original_data)
```

```
original: 'life of brian'
encoded data: 'bGlmZSBvZiBicmlhbg==\012'
decoded data: 'life of brian'
```

Example 4-20 shows how to convert a username and a password to an HTTP basic authentication string. (Note that you don't really have to work for the NSA to be able to decode this format.)

Example 4-20. Using the base64 Module for Basic Authentication

```
File: base64-example-3.py

import base64

def getbasic(user, password):
    # basic authentication (according to HTTP)
    return base64.encodestring(user + ":" + password)

print getbasic("Aladdin", "open sesame")
```

```
'QWxhZGRpbjpvcGVuIHNlc2FtZQ=='
```

Finally, Example 4-21 shows a small utility that converts a GIF image to a Python script, for use with the Tkinter library.

Example 4-21. Using the base64 Module to Wrap GIF Images for Tkinter

```
File: base64-example-4.py

import base64, sys

if not sys.argv[1:]:
    print "Usage: gif2tk.py giffile >pyfile"
    sys.exit(1)

data = open(sys.argv[1], "rb").read()

if data[:4] != "GIF8":
    print sys.argv[1], "is not a GIF file"
    sys.exit(1)

print '# generated from', sys.argv[1], 'by gif2tk.py'
print
print 'from Tkinter import PhotoImage'
print
print 'image = PhotoImage(data="""'
print base64.encodestring(data),
print '""")'
```

```
# generated from samples/sample.gif by gif2tk.py

from Tkinter import PhotoImage

image = PhotoImage(data="""
R0lGODlhoAB4APcAAAAAAAIAAAACAAICAAAAAgIAAgACAgICAgAQEBIwEBIyMBJRUlISE/LRUBAQE
...
AjmQBFmQBnmQCJmQCrmQDNmQDvmQEBmREnkRAQEAOw==
""")
```

4.12 The binhex Module

The `binhex` module in Example 4-22 converts to and from the Macintosh BinHex format.

Example 4-22. Using the binhex Module

```
File: binhex-example-1.py

import binhex
import sys

infile = "samples/sample.jpg"

binhex.binhex(infile, sys.stdout)

(This file must be converted with BinHex 4.0)

:#R0KEA"XC5jUF'F!2j!)!*!%%TS!N!4RdrrBrq!!%%T'58B!!3%!!!%!!3!!rpX
!3`!)"JB("J8)"`F(#3N)#J`8$3`,#``C%K-2&"dD(aiG'K`F)#3Z*b!L,#-F(#J
h+5``-63d0"mR16di-M`Z-c3brpX!3`%*#3N-#``B$3dB-L%F)6+3-[r!!"%)!)!
!J!-")J!#%3%$%3(ra!!I!!!""3'3"J#3#!%#!`3&"JF)#3S,rm3!Y4!!!J%$!`)
%!`8&"!3!!&p!3)$!!34"4)K-8%'%e&K"b*a&$+"ND%))d+a`495dI!N-f*bJJN
```

4.13 The quopri Module

The `quopri` module implements quoted printable encoding, according to the MIME standard.

This encoding can be used to convert text messages that consist mostly of plain U.S. ASCII text, such as messages written in most European languages, to messages that only use U.S. ASCII. This can be quite useful if you're sending stuff via steam-powered mail transports to people using vintage mail agents. Example 4-23 demonstrates.

Example 4-23. Using the quopri Module

```
File: quopri-example-1.py

import quopri
import StringIO

# helpers (the quopri module only supports file-to-file conversion)

def encodestring(instring, tabs=0):
    outfile = StringIO.StringIO()
    quopri.encode(StringIO.StringIO(instring), outfile, tabs)
    return outfile.getvalue()

def decodestring(instring):
    outfile = StringIO.StringIO()
    quopri.decode(StringIO.StringIO(instring), outfile)
    return outfile.getvalue()

#
# try it out

MESSAGE = "å i åa ä e ö!"

encoded_message = encodestring(MESSAGE)
decoded_message = decodestring(encoded_message)

print "original:", MESSAGE
print "encoded message:", repr(encoded_message)
print "decoded message:", decoded_message

original: å i åa ä e ö!
encoded message: '=E5 i =E5a =E4 e =F6!\012'
decoded message: å i åa ä e ö!
```

As Example 4-23 shows, non-U.S. characters are mapped to an equals sign (=) followed by two hexadecimal digits. So it is the equals sign character itself ("=3D"), as well as whitespace at the end of lines ("=20"). Everything else looks just like before. So provided you don't use too many weird characters, the encoded string is nearly as readable as the original.

(Europeans generally hate this encoding and strongly believe that certain U.S. programmers deserve to be slapped in the head with a huge great fish to the jolly music of Edward German....)

4.14 The uu Module

The `uu` encoding scheme is used to convert arbitrary binary data to plain text. This format is quite popular on the Usenet, but is slowly being superseded by `base64` encoding.

A `uu` encoder takes groups of three bytes (24 bits) and converts each group to a sequence of four printable characters (6 bits per character), using characters from chr(32) (space) to chr(95). Including the length marker and line feed characters, `uu` encoding typically expands data by 40 percent.

An encoded data stream starts with a `begin` line, which includes the file privileges (the Unix mode field as an octal number) and the filename, and ends with an `end` line:

```
begin 666 sample.jpg
M_]C_X  02D9)1@ ! 0   0 !  #_VP!#  @&!@<&!0@'!P<)'0@*#!0-# L+
...more lines like this...
end
```

The `uu` module provides two functions: `encode` and `decode`.

The `encode(infile, outfile, filename)` function, shown in Example 4-24, encodes data from the input file and writes it to the output file. The input and output file arguments can be either filenames or file objects. The third argument is used as filename in the `begin` field.

Example 4-24. Using the uu Module to Encode a Binary File

```
File: uu-example-1.py

import uu
import os, sys

infile = "samples/sample.jpg"

uu.encode(infile, sys.stdout, os.path.basename(infile))

begin 666 sample.jpg
M_]C_X  02D9)1@ ! 0   0 !  #_VP!#  @&!@<&!0@'!P<)"0@*#!0-# L+
M#!D2$P\4'1H?'AT:'!P@)"XG("(L(QP<*#<I+# Q-#0T'R<Y/3@R/"XS-#+_
MVP!# 0D)"0P+#!@-#1@R(1PA,C(R,C(R,C(R,C(R,C(R,C(R,C(R,C(R,C(R
M,C(R,C(R,C(R,C(R,C(R,C(R,C+_P  1" "  ( # 2(  A$! Q$!_\0
M'P   04! 0$! 0$           $" P0%!@<("0H+_\0 M1   @$# P($ P4%
```

The `decode(infile, outfile)` function, shown in Example 4-25, decodes `uu`-encoded data from the input text file and writes it to the output file. Again, both arguments can be either filenames or file objects.

Example 4-25. Using the uu Module to Decode a uu-Encoded File

```
File: uu-example-2.py

import uu
import StringIO
```

```
infile = "samples/sample.uue"
outfile = "samples/sample.jpg"

#
# decode

fi = open(infile)
fo = StringIO.StringIO()

uu.decode(fi, fo)

#
# compare with original data file

data = open(outfile, "rb").read()

if fo.getvalue() == data:
    print len(data), "bytes ok"
```

4.15 The binascii Module

The `binascii` module, shown in Example 4-26, contains support functions for a number of encoding modules, including `base64`, `binhex`, and `uu`.

In 2.0 and newer, it also allows you to convert binary data to and from hexadecimal strings.

Example 4-26. Using the binascii Module

```
File: binascii-example-1.py

import binascii

text = "hello, mrs teal"

data = binascii.b2a_base64(text)
text = binascii.a2b_base64(data)
print text, "<=>", repr(data)

data = binascii.b2a_uu(text)
text = binascii.a2b_uu(data)
print text, "<=>", repr(data)

data = binascii.b2a_hqx(text)
text = binascii.a2b_hqx(data)[0]
print text, "<=>", repr(data)

# 2.0 and newer
data = binascii.b2a_hex(text)
text = binascii.a2b_hex(data)
print text, "<=>", repr(data)

hello, mrs teal <=> 'aGVsbG8sIG1ycyB0ZWFs\012'
hello, mrs teal <=> '/:&5L;&\\L(&UR<R!T96%L\012'
hello, mrs teal <=> 'D\'9XE\'mX)\'ebFb"dC@&X'
hello, mrs teal <=> '68656c6c6f2c206d7273207465616c'
```

Chapter 5. File Formats

5.1 Overview

This chapter describes a number of modules that are used to parse different file formats.

5.1.1 Markup Languages

Python comes with extensive support for the Extensible Markup Language (XML) and Hypertext Markup Language (HTML) file formats. Python also provides basic support for Standard Generalized Markup Language (SGML).

All these formats share the same basic structure because both HTML and XML are derived from SGML. Each document contains a mix of *start tags*, *end tags*, plain text (also called character data), and *entity references*, as shown in the following:

```
<document name="sample.xml">
    <header>This is a header</header>
    <body>This is the body text.  The text can contain
    plain text (&quot;character data&quot;), tags, and
    entities.
    </body>
</document>
```

In the previous example, `<document>`, `<header>`, and `<body>` are start tags. For each start tag, there's a corresponding end tag that looks similar, but has a slash before the tag name. The start tag can also contain one or more *attributes*, like the `name` attribute in this example.

Everything between a start tag and its matching end tag is called an *element*. In the previous example, the `document` element contains two other elements: `header` and `body`.

Finally, `"` is a character entity. It is used to represent reserved characters in the text sections. In this case, it's an ampersand (`&`), which is used to start the entity itself. Other common entities include `<` for "less than" (`<`), and `>` for "greater than" (`>`).

While XML, HTML, and SGML all share the same building blocks, there are important differences between them. In XML, all elements must have both start tags and end tags, and the tags must be properly nested (if they are, the document is said to be *well-formed*). In addition, XML is case-sensitive, so `<document>` and `<Document>` are two different element types.

HTML, in contrast, is much more flexible. The HTML parser can often fill in missing tags; for example, if you open a new paragraph in HTML using the `<P>` tag without closing the previous paragraph, the parser automatically adds a `</P>` end tag. HTML is also case-insensitive. On the other hand, XML allows you to define your own elements, while HTML uses a fixed element set, as defined by the HTML specifications.

SGML is even more flexible. In its full incarnation, you can use a custom *declaration* to define how to translate the source text into an element structure, and a *document type description* (DTD) to validate the structure and fill in missing tags. Technically, both HTML and XML are *SGML applications*; they both have their own SGML declaration, and HTML also has a standard DTD.

Python comes with parsers for all markup flavors. While SGML is the most flexible of the formats, Python's `sgmllib` parser is actually pretty simple. It avoids most of the problems by only understanding enough of the SGML standard to be able to deal with HTML. It doesn't handle DTDs either; instead, you can customize the parser via subclassing.

Python's HTML support is built on the SGML parser. The `htmllib` parser delegates the actual rendering to a formatter object. The `formatter` module contains a couple of standard formatters.

Python's XML support is most complex. In Python 1.5.2, the built-in support was limited to the `xmllib` parser, which is pretty similar to the `sgmllib` module (with one important difference; `xmllib` actually tries to support the entire XML standard). Python 2.0 comes with more advanced XML tools, based on the optional `expat` parser.

5.1.2 Configuration Files

The `ConfigParser` module reads and writes a simple configuration file format, similar to Windows INI files.

The `netrc` file reads `.netrc` configuration files, and the `shlex` module can be used to read any configuration file using a shell script-like syntax.

5.1.3 Archive Formats

Python's standard library provides support for the popular GZIP and ZIP (2.0 only) formats. The `gzip` module reads and writes GZIP files, and the `zipfile` reads and writes ZIP files. Both modules depend on the `zlib` data compression module.

5.2 The xmllib Module

The xmllib module provides a simple XML parser, using regular expressions to pull the XML data apart, as shown in Example 5-1. The parser does basic checks on the document, such as a check to see that there is only one top-level element and a check to see that all tags are balanced.

You feed XML data to this parser piece by piece (as data arrives over a network, for example). The parser calls methods in itself for start tags, data sections, end tags, and entities, among other things.

If you're only interested in a few tags, you can define special start_tag and end_tag methods, where tag is the tag name. The start functions are called with the attributes given as a dictionary.

Example 5-1. Using the xmllib Module to Extract Information from an Element

```
File: xmllib-example-1.py

import xmllib

class Parser(xmllib.XMLParser):
    # get quotation number

    def _ _init_ _(self, file=None):
        xmllib.XMLParser._ _init_ _(self)
        if file:
            self.load(file)

    def load(self, file):
        while 1:
            s = file.read(512)
            if not s:
                break
            self.feed(s)
        self.close()

    def start_quotation(self, attrs):
        print "id =>", attrs.get("id")
        raise EOFError

try:
    c = Parser()
    c.load(open("samples/sample.xml"))
except EOFError:
    pass

id => 031
```

Example 5-2 contains a simple (and incomplete) rendering engine. The parser maintains an element stack (_ _tags), which it passes to the renderer, together with text fragments. The renderer looks up the current tag hierarchy in a style dictionary, and if it isn't already there, it creates a new style descriptor by combining bits and pieces from the stylesheet.

Example 5-2. Using the xmllib Module

```
File: xmllib-example-2.py

import xmllib
import string, sys

STYLESHEET = {
    # each element can contribute one or more style elements
    "quotation": {"style": "italic"},
    "lang": {"weight": "bold"},
    "name": {"weight": "medium"},
}

class Parser(xmllib.XMLParser):
    # a simple styling engine

    def _ _init_ _(self, renderer):
        xmllib.XMLParser._ _init_ _(self)
        self._ _data = []
        self._ _tags = []
        self._ _renderer = renderer

    def load(self, file):
        while 1:
            s = file.read(8192)
            if not s:
                break
            self.feed(s)
        self.close()

    def handle_data(self, data):
        self._ _data.append(data)

    def unknown_starttag(self, tag, attrs):
        if self._ _data:
            text = string.join(self._ _data, "")
            self._ _renderer.text(self._ _tags, text)
        self._ _tags.append(tag)
        self._ _data = []

    def unknown_endtag(self, tag):
        self._ _tags.pop()
        if self._ _data:
            text = string.join(self._ _data, "")
            self._ _renderer.text(self._ _tags, text)
        self._ _data = []

class DumbRenderer:

    def _ _init_ _(self):
        self.cache = {}

    def text(self, tags, text):
        # render text in the style given by the tag stack
```

```
        tags = tuple(tags)
        style = self.cache.get(tags)
        if style is None:
            # figure out a combined style
            style = {}
            for tag in tags:
                s = STYLESHEET.get(tag)
                if s:
                    style.update(s)
            self.cache[tags] = style # update cache
        # write to standard output
        sys.stdout.write("%s =>\n" % style)
        sys.stdout.write("  " + repr(text) + "\n")

#
# try it out

r = DumbRenderer()
c = Parser(r)
c.load(open("samples/sample.xml"))

{'style': 'italic'} =>
  'I\'ve had a lot of developers come up to me and\012say,
  "I haven\'t had this much fun in a long time. It sure
  beats\012writing '
{'style': 'italic', 'weight': 'bold'} =>
  'Cobol'
{'style': 'italic'} =>
  '" -- '
{'style': 'italic', 'weight': 'medium'} =>
  'James Gosling'
{'style': 'italic'} =>
  ', on\012'
{'weight': 'bold'} =>
  'Java'
{'style': 'italic'} =>
  '.'
```

5.3 The xml.parsers.expat Module

(Optional) The `xml.parsers.expat` module is an interface to James Clark's Expat XML parser. Example 5-3 demonstrates this full-featured and fast parser, which is an excellent choice for production use.

Example 5-3. Using the xml.parsers.expat Module

```
File: xml-parsers-expat-example-1.py

from xml.parsers import expat

class Parser:

    def __init__(self):
        self._parser = expat.ParserCreate()
        self._parser.StartElementHandler = self.start
        self._parser.EndElementHandler = self.end
        self._parser.CharacterDataHandler = self.data

    def feed(self, data):
        self._parser.Parse(data, 0)

    def close(self):
        self._parser.Parse("", 1) # end of data
        del self._parser # get rid of circular references

    def start(self, tag, attrs):
        print "START", repr(tag), attrs

    def end(self, tag):
        print "END", repr(tag)

    def data(self, data):
        print "DATA", repr(data)

p = Parser()
p.feed("<tag>data</tag>")
p.close()

START u'tag' {}
DATA u'data'
END u'tag'
```

Note that the parser returns Unicode strings, even if you pass it ordinary text. By default, the parser interprets the source text as UTF-8 (as per the XML standard). To use other encodings, make sure the XML file contains an *encoding* directive. Example 5-4 shows how to read ISO Latin-1 text using `xml.parsers.expat`.

Example 5-4. Using the xml.parsers.expat Module to Read ISO Latin-1 Text

```
File: xml-parsers-expat-example-2.py

from xml.parsers import expat

class Parser:

    def _ _init_ _(self):
        self._parser = expat.ParserCreate()
        self._parser.StartElementHandler = self.start
        self._parser.EndElementHandler = self.end
        self._parser.CharacterDataHandler = self.data

    def feed(self, data):
        self._parser.Parse(data, 0)

    def close(self):
        self._parser.Parse("", 1) # end of data
        del self._parser # get rid of circular references

    def start(self, tag, attrs):
        print "START", repr(tag), attrs

    def end(self, tag):
        print "END", repr(tag)

    def data(self, data):
        print "DATA", repr(data)

p = Parser()
p.feed("""\
<?xml version='1.0' encoding='iso-8859-1'?>
<author>
<name>fredrik lundh</name>
<city>linköping</city>
</author>
"""
)
p.close()
```

```
START u'author' {}
DATA u'\012'
START u'name' {}
DATA u'fredrik lundh'
END u'name'
DATA u'\012'
START u'city' {}
DATA u'link\366ping'
END u'city'
DATA u'\012'
END u'author'
```

5.4 The sgmllib Module

The `sgmllib` module, shown in Example 5-5, provides a basic SGML parser. It works pretty much the same as the `xmllib` parser, but is less restrictive (and less complete).

Like in `xmllib`, this parser calls methods in itself to deal with things like start tags, data sections, end tags, and entities. If you're only interested in a few tags, you can define special `start` and `end` methods.

Example 5-5. Using the sgmllib Module to Extract the Title Element

```
File: sgmllib-example-1.py

import sgmllib
import string

class FoundTitle(Exception):
    pass

class ExtractTitle(sgmllib.SGMLParser):

    def _ _init_ _(self, verbose=0):
        sgmllib.SGMLParser._ _init_ _(self, verbose)
        self.title = self.data = None

    def handle_data(self, data):
        if self.data is not None:
            self.data.append(data)

    def start_title(self, attrs):
        self.data = []

    def end_title(self):
        self.title = string.join(self.data, "")
        raise FoundTitle # abort parsing!

def extract(file):
    # extract title from an HTML/SGML stream
    p = ExtractTitle()
    try:
        while 1:
            # read small chunks
            s = file.read(512)
            if not s:
                break
            p.feed(s)
        p.close()
    except FoundTitle:
        return p.title
    return None

#
```

```
# try it out

print "html", "=>", extract(open("samples/sample.htm"))
print "sgml", "=>", extract(open("samples/sample.sgm"))
```

```
html => A Title.
sgml => Quotations
```

To handle all tags, overload the `unknown_starttag` and `unknown_endtag` methods instead, as Example 5-6 demonstrates.

Example 5-6. Using the sgmllib Module to Format an SGML Document

```
File: sgmllib-example-2.py

import sgmllib
import cgi, sys

class PrettyPrinter(sgmllib.SGMLParser):
    # A simple SGML pretty printer

    def _ _init_ _(self):
        # initialize base class
        sgmllib.SGMLParser._ _init_ _(self)
        self.flag = 0

    def newline(self):
        # force newline, if necessary
        if self.flag:
            sys.stdout.write("\n")
        self.flag = 0

    def unknown_starttag(self, tag, attrs):
        # called for each start tag

        # the attrs argument is a list of (attr, value)
        # tuples. convert it to a string.
        text = ""
        for attr, value in attrs:
            text = text + " %s='%s'" % (attr, cgi.escape(value))

        self.newline()
        sys.stdout.write("<%s%s>\n" % (tag, text))

    def handle_data(self, text):
        # called for each text section
        sys.stdout.write(text)
        self.flag = (text[-1:] != "\n")

    def handle_entityref(self, text):
        # called for each entity
        sys.stdout.write("&%s;" % text)

    def unknown_endtag(self, tag):
        # called for each end tag
```

```
        self.newline()
        sys.stdout.write("<%s>" % tag)

#
# try it out

file = open("samples/sample.sgm")

p = PrettyPrinter()
p.feed(file.read())
p.close()

<chapter>
<title>
Quotations
<title>
<epigraph>
<attribution>
eff-bot, June 1997
<attribution>
<para>
<quote>
Nobody expects the Spanish Inquisition! Amongst
our weaponry are such diverse elements as fear, surprise,
ruthless efficiency, and an almost fanatical devotion to
Guido, and nice red uniforms &mdash; oh, damn!
<quote>
<para>
<epigraph>
<chapter>
```

Example 5-7 checks if an SGML document is "well-formed", in the XML sense. In a well-formed document, all elements are properly nested, with one end tag for each start tag.

To check this, we simply keep a list of open tags, and check that each end tag closes a matching start tag and that there are no open tags when we reach the end of the document.

Example 5-7. Using the sgmllib Module to Check Well-Formedness

```
File: sgmllib-example-3.py

import sgmllib

class WellFormednessChecker(sgmllib.SGMLParser):
    # check that an SGML document is 'well-formed'
    # (in the XML sense).

    def _ _init_ _(self, file=None):
        sgmllib.SGMLParser._ _init_ _(self)
        self.tags = []
        if file:
            self.load(file)

    def load(self, file):
        while 1:
```

```
            s = file.read(8192)
            if not s:
                break
            self.feed(s)
        self.close()

    def close(self):
        sgmllib.SGMLParser.close(self)
        if self.tags:
            raise SyntaxError, "start tag %s not closed" % self.tags[-1]

    def unknown_starttag(self, start, attrs):
        self.tags.append(start)

    def unknown_endtag(self, end):
        start = self.tags.pop()
        if end != start:
            raise SyntaxError, "end tag %s does't match start tag %s" %\
                  (end, start)

try:
    c = WellFormednessChecker()
    c.load(open("samples/sample.htm"))
except SyntaxError:
    raise # report error
else:
    print "document is well-formed"

Traceback (innermost last):
...
SyntaxError: end tag head does't match start tag meta
```

Finally, Example 5-8 shows a class that allows you to filter HTML and SGML documents. To use this class, create your own base class, and implement the `start` and `end` methods.

Example 5-8. Using the sgmllib Module to Filter SGML Documents

```
File: sgmllib-example-4.py

import sgmllib
import cgi, string, sys

class SGMLFilter(sgmllib.SGMLParser):
    # sgml filter.  override start/end to manipulate
    # document elements

    def _ _init_ _(self, outfile=None, infile=None):
        sgmllib.SGMLParser._ _init_ _(self)
        if not outfile:
            outfile = sys.stdout
        self.write = outfile.write
        if infile:
            self.load(infile)

    def load(self, file):
```

```
        while 1:
            s = file.read(8192)
            if not s:
                break
            self.feed(s)
        self.close()

    def handle_entityref(self, name):
        self.write("&%s;" % name)

    def handle_data(self, data):
        self.write(cgi.escape(data))

    def unknown_starttag(self, tag, attrs):
        tag, attrs = self.start(tag, attrs)
        if tag:
            if not attrs:
                self.write("<%s>" % tag)
            else:
                self.write("<%s" % tag)
                for k, v in attrs:
                    self.write(" %s=%s" % (k, repr(v)))
                self.write(">")

    def unknown_endtag(self, tag):
        tag = self.end(tag)
        if tag:
            self.write("</%s>" % tag)

    def start(self, tag, attrs):
        return tag, attrs # override

    def end(self, tag):
        return tag # override

class Filter(SGMLFilter):

    def fixtag(self, tag):
        if tag == "em":
            tag = "i"
        if tag == "string":
            tag = "b"
        return string.upper(tag)

    def start(self, tag, attrs):
        return self.fixtag(tag), attrs

    def end(self, tag):
        return self.fixtag(tag)

c = Filter()
c.load(open("samples/sample.htm"))
```

5.5 The htmllib Module

The `htmlib` module contains a tag-driven HTML parser, which sends data to a formatting object. Example 5-9 uses this module. For more examples on how to parse HTML files using this module, see the descriptions of the `formatter` module.

Example 5-9. Using the htmllib Module

```
File: htmllib-example-1.py

import htmllib
import formatter
import string

class Parser(htmllib.HTMLParser):
    # return a dictionary mapping anchor texts to lists
    # of associated hyperlinks

    def _ _init_ _(self, verbose=0):
        self.anchors = {}
        f = formatter.NullFormatter()
        htmllib.HTMLParser._ _init_ _(self, f, verbose)

    def anchor_bgn(self, href, name, type):
        self.save_bgn()
        self.anchor = href

    def anchor_end(self):
        text = string.strip(self.save_end())
        if self.anchor and text:
            self.anchors[text] = self.anchors.get(text, []) + [self.anchor]

file = open("samples/sample.htm")
html = file.read()
file.close()

p = Parser()
p.feed(html)
p.close()

for k, v in p.anchors.items():
    print k, "=>", v

print

link => ['http://www.python.org']
```

If you're only out to parse an HTML file and not render it to an output device, it's usually easier to use the `sgmllib` module instead.

5.6 The htmlentitydefs Module

The `htmlentitydefs` module contains a dictionary with many ISO Latin-1 character entities used by HTML. Its use is demonstrated in Example 5-10.

Example 5-10. Using the htmlentitydefs Module

```
File: htmlentitydefs-example-1.py

import htmlentitydefs

entities = htmlentitydefs.entitydefs

for entity in "amp", "quot", "copy", "yen":
    print entity, "=", entities[entity]

amp = &
quot = "
copy = \302\251
yen = \302\245
```

Example 5-11 shows how to combine regular expressions with this dictionary to translate entities in a string (the opposite of `cgi.escape`).

Example 5-11. Using the htmlentitydefs Module to Translate Entities

```
File: htmlentitydefs-example-2.py

import htmlentitydefs
import re
import cgi

pattern = re.compile("&(\w+?);")

def descape_entity(m, defs=htmlentitydefs.entitydefs):
    # callback: translate one entity to its ISO Latin value
    try:
        return defs[m.group(1)]
    except KeyError:
        return m.group(0) # use as is

def descape(string):
    return pattern.sub(descape_entity, string)

print descape("&lt;spam&amp;eggs&gt;")
print descape(cgi.escape("<spam&eggs>"))

<spam&eggs>
<spam&eggs>
```

Finally, Example 5-12 shows how to use translate reserved XML characters and ISO Latin-1 characters to an XML string. This is similar to `cgi.escape`, but it also replaces non-ASCII characters.

Example 5-12. Escaping ISO Latin-1 Entities

```
File: htmlentitydefs-example-3.py

import htmlentitydefs
import re, string

# this pattern matches substrings of reserved and non-ASCII characters
pattern = re.compile(r"[&<>\"\x80-\xff]+")

# create character map
entity_map = {}

for i in range(256):
    entity_map[chr(i)] = "&%d;" % i

for entity, char in htmlentitydefs.entitydefs.items():
    if entity_map.has_key(char):
        entity_map[char] = "&%s;" % entity

def escape_entity(m, get=entity_map.get):
    return string.join(map(get, m.group()), "")

def escape(string):
    return pattern.sub(escape_entity, string)

print escape("<spam&eggs>")
print escape("\303\245 i \303\245a \303\244 e \303\266")

&lt;spam&amp;eggs&gt;
&aring; i &aring;a &auml; e &ouml;
```

5.7 The formatter Module

The `formatter` module provides formatter classes that can be used together with the `htmllib` module.

This module provides two class families, *formatters* and *writers*. Formatters convert a stream of tags and data strings from the HTML parser into an event stream suitable for an output device, and writers render that event stream on an output device. Example 5-13 demonstrates.

In most cases, you can use the *AbstractFormatter* class to do the formatting. It calls methods on the writer object, representing different kinds of formatting events. The *AbstractWriter* class simply prints a message for each method call.

Example 5-13. Using the formatter Module to Convert HTML to an Event Stream

```
File: formatter-example-1.py

import formatter
import htmllib

w = formatter.AbstractWriter()
f = formatter.AbstractFormatter(w)

file = open("samples/sample.htm")

p = htmllib.HTMLParser(f)
p.feed(file.read())
p.close()

file.close()

send_paragraph(1)
new_font(('h1', 0, 1, 0))
send_flowing_data('A Chapter.')
send_line_break()
send_paragraph(1)
new_font(None)
send_flowing_data('Some text. Some more text. Some')
send_flowing_data(' ')
new_font((None, 1, None, None))
send_flowing_data('emphasized')
new_font(None)
send_flowing_data(' text. A')
send_flowing_data(' link')
send_flowing_data('[1]')
send_flowing_data('.'
```

In addition to the *AbstractWriter* class, the `formatter` module provides a *NullWriter* class, which ignores all events passed to it, and a *DumbWriter* class that converts the event stream to a plain text document, as shown in Example 5-14.

Example 5-14. Using the formatter Module to Convert HTML to Plain Text

```
File: formatter-example-2.py

import formatter
import htmllib

w = formatter.DumbWriter() # plain text
f = formatter.AbstractFormatter(w)

file = open("samples/sample.htm")

# print html body as plain text
p = htmllib.HTMLParser(f)
p.feed(file.read())
p.close()

file.close()

# print links
print
print
i = 1
for link in p.anchorlist:
    print i, "=>", link
    i = i + 1
```

```
A Chapter.

Some text. Some more text. Some emphasized text. A link[1].

1 => http://www.python.org
```

Example 5-15 provides a custom *Writer*, which in this case is subclassed from the *DumbWriter* class. This version keeps track of the current font style and tweaks the output somewhat depending on the font.

Example 5-15. Using the formatter Module with a Custom Writer

```
File: formatter-example-3.py

import formatter
import htmllib, string

class Writer(formatter.DumbWriter):

    def _ _init_ _(self):
        formatter.DumbWriter._ _init_ _(self)
        self.tag = ""
        self.bold = self.italic = 0
        self.fonts = []

    def new_font(self, font):
        if font is None:
            font = self.fonts.pop()
            self.tag, self.bold, self.italic = font
```

```
        else:
            self.fonts.append((self.tag, self.bold, self.italic))
            tag, bold, italic, typewriter = font
            if tag is not None:
                self.tag = tag
            if bold is not None:
                self.bold = bold
            if italic is not None:
                self.italic = italic

    def send_flowing_data(self, data):
        if not data:
            return
        atbreak = self.atbreak or data[0] in string.whitespace
        for word in string.split(data):
            if atbreak:
                self.file.write(" ")
            if self.tag in ("h1", "h2", "h3"):
                word = string.upper(word)
            if self.bold:
                word = "*" + word + "*"
            if self.italic:
                word = "_" + word + "_"
            self.file.write(word)
            atbreak = 1
        self.atbreak = data[-1] in string.whitespace

w = Writer()
f = formatter.AbstractFormatter(w)

file = open("samples/sample.htm")

# print html body as plain text
p = htmllib.HTMLParser(f)
p.feed(file.read())
p.close()
```

```
_A_ _CHAPTER._

Some text. Some more text. Some *emphasized* text. A link[1].
```

5.8 The ConfigParser Module

The `ConfigParser` module reads configuration files.

The files should be written in a format similar to Windows INI files. The file contains one or more sections, separated by section names written in brackets. Each section can contain one or more configuration items.

Here's the sample file used in Example 5-16:

```
[book]
title: The Python Standard Library
author: Fredrik Lundh
email: fredrik@pythonware.com
version: 2.0-001115

[ematter]
pages: 250

[hardcopy]
pages: 350
```

Example 5-16 uses the `ConfigParser` module to read the sample configuration file.

Example 5-16. Using the ConfigParser Module

```
File: configparser-example-1.py

import ConfigParser
import string

config = ConfigParser.ConfigParser()

config.read("samples/sample.ini")

# print summary
print
print string.upper(config.get("book", "title"))
print "by", config.get("book", "author"),
print  "(" + config.get("book", "email") + ")"
print
print config.get("ematter", "pages"), "pages"
print

# dump entire config file
for section in config.sections():
    print section
    for option in config.options(section):
        print " ", option, "=", config.get(section, option)

THE PYTHON STANDARD LIBRARY
by Fredrik Lundh (fredrik@pythonware.com)
```

```
250 pages

book
  title = The Python Standard Library
  email = fredrik@pythonware.com
  author = Fredrik Lundh
  version = 2.0-001115
  _ _name_ _ = book
ematter
  _ _name_ _ = ematter
  pages = 250
hardcopy
  _ _name_ _ = hardcopy
  pages = 350
```

In Python 2.0, the `ConfigParser` module also allows you to write configuration data to a file, as Example 5-17 shows.

Example 5-17. Using the ConfigParser Module to Write Configuration Data

```
File: configparser-example-2.py

import ConfigParser
import sys

config = ConfigParser.ConfigParser()

# set a number of parameters
config.add_section("book")
config.set("book", "title", "the python standard library")
config.set("book", "author", "fredrik lundh")

config.add_section("ematter")
config.set("ematter", "pages", 250)

# write to screen
config.write(sys.stdout)

[book]
title = the python standard library
author = fredrik lundh

[ematter]
pages = 250
```

5.9 The netrc Module

The `netrc` module parses *.netrc* configuration files, as shown in Example 5-18. Such files are used to store FTP usernames and passwords in a user's home directory (don't forget to configure things so that the file can only be read by the user: "`chmod 0600 ~/.netrc`," in other words).

Example 5-18. Using the netrc Module

```
File: netrc-example-1.py

import netrc


# default is $HOME/.netrc
info = netrc.netrc("samples/sample.netrc")

login, account, password = info.authenticators("secret.fbi")
print "login", "=>", repr(login)
print "account", "=>", repr(account)
print "password", "=>", repr(password)

login => 'mulder'
account => None
password => 'trustno1'
```

5.10 The shlex Module

The `shlex` module provides a simple lexer (also known as tokenizer) for languages based on the Unix shell syntax. Its use is demonstrated in Example 5-19.

Example 5-19. Using the shlex Module

```
File: shlex-example-1.py

import shlex

lexer = shlex.shlex(open("samples/sample.netrc", "r"))
lexer.wordchars = lexer.wordchars + "._"

while 1:
    token = lexer.get_token()
    if not token:
        break
    print repr(token)

'machine'
'secret.fbi'
'login'
'mulder'
'password'
'trustno1'
'machine'
'non.secret.fbi'
'login'
'scully'
'password'
'noway'
```

5.11 The zipfile Module

(New in 2.0) The `zipfile` module allows you to read and write files in the popular ZIP archive format.

5.11.1 Listing the Contents

To list the contents of an existing archive, you can use the `namelist` and `infolist` methods used in Example 5-20. The former returns a list of filenames, and the latter returns a list of *ZipInfo* instances.

Example 5-20. Using the zipfile Module to List Files in a ZIP File

```
File: zipfile-example-1.py

import zipfile

file = zipfile.ZipFile("samples/sample.zip", "r")

# list filenames
for name in file.namelist():
    print name,
print

# list file information
for info in file.infolist():
    print info.filename, info.date_time, info.file_size

sample.txt sample.jpg
sample.txt (1999, 9, 11, 20, 11, 8) 302
sample.jpg (1999, 9, 18, 16, 9, 44) 4762
```

5.11.2 Reading Data from a ZIP File

To read data from an archive, simply use the `read` method used in Example 5-21. It takes a filename as an argument and returns the data as a string.

Example 5-21. Using the zipfile Module to Read Data from a ZIP File

```
File: zipfile-example-2.py

import zipfile

file = zipfile.ZipFile("samples/sample.zip", "r")

for name in file.namelist():
    data = file.read(name)
    print name, len(data), repr(data[:10])

sample.txt 302 'We will pe'
```

```
sample.jpg 4762 '\377\330\377\340\000\020JFIF'
```

5.11.3 Writing Data to a ZIP File

Adding files to an archive is easy. Just pass the filename, and the name you want that file to have in the archive, to the `write` method.

The script in Example 5-22 creates a ZIP file containing all files in the `samples` directory.

Example 5-22. Using the zipfile Module to Store Files in a ZIP File

```
File: zipfile-example-3.py

import zipfile
import glob, os

# open the zip file for writing, and write stuff to it

file = zipfile.ZipFile("test.zip", "w")

for name in glob.glob("samples/*"):
    file.write(name, os.path.basename(name), zipfile.ZIP_DEFLATED)

file.close()

# open the file again, to see what's in it

file = zipfile.ZipFile("test.zip", "r")
for info in file.infolist():
    print info.filename, info.date_time, info.file_size, info.compress_size

sample.wav (1999, 8, 15, 21, 26, 46) 13260 10985
sample.jpg (1999, 9, 18, 16, 9, 44) 4762 4626
sample.au (1999, 7, 18, 20, 57, 34) 1676 1103
...
```

The third, optional argument to the `write` method controls what compression method to use or, rather, it controls whether data should be compressed at all. The default is `zipfile.ZIP_STORED`, which stores the data in the archive without any compression at all. If the `zlib` module is installed, you can also use `zipfile.ZIP_DEFLATED`, which gives you "deflate" compression.

The `zipfile` module also allows you to add strings to the archive. However, adding data from a string is a bit tricky; instead of just passing in the archive name and the data, you have to create a *ZipInfo* instance and configure it correctly. Example 5-23 offers a simple solution.

Example 5-23. Using the zipfile Module to Store Strings in a ZIP File

```
File: zipfile-example-4.py

import zipfile
import glob, os, time

file = zipfile.ZipFile("test.zip", "w")
```

```
now = time.localtime(time.time())[:6]

for name in ("life", "of", "brian"):
    info = zipfile.ZipInfo(name)
    info.date_time = now
    info.compress_type = zipfile.ZIP_DEFLATED
    file.writestr(info, name*1000)

file.close()

# open the file again, to see what's in it

file = zipfile.ZipFile("test.zip", "r")

for info in file.infolist():
    print info.filename, info.date_time, info.file_size, info.compress_size
```

```
life (2000, 12, 1, 0, 12, 1) 4000 26
of (2000, 12, 1, 0, 12, 1) 2000 18
brian (2000, 12, 1, 0, 12, 1) 5000 31
```

5.12 The gzip Module

The gzip module allows you to read and write gzip-compressed files as if they were ordinary files, as shown in Example 5-24.

Example 5-24. Using the gzip Module to Read a Compressed File

```
File: gzip-example-1.py

import gzip

file = gzip.GzipFile("samples/sample.gz")

print file.read()

Well it certainly looks as though we're in for
a splendid afternoon's sport in this the 127th
Upperclass Twit of the Year Show.
```

The standard implementation doesn't support the seek and tell methods. Example 5-25 shows how to add forward seeking.

Example 5-25. Extending the gzip Module to Support seek/tell

```
File: gzip-example-2.py

import gzip

class gzipFile(gzip.GzipFile):
    # adds seek/tell support to GzipFile

    offset = 0

    def read(self, size=None):
        data = gzip.GzipFile.read(self, size)
        self.offset = self.offset + len(data)
        return data

    def seek(self, offset, whence=0):
        # figure out new position (we can only seek forwards)
        if whence == 0:
            position = offset
        elif whence == 1:
            position = self.offset + offset
        else:
            raise IOError, "Illegal argument"
        if position < self.offset:
            raise IOError, "Cannot seek backwards"

        # skip forward, in 16k blocks
```

```
        while position > self.offset:
            if not self.read(min(position - self.offset, 16384)):
                break

    def tell(self):
        return self.offset

#
# try it

file = gzipFile("samples/sample.gz")
file.seek(80)

print file.read()
```

```
this the 127th
Upperclass Twit of the Year Show.
```

Chapter 6. Mail and News Message Processing

"To be removed from our list of future commercial postings by [SOME] PUBLISHING COMPANY an Annual Charge of Ninety Five dollars is required. Just send $95.00 with your Name, Address and Name of the Newsgroup to be removed from our list."

—Newsgroup spammer, July 1996

6.1 Overview

Python comes with a rich set of modules for processing mail and news messages, as well as some common mail archive (mailbox) formats.

6.2 The rfc822 Module

The `rfc822` module contains a parser for mail and news messages (and any other messages that conform to the RFC 822 standard, such as HTTP headers).

Basically, an RFC 822–style message consists of a number of header fields, followed by at least one blank line, and the message body itself.

For example, here's a short mail message. The first five lines make up the message header, and the actual message (a single line, in this case) follows after an empty line:

```
Message-Id: <20001114144603.00abb310@oreilly.com>
Date: Tue, 14 Nov 2000 14:55:07 -0500
To: "Fredrik Lundh" <fredrik@effbot.org>
From: Frank
Subject: Re: python library book!

Where is it?
```

Example 6-1 shows how the message parser reads the headers and returns a dictionary-like object, with the message headers as keys.

Example 6-1. Using the rfc822 Module

```
File: rfc822-example-1.py

import rfc822

file = open("samples/sample.eml")

message = rfc822.Message(file)

for k, v in message.items():
    print k, "=", v

print len(file.read()), "bytes in body"

subject = Re: python library book!
from = "Frank" <your@editor>
message-id = <20001114144603.00abb310@oreilly.com>
to = "Fredrik Lundh" <fredrik@effbot.org>
date = Tue, 14 Nov 2000 14:55:07 -0500
25 bytes in body
```

The message object also provides a couple of convenience methods, which parse address fields and dates for you, as shown in Example 6-2.

Example 6-2. Parsing Header Fields Using the rfc822 Module

```
File: rfc822-example-2.py
```

```
import rfc822

file = open("samples/sample.eml")

message = rfc822.Message(file)

print message.getdate("date")
print message.getaddr("from")
print message.getaddrlist("to")

(2000, 11, 14, 14, 55, 7, 0, 0, 0)
('Frank', 'your@editor')
[('Fredrik Lundh', 'fredrik@effbot.org')]
```

The address fields are parsed into (mail, real name) tuples. The date field is parsed into a 9-element time tuple, ready for use with the `time` module.

6.3 The mimetools Module

The *Multipurpose Internet Mail Extensions* (MIME) standard defines how to store non-ASCII text, images, and other data in RFC 822-style messages.

The `mimetools` module, shown in Example 6-3, contains a number of tools for writing programs that read or write MIME messages. Among other things, it contains a version of the `rfc822` module's *Message* class, which knows a bit more about MIME encoded messages.

Example 6-3. Using the mimetools Module

```
File: mimetools-example-1.py

import mimetools

file = open("samples/sample.msg")

msg = mimetools.Message(file)

print "type", "=>", msg.gettype()
print "encoding", "=>", msg.getencoding()
print "plist", "=>", msg.getplist()

print "header", "=>"
for k, v in msg.items():
    print "  ", k, "=", v

type => text/plain
encoding => 7bit
plist => ['charset="iso-8859-1"']
header =>
   mime-version = 1.0
   content-type = text/plain;
 charset="iso-8859-1"
   to = effbot@spam.egg
   date = Fri, 15 Oct 1999 03:21:15 -0400
   content-transfer-encoding = 7bit
   from = "Fredrik Lundh" <fredrik@pythonware.com>
   subject = By the way...
...
```

6.4 The MimeWriter Module

The `MimeWriter` module (shown in Example 6-4) can be used to write "multipart" messages, as defined by the MIME mail standard.

Example 6-4. Using the MimeWriter Module

```
File: mimewriter-example-1.py

import MimeWriter

# data encoders
import quopri
import base64
import StringIO

import sys

TEXT = """
here comes the image you asked for.  hope
it's what you expected.

</F>"""

FILE = "samples/sample.jpg"

file = sys.stdout

#
# create a mime multipart writer instance

mime = MimeWriter.MimeWriter(file)
mime.addheader("Mime-Version", "1.0")

mime.startmultipartbody("mixed")

# add a text message

part = mime.nextpart()
part.addheader("Content-Transfer-Encoding", "quoted-printable")
part.startbody("text/plain")

quopri.encode(StringIO.StringIO(TEXT), file, 0)

# add an image

part = mime.nextpart()
part.addheader("Content-Transfer-Encoding", "base64")
part.startbody("image/jpeg")

base64.encode(open(FILE, "rb"), file)
```

```
mime.lastpart()
```

The output looks something like:

```
Content-Type: multipart/mixed;
    boundary='host.1.-852461.936831373.130.24813'

--host.1.-852461.936831373.130.24813
Content-Type: text/plain
Context-Transfer-Encoding: quoted-printable

here comes the image you asked for.  hope
it's what you expected.

</F>

--host.1.-852461.936831373.130.24813
Content-Type: image/jpeg
Context-Transfer-Encoding: base64

/9j/4AAQSkZJRgABAQAAAQABAAD/2wBDAAgGBgcGBQgHBwcJCQgKDBQNDAsLDBkSEw8UHRof
HBwgJC4nICIsIxwcKDcpLDAxNDQ0Hyc5PTgyPC4zNDL/2wBDAQkJCQwLDBgNDRgyIRwhMjIy
...
1e5vLrSYbJnEVpEgjCLx5mPU0qsVK0UaxjdNlS+1U6pfzTR8IzEhj2HrVG6m8m18xc8cIKSC
tCuFyC746j/Cq2pTia4WztfmKjGBXTCmo6IUpt==

--host.1.-852461.936831373.130.24813--
```

Example 6-5, which is a bit larger, uses a helper class that stores each subpart in the most suitable way.

Example 6-5. A Helper Class for the MimeWriter Module

```
File: mimewriter-example-2.py

import MimeWriter
import string, StringIO, sys
import re, quopri, base64

# check if string contains non-ascii characters
must_quote = re.compile("[\177-\377]").search


#
# encoders

def encode_quoted_printable(infile, outfile):
    quopri.encode(infile, outfile, 0)

class Writer:

    def _ _init_ _(self, file=None, blurb=None):
        if file is None:
            file = sys.stdout
        self.file = file
```

```
        self.mime = MimeWriter.MimeWriter(file)
        self.mime.addheader("Mime-Version", "1.0")

        file = self.mime.startmultipartbody("mixed")
        if blurb:
            file.write(blurb)

    def close(self):
        "End of message"
        self.mime.lastpart()
        self.mime = self.file = None

    def write(self, data, mimetype="text/plain"):
        "Write data from string or file to message"

        # data is either an opened file or a string
        if type(data) is type(""):
            file = StringIO.StringIO(data)
        else:
            file = data
            data = None

        part = self.mime.nextpart()

        typ, subtyp = string.split(mimetype, "/", 1)

        if typ == "text":

            # text data
            encoding = "quoted-printable"
            encoder = lambda i, o: quopri.encode(i, o, 0)

            if data and not must_quote(data):
                # copy, don't encode
                encoding = "7bit"
                encoder = None

        else:

            # binary data (image, audio, application, ...)
            encoding = "base64"
            encoder = base64.encode

        #
        # write part headers

        if encoding:
            part.addheader("Content-Transfer-Encoding", encoding)

        part.startbody(mimetype)

        #
        # write part body

        if encoder:
            encoder(file, self.file)
```

```
        elif data:
            self.file.write(data)
        else:
            while 1:
                data = infile.read(16384)
                if not data:
                    break
                outfile.write(data)

#
# try it out

BLURB = "if you can read this, your mailer is not MIME-aware\n"

mime = Writer(sys.stdout, BLURB)

# add a text message
mime.write("""\
here comes the image you asked for.  hope
it's what you expected.
""", "text/plain")

# add an image
mime.write(open("samples/sample.jpg", "rb"), "image/jpeg")

mime.close()
```

6.5 The mailbox Module

The `mailbox` module contains code that deals with a number of different mailbox formats (mostly Unix formats), as shown in Example 6-6. Most mailbox formats simply store plain RFC 822–style messages in a long text file, using some kind of separator line to tell one message from another.

Example 6-6. Using the mailbox Module

```
File: mailbox-example-1.py

import mailbox

mb = mailbox.UnixMailbox(open("/var/spool/mail/effbot"))

while 1:
    msg = mb.next()
    if not msg:
        break
    for k, v in msg.items():
        print k, "=", v
    body = msg.fp.read()
    print len(body), "bytes in body"

subject = for he's a ...
message-id = <199910150027.CAA03202@spam.egg>
received = (from fredrik@pythonware.com)
 by spam.egg (8.8.7/8.8.5) id CAA03202
 for effbot; Fri, 15 Oct 1999 02:27:36 +0200
from = Fredrik Lundh <fredrik@pythonware.com>
date = Fri, 15 Oct 1999 12:35:36 +0200
to = effbot@spam.egg
1295 bytes in body
```

6.6 The mailcap Module

The `mailcap` module in Example 6-7 contains code that deals with *mailcap* files, which contain information on how to handle different document formats (on Unix platforms).

Example 6-7. Using the mailcap Module to Get a Capability Dictionary

```
File: mailcap-example-1.py

import mailcap

caps = mailcap.getcaps()

for k, v in caps.items():
    print k, "=", v

image/* = [{'view': 'pilview'}]
application/postscript = [{'view': 'ghostview'}]
```

In Example 6-7, the system uses `pilview` for all kinds of images, and `ghostscript` viewer for PostScript documents. Example 6-8 shows how to find a viewer using `mailcap`.

Example 6-8. Using the mailcap Module to Find a Viewer

```
File: mailcap-example-2.py

import mailcap

caps = mailcap.getcaps()

command, info = mailcap.findmatch(
    caps, "image/jpeg", "view", "samples/sample.jpg"
    )

print command

pilview samples/sample.jpg
```

6.7 The mimetypes Module

The `mimetypes` module contains support for determining the MIME type for a given uniform resource locator. This is based on a built-in table, plus Apache and Netscape configuration files, if they are found. This module is demonstrated in Example 6-9.

Example 6-9. Using the mimetypes Module

```
File: mimetypes-example-1.py

import mimetypes
import glob, urllib

for file in glob.glob("samples/*"):
    url = urllib.pathname2url(file)
    print file, mimetypes.guess_type(url)

samples\sample.au ('audio/basic', None)
samples\sample.ini (None, None)
samples\sample.jpg ('image/jpeg', None)
samples\sample.msg (None, None)
samples\sample.tar ('application/x-tar', None)
samples\sample.tgz ('application/x-tar', 'gzip')
samples\sample.txt ('text/plain', None)
samples\sample.wav ('audio/x-wav', None)
samples\sample.zip ('application/zip', None)
```

6.8 The packmail Module

(Obsolete) The `packmail` module contains tools to create Unix *shell archives.* If you have the right tools installed (if you have a Unix box, they are installed), you can unpack such an archive simply by executing it. Example 6-10 shows how to pack a single file using `packmail`, while Example 6-11 shows how the module can pack an entire directory tree.

Example 6-10. Using the packmail Module to Pack a Single File

```
File: packmail-example-1.py

import packmail
import sys

packmail.pack(sys.stdout, "samples/sample.txt", "sample.txt")

echo sample.txt
sed "s/^X//" >sample.txt <<"!"
XWe will perhaps eventually be writing only small
Xmodules, which are identified by name as they are
Xused to build larger ones, so that devices like
Xindentation, rather than delimiters, might become
Xfeasible for expressing local structure in the
Xsource language.
X     -- Donald E. Knuth, December 1974
!
```

Example 6-11. Using the packmail Module to Pack an Entire Directory Tree

```
File: packmail-example-2.py

import packmail
import sys

packmail.packtree(sys.stdout, "samples")
```

Note that this module cannot handle binary files, such as sound snippets and images.

6.9 The mimify Module

The `mimify` module converts MIME-encoded text messages from encoded formats to plain text (typically ISO Latin 1), and back. It can be used as a command-line tool and as a conversion filter for certain mail agents:

```
$ mimify.py -e raw-message mime-message
$ mimify.py -d mime-message raw-message
```

It can also be used as a module, as shown in Example 6-12.

Example 6-12. Using the mimify Module to Decode a Message

```
File: mimify-example-1.py

import mimify
import sys

mimify.unmimify("samples/sample.msg", sys.stdout, 1)
```

Here's a MIME message containing two parts, one encoded as quoted-printable and the other as base64. The third argument to `unmimify` controls whether base64-encoded parts should be decoded or not:

```
MIME-Version: 1.0
Content-Type: multipart/mixed; boundary='boundary'

this is a multipart sample file.  the two
parts both contain ISO Latin 1 text, with
different encoding techniques.

--boundary
Content-Type: text/plain
Content-Transfer-Encoding: quoted-printable

sillmj=F6lke! blindstyre! medisterkorv!

--boundary
Content-Type: text/plain
Content-Transfer-Encoding: base64

a29tIG5lciBiYXJhLCBvbSBkdSB09nJzIQ==

--boundary--
```

Here's the decoded result (much more readable, at least if you know the language):

```
MIME-Version: 1.0
Content-Type: multipart/mixed; boundary= 'boundary'

this is a multipart sample file.  the two
parts both contain ISO Latin 1 text, with
different encoding techniques.
```

```
--boundary
Content-Type: text/plain

sillmjölke! blindstyre! medisterkorv!

--boundary
Content-Type: text/plain

kom ner bara, om du törs!
```

Example 6-13 demonstrates that encoding messages is just as easy.

Example 6-13. Using the mimify Module to Encode a Message

```
File: mimify-example-2.py

import mimify
import StringIO, sys

#
# decode message into a string buffer

file = StringIO.StringIO()

mimify.unmimify("samples/sample.msg", file, 1)

#
# encode message from string buffer

file.seek(0) # rewind

mimify.mimify(file, sys.stdout)
```

6.10 The multifile Module

The `multifile` module is a support module that allows you to treat each part of a multipart MIME message as an individual file, as shown in Example 6-14.

Example 6-14. Using the multifile Module

```
File: multifile-example-1.py

import multifile
import cgi, rfc822

infile = open("samples/sample.msg")

message = rfc822.Message(infile)

# print parsed header
for k, v in message.items():
    print k, "=", v

# use cgi support function to parse content-type header
type, params = cgi.parse_header(message["content-type"])

if type[:10] == "multipart/":

    # multipart message
    boundary = params["boundary"]

    file = multifile.MultiFile(infile)

    file.push(boundary)

    while file.next():

        submessage = rfc822.Message(file)

        # print submessage
        print "-" * 68
        for k, v in submessage.items():
            print k, "=", v
        print
        print file.read()

    file.pop()

else:

    # plain message
    print infile.read()
```

Chapter 7. Network Protocols

"Increasingly, people seem to misinterpret complexity as sophistication, which is baffling—the incomprehensible should cause suspicion rather than admiration. Possibly this trend results from a mistaken belief that using a somewhat mysterious device confers an aura of power on the user."

—Niklaus Wirth

7.1 Overview

This chapter describes Python's socket protocol support and the networking modules built on top of the `socket` module. These include client handlers for most popular Internet protocols, as well as several frameworks that can be used to implement Internet servers.

For the low-level examples in this chapter, I'll use two protocols for illustration: the Internet Time Protocol and the Hypertext Transfer Protocol.

7.1.1 Internet Time Protocol

The Internet Time Protocol (RFC 868, Postel and Harrenstien, 1983) is a simple protocol that allows a network client to get the current time from a server.

Since this protocol is relatively lightweight, many (but far from all) Unix systems provide this service. It's also about as easy to implement as a network protocol can possibly be. The server simply waits for a connection request and immediately returns the current time as a 4-byte integer containing the number of seconds since January 1, 1900.

In fact, the protocol is so simple that I can include the entire specification:

```
File: rfc868.txt

Network Working Group                                  J. Postel - ISI
Request for Comments: 868                        K. Harrenstien - SRI
                                                              May 1983

                              Time Protocol

This RFC specifies a standard for the ARPA Internet community.  Hosts on
the ARPA Internet that choose to implement a Time Protocol are expected
to adopt and implement this standard.

This protocol provides a site-independent, machine readable date and
time.  The Time service sends back to the originating source the time in
seconds since midnight on January first 1900.

One motivation arises from the fact that not all systems have a
date/time clock, and all are subject to occasional human or machine
error.  The use of time-servers makes it possible to quickly confirm or
correct a system's idea of the time, by making a brief poll of several
independent sites on the network.

This protocol may be used either above the Transmission Control Protocol
(TCP) or above the User Datagram Protocol (UDP).

When used via TCP the time service works as follows:

   S: Listen on port 37 (45 octal).
   U: Connect to port 37.
```

```
   S: Send the time as a 32 bit binary number.
   U: Receive the time.
   U: Close the connection.
   S: Close the connection.

   The server listens for a connection on port 37.  When the connection
   is established, the server returns a 32-bit time value and closes the
   connection.  If the server is unable to determine the time at its
   site, it should either refuse the connection or close it without
   sending anything.

When used via UDP the time service works as follows:

   S: Listen on port 37 (45 octal).
   U: Send an empty datagram to port 37.
   S: Receive the empty datagram.
   S: Send a datagram containing the time as a 32 bit binary number.
   U: Receive the time datagram.

   The server listens for a datagram on port 37.  When a datagram
   arrives, the server returns a datagram containing the 32-bit time
   value.  If the server is unable to determine the time at its site, it
   should discard the arriving datagram and make no reply.

The Time

The time is the number of seconds since 00:00 (midnight) 1 January 1900
GMT, such that the time 1 is 12:00:01 am on 1 January 1900 GMT; this
base will serve until the year 2036.

For example:

   the time  2,208,988,800 corresponds to 00:00  1 Jan 1970 GMT,
             2,398,291,200 corresponds to 00:00  1 Jan 1976 GMT,
             2,524,521,600 corresponds to 00:00  1 Jan 1980 GMT,
             2,629,584,000 corresponds to 00:00  1 May 1983 GMT,
        and -1,297,728,000 corresponds to 00:00 17 Nov 1858 GMT.
```

7.1.2 Hypertext Transfer Protocol

The Hypertext Transfer Protocol (HTTP, RFC 2616, Fielding et al.) is something completely different. The most recent specification (Version 1.1) is over 100 pages.

In its simplest form, this protocol is very straightforward. To fetch a document, the client connects to the server and sends a request such as the following:

```
GET /hello.txt HTTP/1.0
Host: hostname
User-Agent: name

[optional request body]
```

In return, the server returns a response like this:

```
HTTP/1.0 200 OK
Content-Type: text/plain
```

```
Content-Length: 7

Hello
```

Both the request and response headers usually contain more fields, but the `Host` field in the request header is the only one that must always be present.

The header lines are separated by "`\r\n`", and the header must be followed by an empty line, even if there is no body (this applies to both the request and the response).

The rest of the HTTP specification deals with stuff like content negotiation, cache mechanics, persistent connections, and much more. For the full story, see *Hypertext TransferProtocol—HTTP/1.1* (http://www.w3.org/Protocols).

7.2 The socket Module

The `socket` module implements an interface to the socket communication layer. You can create both client and server sockets using this module.

Let's start with a client example. The client in Example 7-1 connects to a time protocol server, reads the 4-byte response, and converts it to a time value.

Example 7-1. Using the socket Module to Implement a Time Client

```
File: socket-example-1.py

import socket
import struct, time

# server
HOST = "www.python.org"
PORT = 37

# reference time (in seconds since 1900-01-01 00:00:00)
TIME1970 = 2208988800L # 1970-01-01 00:00:00

# connect to server
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.connect((HOST, PORT))

# read 4 bytes, and convert to time value
t = s.recv(4)
t = struct.unpack("!I", t)[0]
t = int(t - TIME1970)

s.close()

# print results
print "server time is", time.ctime(t)
print "local clock is", int(time.time()) - t, "seconds off"

server time is Sat Oct 09 16:42:36 1999
local clock is 8 seconds off
```

The `socket` factory function creates a new socket of the given type (in this case, an Internet stream socket, also known as a TCP socket). The `connect` method attempts to connect this socket to the given server. Once that has succeeded, the `recv` method is used to read data.

Creating a server socket is done in a similar fashion. But instead of connecting to a server, you `bind` the socket to a port on the local machine, tell it to `listen` for incoming connection requests, and process each request as fast as possible.

Example 7-2 creates a time server, bound to port 8037 on the local machine (port numbers up to 1024 are reserved for system services, and you have to have root privileges to use them to implement services on a Unix system).

Example 7-2. Using the socket Module to Implement a Time Server

```
File: socket-example-2.py

import socket
import struct, time

# user-accessible port
PORT = 8037

# reference time
TIME1970 = 2208988800L

# establish server
service = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
service.bind(("", PORT))
service.listen(1)

print "listening on port", PORT

while 1:
    # serve forever
    channel, info = service.accept()
    print "connection from", info
    t = int(time.time()) + TIME1970
    t = struct.pack("!I", t)
    channel.send(t) # send timestamp
    channel.close() # disconnect

listening on port 8037
connection from ('127.0.0.1', 1469)
connection from ('127.0.0.1', 1470)
...
```

The `listen` call tells the socket that we're willing to accept incoming connections. The argument gives the size of the connection queue (which holds connection requests that our program hasn't gotten around to processing yet). Finally, the `accept` loop returns the current time to any client bold enough to connect.

Note that the `accept` function returns a new socket object, which is directly connected to the client. The original socket is only used to establish the connection; all further traffic goes via the new socket.

To test this server, we can use Example 7-3, a generalized version of Example 7-1.

Example 7-3. A Time Protocol Client

```
File: timeclient.py

import socket
import struct, sys, time

# default server
host = "localhost"
port = 8037
```

```
# reference time (in seconds since 1900-01-01 00:00:00)
TIME1970 = 2208988800L # 1970-01-01 00:00:00

def gettime(host, port):
    # fetch time buffer from stream server
    s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
    s.connect((host, port))
    t = s.recv(4)
    s.close()
    t = struct.unpack("!I", t)[0]
    return int(t - TIME1970)

if _ _name_ _ == "_ _main_ _":
    # command-line utility
    if sys.argv[1:]:
        host = sys.argv[1]
        if sys.argv[2:]:
            port = int(sys.argv[2])
        else:
            port = 37 # default for public servers

    t = gettime(host, port)
    print "server time is", time.ctime(t)
    print "local clock is", int(time.time()) - t, "seconds off"
```

```
server time is Sat Oct 09 16:58:50 1999
local clock is 0 seconds off
```

The sample script in Example 7-3 can also be used as a module; to get the current time from a server, import the `timeclient` module, then call the `gettime` function.

Thus far, we've used stream (or TCP) sockets. The time protocol specification also mentions UDP sockets, or datagrams. Stream sockets work pretty much like a phone line; you'll know if someone at the remote end picks up the receiver, and you'll notice when she hangs up. In contrast, sending datagrams is more like shouting into a dark room. There might be someone there, but you won't know unless she replies.

Example 7-4 shows that you don't need to connect to send data over a datagram socket. Instead, you use the `sendto` method, which takes both the data and the address of the receiver. To read incoming datagrams, use the `recvfrom` method.

Example 7-4. Using the socket Module to Implement a Datagram Time Client

```
File: socket-example-4.py

import socket
import struct, time

# server
HOST = "localhost"
PORT = 8037

# reference time (in seconds since 1900-01-01 00:00:00)
TIME1970 = 2208988800L # 1970-01-01 00:00:00

# connect to server
```

```
s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)

# send empty packet
s.sendto("", (HOST, PORT))

# read 4 bytes from server, and convert to time value
t, server = s.recvfrom(4)
t = struct.unpack("!I", t)[0]
t = int(t - TIME1970)

s.close()

print "server time is", time.ctime(t)
print "local clock is", int(time.time()) - t, "seconds off"

server time is Sat Oct 09 16:42:36 1999
local clock is 8 seconds off
```

Note that `recvfrom` returns two values: the actual data and the address of the sender. Use the latter if you need to reply.

Example 7-5 shows the corresponding server.

Example 7-5. Using the socket Module to Implement a Datagram Time Server

```
File: socket-example-5.py

import socket
import struct, time

# user-accessible port
PORT = 8037

# reference time
TIME1970 = 2208988800L

# establish server
service = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
service.bind(("", PORT))

print "listening on port", PORT

while 1:
    # serve forever
    data, client = service.recvfrom(0)
    print "connection from", client
    t = int(time.time()) + TIME1970
    t = struct.pack("!I", t)
    service.sendto(t, client) # send timestamp

listening on port 8037
connection from ('127.0.0.1', 1469)
connection from ('127.0.0.1', 1470)
...
```

The main difference is that the server uses `bind` to assign a known port number to the socket and sends data back to the client address returned by `recvfrom`.

7.3 The select Module

This `select` module, shown in Example 7-6, allows you to check for incoming data on one or more sockets, pipes, or other compatible stream objects.

You can pass one or more sockets to the `select` function to wait for them to become readable, writable, or signal an error:

- A socket becomes *ready for reading* when someone connects after a call to `listen` (which means that `accept` won't block) when data arrives from the remote end, or when the socket is closed or reset (in this case, `recv` will return an empty string).
- A socket becomes *ready for writing* when the connection is established after a non-blocking call to `connect` or when data can be written to the socket.
- A socket signals an *error condition* when the connection fails after a non-blocking call to `connect`.

Example 7-6. Using the select Module to Wait for Data Arriving Over Sockets

```
File: select-example-1.py

import select
import socket
import time

PORT = 8037

TIME1970 = 2208988800L

service = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
service.bind(("", PORT))
service.listen(1)

print "listening on port", PORT

while 1:
    is_readable = [service]
    is_writable = []
    is_error = []
    r, w, e = select.select(is_readable, is_writable, is_error, 1.0)
    if r:
        channel, info = service.accept()
        print "connection from", info
        t = int(time.time()) + TIME1970
        t = chr(t>>24&255) + chr(t>>16&255) + chr(t>>8&255) + chr(t&255)
        channel.send(t) # send timestamp
        channel.close() # disconnect
    else:
        print "still waiting"
```

```
listening on port 8037
still waiting
still waiting
connection from ('127.0.0.1', 1469)
still waiting
connection from ('127.0.0.1', 1470)
...
```

In Example 7-6, we wait for the listening socket to become readable, which indicates that a connection request has arrived. We treat the channel socket as usual, since it's not very likely that writing the four bytes will fill the network buffers. If you need to send larger amounts of data to the client, you should add the data to the `is_writable` list at the top of the loop and write only when told to by `select`.

If you set the socket in *non-blocking mode* (by calling the `setblocking` method), you can use `select` to wait for a socket to become connected, but the `asyncore` module (see the next section) provides a powerful framework that handles all this for you, so I won't go into further detail here.

7.4 The asyncore Module

The `asyncore` module provides a "reactive" socket implementation. Instead of creating socket objects and calling methods on them to do things, this module allows you to write code that is called when something can be done. To implement an asynchronous socket handler, subclass the *dispatcher* class, and override one or more of the following methods:

- `handle_connect` is called when a connection is successfully established.
- `handle_expt` is called when a connection fails.
- `handle_accept` is called when a connection request is made to a listening socket. The callback should call the `accept` method to get the client socket.
- `handle_read` is called when there is data waiting to be read from the socket. The callback should call the `recv` method to get the data.
- `handle_write` is called when data can be written to the socket. Use the `send` method to write data.
- `handle_close` is called when the socket is closed or reset.
- `handle_error(type, value, traceback)` is called if a Python error occurs in any of the other callbacks. The default implementation prints an abbreviated traceback to `sys.stdout`.

Example 7-7 shows a time client, similar to the one for the `socket` module.

Example 7-7. Using the asyncore Module to Get the Time from a Time Server

```
File: asyncore-example-1.py

import asyncore
import socket, time

# reference time (in seconds since 1900-01-01 00:00:00)
TIME1970 = 2208988800L # 1970-01-01 00:00:00

class TimeRequest(asyncore.dispatcher):
    # time requestor (as defined in RFC 868)

    def _ _init_ _(self, host, port=37):
        asyncore.dispatcher._ _init_ _(self)
        self.create_socket(socket.AF_INET, socket.SOCK_STREAM)
        self.connect((host, port))

    def writable(self):
        return 0 # don't have anything to write

    def handle_connect(self):
        pass # connection succeeded
```

```
    def handle_expt(self):
        self.close() # connection failed, shutdown

    def handle_read(self):
        # get local time
        here = int(time.time()) + TIME1970

        # get and unpack server time
        s = self.recv(4)
        there = ord(s[3]) + (ord(s[2])<<8) + (ord(s[1])<<16) + (ord(s[0])<<24L)

        self.adjust_time(int(here - there))

        self.handle_close() # we don't expect more data

    def handle_close(self):
        self.close()

    def adjust_time(self, delta):
        # override this method!
        print "time difference is", delta

#
# try it out

request = TimeRequest("www.python.org")

asyncore.loop()

log: adding channel <TimeRequest  at 8cbe90>
time difference is 28
log: closing channel 192:<TimeRequest connected at 8cbe90>
```

If you don't want the log messages, override the `log` method in your *dispatcher* subclass.

Example 7-8 shows the corresponding time server. Note that it uses two *dispatcher* subclasses, one for the listening socket, and one for the client channel.

Example 7-8. Using the asyncore Module to Implement a Time Server

```
File: asyncore-example-2.py

import asyncore
import socket, time

# reference time
TIME1970 = 2208988800L

class TimeChannel(asyncore.dispatcher):

    def handle_write(self):
        t = int(time.time()) + TIME1970
        t = chr(t>>24&255) + chr(t>>16&255) + chr(t>>8&255) + chr(t&255)
        self.send(t)
        self.close()
```

```
class TimeServer(asyncore.dispatcher):

    def __init__(self, port=37):
        self.port = port
        self.create_socket(socket.AF_INET, socket.SOCK_STREAM)
        self.bind(("", port))
        self.listen(5)
        print "listening on port", self.port

    def handle_accept(self):
        channel, addr = self.accept()
        TimeChannel(channel)

server = TimeServer(8037)
asyncore.loop()

log: adding channel <TimeServer  at 8cb940>
listening on port 8037
log: adding channel <TimeChannel  at 8b2fd0>
log: closing channel 52:<TimeChannel connected at 8b2fd0>
```

In addition to the plain *dispatcher*, this module also includes a *dispatcher_with_send* class. This class allows you send larger amounts of data, without clogging up the network transport buffers.

The module in Example 7-9 defines an *AsyncHTTP* class based on the *dispatcher_with_send* class. When you create an instance of this class, it issues an HTTP GET request and sends the incoming data to a "consumer" target object.

Example 7-9. Using the asyncore Module to Do HTTP Requests

```
File: SimpleAsyncHTTP.py

import asyncore
import string, socket
import StringIO
import mimetools, urlparse

class AsyncHTTP(asyncore.dispatcher_with_send):
    # HTTP requester

    def __init__(self, uri, consumer):
        asyncore.dispatcher_with_send.__init__(self)

        self.uri = uri
        self.consumer = consumer

        # turn the uri into a valid request
        scheme, host, path, params, query, fragment = urlparse.urlparse(uri)
        assert scheme == "http", "only supports HTTP requests"
        try:
            host, port = string.split(host, ":", 1)
            port = int(port)
        except (TypeError, ValueError):
            port = 80 # default port
        if not path:
```

```
            path = "/"
        if params:
            path = path + ";" + params
        if query:
            path = path + "?" + query

        self.request = "GET %s HTTP/1.0\r\nHost: %s\r\n\r\n" % (path, host)

        self.host = host
        self.port = port

        self.status = None
        self.header = None

        self.data = ""

        # get things going!
        self.create_socket(socket.AF_INET, socket.SOCK_STREAM)
        self.connect((host, port))

    def handle_connect(self):
        # connection succeeded
        self.send(self.request)

    def handle_expt(self):
        # connection failed; notify consumer (status is None)
        self.close()
        try:
            http_header = self.consumer.http_header
        except AttributeError:
            pass
        else:
            http_header(self)

    def handle_read(self):
        data = self.recv(2048)
        if not self.header:
            self.data = self.data + data
            try:
                i = string.index(self.data, "\r\n\r\n")
            except ValueError:
                return # continue
            else:
                # parse header
                fp = StringIO.StringIO(self.data[:i+4])
                # status line is "HTTP/version status message"
                status = fp.readline()
                self.status = string.split(status, " ", 2)
                # followed by a rfc822-style message header
                self.header = mimetools.Message(fp)
                # followed by a newline, and the payload (if any)
                data = self.data[i+4:]
                self.data = ""
                # notify consumer (status is non-zero)
                try:
                    http_header = self.consumer.http_header
```

```
                except AttributeError:
                    pass
                else:
                    http_header(self)
                if not self.connected:
                    return # channel was closed by consumer

        self.consumer.feed(data)

    def handle_close(self):
        self.consumer.close()
        self.close()
```

Example 7-10 shows a simple script that uses that class.

Example 7-10. Using the SimpleAsyncHTTP Class

```
File: asyncore-example-3.py

import SimpleAsyncHTTP
import asyncore

class DummyConsumer:
    size = 0

    def http_header(self, request):
        # handle header
        if request.status is None:
            print "connection failed"
        else:
            print "status", "=>", request.status
            for key, value in request.header.items():
                print key, "=", value

    def feed(self, data):
        # handle incoming data
        self.size = self.size + len(data)

    def close(self):
        # end of data
        print self.size, "bytes in body"

#
# try it out

consumer = DummyConsumer()

request = SimpleAsyncHTTP.AsyncHTTP(
    "http://www.pythonware.com",
    consumer
    )

asyncore.loop()

log: adding channel <AsyncHTTP  at 8e2850>
```

```
status => ['HTTP/1.1', '200', 'OK\015\012']
server = Apache/Unix (Unix)
content-type = text/html
content-length = 3730
...
3730 bytes in body
log: closing channel 156:<AsyncHTTP connected at 8e2850>
```

Note that the consumer interface is designed to be compatible with the `htmllib` and `xmllib` parsers, allowing you to parse HTML or XML data on the fly. Note that the `http_header` method is optional; if it isn't defined, it's simply ignored.

A problem with Example 7-10 is that it doesn't work for redirected resources. Example 7-11 adds an extra consumer layer, which handles the redirection.

Example 7-11. Using the SimpleAsyncHTTP Class with Redirection

```
File: asyncore-example-4.py

import SimpleAsyncHTTP
import asyncore

class DummyConsumer:
    size = 0

    def http_header(self, request):
        # handle header
        if request.status is None:
            print "connection failed"
        else:
            print "status", "=>", request.status
            for key, value in request.header.items():
                print key, "=", value

    def feed(self, data):
        # handle incoming data
        self.size = self.size + len(data)

    def close(self):
        # end of data
        print self.size, "bytes in body"

class RedirectingConsumer:

    def _ _init_ _(self, consumer):
        self.consumer = consumer

    def http_header(self, request):
        # handle header
        if request.status is None or\
           request.status[1] not in ("301", "302"):
            try:
                http_header = self.consumer.http_header
            except AttributeError:
                pass
```

```
            else:
                return http_header(request)
        else:
            # redirect!
            uri = request.header["location"]
            print "redirecting to", uri, "..."
            request.close()
            SimpleAsyncHTTP.AsyncHTTP(uri, self)

    def feed(self, data):
        self.consumer.feed(data)

    def close(self):
        self.consumer.close()

#
# try it out

consumer = RedirectingConsumer(DummyConsumer())

request = SimpleAsyncHTTP.AsyncHTTP(
    "http://www.pythonware.com/library",
    consumer
    )

asyncore.loop()

log: adding channel <AsyncHTTP  at 8e64b0>
redirecting to http://www.pythonware.com/library/ ...
log: closing channel 48:<AsyncHTTP connected at 8e64b0>
log: adding channel <AsyncHTTP  at 8ea790>
status => ['HTTP/1.1', '200', 'OK\015\012']
server = Apache/Unix (Unix)
content-type = text/html
content-length = 387
...
387 bytes in body
log: closing channel 236:<AsyncHTTP connected at 8ea790>
```

If the server returns status 301 (permanent redirection) or 302 (temporary redirection), the redirecting consumer closes the current request and then issues a new one for the new address. All other calls to the consumer are delegated to the original consumer.

7.5 The asynchat Module

The asynchat module is an extension to asyncore. It provides additional support for line-oriented protocols. It also provides improved buffering support, via the push methods and the "producer" mechanism.

Example 7-12 implements a very minimal HTTP responder. It simply returns an HTML document containing information from an HTTP request (the output appears in the browser window).

Example 7-12. Using the asynchat Module to Implement a Minimal HTTP Server

```
File: asynchat-example-1.py

import asyncore, asynchat
import os, socket, string

PORT = 8000

class HTTPChannel(asynchat.async_chat):

    def _ _init_ _(self, server, sock, addr):
        asynchat.async_chat._ _init_ _(self, sock)
        self.set_terminator("\r\n")
        self.request = None
        self.data = ""
        self.shutdown = 0

    def collect_incoming_data(self, data):
        self.data = self.data + data

    def found_terminator(self):
        if not self.request:
            # got the request line
            self.request = string.split(self.data, None, 2)
            if len(self.request) != 3:
                self.shutdown = 1
            else:
                self.push("HTTP/1.0 200 OK\r\n")
                self.push("Content-type: text/html\r\n")
                self.push("\r\n")
            self.data = self.data + "\r\n"
            self.set_terminator("\r\n\r\n") # look for end of headers
        else:
            # return payload.
            self.push("<html><body><pre>\r\n")
            self.push(self.data)
            self.push("</pre></body></html>\r\n")
            self.close_when_done()

class HTTPServer(asyncore.dispatcher):

    def _ _init_ _(self, port):
```

```
        self.create_socket(socket.AF_INET, socket.SOCK_STREAM)
        self.bind(("", port))
        self.listen(5)

    def handle_accept(self):
        conn, addr = self.accept()
        HTTPChannel(self, conn, addr)

#
# try it out

s = HTTPServer(PORT)
print "serving at port", PORT, "..."
asyncore.loop()
```

```
GET / HTTP/1.1
Accept: */*
Accept-Language: en, sv
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; Bruce/1.0)
Host: localhost:8000
Connection: Keep-Alive
```

The producer interface allows you to "push" objects that are too large to store in memory. `asyncore` calls the producer's `more` method whenever it needs more data. To signal end of file, just return an empty string.

Example 7-13 implements a very simple file-based HTTP server, using a simple *FileProducer* class that reads data from a file, a few kilobytes at the time.

Example 7-13. Using the asynchat Module to Implement a Simple HTTP Server

```
File: asynchat-example-2.py

import asyncore, asynchat
import os, socket, string, sys
import StringIO, mimetools

ROOT = "."

PORT = 8000

class HTTPChannel(asynchat.async_chat):

    def _ _init_ _(self, server, sock, addr):
        asynchat.async_chat._ _init_ _(self, sock)
        self.server = server
        self.set_terminator("\r\n\r\n")
        self.header = None
        self.data = ""
        self.shutdown = 0

    def collect_incoming_data(self, data):
        self.data = self.data + data
        if len(self.data) > 16384:
            # limit the header size to prevent attacks
```

```
            self.shutdown = 1

    def found_terminator(self):
        if not self.header:
            # parse http header
            fp = StringIO.StringIO(self.data)
            request = string.split(fp.readline(), None, 2)
            if len(request) != 3:
                # badly formed request; just shut down
                self.shutdown = 1
            else:
                # parse message header
                self.header = mimetools.Message(fp)
                self.set_terminator("\r\n")
                self.server.handle_request(
                    self, request[0], request[1], self.header
                    )
                self.close_when_done()
            self.data = ""
        else:
            pass # ignore body data, for now

    def pushstatus(self, status, explanation="OK"):
        self.push("HTTP/1.0 %d %s\r\n" % (status, explanation))


class FileProducer:
    # a producer that reads data from a file object

    def _ _init_ _(self, file):
        self.file = file

    def more(self):
        if self.file:
            data = self.file.read(2048)
            if data:
                return data
            self.file = None
        return ""


class HTTPServer(asyncore.dispatcher):

    def _ _init_ _(self, port=None, request=None):
        if not port:
            port = 80
        self.port = port
        if request:
            self.handle_request = request # external request handler
        self.create_socket(socket.AF_INET, socket.SOCK_STREAM)
        self.bind(("", port))
        self.listen(5)

    def handle_accept(self):
        conn, addr = self.accept()
        HTTPChannel(self, conn, addr)
```

```
    def handle_request(self, channel, method, path, header):
        try:
            # this is not safe!
            while path[:1] == "/":
                path = path[1:]
            filename = os.path.join(ROOT, path)
            print path, "=>", filename
            file = open(filename, "r")
        except IOError:
            channel.pushstatus(404, "Not found")
            channel.push("Content-type: text/html\r\n")
            channel.push("\r\n")
            channel.push("<html><body>File not found.</body></html>\r\n")
        else:
            channel.pushstatus(200, "OK")
            channel.push("Content-type: text/html\r\n")
            channel.push("\r\n")
            channel.push_with_producer(FileProducer(file))

#
# try it out

s = HTTPServer(PORT)
print "serving at port", PORT
asyncore.loop()

serving at port 8000
log: adding channel <HTTPServer  at 8e54d0>
log: adding channel <HTTPChannel  at 8e64a0>
samples/sample.htm => .\samples/sample.htm
log: closing channel 96:<HTTPChannel connected at 8e64a0>
```

7.6 The urllib Module

The `urllib` module provides a unified client interface for HTTP, FTP, and gopher. It automatically picks the right protocol handler based on the uniform resource locator (URL) passed to the library.

Fetching data from a URL is extremely easy. Just call the `urlopen` method, and read from the returned stream object, as shown in Example 7-14.

Example 7-14. Using the urllib Module to Fetch a Remote Resource

```
File: urllib-example-1.py

import urllib

fp = urllib.urlopen("http://www.python.org")

op = open("out.html", "wb")

n = 0

while 1:
    s = fp.read(8192)
    if not s:
        break
    op.write(s)
    n = n + len(s)

fp.close()
op.close()

for k, v in fp.headers.items():
    print k, "=", v

print "copied", n, "bytes from", fp.url

server = Apache/1.3.6 (Unix)
content-type = text/html
accept-ranges = bytes
date = Mon, 11 Oct 1999 20:11:40 GMT
connection = close
etag = "741e9-7870-37f356bf"
content-length = 30832
last-modified = Thu, 30 Sep 1999 12:25:35 GMT
copied 30832 bytes from http://www.python.org
```

Note that stream object provides some non-standard attributes. `headers` is a *Message* object (as defined by the `mimetools` module), and `url` contains the actual URL. The latter is updated if the server redirects the client to a new URL.

The `urlopen` function is actually a helper function, which creates an instance of the *FancyURLopener* class and calls its `open` method. To get special behavior, you can subclass that class. For instance, the class in

Example 7-15 automatically logs in to the server when necessary.

Example 7-15. Using the urllib Module with Automatic Authentication

```
File: urllib-example-3.py

import urllib

class myURLOpener(urllib.FancyURLopener):
    # read an URL, with automatic HTTP authentication

    def setpasswd(self, user, passwd):
        self._ _user = user
        self._ _passwd = passwd

    def prompt_user_passwd(self, host, realm):
        return self._ _user, self._ _passwd

urlopener = myURLOpener()
urlopener.setpasswd("mulder", "trustno1")

fp = urlopener.open("http://www.secretlabs.com")
print fp.read()
```

7.7 The urlparse Module

The `urlparse` module contains functions to process URLs, and to convert between URLs and platform-specific filenames. Example 7-16 demonstrates.

Example 7-16. Using the urlparse Module

```
File: urlparse-example-1.py

import urlparse

print urlparse.urlparse("http://host/path;params?query#fragment")

('http', 'host', '/path', 'params', 'query', 'fragment')
```

A common use is to split an HTTP URL into host and path components (an HTTP request involves asking the host to return data identified by the path), as shown in Example 7-17.

Example 7-17. Using the urlparse Module to Parse HTTP Locators

```
File: urlparse-example-2.py

import urlparse

scheme, host, path, params, query, fragment =\
        urlparse.urlparse("http://host/path;params?query#fragment")

if scheme == "http":
    print "host", "=>", host
    if params:
        path = path + ";" + params
    if query:
        path = path + "?" + query
    print "path", "=>", path

host => host
path => /path;params?query
```

Alternatively, Example 7-18 shows how you can use the `urlunparse` function to put the URL back together again.

Example 7-18. Using the urlparse Module to Parse HTTP Locators

```
File: urlparse-example-3.py

import urlparse

scheme, host, path, params, query, fragment =\
```

```
        urlparse.urlparse("http://host/path;params?query#fragment")

if scheme == "http":
    print "host", "=>", host
    print "path", "=>", urlparse.urlunparse(
    (None, None, path, params, query, None)
    )
```

```
host => host
path => /path;params?query
```

Example 7-19 uses the `urljoin` function to combine an absolute URL with a second, possibly relative URL.

Example 7-19. Using the urlparse Module to Combine Relative Locators

```
File: urlparse-example-4.py

import urlparse

base = "http://spam.egg/my/little/pony"

for path in "/index", "goldfish", "../black/cat":
    print path, "=>", urlparse.urljoin(base, path)
```

```
/index => http://spam.egg/index
goldfish => http://spam.egg/my/little/goldfish
../black/cat => http://spam.egg/my/black/cat
```

7.8 The cookie Module

(New in 2.0) This module provides basic cookie support for HTTP clients and servers. Example 7-20 shows its use.

Example 7-20. Using the cookie Module

```
File: cookie-example-1.py

import Cookie
import os, time

cookie = Cookie.SimpleCookie()
cookie["user"] = "Mimi"
cookie["timestamp"] = time.time()

print cookie

# simulate CGI roundtrip
os.environ["HTTP_COOKIE"] = str(cookie)

print

cookie = Cookie.SmartCookie()
cookie.load(os.environ["HTTP_COOKIE"])

for key, item in cookie.items():
    # dictionary items are "Morsel" instances
    # use value attribute to get actual value
    print key, repr(item.value)
```

```
Set-Cookie: timestamp=736513200;
Set-Cookie: user=Mimi;

user 'Mimi'
timestamp '736513200'
```

7.9 The robotparser Module

(New in 2.0) The `robotparser` module reads `robots.txt` files, which are used to implement the *Robot Exclusion Protocol* (http://info.webcrawler.com/mak/projects/robots/robots.html).

If you're implementing an HTTP robot that will visit arbitrary sites on the Net (not just your own sites), it's a good idea to use this module to check that you really are welcome. Example 7-21 demonstrates the `robotparser` module.

Example 7-21. Using the robotparser Module

```
File: robotparser-example-1.py

import robotparser

r = robotparser.RobotFileParser()
r.set_url("http://www.python.org/robots.txt")
r.read()

if r.can_fetch("*", "/index.html"):
    print "may fetch the home page"

if r.can_fetch("*", "/tim_one/index.html"):
    print "may fetch the tim peters archive"

may fetch the home page
```

7.10 The ftplib Module

The `ftplib` module contains a *File Transfer Protocol* (FTP) client implementation.

Example 7-22 demonstrates how to log in and get a directory listing of the login directory. Note that the format of the directory listing is server dependent (it's usually the same as the format used by the directory listing utility on the server host platform).

Example 7-22. Using the ftplib Module to Get a Directory Listing

```
File: ftplib-example-1.py

import ftplib

ftp = ftplib.FTP("www.python.org")
ftp.login("anonymous", "ftplib-example-1")

print ftp.dir()

ftp.quit()

total 34
drwxrwxr-x  11 root     4127         512 Sep 14 14:18 .
drwxrwxr-x  11 root     4127         512 Sep 14 14:18 ..
drwxrwxr-x   2 root     4127         512 Sep 13 15:18 RCS
lrwxrwxrwx   1 root     bin           11 Jun 29 14:34 README -> welcome.msg
drwxr-xr-x   3 root     wheel        512 May 19  1998 bin
drwxr-sr-x   3 root     1400         512 Jun  9  1997 dev
drwxrwxr--   2 root     4127         512 Feb  8  1998 dup
drwxr-xr-x   3 root     wheel        512 May 19  1998 etc
...
```

Downloading files is easy; just use the appropriate `retr` function. Note that when you download a text file, you have to add line endings yourself. The function in Example 7-23 uses a `lambda` expression to do that on the fly.

Example 7-23. Using the ftplib Module to Retrieve Files

```
File: ftplib-example-2.py

import ftplib
import sys

def gettext(ftp, filename, outfile=None):
    # fetch a text file
    if outfile is None:
        outfile = sys.stdout
    # use a lambda to add newlines to the lines read from the server
    ftp.retrlines("RETR " + filename, lambda s, w=outfile.write: w(s+"\n"))
```

```
def getbinary(ftp, filename, outfile=None):
    # fetch a binary file
    if outfile is None:
        outfile = sys.stdout
    ftp.retrbinary("RETR " + filename, outfile.write)

ftp = ftplib.FTP("www.python.org")
ftp.login("anonymous", "ftplib-example-2")

gettext(ftp, "README")
getbinary(ftp, "welcome.msg")

WELCOME to python.org, the Python programming language home site.

You are number %N of %M allowed users.  Ni!

Python Web site: http://www.python.org/

CONFUSED FTP CLIENT?  Try begining your login password with '-' dash.
This turns off continuation messages that may be confusing your client.
...
```

Finally, Example 7-24 is a simple one that copies files to the FTP server. This script uses the file extension to figure out if the file is a text file or a binary file.

Example 7-24. Using the ftplib Module to Store Files

```
File: ftplib-example-3.py

import ftplib
import os

def upload(ftp, file):
    ext = os.path.splitext(file)[1]
    if ext in (".txt", ".htm", ".html"):
        ftp.storlines("STOR " + file, open(file))
    else:
        ftp.storbinary("STOR " + file, open(file, "rb"), 1024)

ftp = ftplib.FTP("ftp.fbi.gov")
ftp.login("mulder", "trustno1")

upload(ftp, "trixie.zip")
upload(ftp, "file.txt")
upload(ftp, "sightings.jpg")
```

7.11 The gopherlib Module

The `gopherlib` module contains a gopher client implementation, shown in Example 7-25.

Example 7-25. Using the gopherlib Module

```
File: gopherlib-example-1.py

import gopherlib

host = "gopher.spam.egg"

f = gopherlib.send_selector("1/", host)
for item in gopherlib.get_directory(f):
    print item

['0', "About Spam.Egg's Gopher Server", "0/About's Spam.Egg's
Gopher Server", 'gopher.spam.egg', '70', '+']
['1', 'About Spam.Egg', '1/Spam.Egg', 'gopher.spam.egg', '70', '+']
['1', 'Misc', '1/Misc', 'gopher.spam.egg', '70', '+']
...
```

7.12 The httplib Module

The `httplib` module, shown in Example 7-26, provides an HTTP client interface.

Example 7-26. Using the httplib Module

```
File: httplib-example-1.py

import httplib

USER_AGENT = "httplib-example-1.py"

class Error:
    # indicates an HTTP error
    def _ _init_ _(self, url, errcode, errmsg, headers):
        self.url = url
        self.errcode = errcode
        self.errmsg = errmsg
        self.headers = headers
    def _ _repr_ _(self):
        return (
            "<Error for %s: %s %s>" %
            (self.url, self.errcode, self.errmsg)
            )

class Server:

    def _ _init_ _(self, host):
        self.host = host

    def fetch(self, path):
        http = httplib.HTTP(self.host)

        # write header
        http.putrequest("GET", path)
        http.putheader("User-Agent", USER_AGENT)
        http.putheader("Host", self.host)
        http.putheader("Accept", "*/*")
        http.endheaders()

        # get response
        errcode, errmsg, headers = http.getreply()

        if errcode != 200:
            raise Error(errcode, errmsg, headers)

        file = http.getfile()
        return file.read()

if _ _name_ _ == "_ _main_ _":
```

```
    server = Server("www.pythonware.com")
    print server.fetch("/index.htm")
```

Note that the HTTP client provided `httplib` blocks while waiting for the server to respond. For an asynchronous solution, which among other things allows you to issue multiple requests in parallel, see the examples for the `asyncore` module.

7.12.1 Posting Data to an HTTP Server

The `httplib` module also allows you to send other HTTP commands, such as `POST`, as shown in Example 7-27.

Example 7-27. Using the httplib Module to Post Data

```
File: httplib-example-2.py

import httplib

USER_AGENT = "httplib-example-2.py"

def post(host, path, data, type=None):

    http = httplib.HTTP(host)

    # write header
    http.putrequest("PUT", path)
    http.putheader("User-Agent", USER_AGENT)
    http.putheader("Host", host)
    if type:
        http.putheader("Content-Type", type)
    http.putheader("Content-Length", str(len(size)))
    http.endheaders()

    # write body
    http.send(data)

    # get response
    errcode, errmsg, headers = http.getreply()

    if errcode != 200:
        raise Error(errcode, errmsg, headers)

    file = http.getfile()
    return file.read()

if _ _name_ _ == "_ _main_ _":

    post("www.spam.egg", "/bacon.htm", "a piece of data", "text/plain")
```

7.13 The poplib Module

The `poplib` module (shown in Example 7-28) provides a *Post Office Protocol* (POP3) client implementation. This protocol is used to "pop" (copy) messages from a central mail server to your local computer.

Example 7-28. Using the poplib Module

```
File: poplib-example-1.py

import poplib
import string, random
import StringIO, rfc822

SERVER = "pop.spam.egg"

USER   = "mulder"
PASSWORD = "trustno1"

# connect to server
server = poplib.POP3(SERVER)

# login
server.user(USER)
server.pass_(PASSWORD)

# list items on server
resp, items, octets = server.list()

# download a random message
id, size = string.split(random.choice(items))
resp, text, octets = server.retr(id)

text = string.join(text, "\n")
file = StringIO.StringIO(text)

message = rfc822.Message(file)

for k, v in message.items():
    print k, "=", v

print message.fp.read()

subject = ANN: (the eff-bot guide to) The Standard Python Library
message-id = <199910120808.KAA09206@spam.egg>
received = (from fredrik@spam.egg)
 by spam.egg (8.8.7/8.8.5) id KAA09206
 for mulder; Tue, 12 Oct 1999 10:08:47 +0200
from = Fredrik Lundh <fredrik@spam.egg>
date = Tue, 12 Oct 1999 10:08:47 +0200
to = mulder@spam.egg
```

7.14 The imaplib Module

The `imaplib` module, shown in Example 7-29, provides an *Internet Message Access Protocol* (IMAP) client implementation. This protocol lets you access mail folders stored on a central mail server as if they were local.

Example 7-29. Using the imaplib Module

```
File: imaplib-example-1.py

import imaplib
import string, random
import StringIO, rfc822

SERVER = "imap.spam.egg"

USER   = "mulder"
PASSWORD = "trustno1"

# connect to server
server = imaplib.IMAP4(SERVER)

# login
server.login(USER, PASSWORD)
server.select()

# list items on server
resp, items = server.search(None, "ALL")
items = string.split(items[0])

# fetch a random item
id = random.choice(items)
resp, data = server.fetch(id, "(RFC822)")
text = data[0][1]

file = StringIO.StringIO(text)

message = rfc822.Message(file)

for k, v in message.items():
    print k, "=", v

print message.fp.read()

server.logout()

subject = ANN: (the eff-bot guide to) The Standard Python Library
message-id = <199910120816.KAA12177@larch.spam.egg>
to = mulder@spam.egg
date = Tue, 12 Oct 1999 10:16:19 +0200 (MET DST)
from = <effbot@spam.egg>
```

```
received = (effbot@spam.egg) by imap.algonet.se (8.8.8+Sun/8.6.12)
id KAA12177 for effbot@spam.egg; Tue, 12 Oct 1999 10:16:19 +0200
(MET DST)

body text for test 5
```

7.15 The smtplib Module

The `smtplib` module (shown in Example 7-30) provides a *Simple Mail Transfer Protocol* (SMTP) client implementation. This protocol is used to send mail through Unix mail servers.

To read mail, use the `poplib` or `imaplib` modules.

Example 7-30. Using the smtplib Module

```
File: smtplib-example-1.py

import smtplib
import string, sys

HOST = "localhost"

FROM = "effbot@spam.egg"
TO = "fredrik@spam.egg"

SUBJECT = "for your information!"

BODY = "next week: how to fling an otter"

body = string.join((
    "From: %s" % FROM,
    "To: %s" % TO,
    "Subject: %s" % SUBJECT,
    "",
    BODY), "\r\n")

print body

server = smtplib.SMTP(HOST)
server.sendmail(FROM, [TO], body)
server.quit()

From: effbot@spam.egg
To: fredrik@spam.egg
Subject: for your information!

next week: how to fling an otter
```

7.16 The telnetlib Module

The `telnetlib` module provides a telnet client implementation.

Example 7-31 connects to a Unix computer, logs in, and then retrieves a directory listing.

Example 7-31. Using the telnetlib Module to Log In to a Remote Server

```
File: telnetlib-example-1.py

import telnetlib
import sys

HOST = "spam.egg"

USER = "mulder"
PASSWORD = "trustno1"

telnet = telnetlib.Telnet(HOST)

telnet.read_until("login: ")
telnet.write(USER + "\n")

telnet.read_until("Password: ")
telnet.write(PASSWORD + "\n")

telnet.write("ls librarybook\n")
telnet.write("exit\n")

print telnet.read_all()

[spam.egg mulder]$ ls
README                              os-path-isabs-example-1.py
SimpleAsyncHTTP.py                  os-path-isdir-example-1.py
aifc-example-1.py                   os-path-isfile-example-1.py
anydbm-example-1.py                 os-path-islink-example-1.py
array-example-1.py                  os-path-ismount-example-1.py
...
```

7.17 The nntplib Module

The nntplib module provides a *Network News Transfer Protocol* (NNTP) client implementation.

7.17.1 Listing messages

Prior to reading messages from a news server, you have to connect to the server and then select a newsgroup. The script in Example 7-32 also downloads a complete list of all messages on the server and extracts some more or less interesting statistics from that list.

Example 7-32. Using the nntplib Module to List Messages

```
File: nntplib-example-1.py

import nntplib
import string

SERVER = "news.spam.egg"
GROUP  = "comp.lang.python"
AUTHOR = "fredrik@pythonware.com" # eff-bots human alias

# connect to server
server = nntplib.NNTP(SERVER)

# choose a newsgroup
resp, count, first, last, name = server.group(GROUP)
print "count", "=>", count
print "range", "=>", first, last

# list all items on the server
resp, items = server.xover(first, last)

# extract some statistics
authors = {}
subjects = {}
for id, subject, author, date, message_id, references, size, lines in items:
    authors[author] = None
    if subject[:4] == "Re: ":
        subject = subject[4:]
    subjects[subject] = None
    if string.find(author, AUTHOR) >= 0:
        print id, subject

print "authors", "=>", len(authors)
print "subjects", "=>", len(subjects)

count => 607
range => 57179 57971
57474 Three decades of Python!
```

```
...
57477 More Python books coming...
authors => 257
subjects => 200
```

7.17.2 Downloading Messages

Downloading a message is easy. Just call the `article` method, as shown in Example 7-33.

Example 7-33. Using the nntplib Module to Download Messages

```
File: nntplib-example-2.py

import nntplib
import string

SERVER = "news.spam.egg"
GROUP  = "comp.lang.python"
KEYWORD = "tkinter"

# connect to server
server = nntplib.NNTP(SERVER)

resp, count, first, last, name = server.group(GROUP)
resp, items = server.xover(first, last)
for id, subject, author, date, message_id, references, size, lines in items:
    if string.find(string.lower(subject), KEYWORD) >= 0:
        resp, id, message_id, text = server.article(id)
        print author
        print subject
        print len(text), "lines in article"

"Fredrik Lundh" <fredrik@pythonware.com>
Re: Programming Tkinter (In Python)
110 lines in article
...
```

Example 7-34 shows how you can further manipulate the messages by wrapping it up in a *Message* object (using the `rfc822` module).

Example 7-34. Using the nntplib and rfc822 Modules to Process Messages

```
File: nntplib-example-3.py

import nntplib
import string, random
import StringIO, rfc822

SERVER = "news.spam.egg"
GROUP  = "comp.lang.python"

# connect to server
server = nntplib.NNTP(SERVER)
```

```
resp, count, first, last, name = server.group(GROUP)
for i in range(10):
    try:
        id = random.randint(int(first), int(last))
        resp, id, message_id, text = server.article(str(id))
    except (nntplib.error_temp, nntplib.error_perm):
        pass # no such message (maybe it was deleted?)
    else:
        break # found a message!
else:
    raise SystemExit

text = string.join(text, "\n")
file = StringIO.StringIO(text)

message = rfc822.Message(file)

for k, v in message.items():
    print k, "=", v

print message.fp.read()

mime-version = 1.0
content-type = text/plain; charset="iso-8859-1"
message-id = <008501bf1417$1cf90b70$f29b12c2@sausage.spam.egg>
lines = 22
...
from = "Fredrik Lundh" <fredrik@pythonware.com>
nntp-posting-host = parrot.python.org
subject = ANN: (the eff-bot guide to) The Standard Python Library
...
</F>
```

Once you've gotten this far, you can use modules like `htmllib`, `uu`, and `base64` to further process the messages.

7.18 The SocketServer Module

The `SocketServer` module provides a framework for various kinds of socket-based servers. The module provides a number of classes that can be mixed and matched to create servers for different purposes.

Example 7-35 implements an Internet Time Protocol server using this module. Use the `timeclient` script to try it out.

Example 7-35. Using the SocketServer Module

```
File: socketserver-example-1.py

import SocketServer
import time

# user-accessible port
PORT = 8037

# reference time
TIME1970 = 2208988800L

class TimeRequestHandler(SocketServer.StreamRequestHandler):
    def handle(self):
        print "connection from", self.client_address
        t = int(time.time()) + TIME1970
        b = chr(t>>24&255) + chr(t>>16&255) + chr(t>>8&255) + chr(t&255)
        self.wfile.write(b)

server = SocketServer.TCPServer(("", PORT), TimeRequestHandler)
print "listening on port", PORT
server.serve_forever()

connection from ('127.0.0.1', 1488)
connection from ('127.0.0.1', 1489)
...
```

7.19 The BaseHTTPServer Module

This is a basic framework for HTTP servers, built on top of the `SocketServer` framework.

Example 7-36 generates a random message each time you reload the page. The `path` variable contains the current URL, which you can use to generate different contents for different URLs (as it stands, the script returns an error page for anything but the root path).

Example 7-36. Using the BaseHTTPServer Module

```
File: basehttpserver-example-1.py

import BaseHTTPServer
import cgi, random, sys

MESSAGES = [
    "That's as maybe, it's still a frog.",
    "Albatross! Albatross! Albatross!",
    "It's Wolfgang Amadeus Mozart.",
    "A pink form from Reading.",
    "Hello people, and welcome to 'It's a Tree.'"
    "I simply stare at the brick and it goes to sleep.",
]

class Handler(BaseHTTPServer.BaseHTTPRequestHandler):

    def do_GET(self):
        if self.path != "/":
            self.send_error(404, "File not found")
            return
        self.send_response(200)
        self.send_header("Content-type", "text/html")
        self.end_headers()
        try:
            # redirect stdout to client
            stdout = sys.stdout
            sys.stdout = self.wfile
            self.makepage()
        finally:
            sys.stdout = stdout # restore

    def makepage(self):
        # generate a random message
        tagline = random.choice(MESSAGES)
        print "<html>"
        print "<body>"
        print "<p>Today's quote: "
        print "<i>%s</i>" % cgi.escape(tagline)
        print "</body>"
        print "</html>"
```

```
PORT = 8000

httpd = BaseHTTPServer.HTTPServer(("", PORT), Handler)
print "serving at port", PORT
httpd.serve_forever()
```

See the SimpleHTTPServer and CGIHTTPServer modules for more extensive HTTP frameworks.

7.20 The SimpleHTTPServer Module

The `SimpleHTTPServer` module is a simple HTTP server that provides standard GET and HEAD request handlers. The pathname given by the client is interpreted as a relative filename (relative to the current directory when the server was started, that is). The module's use is demonstrated in Example 7-37.

Example 7-37. Using the SimpleHTTPServer Module

```
File: simplehttpserver-example-1.py

import SimpleHTTPServer
import SocketServer

# minimal web server.  serves files relative to the
# current directory.

PORT = 8000

Handler = SimpleHTTPServer.SimpleHTTPRequestHandler

httpd = SocketServer.TCPServer(("", PORT), Handler)

print "serving at port", PORT
httpd.serve_forever()

serving at port 8000
localhost - - [11/Oct/1999 15:07:44] code 403, message Directory listing not sup
ported
localhost - - [11/Oct/1999 15:07:44] "GET / HTTP/1.1" 403 -
localhost - - [11/Oct/1999 15:07:56] "GET /samples/sample.htm HTTP/1.1" 200 -
```

The server ignores drive letters and relative pathnames (such as `..'). However, it does not implement any other access control mechanisms, so be careful.

Example 7-38 implements a truly minimal web proxy. When sent to a proxy, the HTTP requests should include the full URI for the target server. This server uses `urllib` to fetch data from the target.

Example 7-38. Using the SimpleHTTPServer Module as a Proxy

```
File: simplehttpserver-example-2.py

# a truly minimal HTTP proxy

import SocketServer
import SimpleHTTPServer
import urllib

PORT = 1234

class Proxy(SimpleHTTPServer.SimpleHTTPRequestHandler):
```

```
    def do_GET(self):
        self.copyfile(urllib.urlopen(self.path), self.wfile)

httpd = SocketServer.ForkingTCPServer(('', PORT), Proxy)
print "serving at port", PORT
httpd.serve_forever()
```

7.21 The CGIHTTPServer Module

The `CGIHTTPServer` module shown in Example 7-39 is a simple HTTP server that can call external scripts through the common gateway interface (CGI).

Example 7-39. Using the CGIHTTPServer Module

```
File: cgihttpserver-example-1.py

import CGIHTTPServer
import BaseHTTPServer

class Handler(CGIHTTPServer.CGIHTTPRequestHandler):
    cgi_directories = ["/cgi"]

PORT = 8000

httpd = BaseHTTPServer.HTTPServer(("", PORT), Handler)
print "serving at port", PORT
httpd.serve_forever()
```

7.22 The cgi Module

The `cgi` module provides a number of support functions and classes for CGI scripts. Among other things, it can parse CGI form data.

Example 7-40 shows a simple CGI script that returns a list of a files in a given directory (relative to the root directory specified in the script).

Example 7-40. Using the cgi Module

```
File: cgi-example-1.py

import cgi
import os, urllib

ROOT = "samples"

# header
print "text/html"
print

query = os.environ.get("QUERY_STRING")
if not query:
    query = "."

script = os.environ.get("SCRIPT_NAME", "")
if not script:
    script = "cgi-example-1.py"

print "<html>"
print "<head>"
print "<title>file listing</title>"
print "</head>"
print "</html>"

print "<body>"

try:
    files = os.listdir(os.path.join(ROOT, query))
except os.error:
    files = []

for file in files:
    link = cgi.escape(file)
    if os.path.isdir(os.path.join(ROOT, query, file)):
        href = script + "?" + os.path.join(query, file)
        print "<p><a href= '%s'>%s</a>" % (href, cgi.escape(link))
    else:
        print "<p>%s" % link

print "</body>"
```

```
print "</html>"
```

```
text/html

<html>
<head>
<title>file listing</title>
</head>
</html>
<body>
<p>sample.gif
<p>sample.gz
<p>sample.netrc
...
<p>sample.txt
<p>sample.xml
<p>sample~
<p><a href='cgi-example-1.py?web'>web</a>
</body>
</html>
```

7.23 The webbrowser Module

(New in 2.0) The `webbrowser` module provides a basic interface to the system's standard web browser. It provides an `open` function, which takes a filename or a URL, and displays it in the browser. If you call `open` again, it attempts to display the new page in the same browser window. Example 7-41 demonstrates the `webbrowser` module.

Example 7-41. Using the webbrowser Module

```
File: webbrowser-example-1.py

import webbrowser
import time

webbrowser.open("http://www.pythonware.com")

# wait a while, and then go to another page
time.sleep(5)
webbrowser.open(
    "http://www.pythonware.com/people/fredrik/librarybook.htm"
    )
```

On Unix, this module supports lynx, Netscape, Mosaic, Konquerer, and Grail. On Windows and Macintosh, it uses the standard browser (as defined in the registry or the Internet configuration panel).

Chapter 8. Internationalization

8.1 The locale Module

The `locale` module, as shown in Example 8-1, provides an interface to C's localization functions. It also provides functions to convert between numbers and strings based on the current locale. (Functions like `int` and `float`, as well as the numeric conversion functions in `string`, are not affected by the current locale.)

Example 8-1. Using the locale Module for Data Formatting

```
File: locale-example-1.py

import locale

print "locale", "=>", locale.setlocale(locale.LC_ALL, "")

# integer formatting
value = 4711
print locale.format("%d", value, 1), "==",
print locale.atoi(locale.format("%d", value, 1))

# floating point
value = 47.11
print locale.format("%f", value, 1), "==",
print locale.atof(locale.format("%f", value, 1))

info = locale.localeconv()
print info["int_curr_symbol"]

locale => Swedish_Sweden.1252
4,711 == 4711
47,110000 == 47.11
SEK
```

Example 8-2 shows how you can use the `locale` module to get the platform locale.

Example 8-2. Using the locale Module to Get the Platform Locale

```
File: locale-example-2.py

import locale

language, encoding = locale.getdefaultlocale()

print "language", language
print "encoding", encoding

language sv_SE
encoding cp1252
```

8.2 The unicodedata Module

(New in 2.0) The `unicodedata` module contains Unicode character properties, such as character categories, decomposition data, and numerical values. Its use is shown in Example 8-3.

Example 8-3. Using the unicodedata Module

```
File: unicodedata-example-1.py

import unicodedata

for char in [u"A", u"-", u"1", u"\N{LATIN CAPITAL LETTER O WITH DIAERESIS}"]:
    print repr(char),
    print unicodedata.category(char),
    print repr(unicodedata.decomposition(char)),

    print unicodedata.decimal(char, None),
    print unicodedata.numeric(char, None)

u'A' Lu '' None None
u'-' Pd '' None None
u'1' Nd '' 1 1.0
u'\303\226' Lu '004F 0308' None None
```

Note that in Python 2.0, properties for CJK ideographs and Hangul syllables are missing. This affects characters in the range 0x3400-0x4DB5, 0x4E00-0x9FA5, and 0xAC00-D7A3. The first character in each range has correct properties, so you can work around this problem by simply mapping each character to the beginning:

```
def remap(char):
    # fix for broken unicode property database in Python 2.0
    c = ord(char)
    if 0x3400 <= c <= 0x4DB5:
        return unichr(0x3400)
    if 0x4E00 <= c <= 0x9FA5:
        return unichr(0x4E00)
    if 0xAC00 <= c <= 0xD7A3:
        return unichr(0xAC00)
    return char
```

This bug has been fixed in Python 2.1.

8.3 The ucnhash Module

(Implementation, 2.0 only) The `ucnhash` module is an implementation module, which provides a name to character code mapping for Unicode string literals. If this module is present, you can use `\N{}` escapes to map Unicode character names to codes, as shown in Example 8-4.

Example 8-4. Using the ucnhash Module

```
File: ucnhash-example-1.py

# Python imports this module automatically, when it sees
# the first \N{} escape
# import ucnhash

print repr(u"\N{FROWN}")
print repr(u"\N{SMILE}")
print repr(u"\N{SKULL AND CROSSBONES}")

u'\u2322'
u'\u2323'
u'\u2620'
```

Chapter 9. Multimedia Modules

> *"Wot? No quote?"*
>
> —Guido van Rossum

9.1 Overview

Python comes with a small set of modules for dealing with image files and audio files.

See the *Pythonware Image Library* (PIL, http://www.pythonware.com/products/pil/;) and *PythonWare Sound Toolkit* (PST, http://www.pythonware.com/products/pst/;) for more alternatives.

9.2 The imghdr Module

The `imghdr` module identifies different image file formats. The current version identifies `bmp`, `gif`, `jpeg`, `pbm`, `pgm`, `png`, `ppm`, `rast` (Sun raster), `rgb` (SGI), `tiff`, and `xbm` images. Example 9-1 demonstrates.

Example 9-1. Using the imghdr Module

```
File: imghdr-example-1.py

import imghdr

result = imghdr.what("samples/sample.jpg")

if result:
    print "file format:", result
else:
    print "cannot identify file"

file format: jpeg
import Image

im = Image.open("samples/sample.jpg")
print im.format, im.mode, im.size
```

9.3 The sndhdr module

This sndhdr module, shown in Example 9-2, can be used to identify different audio file formats and extract basic information about a file's contents.

If successful, the what function returns a 5-tuple, containing the filetype, the sampling rate, the number of channels, the number of frames in the file (-1 means unknown), and the number of bits per sample.

Example 9-2. Using the sndhdr Module

```
File: sndhdr-example-1.py

import sndhdr

result = sndhdr.what("samples/sample.wav")

if result:
    print "file format:", result
else:
    print "cannot identify file"

file format: ('wav', 44100, 1, -1, 16)
```

9.4 The whatsound Module

(Obsolete) The `whatsound` module is an alias for `sndhdr`. It is used in Example 9-3.

Example 9-3. Using the whatsound Module

```
File: whatsound-example-1.py

import whatsound # same as sndhdr

result = whatsound.what("samples/sample.wav")

if result:
    print "file format:", result
else:
    print "cannot identify file"

file format: ('wav', 44100, 1, -1, 16)
```

9.5 The aifc Module

The `aifc` module reads and writes AIFF and AIFC audio files (as used on SGI and Macintosh computers). Example 9-4 shows how it's used.

Example 9-4. Using the aifc Module

```
File: SimpleAsyncHTTP.py

import asyncore
import string, socket
import StringIO
import mimetools, urlparse

class AsyncHTTP(asyncore.dispatcher_with_send):
    # HTTP requestor

    def _ _init_ _(self, uri, consumer):
        asyncore.dispatcher_with_send._ _init_ _(self)

        self.uri = uri
        self.consumer = consumer

        # turn the uri into a valid request
        scheme, host, path, params, query, fragment = urlparse.urlparse(uri)
        assert scheme == "http", "only supports HTTP requests"
        try:
            host, port = string.split(host, ":", 1)
            port = int(port)
        except (TypeError, ValueError):
            port = 80 # default port
        if not path:
            path = "/"
        if params:
            path = path + ";" + params
        if query:
            path = path + "?" + query

        self.request = "GET %s HTTP/1.0\r\nHost: %s\r\n\r\n" % (path, host)

        self.host = host
        self.port = port

        self.status = None
        self.header = None

        self.data = ""

        # get things going!
        self.create_socket(socket.AF_INET, socket.SOCK_STREAM)
        self.connect((host, port))
```

```
    def handle_connect(self):
        # connection succeeded
        self.send(self.request)

    def handle_expt(self):
        # connection failed; notify consumer (status is None)
        self.close()
        try:
            http_header = self.consumer.http_header
        except AttributeError:
            pass
        else:
            http_header(self)

    def handle_read(self):
        data = self.recv(2048)
        if not self.header:
            self.data = self.data + data
            try:
                i = string.index(self.data, "\r\n\r\n")
            except ValueError:
                return # continue
            else:
                # parse header
                fp = StringIO.StringIO(self.data[:i+4])
                # status line is "HTTP/version status message"
                status = fp.readline()
                self.status = string.split(status, " ", 2)
                # followed by a rfc822-style message header
                self.header = mimetools.Message(fp)
                # followed by a newline, and the payload (if any)
                data = self.data[i+4:]
                self.data = ""
                # notify consumer (status is non-zero)
                try:
                    http_header = self.consumer.http_header
                except AttributeError:
                    pass
                else:
                    http_header(self)
                if not self.connected:
                    return # channel was closed by consumer

        self.consumer.feed(data)

    def handle_close(self):
        self.consumer.close()
        self.close()
```

9.6 The sunau Module

The `sunau` module in Example 9-5 reads and writes Sun AU audio files.

Example 9-5. Using the sunau Module

```
File: sunau-example-1.py

import sunau

w = sunau.open("samples/sample.au", "r")

if w.getnchannels() == 1:
    print "mono,",
else:
    print "stereo,",

print w.getsampwidth()*8, "bits,",
print w.getframerate(), "Hz sampling rate"

mono, 16 bits, 8012 Hz sampling rate
```

9.7 The sunaudio Module

The `sunaudio` module, shown in Example 9-6, identifies Sun AU audio files and extracts basic information about the file contents. The `sunau` module provides more complete support for Sun AU files.

Example 9-6. Using the sunaudio Module

```
File: sunaudio-example-1.py

import sunaudio

file = "samples/sample.au"

print sunaudio.gethdr(open(file, "rb"))

(6761, 1, 8012, 1, 'sample.au')
```

9.8 The wave Module

The `wave` module reads and writes Microsoft WAV audio files, as Example 9-7 shows.

Example 9-7. Using the wave Module

```
File: wave-example-1.py

import wave

w = wave.open("samples/sample.wav", "r")

if w.getnchannels() == 1:
    print "mono,",
else:
    print "stereo,",

print w.getsampwidth()*8, "bits,",
print w.getframerate(), "Hz sampling rate"

mono, 16 bits, 44100 Hz sampling rate
```

9.9 The audiodev Module

(Unix only) The `audiodev` module provides sound playing support for Sun and SGI computers. Example 9-8 demonstrates this module.

Example 9-8. Using the audiodev Module

```
File: audiodev-example-1.py

import audiodev
import aifc

sound = aifc.open("samples/sample.aiff", "r")

player = audiodev.AudioDev()

player.setoutrate(sound.getframerate())
player.setsampwidth(sound.getsampwidth())
player.setnchannels(sound.getnchannels())

bytes_per_frame = sound.getsampwidth() * sound.getnchannels()
bytes_per_second = sound.getframerate() * bytes_per_frame

while 1:
    data = sound.readframes(bytes_per_second)
    if not data:
        break
    player.writeframes(data)

player.wait()
```

9.10 The winsound Module

(Windows only) The `winsound` module allows you to play Wave sound files on a Windows machine. Example 9-9 shows how `winsound` is used.

Example 9-9. Using the winsound Module

```
File: winsound-example-1.py

import winsound

file = "samples/sample.wav"

winsound.PlaySound(
    file,
    winsound.SND_FILENAME|winsound.SND_NOWAIT,
    )
```

9.11 The colorsys Module

The `colorsys` module (shown in Example 9-10) contains functions to convert between RGB, YIQ (video), HLS, and HSV color values.

Example 9-10. Using the colorsys Module

```
File: colorsys-example-1.py

import colorsys

# gold
r, g, b = 1.00, 0.84, 0.00

print "RGB", (r, g, b)

y, i, q = colorsys.rgb_to_yiq(r, g, b)
print "YIQ", (y, i, q), "=>", colorsys.yiq_to_rgb(y, i, q)

h, l, s = colorsys.rgb_to_hls(r, g, b)
print "HLS", (h, l, s), "=>", colorsys.hls_to_rgb(h, l, s)

h, s, v = colorsys.rgb_to_hsv(r, g, b)
print "HSV", (h, s, v), "=>", colorsys.hsv_to_rgb(h, s, v)

RGB (1.0, 0.84, 0.0)
YIQ (0.7956, 0.3648, -0.2268) => (0.9999998292, 0.8400000312, 0.0)
HLS (0.14, 0.5, 1.0) => (1.0, 0.84, 0.0)
HSV (0.14, 1.0, 1.0) => (1.0, 0.84, 0.0)
```

Chapter 10. Data Storage

> *"Unlike mainstream component programming, scripts usually do not introduce new components but simply 'wire' existing ones. Scripts can be seen as introducing behavior but no new state ... Of course, there is nothing to stop a 'scripting' language from introducing persistent state — it then simply turns into a normal programming language."*
>
> —Clemens Szyperski, in *Component Software*

10.1 Overview

Python comes with drivers for a number of very similar database managers, all modeled after Unix's `dbm` library. These databases behave like ordinary dictionaries, except that you can only use strings for keys and values (the `shelve` module can handle any kind of value).

10.2 The anydbm Module

The `anydbm` module provides a unified interface to the simple database drivers supported by Python.

The first time it is imported, the `anydbm` module looks for a suitable database driver, testing for `dbhash`, `gdbm`, `dbm`, or `dumbdbm`, in that order. If no such module is found, it raises an `ImportError` exception.

In Example 10-1, the `open` function is used to open or create a database, using the chosen database handler.

Example 10-1. Using the anydbm Module

```
File: anydbm-example-1.py

import anydbm

db = anydbm.open("database", "c")
db["1"] = "one"
db["2"] = "two"
db["3"] = "three"
db.close()

db = anydbm.open("database", "r")
for key in db.keys():
    print repr(key), repr(db[key])

'2' 'two'
'3' 'three'
'1' 'one'
```

10.3 The whichdb Module

The whichdb module can be used to figure out which database handler was used for a given database file, as shown in Example 10-2.

Example 10-2. Using the whichdb Module

```
File: whichdb-example-1.py

import whichdb

filename = "database"

result = whichdb.whichdb(filename)

if result:
    print "file created by", result
    handler = _ _import_ _(result)
    db = handler.open(filename, "r")
    print db.keys()
else:
    # cannot identify data base
    if result is None:
        print "cannot read database file", filename
    else:
        print "cannot identify database file", filename
    db = None
```

Example 10-2 uses the _ _import_ _ function to import a module with the given name.

10.4 The shelve Module

The `shelve` module, shown in Example 10-3, uses the database handlers to implement persistent dictionaries. A `shelve` object uses string keys, but the value can be of any datatype, as long as it can be handled by the `pickle` module.

Example 10-3. Using the shelve Module

```
File: shelve-example-1.py

import shelve

db = shelve.open("database", "c")
db["one"] = 1
db["two"] = 2
db["three"] = 3
db.close()

db = shelve.open("database", "r")
for key in db.keys():
    print repr(key), repr(db[key])

'one' 1
'three' 3
'two' 2
```

Example 10-4 shows how to use the `shelve` module with a given database driver.

Example 10-4. Using the shelve Module with a Given Database

```
File: shelve-example-3.py

import shelve
import gdbm

def gdbm_shelve(filename, flag="c"):
    return shelve.Shelf(gdbm.open(filename, flag))

db = gdbm_shelve("dbfile")
```

10.5 The dbhash Module

(Optional) The dbhash module provides a dbm-compatible interface to the bsddb database handler. Example 10-5 uses this module.

Example 10-5. Using the dbhash Module

```
File: dbhash-example-1.py

import dbhash

db = dbhash.open("dbhash", "c")
db["one"] = "the foot"
db["two"] = "the shoulder"
db["three"] = "the other foot"
db["four"] = "the bridge of the nose"
db["five"] = "the naughty bits"
db["six"] = "just above the elbow"
db["seven"] = "two inches to the right of a very naughty bit indeed"
db["eight"] = "the kneecap"
db.close()

db = dbhash.open("dbhash", "r")
for key in db.keys():
    print repr(key), repr(db[key])
```

10.6 The dbm Module

(Optional) The `dbm` module provides an interface to the `dbm` database handler (available on many Unix platforms). This is shown in Example 10-6.

Example 10-6. Using the dbm Module

```
File: dbm-example-1.py

import dbm

db = dbm.open("dbm", "c")
db["first"] = "bruce"
db["second"] = "bruce"
db["third"] = "bruce"
db["fourth"] = "bruce"
db["fifth"] = "michael"
db["fifth"] = "bruce" # overwrite
db.close()

db = dbm.open("dbm", "r")
for key in db.keys():
    print repr(key), repr(db[key])

'first' 'bruce'
'second' 'bruce'
'fourth' 'bruce'
'third' 'bruce'
'fifth' 'bruce'
```

10.7 The dumbdbm Module

The `dumbdbm` module, shown in Example 10-7, is a very simple database implementation, similar to `dbm` and friends, but written in pure Python. It uses two files: a binary file (*.dat*), which contain the data, and a text file (*.dir*), which contains data descriptors.

Example 10-7. Using the dumbdbm Module

```
File: dumbdbm-example-1.py

import dumbdbm

db = dumbdbm.open("dumbdbm", "c")
db["first"] = "fear"
db["second"] = "surprise"
db["third"] = "ruthless efficiency"
db["fourth"] = "an almost fanatical devotion to the Pope"
db["fifth"] = "nice red uniforms"
db.close()

db = dumbdbm.open("dumbdbm", "r")
for key in db.keys():
    print repr(key), repr(db[key])

'first' 'fear'
'third' 'ruthless efficiency'
'fifth' 'nice red uniforms'
'second' 'surprise'
'fourth' 'an almost fanatical devotion to the Pope'
```

10.8 The gdbm Module

(Optional) The `gdbm` module provides an interface to the GNU `dbm` database handler, as Example 10-8 shows.

Example 10-8. Using the gdbm Module

```
File: gdbm-example-1.py

import gdbm

db = gdbm.open("gdbm", "c")
db["1"] = "call"
db["2"] = "the"
db["3"] = "next"
db["4"] = "defendant"
db.close()


db = gdbm.open("gdbm", "r")

keys = db.keys()
keys.sort()
for key in keys:
    print db[key],

call the next defendant
```

Chapter 11. Tools and Utilities

The standard library comes with a number of modules that can be used both as modules and as command-line utilities.

11.1 The dis Module

The `dis` module is the Python disassembler. It converts byte codes to a format that is slightly more appropriate for human consumption.

You can run the disassembler from the command line. It compiles the given script and prints the disassembled byte codes to the terminal:

```
$ dis.py hello.py

          0 SET_LINENO          0

          3 SET_LINENO          1
          6 LOAD_CONST          0 ('hello again, and welcome to the show')
          9 PRINT_ITEM
         10 PRINT_NEWLINE
         11 LOAD_CONST          1 (None)
         14 RETURN_VALUE
```

You can also use `dis` as a module. The `dis` function takes a class, method, function, or code object as its single argument. Example 11-1 uses the module.

Example 11-1. Using the dis Module

```
File: dis-example-1.py

import dis

def procedure():
    print 'hello'

dis.dis(procedure)

          0 SET_LINENO          3

          3 SET_LINENO          4
          6 LOAD_CONST          1 ('hello')
          9 PRINT_ITEM
         10 PRINT_NEWLINE
         11 LOAD_CONST          0 (None)
         14 RETURN_VALUE
```

11.2 The pdb Module

The pdb module is the standard Python debugger. It is based on the bdb debugger framework.

You can run the debugger from the command line (type n [or next] to go to the next line and help to get a list of available commands):

```
$ pdb.py hello.py
> hello.py(0)?()
(Pdb) n
> hello.py()
(Pdb) n
hello again, and welcome to the show
--Return--
> hello.py(1)?()->None
(Pdb)
```

Example 11-2 shows how to start the debugger from inside a program.

Example 11-2. Using the pdb Module

```
File: pdb-example-1.py

import pdb

def test(n):
    j = 0
    for i in range(n):
        j = j + i
    return n

db = pdb.Pdb()
db.runcall(test, 1)

> pdb-example-1.py(3)test()
-> def test(n):
(Pdb) s
> pdb-example-1.py(4)test()
-> j = 0
(Pdb) s
> pdb-example-1.py(5)test()
-> for i in range(n):
...
```

11.3 The bdb Module

The `bdb` module provides a framework for debuggers. You can use this to create your own custom debuggers, as Example 11-3 shows.

To implement custom behavior, subclass the *Bdb* class, and override the `user` methods (which are called whenever the debugger stops). To control the debugger, use the various `set` methods.

Example 11-3. Using the bdb Mdule

```
File: bdb-example-1.py

import bdb
import time

def spam(n):
    j = 0
    for i in range(n):
        j = j + i
    return n

def egg(n):
    spam(n)
    spam(n)
    spam(n)
    spam(n)

def test(n):
    egg(n)

class myDebugger(bdb.Bdb):

    run = 0

    def user_call(self, frame, args):
        name = frame.f_code.co_name or "<unknown>"
        print "call", name, args
        self.set_continue() # continue

    def user_line(self, frame):
        if self.run:
            self.run = 0
            self.set_trace() # start tracing
        else:
            # arrived at breakpoint
            name = frame.f_code.co_name or "<unknown>"
            filename = self.canonic(frame.f_code.co_filename)
            print "break at", filename, frame.f_lineno, "in", name
        print "continue..."
        self.set_continue() # continue to next breakpoint
```

```
    def user_return(self, frame, value):
        name = frame.f_code.co_name or "<unknown>"
        print "return from", name, value
        print "continue..."
        self.set_continue() # continue

    def user_exception(self, frame, exception):
        name = frame.f_code.co_name or "<unknown>"
        print "exception in", name, exception
        print "continue..."
        self.set_continue() # continue

db = myDebugger()
db.run = 1
db.set_break("bdb-example-1.py", 7)
db.runcall(test, 1)
```

```
continue...
call egg None
call spam None
break at C:\ematter\librarybook\bdb-example-1.py 7 in spam
continue...
call spam None
break at C:\ematter\librarybook\bdb-example-1.py 7 in spam
continue...
call spam None
break at C:\ematter\librarybook\bdb-example-1.py 7 in spam
continue...
call spam None
break at C:\ematter\librarybook\bdb-example-1.py 7 in spam
continue...
```

11.4 The profile Module

The `profile` module is the standard Python profiler.

Like the disassembler and the debugger, you can run the profiler from the command line:

```
$ profile.py hello.py

hello again, and welcome to the show

         3 function calls in 0.785 CPU seconds

   Ordered by: standard name

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
        1    0.001    0.001    0.002    0.002 <string>:1(?)
        1    0.001    0.001    0.001    0.001 hello.py:1(?)
        1    0.783    0.783    0.785    0.785 profile:0(execfile('hello.py'))
        0    0.000             0.000          profile:0(profiler)
```

It can also be used to profile part of a program, as Example 11-4 shows.

Example 11-4. Using the profile Module

```
File: profile-example-1.py

import profile

def func1():
    for i in range(1000):
        pass

def func2():
    for i in range(1000):
        func1()

profile.run("func2()")

        1003 function calls in 2.380 CPU seconds

   Ordered by: standard name

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
        1    0.000    0.000    2.040    2.040 <string>:1(?)
     1000    1.950    0.002    1.950    0.002 profile-example-1.py:3(func1)
        1    0.090    0.090    2.040    2.040 profile-example-1.py:7(func2)
        1    0.340    0.340    2.380    2.380 profile:0(func2())
        0    0.000             0.000          profile:0(profiler)
```

You can modify the report to suit your needs, via the `pstats` module.

11.5 The pstats Module

The `pstats` module is a tool that analyzes data collected by the Python profiler, as Example 11-5 shows.

Example 11-5. Using the pstats Module

```
File: pstats-example-1.py

import pstats
import profile

def func1():
    for i in range(1000):
        pass

def func2():
    for i in range(1000):
        func1()

p = profile.Profile()
p.run("func2()")

s = pstats.Stats(p)
s.sort_stats("time", "name").print_stats()

         1003 function calls in 1.574 CPU seconds

   Ordered by: internal time, function name

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     1000    1.522    0.002    1.522    0.002 pstats-example-1.py:4(func1)
        1    0.051    0.051    1.573    1.573 pstats-example-1.py:8(func2)
        1    0.001    0.001    1.574    1.574 profile:0(func2())
        1    0.000    0.000    1.573    1.573 <string>:1(?)
        0    0.000             0.000          profile:0(profiler)
```

11.6 The tabnanny Module

(New in 2.0) The `tabnanny` module checks Python source files for ambigous indentation. If a file mixes tabs and spaces in a way that throws off indentation, no matter what tab size you're using, the nanny complains.

In the `badtabs.py` file used in the following examples, the first line after the `if` statement uses four spaces followed by a tab. The second uses spaces only.

```
$ tabnanny.py -v samples/badtabs.py
';samples/badtabs.py': *** Line 3: trouble in tab city! ***
offending line:         print "world"

indent not equal e.g. at tab sizes 1, 2, 3, 5, 6, 7, 9
```

Since the Python interpreter reads a tab as eight spaces, the script will run correctly. It will also display correctly in any editor that assumes that a tab is either eight or four spaces. That's not enough to fool the tab nanny, of course.

Example 11-6 shows how you can also use `tabnanny` from your own programs.

Example 11-6. Using the tabnanny Module

```
File: tabnanny-example-1.py

import tabnanny

FILE = "samples/badtabs.py"

file = open(FILE)
for line in file.readlines():
    print repr(line)

# let tabnanny look at it
tabnanny.check(FILE)

'if 1:\012'
'    \011print "hello"\012'
'        print "world"\012'
samples/badtabs.py 3 '        print "world"'\012'
```

To capture the output, you can redirect `sys.stdout` to a `StringIO` object.

Chapter 12. Platform-Specific Modules

12.1 Overview

This chapter describes some platform-specific modules. I've emphasized modules that are available on entire families of platforms (such as Unix or the Windows family).

12.2 The fcntl Module

(Unix only) The `fcntl` module provides an interface to the `ioctl` and `fcntl` functions on Unix. They are used for "out of band" operations on file handles and I/O device handles. This includes things like reading extended attributes, controlling blocking, modifying terminal behavior, and so on.

Exactly how to use these functions is highly platform dependent. For more information on what you can do on your platform, check the corresponding Unix manpages.

This module also provides an interface to Unix's file locking mechanisms. Example 12-1 uses the `flock` function to place an *advisory lock* on the file, while it is being updated.

The output shown later was obtained by running three instances of the program in parallel, like this (all on one command line):

```
python fcntl-example-1.py& python fcntl-example-1.py&
  python fcntl-example-1.py&
```

If you comment out the call to `flock`, the counter will not be updated properly.

Example 12-1. Using the fcntl Module

```
File: fcntl-example-1.py

import fcntl, FCNTL
import os, time

FILE = "counter.txt"

if not os.path.exists(FILE):
    # create the counter file if it doesn't exist
    file = open(FILE, "w")
    file.write("0")
    file.close()

for i in range(20):
    # increment the counter
    file = open(FILE, "r+")
    fcntl.flock(file.fileno(), FCNTL.LOCK_EX)
    counter = int(file.readline()) + 1
    file.seek(0)
    file.write(str(counter))
    file.close() # unlocks the file
    print os.getpid(), "=>", counter
    time.sleep(0.1)

30940 => 1
30942 => 2
30941 => 3
30940 => 4
30941 => 5
30942 => 6
```

12.3 The pwd Module

(Unix only) The pwd module provides an interface to the Unix password "database" (*/etc/passwd* and friends). This database (usually a plain-text file) contains information about the user accounts on the local machine. Example 12-2 demonstrates pwd.

Example 12-2. Using the pwd Module

```
File: pwd-example-1.py

import pwd
import os

print pwd.getpwuid(os.getgid())
print pwd.getpwnam("root")

('effbot', 'dsWjk8', 4711, 4711, 'eff-bot', '/home/effbot', '/bin/bosh')
('root', 'hs2giiw', 0, 0, 'root', '/root', '/bin/bash')
```

The getpwall function returns a list of database entries for all available users. This can be useful if you want to search for a user.

If you have to look up many names, you can use getpwall to preload a dictionary, as shown in Example 12-3.

Example 12-3. Using the pwd Module

```
File: pwd-example-2.py

import pwd
import os

# preload password dictionary
_pwd = {}
for info in pwd.getpwall():
    _pwd[info[0]] = _pwd[info[2]] = info

def userinfo(uid):
    # name or uid integer
    return _pwd[uid]

print userinfo(os.getuid())
print userinfo("root")

('effbot', 'dsWjk8', 4711, 4711, 'eff-bot', '/home/effbot', '/bin/bosh')
('root', 'hs2giiw', 0, 0, 'root', '/root', '/bin/bash')
```

12.4 The grp Module

(Unix only) The `grp` module provides an interface to the Unix group database (*/etc/group*). The `getgrgid` function returns data for a given group identity (see Example 12-4), and `getgrnam` returns data for a group name.

Example 12-4. Using the grp Module

```
File: grp-example-1.py

import grp
import os

print grp.getgrgid(os.getgid())
print grp.getgrnam("wheel")

('effbot', '', 4711, ['effbot'])
('wheel', '', 10, ['root', 'effbot', 'gorbot', 'timbot'])
```

The `getgrall` function returns a list of database entries for all available groups.

If you're going to do a lot of group queries, you can save some time by using `getgrall` to copy all the (current) groups into a dictionary. The `groupinfo` function in Example 12-5 returns the information for either a group identifier (an integer) or a group name (a string).

Example 12-5. Using the grp Module to Cache Group Information

```
File: grp-example-2.py

import grp
import os

# preload password dictionary
_grp = {}
for info in grp.getgrall():
    _grp[info[0]] = _grp[info[2]] = info

def groupinfo(gid):
    # name or gid integer
    return _grp[gid]

print groupinfo(os.getgid())
print groupinfo("wheel")

('effbot', '', 4711, ['effbot'])
('wheel', '', 10, ['root', 'effbot', 'gorbot', 'timbot'])
```

12.5 The nis Module

(Unix only, Optional) The `nis` module provides an interface to the NIS (yellow pages) services, as Example 12-6 shows. It can be used to fetch values from a NIS database, if available.

Example 12-6. Using the nis Module

```
File: nis-example-1.py

import nis
import string

print nis.cat("ypservers")
print string.split(nis.match("bacon", "hosts.byname"))

{'bacon.spam.egg': 'bacon.spam.egg'}
['194.18.155.250', 'bacon.spam.egg', 'bacon', 'spam-010']
```

12.6 The curses Module

(Unix only, Optional) The `curses` module gives you better control of the text terminal window, in a terminal-independent way. Example 12-7 shows its use.

Example 12-7. Using the curses Module

```
File: curses-example-1.py

import curses

text = [
    "a very simple curses demo",
    "",
    "(press any key to exit)"
]

# connect to the screen
screen = curses.initscr()

# setup keyboard
curses.noecho() # no keyboard echo
curses.cbreak() # don't wait for newline

# screen size
rows, columns = screen.getmaxyx()

# draw a border around the screen
screen.border()

# display centered text
y = (rows - len(text)) / 2

for line in text:
    screen.addstr(y, (columns-len(line))/2, line)
    y = y + 1

screen.getch()

curses.endwin()
```

12.7 The termios Module

(Unix only, Optional) The `termios` module provides an interface to the Unix terminal control facilities. It can be used to control most aspects of the terminal communication ports.

In Example 12-8, this module is used to temporarily disable keyboard echo (which is controlled by the `ECHO` flag in the third flag field).

Example 12-8. Using the termios Module

```
File: termios-example-1.py

import termios, TERMIOS
import sys

fileno = sys.stdin.fileno()

attr = termios.tcgetattr(fileno)
orig = attr[:]

print "attr =>", attr[:4] # flags

# disable echo flag
attr[3] = attr[3] & ~TERMIOS.ECHO

try:
    termios.tcsetattr(fileno, TERMIOS.TCSADRAIN, attr)
    message = raw_input("enter secret message: ")
    print
finally:
    # restore terminal settings
    termios.tcsetattr(fileno, TERMIOS.TCSADRAIN, orig)

print "secret =>", repr(message)

attr => [1280, 5, 189, 35387]
enter secret message:
secret => 'and now for something completely different'
```

12.8 The tty Module

(Unix only) The `tty` module contains some utility functions for dealing with tty devices. Example 12-9 shows how to switch the terminal window over to "raw" mode, and back again.

Example 12-9. Using the tty Module

```
File: tty-example-1.py

import tty
import os, sys

fileno = sys.stdin.fileno()

tty.setraw(fileno)
print raw_input("raw input: ")

tty.setcbreak(fileno)
print raw_input("cbreak input: ")

os.system("stty sane") # ...

raw input: this is raw input
cbreak input: this is cbreak input
```

12.9 The resource Module

(Unix only, Optional) The `resource` module is used to query or modify the system resource current settings limits. Example 12-10 shows how to use the module to query, and Example 12-11 shows how to modify resource limits.

Example 12-10. Using the resource Module to Query Current Settings

```
File: resource-example-1.py

import resource

print "usage stats", "=>", resource.getrusage(resource.RUSAGE_SELF)
print "max cpu", "=>", resource.getrlimit(resource.RLIMIT_CPU)
print "max data", "=>", resource.getrlimit(resource.RLIMIT_DATA)
print "max processes", "=>", resource.getrlimit(resource.RLIMIT_NPROC)
print "page size", "=>", resource.getpagesize()

usage stats => (0.03, 0.02, 0, 0, 0, 0, 75, 168, 0, 0, 0, 0, 0, 0, 0, 0)
max cpu => (2147483647, 2147483647)
max data => (2147483647, 2147483647)
max processes => (256, 256)
page size => 4096
```

Example 12-11. Using the resource Module to Limit Resources

```
File: resource-example-2.py

import resource

resource.setrlimit(resource.RLIMIT_CPU, (0, 1))

# pretend we're busy
for i in range(1000):
    for j in range(1000):
        for k in range(1000):
            pass

CPU time limit exceeded
```

12.10 The syslog Module

(Unix only, Optional) The `syslog` module sends messages to the system logger facility (`syslogd`). Exactly what happens to these messages is system-dependent, but they usually end up in a log file named */var/log/messages*, */var/adm/syslog*, or some variation thereof. (If you cannot find it, check with your system administrator.) Example 12-12 demonstrates.

Example 12-12. Using the syslog Module

```
File: syslog-example-1.py

import syslog
import sys

syslog.openlog(sys.argv[0])

syslog.syslog(syslog.LOG_NOTICE, "a log notice")
syslog.syslog(syslog.LOG_NOTICE, "another log notice: %s" % "watch out!")

syslog.closelog()
```

12.11 The msvcrt Module

(Windows/DOS only) The `msvcrt` module gives you access to a number of functions in the Microsoft Visual C/C++ Runtime Library (MSVCRT).

Example 12-13 demonstrates the `getch` function reading a single keypress from the console.

Example 12-13. Using the msvcrt Module to Get Key Presses

```
File: msvcrt-example-1.py

import msvcrt

print "press 'escape' to quit..."

while 1:
    char = msvcrt.getch()
    if char == chr(27):
        break
    print char,
    if char == chr(13):
        print

press 'escape' to quit...
h e l l o
```

The `kbhit` function returns true if a key has been pressed (which means that `getch` won't block), as shown in Example 12-14.

Example 12-14. Using the msvcrt Module to Poll the Keyboard

```
File: msvcrt-example-2.py

import msvcrt
import time

print "press SPACE to enter the serial number"

while not msvcrt.kbhit() or msvcrt.getch() != " ":
    # do something else
    print ".",
    time.sleep(0.1)

print

# clear the keyboard buffer
while msvcrt.kbhit():
    msvcrt.getch()

serial = raw_input("enter your serial number: ")
```

```
print "serial number is", serial

press SPACE to enter the serial number
. . . . . . . . . . . . . . . . . . . . . . . .
enter your serial number: 10
serial number is 10
```

The `locking` function in Example 12-15 can be used to implement cross-process file locking under Windows.

Example 12-15. Using the msvcrt Module for File Locking

```
File: msvcrt-example-3.py

import msvcrt
import os

LK_UNLCK = 0 # unlock the file region
LK_LOCK = 1 # lock the file region
LK_NBLCK = 2 # non-blocking lock
LK_RLCK = 3 # lock for writing
LK_NBRLCK = 4 # non-blocking lock for writing

FILE = "counter.txt"

if not os.path.exists(FILE):
    file = open(FILE, "w")
    file.write("0")
    file.close()

for i in range(20):
    file = open(FILE, "r+")
    # look from current position (0) to end of file
    msvcrt.locking(file.fileno(), LK_LOCK, os.path.getsize(FILE))
    counter = int(file.readline()) + 1
    file.seek(0)
    file.write(str(counter))
    file.close() # unlocks the file
    print os.getpid(), "=>", counter
    time.sleep(0.1)

208 => 21
208 => 22
208 => 23
208 => 24
208 => 25
208 => 26
```

12.12 The nt Module

(Implementation, Windows only) The `nt` module is an implementation module used by the `os` module on Windows platforms. There's hardly any reason to use this module directly; use `os` instead. Example 12-16 shows its use.

Example 12-16. Using the nt Module

```
File: nt-example-1.py

import nt

# in real life, use os.listdir and os.stat instead!
for file in nt.listdir("."):
    print file, nt.stat(file)[6]

aifc-example-1.py 314
anydbm-example-1.py 259
array-example-1.py 48
```

12.13 The _winreg Module

(Windows only, New in 2.0) The `_winreg` module provides a basic interface to the Windows registry database. Example 12-17 demonstrates the module.

Example 12-17. Using the _winreg Module

```
File: winreg-example-1.py

import _winreg

explorer = _winreg.OpenKey(
    _winreg.HKEY_CURRENT_USER,
    "Software\\Microsoft\\Windows\CurrentVersion\\Explorer"
    )

#list values owned by this registry key
try:
    i = 0
    while 1:
      name, value, type= _winreg.EnumValue(explorer, i)
      print repr(name),
      i += 1
except WindowsError:
    print

value, type = _winreg.QueryValueEx(explorer, "Logon User Name")

print
print "user is", repr(value)
```

```
'Logon User Name' 'CleanShutdown' 'ShellState' 'Shutdown Setting'
'Reason Setting' 'FaultCount' 'FaultTime' 'IconUnderline'...

user is u'Effbot'
```

12.14 The posix Module

(Implementation, Unix/POSIX only) The `posix` module is an implementation module used by the `os` module on Unix and other POSIX systems. While everything in here can be (and should be) accessed via the `os` module, you may wish to explicitly refer to this module in situations where you want to make it clear that you expect POSIX behavior. Example 12-18 demonstrates.

Example 12-18. Using the posix Module

```
File: posix-example-1.py

import posix

for file in posix.listdir("."):
    print file, posix.stat(file)[6]

aifc-example-1.py 314
anydbm-example-1.py 259
array-example-1.py 48
```

Chapter 13. Implementation Support Modules

13.1 The dospath Module

The `dospath` module, shown in Example 13-1, provides `os.path` functionality on DOS platforms. You can also use it to handle DOS paths on other platforms.

Example 13-1. Using the dospath Module

```
File: dospath-example-1.py

import dospath

file = "/my/little/pony"

print "isabs", "=>", dospath.isabs(file)
print "dirname", "=>", dospath.dirname(file)
print "basename", "=>", dospath.basename(file)
print "normpath", "=>", dospath.normpath(file)
print "split", "=>", dospath.split(file)
print "join", "=>", dospath.join(file, "zorba")

isabs => 1
dirname => /my/little
basename => pony
normpath => \my\little\pony
split => ('/my/little', 'pony')
join => /my/little/pony\zorba
```

Note that Python's DOS support can use both forward (/) and backward slashes (\ ) as directory separators.

13.2 The macpath Module

The `macpath` module (see Example 13-2) provides `os.path` functionality on Macintosh platforms. You can also use it to handle Macintosh paths on other platforms.

Example 13-2. Using the macpath Module

```
File: macpath-example-1.py

import macpath

file = "my:little:pony"

print "isabs", "=>", macpath.isabs(file)
print "dirname", "=>", macpath.dirname(file)
print "basename", "=>", macpath.basename(file)
print "normpath", "=>", macpath.normpath(file)
print "split", "=>", macpath.split(file)
print "join", "=>", macpath.join(file, "zorba")

isabs => 1
dirname => my:little
basename => pony
normpath => my:little:pony
split => ('my:little', 'pony')
join => my:little:pony:zorba
```

13.3 The ntpath Module

The `ntpath` module (see Example 13-3) provides `os.path` functionality on Windows platforms. You can also use it to handle Windows paths on other platforms.

Example 13-3. Using the ntpath Module

```
File: ntpath-example-1.py

import ntpath

file = "/my/little/pony"

print "isabs", "=>", ntpath.isabs(file)
print "dirname", "=>", ntpath.dirname(file)
print "basename", "=>", ntpath.basename(file)
print "normpath", "=>", ntpath.normpath(file)
print "split", "=>", ntpath.split(file)
print "join", "=>", ntpath.join(file, "zorba")

isabs => 1
dirname => /my/little
basename => pony

normpath => \my\little\pony
split => ('/my/little', 'pony')
join => /my/little/pony\zorba
```

Note that this module treats both forward slashes (/) and backward slashes (\ ) as directory separators.

13.4 The posixpath Module

The `posixpath` module, shown in Example 13-4, provides `os.path` functionality on Unix and other POSIX-compatible platforms. You can also use it to handle POSIX paths on other platforms. In addition, it can be used to process URLs.

Example 13-4. Using the posixpath Module

```
File: posixpath-example-1.py

import posixpath

file = "/my/little/pony"

print "isabs", "=>", posixpath.isabs(file)
print "dirname", "=>", posixpath.dirname(file)
print "basename", "=>", posixpath.basename(file)
print "normpath", "=>", posixpath.normpath(file)
print "split", "=>", posixpath.split(file)
print "join", "=>", posixpath.join(file, "zorba")

isabs => 1
dirname => /my/little
basename => pony
normpath => /my/little/pony
split => ('/my/little', 'pony')
join => /my/little/pony/zorba
```

13.5 The strop Module

(Obsolete) The `strop` is a low-level module that provides fast C implementations of most functions in the `string` module. It is automatically included by `string`, so there's seldom any need to access it directly.

However, one reason to use this module is if you need to tweak the path *before* you start loading Python modules. Example 13-5 demonstrates the module.

Example 13-5. Using the strop Module

```
File: strop-example-1.py

import strop
import sys

# assuming we have an executable named ".../executable", add a
# directory named ".../executable-extra" to the path

if strop.lower(sys.executable)[-4:] == ".exe":
    extra = sys.executable[:-4] # windows
else:
    extra = sys.executable

sys.path.insert(0, extra + "-extra")

import mymodule
```

In Python 2.0 and later, you should use string methods instead of `strop`. In Example 13-5, replace "`strop.lower(sys.executable)`" with "`sys.executable.lower()`."

13.6 The imp Module

The `imp` module contains functions that can be used to implement your own `import` behavior. Example 13-6 overloads the import statement with a version that logs from where it gets the modules.

Example 13-6. Using the imp Module

```
File: imp-example-1.py

import imp
import sys

def my_import(name, globals=None, locals=None, fromlist=None):
    try:
        module = sys.modules[name] # already imported?
    except KeyError:
        file, pathname, description = imp.find_module(name)
        print "import", name, "from", pathname, description
        module = imp.load_module(name, file, pathname, description)
    return module

import _ _builtin_ _
_ _builtin_ _._ _import_ _ = my_import

import xmllib

import xmllib from /python/lib/xmllib.py ('.py', 'r', 1)
import re from /python/lib/re.py ('.py', 'r', 1)

import sre from /python/lib/sre.py ('.py', 'r', 1)
import sre_compile from /python/lib/sre_compile.py ('.py', 'r', 1)
import _sre from /python/_sre.pyd ('.pyd', 'rb', 3)
```

Note that the alternative version shown here doesn't support packages. For a more extensive example, see the sources for the `knee` module.

13.7 The new Module

(Optional in 1.5.2) The `new` modules is a low-level module that allows you to create various kinds of internal objects, such as class objects, function objects, and other kinds that are usually created by the Python runtime system. Example 13-7 demonstrates this module.

Note that if you're using 1.5.2, you may have to rebuild Python to use this module; it isn't enabled by the default on all platforms. In 2.0 and later, however, it's always available.

Example 13-7. Using the new Module

```
File: new-example-1.py

import new

class Sample:

    a = "default"

    def _ _init_ _(self):
        self.a = "initialised"

    def _ _repr_ _(self):
        return self.a

#
# create instances

a = Sample()
print "normal", "=>", a

b = new.instance(Sample, {})
print "new.instance", "=>", b

b._ _init_ _()
print "after _ _init_ _", "=>", b

c = new.instance(Sample, {"a": "assigned"})
print "new.instance w. dictionary", "=>", c
```

```
normal => initialised
new.instance => default
after _ _init_ _ => initialised
new.instance w. dictionary => assigned
```

13.8 The pre Module

(Implementation) The `pre` module, used in Example 13-8, is a low-level implementation module for the 1.5.2 `re` module. There's usually no need to use this module directly (and code using it may stop working in future releases).

Example 13-8. Using the pre Module

```
File: pre-example-1.py

import pre

p = pre.compile("[Python]+")

print p.findall("Python is not that bad")

['Python', 'not', 'th', 't']
```

13.9 The sre Module

(Implementation) The `sre` module, used in Example 13-9, is a low-level implementation module for the 2.0 `re` module. There's usually no need to use this module directly (and code using it may stop working in future releases).

Example 13-9. Using the sre Module

```
File: sre-example-1.py

import sre

text = "The Bookshop Sketch"

# a single character
m = sre.match(".", text)
if m: print repr("."), "=>", repr(m.group(0))

# and so on, for all 're' examples...

'.' => 'T'
```

13.10 The py_compile Module

The `py_compile` module, shown in Example 13-10, allows you to explicitly compile Python modules to bytecode. It behaves like Python's `import` statement, but takes a filename, not a module name.

Example 13-10. Using the py_compile Module

```
File: py-compile-example-1.py

import py_compile

# explicitly compile this module
py_compile.compile("py-compile-example-1.py")
```

The `compileall` module can be used to compile all Python files in an entire directory tree.

13.11 The compileall Module

The `compileall` module (see Example 13-11) contains functions to compile all Python scripts in a given directory (or along the Python path) to byte code. It can also be used as a script (on Unix platforms, it's automatically run when Python is installed).

Example 13-11. Using the compileall Module to Compile All Scripts in a Directory

```
File: compileall-example-1.py

import compileall

print "This may take a while!"

compileall.compile_dir(".", force=1)

This may take a while!
Listing . ...
Compiling .\SimpleAsyncHTTP.py ...
Compiling .\aifc-example-1.py ...
Compiling .\anydbm-example-1.py ...
...
```

13.12 The ihooks Module

The `ihooks` module, shown in Example 13-12, provides a framework for import replacements. The idea is to allow several alternate import mechanisms to coexist.

Example 13-12. Using the ihooks Module

```
File: ihooks-example-1.py

import ihooks, imp, os

def import_from(filename):
    "Import module from a named file"

    loader = ihooks.BasicModuleLoader()
    path, file = os.path.split(filename)
    name, ext  = os.path.splitext(file)
    m = loader.find_module_in_dir(name, path)
    if not m:
        raise ImportError, name
    m = loader.load_module(name, m)
    return m

colorsys = import_from("/python/lib/colorsys.py")

print colorsys

<module 'colorsys' from '/python/lib/colorsys.py'>
```

13.13 The linecache Module

The `linecache` module in Example 13-13 is used to read lines from module source code. It caches recently visited modules (the entire source file, actually).

Example 13-13. Using the linecache module

```
File: linecache-example-1.py

import linecache

print linecache.getline("linecache-example-1.py", 5)
```

print linecache.getline("linecache-example-1.py", 5)

This module is used by the `traceback` module.

13.14 The macurl2path Module

(Implementation) The `macurl2path` module, shown in Example 13-14, contains code to map between URLs and Macintosh filenames. It should not be used directly; use the mechanisms in `urllib` instead.

Example 13-14. Using the macurl2path Module

```
File: macurl2path-example-1.py

import macurl2path

file = ":my:little:pony"

print macurl2path.pathname2url(file)
print macurl2path.url2pathname(macurl2path.pathname2url(file))

my/little/pony
:my:little:pony
```

13.15 The nturl2path module

(Implementation) The `nturl2path` module, shown in Example 13-15, contains code to map between URLs and Windows filenames.

Example 13-15. Using the nturl2path Module

```
File: nturl2path-example-1.py

import nturl2path

file = r"c:\my\little\pony"

print nturl2path.pathname2url(file)
print nturl2path.url2pathname(nturl2path.pathname2url(file))

///C|/my/little/pony
C:\my\little\pony
```

This module should not be used directly; for portability, access these functions via the `urllib` module instead, as shown in Example 13-16.

Example 13-16. Using the nturl2path Module via the urllib Module

```
File: nturl2path-example-2.py

import urllib

file = r"c:\my\little\pony"

print urllib.pathname2url(file)
print urllib.url2pathname(urllib.pathname2url(file))

///C|/my/little/pony
C:\my\little\pony
```

13.16 The tokenize Module

The `tokenize` module splits a Python source file into individual tokens. It can be used for syntax highlighting or for various kinds of code-analysis tools.

In Example 13-17, we simply print the tokens.

Example 13-17. Using the tokenize Module

```
File: tokenize-example-1.py

import tokenize

file = open("tokenize-example-1.py")

def handle_token(type, token, (srow, scol), (erow, ecol), line):
    print "%d,%d-%d,%d:\t%s\t%s" % \
        (srow, scol, erow, ecol, tokenize.tok_name[type], repr(token))

tokenize.tokenize(
    file.readline,
    handle_token
    )

1,0-1,6:     NAME    'import'
1,7-1,15:    NAME    'tokenize'
1,15-1,16:   NEWLINE '\012'
2,0-2,1:     NL      '\012'
3,0-3,4:     NAME    'file'
3,5-3,6:     OP      '='
3,7-3,11:    NAME    'open'
3,11-3,12:   OP      '('
3,12-3,35:   STRING  '"tokenize-example-1.py"'
3,35-3,36:   OP      ')'
3,36-3,37:   NEWLINE '\012'
...
```

Note that the `tokenize` function takes two callable objects: the first argument is called repeatedly to fetch new code lines, and the second argument is called for each token.

13.17 The keyword Module

The `keyword` module (see Example 13-18) contains a list of the keywords used in the current version of Python. It also provides a dictionary with the keywords as keys, and a predicate function that can be used to check if a given word is a Python keyword.

Example 13-18. Using the keyword Module

```
File: keyword-example-1.py

import keyword

name = raw_input("Enter module name: ")

if keyword.iskeyword(name):
    print name, "is a reserved word."
    print "here's a complete list of reserved words:"
    print keyword.kwlist

Enter module name: assert
assert is a reserved word.
here's a complete list of reserved words:
['and', 'assert', 'break', 'class', 'continue', 'def', 'del',
'elif', 'else', 'except', 'exec', 'finally', 'for', 'from',
'global', 'if', 'import', 'in', 'is', 'lambda', 'not', 'or',
'pass', 'print', 'raise', 'return', 'try', 'while']
```

13.18 The parser Module

(Optional) The `parser` module provides an interface to Python's built-in parser and compiler.

Example 13-19 compiles a simple expression into an *abstract syntax tree* (AST), turns the AST into a nested list, dumps the contents of the tree (where each node contains either a grammar symbol or a token), increments all numbers by one, and, finally, turns the list back into a code object. At least that's what I think it does.

Example 13-19. Using the parser Module

```
File: parser-example-1.py

import parser
import symbol, token

def dump_and_modify(node):
    name = symbol.sym_name.get(node[0])
    if name is None:
        name = token.tok_name.get(node[0])
    print name,
    for i in range(1, len(node)):
        item = node[i]
        if type(item) is type([]):
            dump_and_modify(item)
        else:
            print repr(item)
            if name == "NUMBER":
                # increment all numbers!
                node[i] = repr(int(item)+1)

ast = parser.expr("1 + 3")

list = ast.tolist()

dump_and_modify(list)

ast = parser.sequence2ast(list)

print eval(parser.compileast(ast))

eval_input testlist test and_test not_test comparison
expr xor_expr and_expr shift_expr arith_expr term factor
power atom NUMBER '1'
PLUS '+'
term factor power atom NUMBER '3'
NEWLINE ''
ENDMARKER ''
6
```

13.19 The symbol Module

The `symbol` module, used in Example 13-20, contains a listing of non-terminal symbols from the Python grammar. It's probably only useful if you're dabbling with the `parser` module.

Example 13-20. Using the symbol Module

```
File: symbol-example-1.py

import symbol

print "print", symbol.print_stmt
print "return", symbol.return_stmt

print 268
return 274
```

13.20 The token Module

The `token` module, shown in Example 13-21, contains a list of all tokens used by the standard Python tokenizer.

Example 13-21. Using the token Module

```
File: token-example-1.py

import token

print "NUMBER", token.NUMBER
print "PLUS", token.STAR
print "STRING", token.STRING

NUMBER 2
PLUS 16
STRING 3
```

Chapter 14. Other Modules

14.1 Overview

This chapter describes a number of less-common modules. Some are useful, others are quite obscure, and some are just plain obsolete.

14.2 The pyclbr Module

The `pyclbr` module, shown in Example 14-1, contains a basic Python class parser.

In 1.5.2, the module exports a single function, `readmodule`, which parses a given module, and returns a list of all classes defined at the module's top level.

Example 14-1. Using the pyclbr Module

```
File: pyclbr-example-1.py

import pyclbr

mod = pyclbr.readmodule("cgi")

for k, v in mod.items():
    print k, v

MiniFieldStorage <pyclbr.Class instance at 7873b0>
InterpFormContentDict <pyclbr.Class instance at 79bd00>
FieldStorage <pyclbr.Class instance at 790e20>
SvFormContentDict <pyclbr.Class instance at 79b5e0>
StringIO <pyclbr.Class instance at 77dd90>
FormContent <pyclbr.Class instance at 79bd60>
FormContentDict <pyclbr.Class instance at 79a9c0>
```

In 2.0 and later, there's also an alternative interface, `readmodule_ex`, which returns global functions as well. This is shown in Example 14-2.

Example 14-2. Using the pyclbr Module to Read Classes and Functions

```
File: pyclbr-example-3.py

import pyclbr

# 2.0 and later
mod = pyclbr.readmodule_ex("cgi")

for k, v in mod.items():
    print k, v

MiniFieldStorage <pyclbr.Class instance at 00905D2C>
parse_header <pyclbr.Function instance at 00905BD4>
test <pyclbr.Function instance at 00906FBC>
print_environ_usage <pyclbr.Function instance at 00907C94>
parse_multipart <pyclbr.Function instance at 00905294>
FormContentDict <pyclbr.Class instance at 008D3494>
initlog <pyclbr.Function instance at 00904AAC>
parse <pyclbr.Function instance at 00904EFC>
StringIO <pyclbr.Class instance at 00903EAC>
```

```
SvFormContentDict <pyclbr.Class instance at 00906824>
...
```

To get more information about each class, use the various attributes in the *Class* instances, as Example 14-3 shows.

Example 14-3. Using the pyclbr Module

```
File: pyclbr-example-2.py

import pyclbr
import string

mod = pyclbr.readmodule("cgi")

def dump(c):
    # print class header
    s = "class " + c.name
    if c.super:
        s = s +  "(" + string.join(map(lambda v: v.name, c.super), ", ") + ")"
    print s + ":"
    # print method names, sorted by line number
    methods = c.methods.items()
    methods.sort(lambda a, b: cmp(a[1], b[1]))
    for method, lineno in methods:
        print "  def " + method
    print

for k, v in mod.items():
    dump(v)

class MiniFieldStorage:
  def _ _init_ _
  def _ _repr_ _

class InterpFormContentDict(SvFormContentDict):
  def _ _getitem_ _
  def values
  def items

...
```

14.3 The filecmp Module

(New in 2.0) The `filecmp` module, shown in Example 14-4, contains functions to compare files and directories.

Example 14-4. Using the filecmp Module

```
File: filecmp-example-1.py

import filecmp

if filecmp.cmp("samples/sample.au", "samples/sample.wav"):
    print "files are identical"
else:
    print "files differ!"

# files differ!
```

In 1.5.2 and earlier, you can use the `cmp` and `dircmp` modules instead.

14.4 The cmd Module

The `cmd` module (see Example 14-5) provides a simple framework for command-line interfaces (CLI). This is used by the `pdb` debugger module, but you can also use it for your own programs.

To implement your own command-line interface, subclass the *Cmd* class, and define `do` and `help` methods. The base class automatically turns all `do` methods into commands and uses the `help` methods to show help information.

Example 14-5. Using the cmd Module

```
File: cmd-example-1.py

import cmd
import string, sys

class CLI(cmd.Cmd):

    def _ _init_ _(self):
        cmd.Cmd._ _init_ _(self)
        self.prompt = '> '

    def do_hello(self, arg):
        print "hello again", arg, "!"

    def help_hello(self):
        print "syntax: hello [message]",
        print "-- prints a hello message"

    def do_quit(self, arg):
        sys.exit(1)

    def help_quit(self):
        print "syntax: quit",
        print "-- terminates the application"

    # shortcuts
    do_q = do_quit

#
# try it out

cli = CLI()
cli.cmdloop()

> help

Documented commands (type help <topic>):
========================================
hello           quit
```

```
Undocumented commands:
======================
help            q

> hello world
hello again world !
> q
```

14.5 The rexec Module

The `rexec` module, shown in Example 14-6, provides versions of `exec`, `eval`, and `import`, which execute code in a restricted execution environment. In this environment, functions that can damage resources on the local machine are no longer available.

Example 14-6. Using the rexec Module

```
File: rexec-example-1.py

import rexec

r = rexec.RExec()
print r.r_eval("1+2+3")
print r.r_eval("_ _import_ _('os').remove('file')")

6
Traceback (innermost last):
  File "rexec-example-1.py", line 5, in ?
    print r.r_eval("_ _import_ _('os').remove('file')")
  File "/usr/local/lib/python1.5/rexec.py", line 257, in r_eval
    return eval(code, m._ _dict_ _)
  File "<string>", line 0, in ?
AttributeError: remove
```

14.6 The Bastion Module

The `Bastion` module, shown in Example 14-7, allows you to control how a given object is used. It can be used to pass objects from unrestricted parts of your application to code running in restricted mode.

To create a restricted instance, simply call the `Bastion` wrapper. By default, all instance variables are hidden, as well as all methods that start with an underscore.

Example 14-7. Using the Bastion Module

```
File: bastion-example-1.py

import Bastion

class Sample:
    value = 0

    def _set(self, value):
        self.value = value

    def setvalue(self, value):
        if 10 < value <= 20:
            self._set(value)
        else:
            raise ValueError, "illegal value"

    def getvalue(self):
        return self.value

#
# try it

s = Sample()
s._set(100) # cheat
print s.getvalue()

s = Bastion.Bastion(Sample())
s._set(100) # attempt to cheat
print s.getvalue()

100
Traceback (innermost last):
...
AttributeError: _set
```

You can control which functions to publish. In Example 14-8, the internal method can be called from outside, but the `getvalue` no longer works.

Example 14-8. Using the Bastion Module with a Non-Standard Filter

```
File: bastion-example-2.py

import Bastion

class Sample:
    value = 0

    def _set(self, value):
        self.value = value

    def setvalue(self, value):
        if 10 < value <= 20:
            self._set(value)
        else:
            raise ValueError, "illegal value"

    def getvalue(self):
        return self.value

#
# try it

def is_public(name):
    return name[:3] != "get"

s = Bastion.Bastion(Sample(), is_public)
s._set(100) # this works
print s.getvalue() # but not this

100
Traceback (innermost last):
...
AttributeError: getvalue
```

14.7 The readline Module

(Optional) The `readline` module, shown in Example 14-9, activates input editing on Unix, using the GNU readline library (or compatible).

Once imported, this module provides improved command-line editing, as well as command history. It also enhances the `input` and `raw_input` functions.

Example 14-9. Using the readline Module

```
File: readline-example-1.py

import readline # activate readline editing
```

14.8 The rlcompleter Module

(Optional, Unix only) The `rlcompleter` module provides word completion for the `readline` module.

To enable word completion, just import this module. By default, the completion function is bound to the Esc key. Press Esc twice to finish the current word. To change the key, you can use something like:

```
import readline
readline.parse_and_bind("tab: complete")
```

The script in Example 14-10 shows how to use the completion functions from within a program.

Example 14-10. Using the rlcompleter Module to Expand Names

```
File: rlcompleter-example-1.py

import rlcompleter
import sys

completer = rlcompleter.Completer()

for phrase in "co", "sys.p", "is":
    print phrase, "=>",
    # emulate readline completion handler
    try:
        for index in xrange(sys.maxint):
            term = completer.complete(phrase, index)
            if term is None:
                break
            print term,
    except:
        pass
    print

co => continue compile complex coerce completer
sys.p => sys.path sys.platform sys.prefix
is => is isinstance issubclass
```

14.9 The statvfs Module

The `statvfs` module, used in Example 14-11, contains a number of constants and test functions that can be used with the optional `os.statvfs` function, which returns information about a filesystem.

Example 14-11. Using the statvfs Module

```
File: statvfs-example-1.py

import statvfs
import os

st = os.statvfs(".")

print "preferred block size", "=>", st[statvfs.F_BSIZE]
print "fundamental block size", "=>", st[statvfs.F_FRSIZE]
print "total blocks", "=>", st[statvfs.F_BLOCKS]
print "total free blocks", "=>", st[statvfs.F_BFREE]
print "available blocks", "=>", st[statvfs.F_BAVAIL]
print "total file nodes", "=>", st[statvfs.F_FILES]
print "total free nodes", "=>", st[statvfs.F_FFREE]
print "available nodes", "=>", st[statvfs.F_FAVAIL]
print "max file name length", "=>", st[statvfs.F_NAMEMAX]

preferred block size => 8192
fundamental block size => 1024
total blocks => 749443
total free blocks => 110442
available blocks => 35497
total file nodes => 92158
total free nodes => 68164
available nodes => 68164
max file name length => 255
```

14.10 The calendar Module

The `calendar` module is a Python reimplementation of the Unix *cal* command. It simply prints the calendar for any given month or year to standard output.

In Example 14-12, `prmonth(year, month)` prints the calendar for a given month.

Example 14-12. Using the calendar Module

```
File: calendar-example-1.py

import calendar
calendar.prmonth(1999, 12)

    December 1999
Mo Tu We Th Fr Sa Su
       1  2  3  4  5
 6  7  8  9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31
```

In Example 14-13, `prcal(year)` prints the calendar for a given year.

Example 14-13. Using the calendar Module

```
File: calendar-example-2.py

import calendar
calendar.prcal(2000)

                                  2000

       January                   February                   March
Mo Tu We Th Fr Sa Su      Mo Tu We Th Fr Sa Su      Mo Tu We Th Fr Sa Su
                1  2          1  2  3  4  5  6             1  2  3  4  5
 3  4  5  6  7  8  9       7  8  9 10 11 12 13       6  7  8  9 10 11 12
10 11 12 13 14 15 16      14 15 16 17 18 19 20      13 14 15 16 17 18 19
17 18 19 20 21 22 23      21 22 23 24 25 26 27      20 21 22 23 24 25 26
24 25 26 27 28 29 30      28 29                     27 28 29 30 31
31

        April                      May                      June
Mo Tu We Th Fr Sa Su      Mo Tu We Th Fr Sa Su      Mo Tu We Th Fr Sa Su
                1  2       1  2  3  4  5  6  7                1  2  3  4
 3  4  5  6  7  8  9       8  9 10 11 12 13 14       5  6  7  8  9 10 11
10 11 12 13 14 15 16      15 16 17 18 19 20 21      12 13 14 15 16 17 18
17 18 19 20 21 22 23      22 23 24 25 26 27 28      19 20 21 22 23 24 25
24 25 26 27 28 29 30      29 30 31                  26 27 28 29 30
```

```
       July                     August                  September
Mo Tu We Th Fr Sa Su     Mo Tu We Th Fr Sa Su     Mo Tu We Th Fr Sa Su
                1  2         1  2  3  4  5  6                  1  2  3
 3  4  5  6  7  8  9      7  8  9 10 11 12 13      4  5  6  7  8  9 10
10 11 12 13 14 15 16     14 15 16 17 18 19 20     11 12 13 14 15 16 17
17 18 19 20 21 22 23     21 22 23 24 25 26 27     18 19 20 21 22 23 24
24 25 26 27 28 29 30     28 29 30 31              25 26 27 28 29 30
31

      October                  November                 December
Mo Tu We Th Fr Sa Su     Mo Tu We Th Fr Sa Su     Mo Tu We Th Fr Sa Su
                   1            1  2  3  4  5                  1  2  3
 2  3  4  5  6  7  8      6  7  8  9 10 11 12      4  5  6  7  8  9 10
 9 10 11 12 13 14 15     13 14 15 16 17 18 19     11 12 13 14 15 16 17
16 17 18 19 20 21 22     20 21 22 23 24 25 26     18 19 20 21 22 23 24
23 24 25 26 27 28 29     27 28 29 30              25 26 27 28 29 30 31
30 31
```

Note that the calendars are printed using European conventions; in other words, Monday is the first day of the week.

This module contains a number of support functions that can be useful if you want to output calendars in other formats. It's probably easiest to copy the entire file, and tweak it to suit your needs.

14.11 The sched Module

The `sched` module is a simple event scheduler for non-threaded environments. Example 14-14 demonstrates.

Example 14-14. Using the sched Module

```
File: sched-example-1.py

import sched
import time, sys

scheduler = sched.scheduler(time.time, time.sleep)

# add a few operations to the queue
scheduler.enter(0.5, 100, sys.stdout.write, ("one\n",))
scheduler.enter(1.0, 300, sys.stdout.write, ("three\n",))
scheduler.enter(1.0, 200, sys.stdout.write, ("two\n",))

scheduler.run()

one
two
three
```

14.12 The statcache Module

The `statcache` module, shown in Example 14-15, contains a function that returns information about files. It's an extension of the `os.stat` function in that it keeps a cache with recently collected information.

Example 14-15. Using the statcache Module

```
File: statcache-example-1.py

import statcache
import os, stat, time

now = time.time()
for i in range(1000):
    st = os.stat("samples/sample.txt")
print "os.stat", "=>", time.time() - now

now = time.time()
for i in range(1000):
    st = statcache.stat("samples/sample.txt")
print "statcache.stat", "=>", time.time() - now

print "mode", "=>", oct(stat.S_IMODE(st[stat.ST_MODE]))
print "size", "=>", st[stat.ST_SIZE]
print "last modified", "=>", time.ctime(st[stat.ST_MTIME])

os.stat => 0.371000051498
statcache.stat => 0.0199999809265
mode => 0666
size => 305
last modified => Sun Oct 10 18:39:37 1999
```

14.13 The grep Module

The `grep` module provides different ways to search for text in text files, as Example 14-16 shows.

Example 14-16. Using the grep Module

```
File: grep-example-1.py

import grep
import glob

grep.grep("\<rather\>", glob.glob("samples/*.txt"))

# 4: indentation, rather than delimiters, might become
```

14.14 The dircache Module

(Obsolete) The `dircache` module contains a function to get a list of files in a directory. It's an extension of the `os.listdir` function in that it keeps a cache to avoid rereading a directory that hasn't been modified. Example 14-17 demonstrates this.

Example 14-17. Using the dircache Module

```
File: dircache-example-1.py

import dircache

import os, time

#
# test cached version

t0 = time.clock()

for i in range(100):
    dircache.listdir(os.sep)

print "cached", time.clock() - t0

#
# test standard version

t0 = time.clock()

for i in range(100):
    os.listdir(os.sep)

print "standard", time.clock() - t0

cached 0.0664509964968
standard 0.5560845807
```

14.15 The dircmp Module

(Obsolete, Only in 1.5.2) The `dircmp` module provides a class that can be used to compare the contents of two disk directories, as Example 14-18 shows.

Example 14-18. Using the dircmp Module

```
File: dircmp-example-1.py

import dircmp

d = dircmp.dircmp()
d.new("samples", "oldsamples")
d.run()
d.report()

diff samples oldsamples
Only in samples : ['sample.aiff', 'sample.au', 'sample.wav']
Identical files : ['sample.gif', 'sample.gz', 'sample.jpg', ...]
```

In Python 2.0 and later, this module has been replaced by `filecmp`.

14.16 The cmp Module

(Obsolete, Only in 1.5.2) The `cmp` module contains a function to compare two files, as Example 14-19 demonstrates.

Example 14-19. Using the cmp Module

```
File: cmp-example-1.py

import cmp

if cmp.cmp("samples/sample.au", "samples/sample.wav"):
    print "files are identical"
else:
    print "files differ!"
```

```
files differ!
```

In Python 2.0 and later, this module has been replaced by the `filecmp` module.

14.17 The cmpcache Module

(Obsolete, Only in 1.5.2) The `cmpcache` module contains a function that compares two files. It's an extension of the `cmp` module in that it keeps a cache over recently made comparisons. Example 14-20 shows the module's use.

Example 14-20. Using the cmpcache Module

```
File: cmpcache-example-1.py

import cmpcache

if cmpcache.cmp("samples/sample.au", "samples/sample.wav"):
    print "files are identical"
else:
    print "files differ!"
```

```
files differ!
```

In Python 2.0 and later, this module has been replaced by the `filecmp` module.

14.18 The util Module

(Obsolete, Only in 1.5.2) The `util` module is included for backward-compatibility only. New code should use the replacement constructs shown in Examples 14-21 through 14-23.

Example 14-21 shows how `remove(sequence, item)` removes the given item, if found in the sequence.

Example 14-21. Emulating the util Module's remove Function

```
File: util-example-1.py

def remove(sequence, item):
    if item in sequence:
        sequence.remove(item)
```

Example 14-22 shows how `readfile(filename) => string` reads the contents of a text file as a single string.

Example 14-22. Emulating the util Module's readfile Function

```
File: util-example-2.py

def readfile(filename):
    file = open(filename, "r")
    return file.read()
```

Example 14-23 shows how `readopenfile(file) => string` returns the contents of an open file (or other file object).

Example 14-23. Emulating the util Module's readopenfile Function

```
File: util-example-3.py

def readopenfile(file):
    return file.read()
```

14.19 The soundex Module

(Optional, Only 1.5.2) The `soundex` module implements a simple hash algorithm, which converts words to 6-character strings based on their English pronunciation.

As of Version 2.0, this module is no longer included.

`get_soundex(word)` returns the `soundex` string for the given word. Words that sound similar should give the same `soundex` string. `sound_similar(word1, word2)` returns true if the two words have the same `soundex`. Example 14-24 uses both functions.

Example 14-24. Using the soundex Module

```
File: soundex-example-1.py

import soundex

a = "fredrik"
b = "friedrich"

print soundex.get_soundex(a), soundex.get_soundex(b)

print soundex.sound_similar(a, b)

F63620 F63620
1
```

14.20 The timing Module

(Obsolete, Unix only) The `timing` module can be used to time the execution of a Python program. Example 14-25 demonstrates.

Example 14-25. Using the timing Module

```
File: timing-example-1.py

import timing
import time

def procedure():
    time.sleep(1.234)

timing.start()
procedure()
timing.finish()

print "seconds:", timing.seconds()
print "milliseconds:", timing.milli()
print "microseconds:", timing.micro()

seconds: 1
milliseconds: 1239
microseconds: 1239999
```

The script in Example 14-26 shows how you can emulate this module using functions in the standard `time` module.

Example 14-26. Emulating the timing Module

```
File: timing-example-2.py

import time

t0 = t1 = 0

def start():
    global t0
    t0 = time.time()


def finish():
    global t1
    t1 = time.time()

def seconds():
    return int(t1 - t0)
```

```
def milli():
    return int((t1 - t0) * 1000)

def micro():
    return int((t1 - t0) * 1000000)
```

You can use `time.clock()` instead of `time.time()` to get CPU time, where supported.

14.21 The posixfile Module

(Obsolete, Unix only) The `posixfile` module provides a file-like object with support for file locking, as Example 14-27 shows. New programs should use the `fcntl` module instead.

Example 14-27. Using the posixfile Module

```
File: posixfile-example-1.py

import posixfile
import string

filename = "counter.txt"

try:
    # open for update
    file = posixfile.open(filename, "r+")
    counter = int(file.read(6)) + 1
except IOError:
    # create it
    file = posixfile.open(filename, "w")
    counter = 0

file.lock("w|", 6)

file.seek(0) # rewind
file.write("%06d" % counter)

file.close() # releases lock
```

14.22 The bisect Module

The `bisect` module provides functions to insert items in sorted sequences.

`insort(sequence, item)` inserts an item into the sequence, keeping it sorted. The sequence can be any mutable sequence object that implements `__getitem__` and `insert`; Example 14-28 demonstrates.

Example 14-28. Using the bisect Module to Insert Items in an Ordered List

```
File: bisect-example-1.py

import bisect

list = [10, 20, 30]

bisect.insort(list, 25)
bisect.insort(list, 15)

print list

[10, 15, 20, 25, 30]
```

In Example 14-29, `bisect(sequence, item) => index` returns the index where the item should be inserted. The sequence is not modified.

Example 14-29. Using the bisect Module to Find Insertion Points

```
File: bisect-example-2.py

import bisect

list = [10, 20, 30]

print list
print bisect.bisect(list, 25)
print bisect.bisect(list, 15)

[10, 20, 30]
2
1
```

14.23 The knee Module

The `knee` module is a Python reimplementation of the package import mechanism that was introduced in Python 1.5. Since this is already supported by the standard interpreter, this module is mainly provided to show how things are done in there. It does work, though. Just import the module to enable it, as Example 14-30 shows.

Example 14-30. Using the knee Module

```
File: knee-example-1.py

import knee

# that's all, folks!
```

14.24 The tzparse Module

(Obsolete) The (highly incomplete) `tzparse` module contains a parser for time zone specifications. When you import this module, it parses the content of the `TZ` environment variable; Example 14-31 demonstrates.

Example 14-31. Using the tzparse Module

```
File: tzparse-example-1.py

import os
if not os.environ.has_key("TZ"):
    # set it to something...
    os.environ["TZ"] = "EST+5EDT;100/2,300/2"

# importing this module will parse the TZ variable
import tzparse

print "tzparams", "=>", tzparse.tzparams
print "timezone", "=>", tzparse.timezone
print "altzone", "=>", tzparse.altzone
print "daylight", "=>", tzparse.daylight
print "tzname", "=>", tzparse.tzname

tzparams => ('EST', 5, 'EDT', 100, 2, 300, 2)
timezone => 18000
altzone => 14400
daylight => 1
tzname => ('EST', 'EDT')
```

In addition to the variables shown in Example 14-31, this module contains a number of time manipulation functions that use the defined time zone.

14.25 The regex Module

(Obsolete) The `regex` module, shown in Example 14-32, is the old (pre-1.5) regular expression machinery. New code should use `re` where possible.

Note that `regex` is faster than the `re` module used in Python 1.5.2, but slower than the new version used in 1.6 and later.

Example 14-32. Using the regex Module

```
File: regex-example-1.py

import regex

text = "Man's crisis of identity in the latter half of the 20th century"

p = regex.compile("latter") # literal
print p.match(text)
print p.search(text), repr(p.group(0))

p = regex.compile("[0-9]+") # number
print p.search(text), repr(p.group(0))

p = regex.compile("\<\w\w\>") # two-letter word
print p.search(text), repr(p.group(0))

p = regex.compile("\w+$") # word at the end
print p.search(text), repr(p.group(0))

-1
32 'latter'
51 '20'
13 'of'
56 'century'
```

14.26 The regsub Module

(Obsolete) The `regsub` module, shown in Example 14-33, provides string replacements, based on regular expressions. New code should use the `re` module's `replace` function instead.

Example 14-33. Using the regsub Module

```
File: regsub-example-1.py

import regsub

text = "Well, there's spam, egg, sausage, and spam."

print regsub.sub("spam", "ham", text) # just the first
print regsub.gsub("spam", "bacon", text) # all of them

Well, there's ham, egg, sausage, and spam.
Well, there's bacon, egg, sausage, and bacon.
```

14.27 The reconvert Module

(Obsolete) The `reconvert` module, shown in Example 14-34, converts old-style regular expressions as used by the `regex` module to the new style used by the `re` module. It can also be used as a command-line tool.

Example 14-34. Using the reconvert Module

```
File: reconvert-example-1.py

import reconvert

for pattern in "abcd", "a\(b*c\)d", "\<\w+\>":
    print pattern, "=>", reconvert.convert(pattern)

abcd => abcd
a\(b*c\)d => a(b*c)d
\<\w+\> => \b\w+\b
```

14.28 The regex_syntax Module

(Obsolete) The `regex_syntax` module, shown in Example 14-35, contains a bunch of flags that can be used to change the behavior of the `regex` regular expression module.

Example 14-35. Using the regex_syntax Module

```
File: regex-syntax-example-1.py

import regex_syntax
import regex

def compile(pattern, syntax):
    syntax = regex.set_syntax(syntax)
    try:
        pattern = regex.compile(pattern)
    finally:
        # restore original syntax
        regex.set_syntax(syntax)
    return pattern

def compile_awk(pattern):
    return compile(pattern, regex_syntax.RE_SYNTAX_AWK)

def compile_grep(pattern):
    return compile(pattern, regex_syntax.RE_SYNTAX_GREP)

def compile_emacs(pattern):
    return compile(pattern, regex_syntax.RE_SYNTAX_EMACS)
```

14.29 The find Module

(Only 1.5.2, Obsolete) The `find` module provides a single function, with the same name as the module: `find(pattern, directory) => list` scans a given directory and all its subdirectories for files matching a given pattern, as Example 14-36 shows.

For more information on the pattern syntax, see the `fnmatch` module.

Example 14-36. Using the find Module

```
File: find-example-1.py

import find

# find all JPEG files in or beneath the current directory
for file in find.find("*.jpg", "."):
    print file
```

```
.\samples\sample.jpg
```

Colophon

Our look is the result of reader comments, our own experimentation, and feedback from distribution channels. Distinctive covers complement our distinctive approach to technical topics, breathing personality and life into potentially dry subjects.

The animals on the cover of *Python Standard Library* are harvest mice. Many species of harvest mice populate North American grasslands and marshes, while only one species-Micromys minutus, the Old World harvest mouse-resides in the grasslands and farmlands of Europe and Asia.

Smaller than the common house mouse, the harvest mouse sports prominent ears and a very long hairy tail, and its hind feet have an opposable fifth toe for grasping and climbing stems. Behaviorally, harvest mice set themselves apart from other mice species by building breeding nests suspended in high grasses. These nests are baseball-sized globes of woven grass with small entrance holes and are lined with soft plant material, such as dandelion fluff, to keep the young warm. The young are born in litters of three to six, completely dependent on the mother (the father is not allowed in the nest). By the time they are five weeks old, however, they are independent and sexually mature. Overall, harvest mice typically live for six to eighteen months in the wild-enough time for a female to produce one to six litters in her lifetime. These numbers are much higher for mice in captivity.

The harvest mouse is a "cover dependent" species, as it relies on brush and vegetation to hide its small, brown body from predators as it forages for seeds and insect larvae. It moves slowly and adopts a still "camouflage posture" as further defense; overall, it is much more calm than the common house mouse.

The Western, Eastern, and Fulvous harvest mice (*Reithrodontomys megalotis*, *Reithrodontomys humulis*, and *Reithrodontomys fulvescens*, respectively) currently populate various regions of the United States and Canada with relative success, challenged somewhat by habitat loss due to crop farming, cattle grazing, and urbanization. However, their cousin the Saltmarsh harvest mouse (*Reithrodontomys raviventris*) suffers severe threat due to the filling in of its dwindling marshland home in the San Francisco Bay Area. The only endangered harvest mouse species, its members number in only the hundreds to the few thousands.

Catherine Morris was the production editor and proofreader, and Linley Dolby was the copyeditor for *Python Standard Library*. Emily Quill, Matt Hutchinson, and Claire Cloutier provided quality control. Joe Wizda wrote the index. Interior composition was done by Gabe Weiss, Matt Hutchinson, and Catherine Morris.

Hanna Dyer designed the cover of this book, based on a series design by Edie Freedman. The cover image is a 19th-century engraving from the Dover Pictorial Archive. Emma Colby produced the cover layout with Quark™XPress 4.1 using Adobe's ITC Garamond font. Emma Colby also designed the CD label.

David Futato designed the interior layout based on a series design by Nancy Priest. The print version of this book was created by translating the DocBook SGML markup of its source files into a set of gtroff macros using a filter developed at O'Reilly & Associates by Norman Walsh. Steve Talbott designed and wrote the underlying macro set on the basis of the GNU troff -gs macros; Lenny Muellner adapted them to SGML and implemented the book design. The GNU groff text formatter Version 1.11.1 was used to generate PostScript output. The text and heading fonts are ITC Garamond Light and Garamond Book; the code font is Constant Willison. This colophon was written by Sarah Jane Shangraw.

The online edition of this book was created by the Safari production group (John Chodacki, Becki Maisch, and Madeleine Newell) using a set of Frame-to-XML conversion and cleanup tools written and maintained by Erik Ray, Benn Salter, John Chodacki, and Jeff Liggett.

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