

Chapter 19. GUI Programming

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In this chapter, we will give you a brief introduction to the subject of graphical user interface (GUI) programming. If you are somewhat new to this area or want to learn more about it, or if you want to see how it is done in Python, then this chapter is for you. We cannot show you everything about GUI application development here in this one chapter, but we will give you a very solid introduction to it. The primary GUI toolkit we will be using is Tk, Python's default GUI, and we will access Tk from its Python interface called Tkinter (short for "Tk interface").

Tk is not the "latest and greatest" nor does it have the most robust set of GUI building blocks, but it is fairly simple to use and will allow you to build GUIs that run on most platforms. We will present several simple and intermediate examples using Tkinter, followed by a few examples using other toolkits. Once you have completed this chapter, you will have the skills to build more complex applications and/or move to a more modern graphical toolkit. Python has *bindings* or *adapters* to most of the major toolkits out there, including commercial systems.

19.1. Introduction

19.1.1. What Are Tcl, Tk, and Tkinter?

Tkinter is Python's default GUI library. It is based on the Tk toolkit, originally designed for the Tool Command Language (Tcl). Due to Tk's popularity, it has been ported to a variety of other scripting languages, including Perl (Perl/Tk), Ruby (Ruby/Tk), and Python (Tkinter). With the GUI development portability and flexibility of Tk, along with the simplicity of scripting language integrated with the power of systems language, you are given the tools to rapidly design and implement a wide variety of commercial-quality GUI applications.

If you are new to GUI programming, you will be pleasantly surprised at how easy it is. You will also find that Python, along with Tkinter, provides a fast and exciting way to build applications that are fun (and perhaps useful) and that would have taken much longer if you had had to program directly in C/C++ with the native windowing system's libraries. Once you have designed the application and the look and feel that goes along with your program, you will use basic building blocks known as *widgets* to piece together the desired components, and finally, to attach functionality to "make it real."

If you are an old hand at using Tk, either with Tcl or Perl, you will find Python a refreshing way to program GUIs. On top of that, it provides an even faster rapid prototyping system for building them. Remember that you also have Python's system accessibility, networking functionality, XML, numerical and visual processing, database access, and all the other standard library and third-party extension modules.

Once you get Tkinter up on your system, it will take less than 15 minutes to get your first GUI application running.

19.1.2. Getting Tkinter Installed and Working

Like threading, Tkinter is not necessarily turned on by default on your system. You can tell whether Tkinter is available for your Python interpreter by attempting to import the `Tkinter` module. If Tkinter is available, then no errors occur:

```
>>> import Tkinter
>>>
```

If your Python interpreter was *not* compiled with Tkinter enabled, the module import fails:

```
>>> import Tkinter
Traceback (innermost last):
  File "<stdin>", line 1, in ?
  File "/usr/lib/python1.5/lib-tk/Tkinter.py", line 8, in ?
    import _tkinter # If this fails your Python may not
be configured for Tk
ImportError: No module named _tkinter
```

You may have to recompile your Python interpreter to get access to Tkinter. This usually involves editing the `Modules/Setup` file and enabling all the correct settings to compile your Python interpreter with hooks to Tkinter or choosing to have Tk installed on your system. Check the `README` file for your Python

distribution for specific instructions on getting Tkinter to compile on your system. Be sure, after your compilation, that you start the *new* Python interpreter you just created; otherwise, it will act just like your old one without Tkinter (and in fact, it *is* your old one).

19.1.3. Client/Server ArchitectureTake Two

In the earlier chapter on network programming, we introduced the notion of client/server computing. A windowing system is another example of a software server. These run on a machine with an attached display, such as a monitor of some sort. There are clients, too, programs that require a windowing environment to execute, also known as GUI applications. Such applications cannot run without a windows system.

The architecture becomes even more interesting when networking comes into play. Usually when a GUI application is executed, it displays to the machine that it started on (via the windowing server), but it is possible in some networked windowing environments, such as the X Window system on Unix, to choose another machine's window server to display to. In such situations, you can be running a GUI program on one machine, but have it displayed on another!



19.2. Tkinter and Python Programming

19.2.1. Tkinter Module: Adding Tk to your Applications

So what do you need to do to have Tkinter as part of your application? Well, first of all, it is not necessary to have an application already. You can create a pure GUI if you want, but it probably isn't too useful without some underlying software that does something interesting.

There are basically five main steps that are required to get your GUI up and running:

1. Import the `Tkinter` module (or `from Tkinter import *`).
2. Create a top-level windowing object that contains your entire GUI application.
3. Build all your GUI components (and functionality) on top (or "inside") of your top-level windowing object.
4. Connect these GUI components to the underlying application code.
5. Enter the main event loop.

The first step is trivial: All GUIs that use Tkinter must import the `Tkinter` module. Getting access to Tkinter is the first step (see [Section 19.1.2](#)).

19.2.2. Introduction to GUI Programming

Before going to the examples, we will give you a brief introduction to GUI application development in general. This will provide you with some of the background you need to move forward.

Setting up a GUI application is similar to an artist's producing a painting. Conventionally, there is a single canvas onto which the artist must put all the work. The way it works is like this: You start with a clean slate, a "top-level" windowing object on which you build the rest of your components. Think of it as a foundation to a house or the easel for an artist. In other words, you have to pour the concrete or set up your easel before putting together the actual structure or canvas on top of it. In Tkinter, this foundation is known as the top-level window object.

In GUI programming, a top-level root windowing object contains all of the little windowing objects that will be part of your complete GUI application. These can be text labels, buttons, list boxes, etc. These individual little GUI components are known as *widgets*. So when we say create a top-level window, we just mean that you need such a thing as a place where you put all your widgets. In Python, this would typically look like this line:

```
top = Tkinter.Tk() # or just Tk() with "from Tkinter import *"
```

The object returned by `Tkinter.Tk()` is usually referred to as the *root window*, hence the reason why

some applications use `root` rather than `top` to indicate as such. Top-level windows are those that show up standalone as part of your application. You may have more than one top-level window for your GUI, but only one of them should be your root window. You may choose to completely design all your widgets first, then add the real functionality, or do a little of this and a little of that along the way. (This means mixing and matching [steps 3](#) and [4](#) from our list.)

Widgets may be standalone or be containers. If a widget "contains" other widgets, it is considered the *parent* of those widgets. Accordingly, if a widget is "contained" in another widget, it's considered a *child* of the parent, the parent being the next immediate enclosing container widget.

Usually, widgets have some associated behaviors, such as when a button is pressed, or text is filled into a text field. These types of user behaviors are called *events*, and the actions that the GUI takes to respond to such events are known as *callbacks*.

Actions may include the actual button press (and release), mouse movement, hitting the RETURN or Enter key, etc. All of these are known to the system literally as *events*. The entire system of events that occurs from the beginning to the end of a GUI application is what drives it. This is known as event-driven processing.

One example of an event with a callback is a simple mouse move. Let's say the mouse pointer is sitting somewhere on top of your GUI application. If the mouse is moved to another part of your application, something has to cause the movement of the mouse on your screen so that it *looks* as if it is moving to another location. These are mouse move events that the system must process to give you the illusion (and reality) that your mouse is moving across the window. When you release the mouse, there are no more events to process, so everything just sits there quietly on the screen again.

The event-driven processing nature of GUIs fits right in with client/server architecture. When you start a GUI application, it must perform some setup procedures to prepare for the core execution, just as when a network server has to allocate a socket and bind it to a local address. The GUI application must establish all the GUI components, then draw (aka render or paint) them to the screen. Tk has a couple of geometry managers that help position the widget in the right place; the main one that you will use is called Pack, aka the *packer*. Another geometry manager is Grid; this is where you specify GUI widgets to be placed in grid coordinates, and Grid will render each object in the GUI in their grid position. For us, we will stick with the packer.

Once the packer has determined the sizes and alignments of all your widgets, it will then place them on the screen for you. When all of the widgets, including the top-level window, finally appear on your screen, your GUI application then enters a "server-like" infinite loop. This infinite loop involves waiting for a GUI event, processing it, then going back to wait for the next event.

The final step we described above says to enter the main loop once all the widgets are ready. This is the "server" infinite loop we have been referring to. In Tkinter, the code that does this is:

```
Tkinter.mainloop()
```

This is normally the last piece of sequential code your program runs. When the main loop is entered, the GUI takes over execution from there. All other action is via callbacks, even exiting your application. When you pull down the File menu to click on the Exit menu option or close the window directly, a callback must be invoked to end your GUI application.

19.2.3. Top-Level Window: `Tkinter.Tk()`

We mentioned above that all main widgets are built into the top-level window object. This object is

created by the Tk class in Tkinter and is created via the normal instantiation:

```
>>> import Tkinter
>>> top = Tkinter.Tk()
```

Within this window, you place individual widgets or multiple-component pieces together to form your GUI. So what kinds of widgets are there? We will now introduce the Tk widgets.

19.2.4. Tk Widgets

There are currently 15 types of widgets in Tk. We describe these widgets in [Table 19.1](#).

Table 19.1. Tk Widgets

<i>Widget</i>	<i>Description</i>
Button	Similar to a Label but provides additional functionality for mouse overs, presses, and releases as well as keyboard activity/events
Canvas	Provides ability to draw shapes (lines, ovals, polygons, rectangles); can contain images or bitmaps
Checkbutton	Set of boxes of which any number can be "checked" (similar to HTML checkbox input)
Entry	Single-line text field with which to collect keyboard input (similar to HTML text input)
Frame	Pure container for other widgets
Label	Used to contain text or images
Listbox	Presents user list of choices to pick from
Menu	Actual list of choices "hanging" from a Menubutton that the user can choose from
Menubutton	Provides infrastructure to contain menus (pulldown, cascading, etc.)
Message	Similar to a Label, but displays multi-line text
Radiobutton	Set of buttons of which only one can be "pressed" (similar to HTML radio input)
Scale	Linear "slider" widget providing an exact value at current setting; with defined starting and ending values
Scrollbar	Provides scrolling functionality to supporting widgets, i.e., Text, Canvas, Listbox, and Entry
Text	Multi-line text field with which to collect (or display) text from user (similar to HTML textarea)
Toplevel	Similar to a Frame, but provides a separate window container

We won't go over the Tk widgets in detail as there is plenty of good documentation available on them,

either from the Tkinter topics page at the main Python Web site or the abundant number of Tcl/Tk printed and online resources (some of which are available in [AppendixB](#)). However, we will present several simple examples to help you get started.

Core Note: Default arguments are your friend



GUI development really takes advantage of default arguments in Python because there are numerous default actions in Tkinter widgets. Unless you know every single option available to you for every single widget you are using, it's best to start out by setting only the parameters you are aware of and letting the system handle the rest. These defaults were chosen carefully. If you do not provide these values, do not worry about your applications appearing odd on the screen. They were created with an optimized set of default arguments as a general rule, and only when you know how to exactly customize your widgets should you use values other than the default.

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19.3. Tkinter Examples

19.3.1. Label Widget

In [Example 19.1](#), we present `tkhello1.py`, the Tkinter version of "Hello World!" In particular, it shows you how a Tkinter application is set up and highlights the `Label` widget.

Example 19.1. Label Widget Demo (`tkhello1.py`)

Our first Tkinter example is ... what else? "Hello World!" In particular, we introduce our first widget, the `Label`.

```
1  #!/usr/bin/env python
2
3  import Tkinter
4
5  top = Tkinter.Tk()
6  label = Tkinter.Label(top, text='Hello World!')
7  label.pack()
8  Tkinter.mainloop()
```

In the first line, we create our top-level window. That is followed by our `Label` widget containing the all-too-famous string. We instruct the packer to manage and display our widget, and finally call `mainloop()` to run our GUI application. [Figure 19-1](#) shows what you will see when you run this GUI application.

Figure 19-1. Tkinter `Label` widget (`tkhello1.py`)



19.3.2. Button Widget

The next example is pretty much the same as the first. However, instead of a simple text label, we will create a button instead. In [Example 19-2](#) is the source code for `tkhello2.py`.

Example 19.2. Button Widget Demo (tkhello2.py)

This example is exactly the same as tkhello1.py except that rather than using a Label widget, we create a Button widget.

```
1  #!/usr/bin/env python
2
3  import Tkinter
4
5  top = Tkinter.Tk()
6  quit = Tkinter.Button(top, text='Hello World!',
7      command=top.quit)
8  quit.pack()
9  Tkinter.mainloop()
```

The first few lines are identical. Things differ only when we create the Button widget. Our button has one additional parameter, the `Tkinter.quit()` method. This installs a callback to our button so that if it is pressed (and released), the entire application will exit. The final two lines are the usual `pack()` and entering of the `mainloop()`. This simple button application is shown in [Figure 19-2](#).

Figure 19-2. Tkinter Label widget (tkhello1.py)



19.3.3. Label and Button Widgets

We combine `tkhello1.py` and `tkhello2.py` into `tkhello3.py`, a script that has both a label and a button. In addition, we are providing more parameters now than before when we were comfortable using all the default arguments that are automatically set for us. The source for `tkhello3.py` is given in [Example 19.3](#).

Example 19.3. Label and Button Widget Demo (tkhello3.py)

This example features both a `Label` and a `Button` widget. Rather than primarily using default arguments when creating the widget, we are able to specify more now that we know more about `Button` widgets and how to configure them.

```
1  #!/usr/bin/env python
2
3  import Tkinter
4  top = Tkinter.Tk()
5
6  hello = Tkinter.Label(top, text='Hello World!')
7  hello.pack()
8
9  quit = Tkinter.Button(top, text='QUIT',
10                        command=top.quit, bg='red', fg='white')
11  quit.pack(fill=Tkinter.X, expand=1)
12
13  Tkinter.mainloop()
```

Besides additional parameters for the widgets, we also see some arguments for the packer. The `fill` parameter tells the packer to let the QUIT button take up the rest of the horizontal real estate, and the `expand` parameter directs the packer to visually fill out the entire horizontal landscape, stretching the button to the left and right sides of the window.

As you can see in [Figure 19-3](#), without any other instructions to the packer, the widgets are placed vertically (on top of each other). Horizontal placement requires creating a new `Frame` object with which to add the buttons. That frame will take the place of the parent object as a single child object (see the buttons in the `listdir.py` module, [Example 19.6](#) in [Section 19.3.6](#)).

Figure 19-3. Tkinter `Label` and `Button` widgets (`tkhello3.py`)



19.3.4. `Label`, `Button`, and `Scale` Widgets

Our final trivial example, `tkhello4.py`, involves the addition of a `Scale` widget. In particular, the `Scale` is used to interact with the `Label` widget. The `Scale` slider is a tool which controls the size of the text font

in the `Label` widget. The greater the slider position, the larger the font, and the same goes for a lesser position, meaning a smaller font. The code for [Example 19.4](#)

Example 19.4. `Label`, `Button`, and `Scale` Demo (`tkhello4.py`)

Our final introductory widget example introduces the `Scale` widget and highlights how widgets can "communicate" with each other using callbacks [such as `resize()`]. The text in the `Label` widget is affected by actions taken on the `Scale` widget.

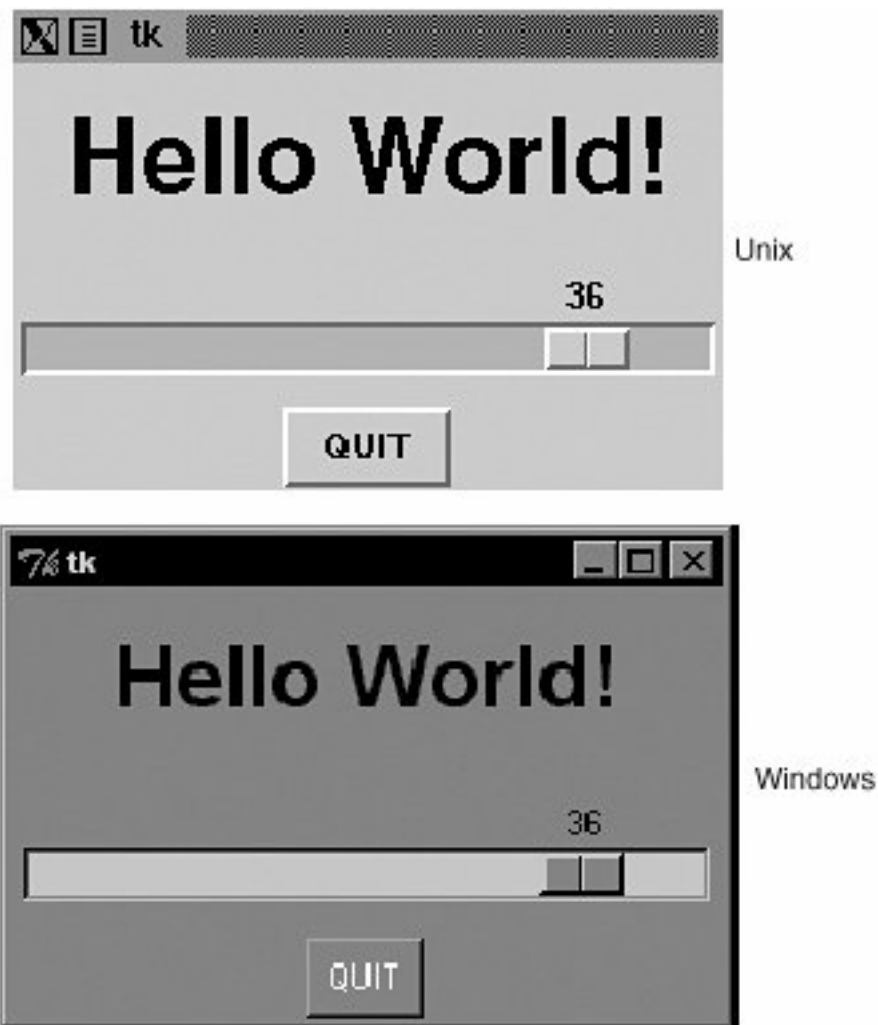
```
1  #!/usr/bin/env python
2
3  from Tkinter import *
4
5  def resize(ev=None):
6      label.config(font='Helvetica -%d bold' % \
7                  scale.get())
8
9  top = Tk()
10 top.geometry('250x150')
11
12 label = Label(top, text='Hello World!',
13              font='Helvetica -12 bold')
14 label.pack(fill=Y, expand=1)
15
16 scale = Scale(top, from_=10, to=40,
17              orient=HORIZONTAL, command=resize)
18 scale.set(12)
19 scale.pack(fill=X, expand=1)
20
21 quit = Button(top, text='QUIT',
22              command=top.quit, activeforeground='white',
23              activebackground='red')
24 quit.pack()
25
26 mainloop()
```

New features of this script include a `resize()` callback function (lines 5-7), which is attached to the `Scale`. This is the code that is activated when the slider on the `Scale` is moved, resizing the size of the text in the `Label`.

We also define the size (250 x 150) of the top-level window (line 10). The final difference between this script and the first three is that we import the attributes from the `Tkinter` module into our namespace with "`from Tkinter import *`." Although not recommended because it "pollutes" your namespace, we do it here mainly because this application involves a great number of references to Tkinter attributes. This would require use of their fully qualified names for each and every attribute access. By using the undesired shortcut, we are able to access attributes with less typing and have code that is easier to read, at some cost.

As you can see from [Figure 19-4](#), both the slider mechanism as well as the current set value show up in the main part of the window. [Figure 19-4](#) shows the state of the GUI after the user moves the scale/slider to a value of 36.

Figure 19-4. Tkinter `Label`, `Button`, and `Scale` widgets (`tkhello4.py`)



As you can see from the code, the initial setting for the scale when the application starts is 12 (line 18).

19.3.5. Partial Function Application Example

Before looking at a longer GUI application, we wanted to review the Partial Function Application (PFA) as introduced back in [Section 11.7.3](#) of [Chapter 11](#).

PFAs were added to Python in version 2.5 and are one piece in a series of significant improvements in functional programming.

2.5

PFAs allow you to "cache" function parameters by effectively "freezing" those predetermined arguments, and then at runtime, when you have the remaining arguments you need, you can thaw them out, send in the final arguments, and have that function called with all parameters.

Best of all, PFAs are not limited to just functions. They will work with any "callable," any object that has a functional interface just by using parentheses, i.e., classes, methods, or callable instances. The use of

PFA's fits perfectly into a situation where there are many callables and many of the calls feature the same arguments over and over again.

GUI programming makes a great use case because there is good probability that you want some consistency in GUI widget look-and-feel, and this consistency comes about when the same parameters are used to create like objects. We are now going to present an application where multiple buttons will have the same foreground and background colors. It would be a waste of typing to give the same arguments to the same instantiators every time we wanted a slightly different button: the foreground and background colors are the same, but only the text is slightly different.

We are going to use traffic road signs as our example with our application attempting creating textual versions of road signs by dividing them up into various categories of sign types like critical, warning, or informational (just like logging levels). The type of the sign determines their color layout when the signs are created. For example, critical signs have the text in bright red with a white backdrop, warning signs are in black text on a goldenrod background, and informational or regulatory signs feature black text on a white background. We have the "Do Not Enter" and "Wrong Way" signs, which are both "critical," plus "Merging Traffic" and "Railroad Crossing," both of which are warnings. Finally, we have the regulatory "Speed Limit" and "One Way" signs.

The application creates the "signs," which are just buttons. When users press the buttons, they just pop up the corresponding Tk dialog, critical/error, warning, or informational. It is not too exciting, but how the buttons are built is. You will find our application featured here in [Example 19.5](#).

Example 19.5. Road Signs PFA GUI Application (`pfaGUI2.py`)

Create road signs with the appropriate foreground and background colors based on sign type. Use PFA's to help "templatize" common GUI parameters.

```
1  #!/usr/bin/env python
2
3  from functools import partial as pto
4  from Tkinter import Tk, Button, X
5  from tkMessageBox import showinfo, showwarning, showerror
6
7  WARN = 'warn'
8  CRIT = 'crit'
9  REGU = 'regu'
10
11 SIGNS = {
12     'do not enter': CRIT,
13     'railroad crossing': WARN,
14     '55\nspeed limit': REGU,
15     'wrong way': CRIT,
16     'merging traffic': WARN,
17     'one way': REGU,
18 }
19
20 critCB = lambda: showerror('Error', 'Error Button Pressed!')
21 warnCB = lambda: showwarning('Warning',
22     'Warning Button Pressed!')
23 infoCB = lambda: showinfo('Info', 'Info Button Pressed!')
24
25 top = Tk()
26 top.title('Road Signs')
27 Button(top, text='QUIT', command=top.quit,
28     bg='red', fg='white').pack()
```

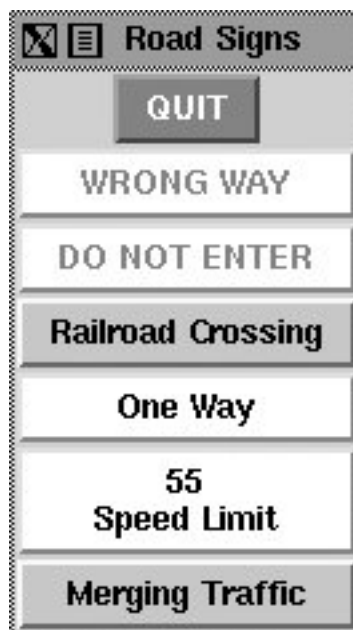
```

29
30 MyButton = pto(Button, top)
31 CritButton = pto(MyButton, command=critCB, bg='white', fg='red')
32 WarnButton = pto(MyButton, command=warnCB, bg='goldenrod1')
33 ReguButton = pto(MyButton, command=infoCB, bg='white')
34
35 for eachSign in SIGNS:
36     signType = SIGNS[eachSign]
37     cmd = '%sButton(text=%r%s).pack(fill=X, expand=True)' % (
38         signType.title(), eachSign,
39         '.upper()' if signType == CRIT else '.title()')
40     eval(cmd)
41
42 top.mainloop()

```

When you execute this application, you will get a GUI that will look something like [Figure 19.5](#).

Figure 19-5. Road signs PFA GUI application on XDarwin in MacOS X (pfaGUI2.py)



Line-by-Line Explanation

Lines 118

We begin our application by importing `functional.partial()`, a few `Tkinter` attributes, and the `Tk` dialogs (lines 1-5). Next, we define some signs along with their categories (lines 7-18).

Lines 2028

The `Tk` dialogs are assigned as button callbacks, which we will use for each button created (lines 20-23). We then launch `Tk`, set the title, and create a `QUIT` button (lines 25-28).


```

13         self.label.pack()
14
15 self.cwd = StringVar(self.top)
16
17 self.dirl = Label(self.top, fg='blue',
18                   font=('Helvetica', 12, 'bold'))
19 self.dirl.pack()
20
21 self.dirfm = Frame(self.top)
22 self.dirsb = Scrollbar(self.dirfm)
23 self.dirsb.pack(side=RIGHT, fill=Y)
24 self.dirs = Listbox(self.dirfm, height=15,
25                     width=50, yscrollcommand=self.dirsb.set)
26 self.dirs.bind('<Double-1>', self.setDirAndGo)
27 self.dirsb.config(command=self.dirs.yview)
28 self.dirs.pack(side=LEFT, fill=BOTH)
29 self.dirfm.pack()
30
31 self.dirn = Entry(self.top, width=50,
32                  textvariable=self.cwd)
33 self.dirn.bind('<Return>', self.doLS)
34 self.dirn.pack()
35
36 self.bfm = Frame(self.top)
37 self.clr = Button(self.bfm, text='Clear',
38                  command=self.clrDir,
39                  activeforeground='white',
40                  activebackground='blue')
41 self.ls = Button(self.bfm,
42                 text='List Directory',
43                 command=self.doLS,
44                 activeforeground='white',
45                 activebackground='green')
46 self.quit = Button(self.bfm, text='Quit',
47                   command=self.top.quit,
48                   activeforeground='white',
49                   activebackground='red')
50 self.clr.pack(side=LEFT)
51 self.ls.pack(side=LEFT)
52 self.quit.pack(side=LEFT)
53 self.bfm.pack()
54
55 if initdir:
56     self.cwd.set(os.curdir)
57     self.doLS()
58
59 def clrDir(self, ev=None):
60     self.cwd.set('')
61
62 def setDirAndGo(self, ev=None):
63     self.last = self.cwd.get()
64     self.dirs.config(selectbackground='red')
65     check = self.dirs.get(self.dirs.curselection())
66     if not check:
67
68         check = os.curdir
69     self.cwd.set(check)
70     self.doLS()

```



```

71     def doLS(self, ev=None):
72         error = ''
73         tdir = self.cwd.get()
74         if not tdir: tdir = os.curdir
75
76         if not os.path.exists(tdir):
77             error = tdir + ': no such file'
78         elif not os.path.isdir(tdir):
79             error = tdir + ': not a directory'
80
81         if error:
82             self.cwd.set(error)
83             self.top.update()
84             sleep(2)
85             if not (hasattr(self, 'last') \
86                     and self.last):
87                 self.last = os.curdir
88             self.cwd.set(self.last)
89             self.dirs.config(\
90                 selectbackground='LightSkyBlue')
91             self.top.update()
92             return
93
94         self.cwd.set(\
95             'FETCHING DIRECTORY CONTENTS...')
96         self.top.update()
97         dirlist = os.listdir(tdir)
98         dirlist.sort()
99         os.chdir(tdir)
100        self.dirl.config(text=os.getcwd())
101        self.dirs.delete(0, END)
102        self.dirs.insert(END, os.curdir)
103        self.dirs.insert(END, os.pardir)
104        for eachFile in dirlist:
105            self.dirs.insert(END, eachFile)
106        self.cwd.set(os.curdir)
107        self.dirs.config(\
108            selectbackground='LightSkyBlue')
109
110    def main():
111        d = DirList(os.curdir)
112        mainloop()
113
114    if __name__ == '__main__':
115        main()

```

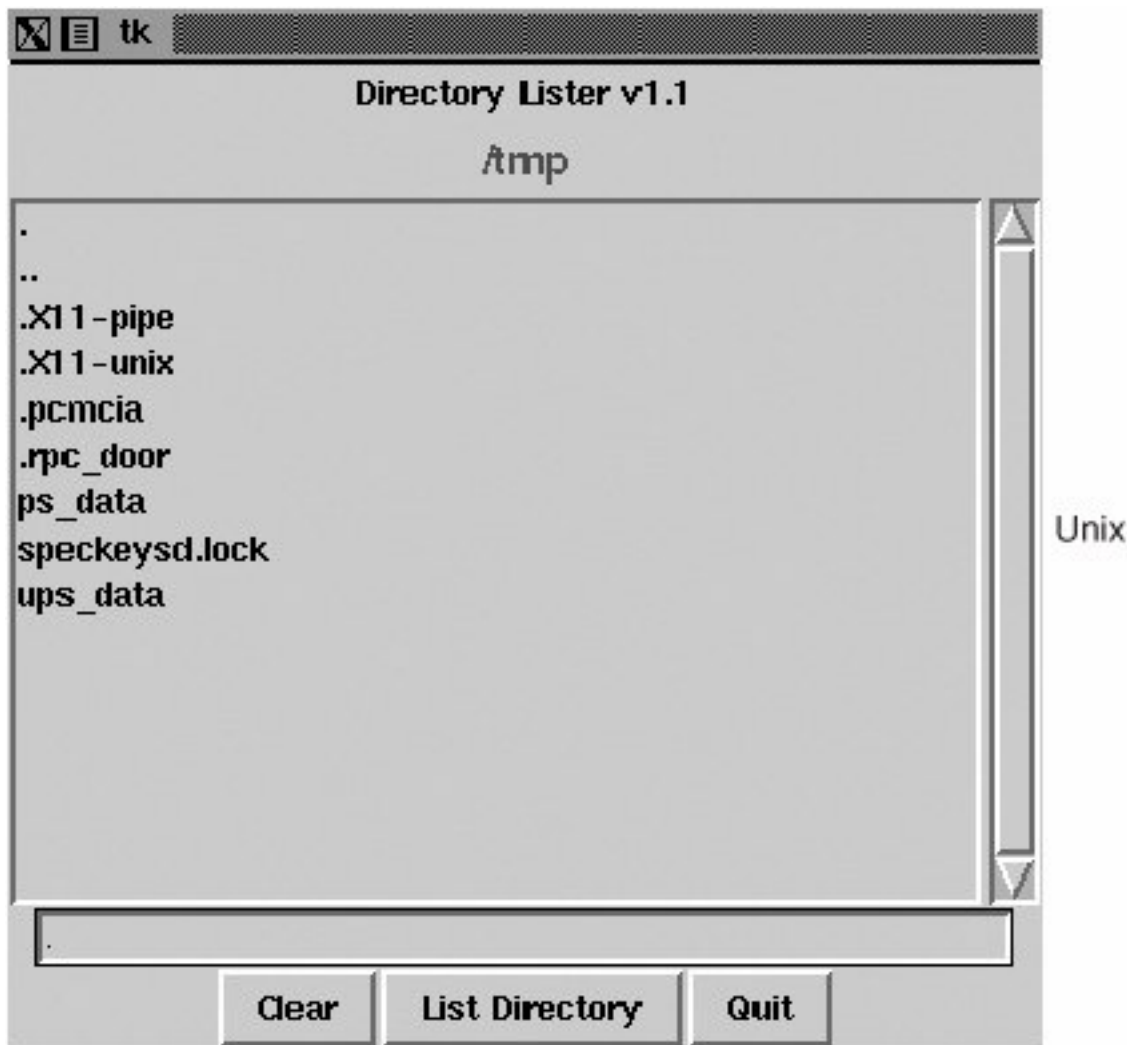
In [Figure 19-6](#), we present what this GUI looks like in a Windows environment.

Figure 19-6. List directory GUI application in Windows (`listdir.py`)



The Unix version of this application is given in [Figure 19-7](#).

Figure 19-7. List directory GUI application in Unix (`listdir.py`)



Line-by-Line Explanation

Lines 15

These first few lines contain the usual Unix startup line and importation of the `os` module, the `time.sleep()` function, and all attributes of the `Tkinter` module.

Lines 913

These lines define the constructor for the `DirList` class, an object that represents our application. The first `Label` we create contains the main title of the application and the version number.

Lines 1519

We declare a Tk variable named `cwd` to hold the name of the directory we are on we will see where this comes in handy later. Another `Label` is created to display the name of the current directory.

Lines 2129

This section defines the core part of our GUI, (the `Listbox`) `dirs`, which contain the list of files of the directory that is being listed. A `Scrollbar` is employed to allow the user to move through a listing if the

number of files exceeds the size of the `Listbox`. Both of these widgets are contained in a `Frame` widget. `Listbox` entries have a callback (`setDirAndGo`) tied to them using the `Listbox bind()` method.

Binding means to tie a keystroke, mouse action, or some other event to a callback to be executed when such an event is generated by the user. `setDirAndGo()` will be called if any item in the `Listbox` is doubleclicked. The `Scrollbar` is tied to the `Listbox` by calling the `Scrollbar.config()` method.

Lines 3134

We then create a text `Entry` field for the user to enter the name of the directory he or she wants to traverse and see its files listed in the `Listbox`. We add a RETURN or Enter key binding to this text entry field so that the user can hit RETURN as an alternative to pressing a button. The same applies for the mouse binding we saw above in the `Listbox`. When the user doubleclicks on a `Listbox` item, it has the same effect as the user's entering the directory name manually into the text `Entry` field and pressing the "go" button.

Lines 3653

We then define a `Button` frame (`bfm`) to hold our three buttons, a "clear" button (`clr`), a "go" button (`ls`), and a "quit" button (`quit`). Each button has its own different configuration and callbacks, if pressed.

Lines 5557

The final part of the constructor initializes the GUI program, starting with the current working directory.

Lines 5960

The `clrDir()` method clears the `cwd` Tk string variable, which contains the current directory that is "active." This variable is used to keep track of what directory we are in and, more important, helps keep track of the previous directory in case errors arise. You will notice the `ev` variables in the callback functions with a default value of `None`. Any such values would be passed in by the windowing system. They may or may not be used in your callback.

Lines 6269

The `setDirAndGo()` method sets the directory to traverse to and issues the call to the method that makes it all happen, `doLS()`.

Lines 71108

`doLS()` is, by far, the key to this entire GUI application. It performs all the safety checks (e.g., is the destination a directory and does it exist?). If there is an error, the last directory is reset to be the current directory. If all goes well, it calls `os.listdir()` to get the actual set of files and replaces the listing in the `Listbox`. While the background work is going on to pull in the new directory's information, the highlighted blue bar becomes bright red. When the new directory has been installed, it reverts to blue.

Lines 110115

The last pieces of code in `listdir.py` represent the main part of the code. `main()` is executed only if this script is invoked directly, and when `main()` runs, it creates the GUI application, then calls `mainloop()` to start the GUI, which is passed control of the application.

We leave all other aspects of the application as an exercise to the reader, recommending that it is easier to view the entire application as a combination of a set of widgets and functionality. If you see the individual pieces clearly, then the entire script will not appear as daunting.

We hope that we have given you a good introduction to GUI programming with Python and Tkinter. Remember that the best way to get familiar with Tkinter programming is by practicing and stealing a few examples! The Python distribution comes with a large number of demonstration applications that you can study.

If you download the source code, you will find Tkinter demo code in `Lib/lib-tk`, `Lib/idlelib`, and `Demo/tkinter`. If you have installed the Win32 version of Python and `C:\Python2x`, then you can get access to the demo code in `Lib\lib-tk` and `Lib\idlelib`. The latter directory contains the most significant sample Tkinter application: the IDLE IDE itself. For further reference, there are several books on Tk programming, one specifically on Tkinter.

 **PREV**

NEXT 

19.4. Brief Tour of Other GUIs

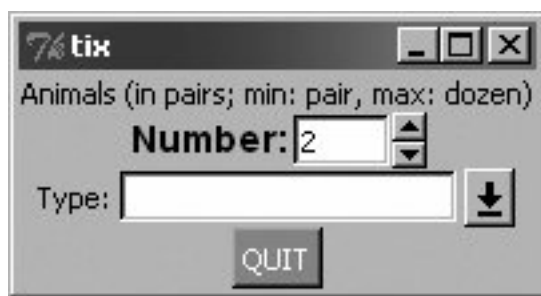
We hope to eventually develop an independent chapter on general GUI development using many of the abundant number of graphical toolkits that exist under Python, but alas, that is for the future. As a proxy, we would like to present a single simple GUI application written using four of the more popular and available toolkits out there: Tix (Tk Interface eXtensions), Pmw (Python MegaWidgets Tkinter extension), wxPython (Python binding to wxWidgets), and PyGTK (Python binding to GTK+). Links to where you can get more information and/or download these toolkits can be found in the reference section at the end of this chapter.

The `Tix` module is already available in the Python standard library. You must download the others, which are third party. Since Pmw is just an extension to Tkinter, it is the easiest to install (just extract into your site packages). wxPython and PyGTK involve the download of more than one file and building (unless you opt for the Win32 versions where binaries are usually available). Once the toolkits are installed and verified, we can begin. Rather than just sticking with the widgets we've already seen in this chapter, we'd like to introduce a few more complex widgets for these examples.

In addition to the `Label` and `Button` widgets we have seen before, we would like to introduce the `Control` or `SpinButton` and `ComboBox`. The `Control` widget is a combination of a text widget with a value inside being "controlled" or "spun up or down" by a set of arrow buttons close by, and the `ComboBox` is usually a text widget and a pulldown menu of options where the currently active or selected item in the list is displayed in the text widget.

Our application is fairly basic: pairs of animals are being moved around, and the number of total animals can range from a pair to a dozen max. The `Control` is used to keep track of the total number while the `ComboBox` is a menu containing the various types of animals that can be selected. In [Figure 19-8](#), each image shows the state of the GUI application immediately after launching. Note that the default number of animals is two, and no animal type has been selected yet.

Figure 19-8. Application using various GUIs under Win32 (`animal*.pyw`)



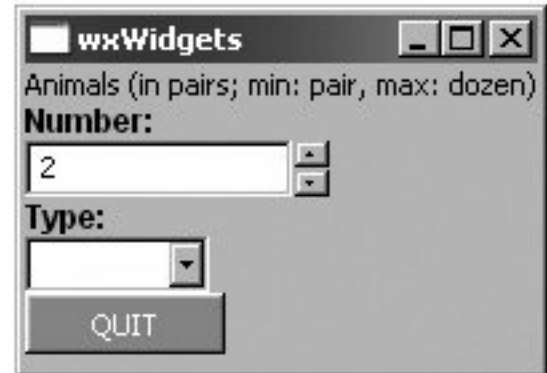
Tix



PyGTK



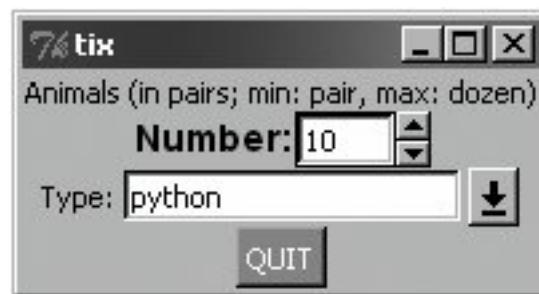
Pmw



wxPython

Things are different once we start to play around with the application, as evidenced in [Figure 19-9](#) after we have modified some of the elements in the Tix application.

Figure 19-9. After modifying the Tix GUI version of our application (`animalTix.pyw`)



Tix

Below, you will find the code for all four versions of our GUI. You will note that although relatively similar, each one differs in its own special way. Also, we use the `.pyw` extension to suppress the popping up of the Dos command or terminal window.

19.4.1. Tk Interface eXtensions (Tix)

We start with an example ([Example 19.7](#)) of using the `Tix` module. Tix is an extension library for Td/T that adds many new widgets, image types, and other commands that keep Tk a viable GUI development toolkit. Let's take look at how to use Tix with Python.

Example 19.7. Tix GUI Demo (`animalTix.pyw`)

Our first example uses the `Tix` module. `Tix` comes with Python!

```
1  #!/usr/bin/env python
2
3  from Tkinter import Label, Button, END
4  from Tix import Tk, Control, ComboBox
5
6  top = Tk()
7  top.tk.eval('package require Tix')
8
9  lb = Label(top,
10     text='Animals (in pairs; min: pair, max: dozen)')
11 lb.pack()
12
13 ct = Control(top, label='Number:',
14     integer=True, max=12, min=2, value=2, step=2)
15 ct.label.config(font='Helvetica -14 bold')
16 ct.pack()
17
18 cb = ComboBox(top, label='Type:', editable=True)
19 for animal in ('dog', 'cat', 'hamster', 'python'):
20     cb.insert(END, animal)
21 cb.pack()
22
23 qb = Button(top, text='QUIT',
24     command=top.quit, bg='red', fg='white')
25 qb.pack()
26
27 top.mainloop()
```

Line-by-Line Explanation

Lines 17

This is all the setup code, module imports, and basic GUI infrastructure. Line 7 asserts that the `Tix` module is available to the application.

Lines 8-27

These lines create all the widgets: `Label` (lines 9-11), `Control` (lines 13-16), `ComboBox` (lines 18-21), and quit `Button` (lines 23-25). The constructors and arguments for the widgets are fairly self-explanatory and do not require elaboration. Finally, we enter the main GUI event loop in line 27.

19.4.2. Python MegaWidgets (PMW)

Next we take a look at Python MegaWidgets as shown in [Example 19.8](#). This module was created to address the aging Tkinter. It basically helps to extend its longevity by adding more modern widgets to the GUI palette.

Example 19.8. Pmw GUI Demo (animalPmw.pyw)

Our second example uses the Python MegaWidgets package.

```
1 #!/usr/bin/env python
2
3 from Tkinter import Button, END, Label, W
4 from Pmw import initialise, ComboBox, Counter
5
6 top = initialise()
7
8 lb = Label(top,
9     text='Animals (in pairs; min: pair, max: dozen)')
10 lb.pack()
11
12 ct = Counter(top, labelpos=W, label_text='Number:',
13     datatype='integer', entryfield_value=2,
14     increment=2, entryfield_validate={'validator':
15     'integer', 'min': 2, 'max': 12})
16 ct.pack()
17
18 cb = ComboBox(top, labelpos=W, label_text='Type:')
19 for animal in ('dog', 'cat', 'hamster', 'python'):
20     cb.insert(end, animal)
21 cb.pack()
22
23 qb = Button(top, text='QUIT',
24     command=top.quit, bg='red', fg='white')
25 qb.pack()
26
27 top.mainloop()
```

The `Pmw` example is so similar to our `Tix` example that we leave line-by-line analysis to the reader. The line of code that differs the most is the constructor for the control widget, the `Pmw Counter`. It provides for entry validation. Instead of specifying the smallest and largest possible values as keyword arguments to the widget constructor, `Pmw` uses a "validator" to ensure that the values do not fall outside our accepted range.

Now, we are finally going to leave the Tk world behind. `Tix` and `Pmw` are extensions to Tk and Tkinter, respectively, but now we are going to change gears to look at completely different toolkits, `wxWidgets` and `GTK+`. You will notice that the number of lines of code starts to increase as we start programming in a more object-oriented way when using these more modern and robust GUI toolkits.

19.4.3. wxWidgets and wxPython

`wxWidgets` (formerly known as `wxWindows`) is a cross-platform toolkit used to build graphical user applications. It is implemented using C++ and is available on a wide number of platforms to which `wxWidgets` defines a consistent and common API. The best part of all is that `wxWidgets` uses the native GUI on each platform, so your program will have the same look-and-feel as all the other applications on your desktop. Another feature is that you are not restricted to developing `wxWidgets` applications in C++. There are interfaces to both Python and Perl. [Example 19.9](#) shows our animal application using `wxPython`.

Example 19.9. wxPython GUI Demo (animalWx.pyw)

Our third example uses wxPython (and wxWidgets). Note that we have placed all our widgets inside a "sizer" for organization and the more object-oriented nature of this application.

```
1 #!/usr/bin/env python
2
3 import wx
4
5 class MyFrame(wx.Frame):
6     def __init__(self, parent=None, id=-1, title=''):
7         wx.Frame.__init__(self, parent, id, title,
8             size=(200, 140))
9         top = wx.Panel(self)
10        sizer = wx.BoxSizer(wx.VERTICAL)
11        font = wx.Font(9, wx.SWISS, wx.NORMAL, wx.BOLD)
12        lb = wx.StaticText(top, -1,
13            'Animals (in pairs; min: pair, max: dozen)')
14        sizer.Add(lb)
15
16        c1 = wx.StaticText(top, -1, 'Number:')
17        c1.SetFont(font)
18        ct = wx.SpinCtrl(top, -1, '2', min=2, max=12)
19        sizer.Add(c1)
20        sizer.Add(ct)
21
22        c2 = wx.StaticText(top, -1, 'Type:')
23        c2.SetFont(font)
24        cb = wx.ComboBox(top, -1, '',
25            choices=('dog', 'cat', 'hamster', 'python'))
26        sizer.Add(c2)
27        sizer.Add(cb)
28
29        qb = wx.Button(top, -1, "QUIT")
30        qb.SetBackgroundColour('red')
31        qb.SetForegroundColour('white')
32        self.Bind(wx.EVT_BUTTON,
33            lambda e: self.Close(True), qb)
34        sizer.Add(qb)
35
36        top.SetSizer(sizer)
37        self.Layout()
38
39 class MyApp(wx.App):
40     def OnInit(self):
41         frame = MyFrame(title="wxWidgets")
42         frame.Show(True)
43         self.SetTopWindow(frame)
44         return True
45
46 def main():
47     app = MyApp()
48     app.MainLoop()
49
50 if __name__ == '__main__':
51     main()
```

Lines 537

Here we instantiate a `Frame` class (lines 5-8), of which the sole member is the constructor. This method's only purpose in life is to create our widgets. Inside the frame, we have a `Panel`. Inside the panel we use a `BoxSizer` to contain and layout all of our widgets (lines 10, 36), which consist of a `Label` (lines 12-14), `SpinCtrl` (lines 16-20), `ComboBox` (lines 22-27), and quit `Button` (lines 29-34).

We have to manually add `Labels` to the `SpinCtrl` and `ComboBox` widgets because they apparently do not come with them. Once we have them all, we add them to the sizer, set the sizer to our panel, and lay everything out. On line 10, you will note that the sizer is vertically oriented, meaning that our widgets will be placed top to bottom.

One weakness of the `SpinCtrl` widget is that it does not support "step" functionality. With the other three examples, we are able to click an arrow selector and have it increment or decrement by units of two, but that is not possible with this widget.

Lines 3951

Our application class instantiates the `Frame` object we just designed, renders it to the screen, and sets it as the top-most window of our application. Finally, the setup lines just instantiate our GUI application and start it running.

19.4.4. GTK+ and PyGTK

Finally, we have the PyGTK version, which is quite similar to the wxPython GUI (See [Example 19.10](#)). The biggest difference is that we use only one class, and it seems more tedious to set the foreground and background colors of objects, buttons in particular.

Example 19.10. PyGTK GUI Demo (animalGtk.pyw)

Our final example uses PyGTK (and GTK+). Like the wxPython example, this one also uses a class for our application. It is interesting to note how similar yet different all of our GUI applications are. This is not surprising and allows programmers to switch between toolkits with relative ease.

```
1  #!/usr/bin/env python
2
3  import pygtk
4  pygtk.require('2.0')
5  import gtk
6  import pango
7
8  class GTKapp(object):
9      def __init__(self):
10         top = gtk.Window(gtk.WINDOW_TOPLEVEL)
11         top.connect("delete_event", gtk.main_quit)
12         top.connect("destroy", gtk.main_quit)
13         box = gtk.VBox(False, 0)
14         lb = gtk.Label(
```

```

15     'Animals (in pairs; min: pair, max: dozen)')
16     box.pack_start(lb)
17
18     sb = gtk.HBox(False, 0)
19     adj = gtk.Adjustment(2, 2, 12, 2, 4, 0)
20     sl = gtk.Label('Number:')
21     sl.modify_font(
22         pango.FontDescription("Arial Bold 10"))
23     sb.pack_start(sl)
24     ct = gtk.SpinButton(adj, 0, 0)
25     sb.pack_start(ct)
26     box.pack_start(sb)
27
28     cb = gtk.HBox(False, 0)
29     c2 = gtk.Label('Type:')
30     cb.pack_start(c2)
31     ce = gtk.combo_box_entry_new_text()
32     for animal in ('dog', 'cat', 'hamster', 'python'):
33         ce.append_text(animal)
34     cb.pack_start(ce)
35     box.pack_start(cb)
36
37     qb = gtk.Button("")
38     red = gtk.gdk.color_parse('red')
39     sty = qb.get_style()
40     for st in (gtk.STATE_NORMAL,
41
42                gtk.STATE_PRELIGHT, gtk.STATE_ACTIVE):
43         sty.bg[st] = red
44     qb.set_style(sty)
45     ql = qb.child
46     ql.set_markup('<span color="white">QUIT</span>')
47     qb.connect_object("clicked",
48                       gtk.Widget.destroy, top)
49     box.pack_start(qb)
50     top.add(box)
51     top.show_all()
52
53 if __name__ == '__main__':
54     animal = GTKapp()
55     gtk.main()

```

Line-by-Line Explanation

Lines 16

We import three different modules and packages, PyGTK, GTK, and Pango, a library for layout and rendering of text, specifically for I18N purposes. We need it here because it represents the core of text and font handling for GTK+ (2.x).

Lines 851

The `GTKapp` class represents all the widgets of our application. The topmost window is created (with handlers for closing it via the window manager), and a vertically oriented sizer (`VBox`) is created to hold

our primary widgets. This is exactly what we did in the wxPython GUI.

However, wanting the static labels for the `SpinButton` and `ComboBox-Entry` to be next to them (unlike above them for the wxPython example), we create little horizontally oriented boxes to contain the label-widget pairs (lines 18-36), and placed those `HBoxes` into the all-encompassing `VBox`.

After creating the quit `Button` and adding the `VBox` to our toplevel window, we render everything on-screen. You will notice that we create the button with an empty label at first. We do this so that a `Label` (child) object will be created as part of the button. Then on lines 45-46, we get access to the label and set the text with white font color.

The reason why we do this is because if you set the style foreground, i.e., in the loop and auxiliary code on lines 41-44, the foreground only affects the button's foreground and not the label for example, if you set the foreground style to white and highlight the button (by pressing TAB until it is "selected") you will see that the inside dotted box identifying the selected widget *is* white, but the label text would still be black if you did not alter it like we did with the markup on line 46.

Lines 53-55

Here we create our application and enter the main event loop.



19.5. Related Modules and Other GUIs

There are other GUI development systems that can be used with Python. We present the appropriate modules along with their corresponding window systems in [Table 19.2](#).

Table 19.2. GUI Systems Available for Python

GUI Module or System	Description
<i>Tk-Related Modules</i>	
Tkinter	TK INTERface: Python's default GUI toolkit http://wiki.python.org/moin/TkInter
Pmw	Python MegaWidgets (Tkinter extension) http://pmw.sf.net
Tix	Tk Interface eXtension (Tk extension) http://tix.sf.net
TkZinc (Zinc)	Extended Tk canvas type (Tk extension) http://www.tkzinc.org
EasyGUI (easygui)	Very simple non-event-driven GUIs (Tkinter extension) http://ferg.org/easygui
TIDE + (IDE Studio)	Tix Integrated Development Environment (including IDE Studio, a Tix-enhanced version of the standard IDLE IDE) http://starship.python.net/crew/mike
<i>wxWidgets-Related Modules</i>	
wxPython	Python binding to wxWidgets, a cross-platform GUI framework (formerly known as wxWindows) http://wxpython.org
Boa Constructor	Python IDE and wxPython GUI builder http://boa-creator.sf.net
PythonCard	wxPython-based desktop application GUI construction kit (inspired by HyperCard) http://pythoncard.sf.net
wxGlade	another wxPython GUI designer (inspired by Glade, the GTK+/GNOME GUI builder) http://wxglade.sf.net
<i>GTK+/GNOME-Related Modules</i>	
PyGTK	Python wrapper for the GIMP Toolkit (GTK+) library http://pygtk.org
GNOME-Python	Python binding to GNOME desktop and development libraries http://gnome.org/start/unstable/bindings http://download.gnome.org/sources/gnome-python
Glade	a GUI builder for GTK+ and GNOME http://glade.gnome.org
PyGUI(GUI)	cross-platform "Pythonic" GUI API (built on Cocoa [MacOS X] and GTK+ [POSIX/X11 and Win32]) http://www.cosc.canterbury.ac.nz/~greg/python_gui

Qt/KDE-Related Modules

PyQt	Python binding for the Qt GUI/XML/SQL C++ toolkit from Trolltech (partially open source [dual-license]) http://riverbankcomputing.co.uk/pyqt
PyKDE	Python binding for the KDE desktop environment http://riverbankcomputing.co.uk/pykde
eric	Python IDE written in PyQt using QScintilla editor widget http://die-offenbachs.de/detlev/eric3 http://ericide.python-hosting.com/
PyQtGPL	Qt (Win32 Cygwin port), Sip, QScintilla, PyQt bundle http://pythonqt.vanrietpaap.nl

Other Open Source GUI Toolkits

FXPy	Python binding to FOX toolkit (http://fox-toolkit.org) http://fxpy.sf.net
pyFLTK (<code>fltk</code>)	Python binding to FLTK toolkit (http://fltk.org) http://pyfltk.sf.net
PyOpenGL (<code>OpenGL</code>)	Python binding to OpenGL (http://opengl.org) http://pyopengl.sf.net

Commercial

<code>win32ui</code>	Microsoft MFC (via Python for Windows Extensions) http://starship.python.net/crew/mhammond/win32
<code>swing</code>	Sun Microsystems Java/Swing (via Jython) http://jython.org

You can find out more about all GUIs related to Python from the general GUI Programming page on the Python wiki at <http://wiki.python.org/moin/GuiProgramming>.

19.6. Exercises

- 19-1.** *Client/Server Architecture.* Describe the roles of a windows (or windowing) server and a windows client.
- 19-2.** *Object-Oriented Programming.* Describe the relationship between child and parent windows.
- 19-3.** *Label Widgets.* Update the `tkhello1.py` script to display your own message instead of "Hello World!"
- 19-4.** *Label and Button Widgets.* Update the `tkhello3.py` script so that there are three new buttons in addition to the QUIT button. Pressing any of the three buttons will result in changing the text label so that it will then contain the text of the `Button` (widget) that was pressed.
- 19-5.** *Label, Button, and Radiobutton Widgets.* Modify your solution to the previous problem so that there are three `Radiobuttons` presenting the choices of text for the `Label`. There are two buttons: the QUIT button and an "Update" button. When the Update button is pressed, the text label will then be changed to contain the text of the selected `Radiobutton`. If no `Radiobutton` has been checked, the `Label` will remain unchanged.
- 19-6.** *Label, Button, and Entry Widgets.* Modify your solution to the previous problem so that the three `Radiobuttons` are replaced by a single `Entry` text field widget with a default value of "Hello World!" (to reflect the initial string in the `Label`). The `Entry` field can be edited by the user with a new text string for the `Label` which will be updated if the Update button is pressed.
- 19-7.** *Label and Entry Widgets and Python I/O.* Create a GUI application that provides an `Entry` field where the user can provide the name of a text file. Open the file and read it, displaying its contents in a `Label`.

Extra Credit (Menus): Replace the `Entry` widget with a menu that has a File Open option that pops up a window to allow the user to specify the file to read. Also add an Exit or Quit option to the menu rather than having a QUIT button.

- 19-8.** *Simple Text Editor.* Use your solution to the previous problem to create a simple text editor. A file can be created from scratch or read and displayed into a `Text` widget that can be edited by the user. When the user quits the application (either with the QUIT button or the Quit/Exit menu option), the user is prompted whether to save the changes.

Extra Credit: Interface your script to a spellchecker and add a button or menu option to spellcheck the file. The words that are misspelled should be highlighted by using a different foreground or background color in the `Text` widget.

- 19-9.** *Multithreaded Chat Applications.* The chat programs from Chapters [13](#), [16](#), and [17](#) need completion. Create a fully-functional multithreaded chat server. A GUI is not really necessary for the server unless you want to create one as a front-end to its configuration, i.e., port number, name, connection to a name server, etc. Create a multithreaded chat client that has separate threads to monitor user input (and sends the message to the server for broadcast) and another thread to accept incoming messages to display to the user. The client front-end GUI should have two portions of the chat window: a larger section with multiple lines to hold all the dialog, and a smaller text entry field to accept input from the user.
- 19-10.** *Using Other GUIs.* The example GUI applications using the various toolkits in Chapter 18.4 are very similar; however, they are not the same. Although it is impossible to make them all look *exactly* alike, tweak them so that they are more consistent than they are now.
- 19-11.** *Using GUI builders.* Download either Boa Constructor (for wxWidgets) or Glade (for GTK+) [or both!], and implement the "animal" GUI by just dragging and dropping the widgets from the corresponding palette. Hook up your new GUIs with callbacks so that they behave just like the sample applications we looked at in that chapter.

Chapter 20. Web Programming

Chapter Topics

- [Introduction](#)
- [Web Surfing with Python: Simple Web Clients](#)
 - `urlparse` and `urllib` Modules
- [Advanced Web Clients](#)
 - Crawler/Spider/Robot
- [CGI: Helping Web Servers Process Client Data](#)
- [Building CGI Applications](#)
- [Using Unicode with CGI](#)
- [Advanced CGI](#)
- [Creating Web Servers](#)
- [Related Modules](#)

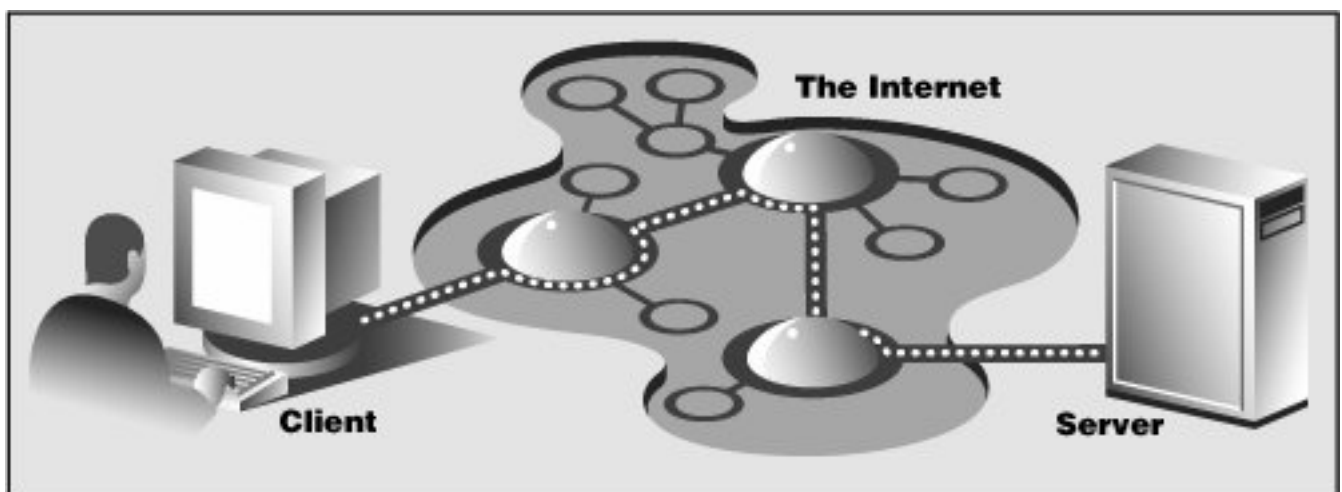
20.1. Introduction

This introductory chapter on Web programming will give you a quick and high-level overview of the kinds of things you can do with Python on the Internet, from Web surfing to creating user feedback forms, from recognizing Uniform Resource Locators to generating dynamic Web page output.

20.1.1. Web Surfing: Client/Server Computing (Again?!?)

Web surfing falls under the same client/server architecture umbrella that we have seen repeatedly. This time, Web *clients* are browsers, applications that allow users to seek documents on the World Wide Web. On the other side are Web *servers*, processes that run on an information provider's host computers. These servers wait for clients and their document requests, process them, and return the requested data. As with most servers in a client/server system, Web servers are designed to run "forever." The Web surfing experience is best illustrated by [Figure 20-1](#). Here, a user runs a Web client program such as a browser and makes a connection to a Web server elsewhere on the Internet to obtain information.

Figure 20-1. Web client and Web server on the Internet. A client sends a request out over the Internet to the server, which then responds with the requested data back to the client.



Clients may issue a variety of requests to Web servers. Such requests may include obtaining a Web page for viewing or submitting a form with data for processing. The request is then serviced by the Web server, and the reply comes back to the client in a special format for display purposes.

The "language" that is spoken by Web clients and servers, the standard protocol used for Web communication, is called *HTTP*, which stands for HyperText Transfer Protocol. HTTP is written "on top of" the TCP and IP protocol suite, meaning that it relies on TCP and IP to carry out its lower-level communication functionality. Its responsibility is not to route or deliver messages TCP and IP handle that but to respond to client requests (by sending and receiving HTTP messages).

HTTP is known as a "stateless" protocol because it does not keep track of information from one client request to the next, similar to the client/server architecture we have seen so far. The server stays running, but client interactions are singular events structured in such a way that once a client request is serviced, it quits. New requests can always be sent, but they are considered separate service requests. Because of the lack of context per request, you may notice that some URLs have a long set of variables

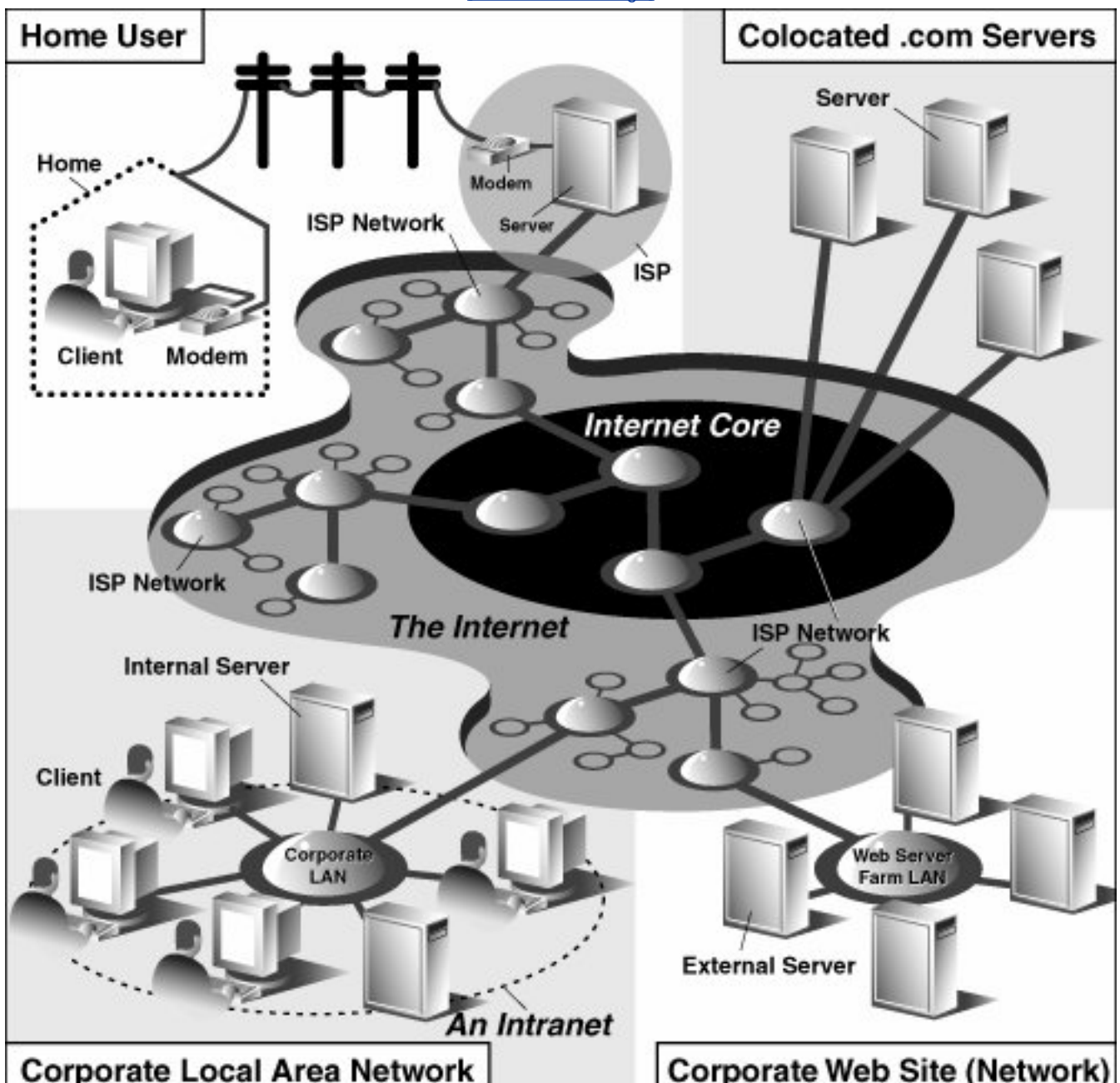
and values chained as part of the request to provide some sort of state information. Another alternative is the use of "cookies" static data stored on the client side which generally contain state information as well. In later parts of this chapter, we will look at how to use both long URLs and cookies to maintain state information.

20.1.2. The Internet

The Internet is a moving and fluctuating "cloud" or "pond" of interconnected clients and servers scattered around the globe. Communication between client and server consists of a series of connections from one lily pad on the pond to another, with the last step connecting to the server. As a client user, all this detail is kept hidden from your view. The abstraction is to have a direct connection between you the client and the server you are "visiting," but the underlying HTTP, TCP, and IP protocols are hidden underneath, doing all of the dirty work. Information regarding the intermediate "nodes" is of no concern or consequence to the general user anyway, so it's good that the implementation is hidden. [Figure 20-2](#) shows an expanded view of the Internet.

Figure 20-2. A grand view of the Internet. The left side illustrates where you would find Web clients while the right side hints as to where Web servers are typically located.

[\[View full size image\]](#)



As you can see from the figure, the Internet is made up of multiply-interconnected networks, all working with some sense of (perhaps disjointed) harmony. The left half of the diagram is focused on the Web clients, users who are either at home dialed-in to their *ISP* (Internet Service Provider) or at work on their company's *LAN* (Local Area Network).

The right-hand side of the diagram concentrates more on Web servers and where they can be found. Corporations with larger Web sites will typically have an entire "Web server farm" located at their ISPs. Such physical placement is called *colocation*, meaning that a company's servers are "co-located" at an ISP along with machines from other corporate customers. These servers are either all providing different data to clients or are part of a redundant system with duplicated information designed for heavy demand (high number of clients). Smaller corporate Web sites may not require as much hardware and networking gear, and hence, may only have one or several colocated servers at their ISP.

In either case, most colocated servers are stored with a larger ISP sitting on a network *backbone*, meaning that they have a "fatter" (meaning wider) and presumably faster connection to the Internet closer to the "core" of the Internet, if you will. This permits clients to access the servers quickly being on a backbone means clients do not have to hop across as many networks to access a server, thus allowing more clients to be serviced within a given time period.

One should also keep in mind that although Web surfing is the most common Internet application, it is not the only one and is certainly not the oldest. The Internet predates the Web by almost three decades. Before the Web, the Internet was mainly used for educational and research purposes. Most of the systems on the Internet run Unix, a multi-user operating system, and many of the original Internet protocols are still around today.

Such protocols include telnet (allows users to log in to a remote host on the Internet and still in use today), *FTP* (the File Transfer Protocol that enables users to share files and data via uploading or downloading and also still in use today), *Gopher* (the precursor to the Web search engine a "gopher"-like piece of software that "tunneled the Internet" looking for the data that you were interested in), *SMTP* or Simple Mail Transfer Protocol (the protocol used for one of the oldest and most widely used Internet applications: electronic mail), and *NNTP* (News-to-News Transfer Protocol).

Since one of Python's initial strengths was Internet programming, you will find support for all of the protocols discussed above in addition to many others. We differentiate between "Internet programming" and "Web programming" by stating that the latter pertains only to applications developed specifically for Web applications, i.e., Web clients and servers, our focus for this chapter. Internet programming covers a wider range of applications, including some of the Internet protocols we previously mentioned, such as FTP, SMTP, etc., as well as network and socket programming in general, as we discussed in a previous chapter.

20.2. Web Surfing with Python: Creating Simple Web Clients

One thing to keep in mind is that a browser is only one type of Web client. Any application that makes a request for data from a Web server is considered a "client." Yes, it is possible to create other clients that retrieve documents or data off the Internet. One important reason to do this is that a browser provides only limited capacity, i.e., it is used primarily for viewing and interacting with Web sites. A client program, on the other hand, has the ability to do more; it can not only download data, but it can also store it, manipulate it, or perhaps even transmit it to another location or application.

Applications that use the `urllib` module to download or access information on the Web [using either `urllib.urlopen()` or `urllib.urlretrieve()`] can be considered a simple Web client. All you need to do is provide a valid Web address.

20.2.1. Uniform Resource Locators

Simple Web surfing involves using Web addresses called *URLs* (Uniform Resource Locators). Such addresses are used to locate a document on the Web or to call a CGI program to generate a document for your client. URLs are part of a larger set of identifiers known as *URIs* (Uniform Resource Identifiers). This superset was created in anticipation of other naming conventions that have yet to be developed. A URL is simply a URI which uses an existing protocol or scheme (i.e., http, ftp, etc.) as part of its addressing. To complete this picture, we'll add that non-URL URIs are sometimes known as *URNs* (Uniform Resource Names), but because URLs are the only URIs in use today, you really don't hear much about URIs or URNs, save perhaps as XML identifiers.

Like street addresses, Web addresses have some structure. An American street address usually is of the form "number street designation," i.e., 123 Main Street. It differs from other countries, which have their own rules. A URL uses the format:

```
prot_sch://net_loc/path:params?query#frag
```

[Table 20.1](#) describes each of the components.

Table 20.1. Web Address Components

URL Component	Description
<i>prot_sch</i>	Network protocol or download scheme
<i>net_loc</i>	Location of server (and perhaps user information)
<i>path</i>	Slash (/) delimited path to file or CGI application
<i>params</i>	Optional parameters
<i>query</i>	Ampersand (&) delimited set of "key=value" pairs
<i>frag</i>	Fragment to a specific anchor within document

`net_loc` can be broken down into several more components, some required, others optional. The `net_loc` string looks like this:

```
user:passwd@host:port
```

These individual components are described in [Table 20.2](#).

Table 20.2. Network Location Components

<code>net_loc</code> Component	Description
<code>user</code>	User name or login
<code>passwd</code>	User password
<code>host</code>	Name or address of machine running Web server [required]
<code>port</code>	Port number (if not 80, the default)

Of the four, the `host` name is the most important. The `port` number is necessary only if the Web server is running on a different port number from the default. (If you aren't sure what a port number is, go back to [Chapter 16](#).)

User names and perhaps passwords are used only when making FTP connections, and even then they usually aren't necessary because the majority of such connections are "anonymous."

Python supplies two different modules, each dealing with URLs in completely different functionality and capacities. One is `urlparse`, and the other is `urllib`. We will briefly introduce some of their functions here.

20.2.2. `urlparse` Module

The `urlparse` module provides basic functionality with which to manipulate URL strings. These functions include `urlparse()`, `urlunparse()`, and `urljoin()`.

`urlparse.urlparse()`

`urlparse()` breaks up a URL string into some of the major components described above. It has the following syntax:

```
urlparse(urlstr, defProtSch=None, allowFrag=None)
```

`urlparse()` parses `urlstr` into a 6-tuple (`prot_sch`, `net_loc`, `path`, `params`, `query`, `frag`). Each of these components has been described above. `defProtSch` indicates a default network protocol or download

scheme in case one is not provided in `urlstr.allowFrag` is a flag that signals whether or not a fragment part of a URL is allowed. Here is what `urlparse()` outputs when given a URL:

```
>>> urlparse.urlparse('http://www.python.org/doc/FAQ.html')
('http', 'www.python.org', '/doc/FAQ.html', '', '', '')
```

`urlparse.urlunparse()`

`urlunparse()` does the exact opposite of `urlparse()` it merges a 6-tuple (`prot_sch`, `net_loc`, `path`, `params`, `query`, `frag`) *urltup*, which could be the output of `urlparse()`, into a single URL string and returns it. Accordingly, we state the following equivalence:

```
urlunparse(urlparse(urlstr))  $\equiv$  urlstr
```

You may have already surmised that the syntax of `urlunparse()` is as follows:

```
urlunparse(urltup)
```

`urlparse.urljoin()`

The `urljoin()` function is useful in cases where many related URLs are needed, for example, the URLs for a set of pages to be generated for a Web site. The syntax for `urljoin()` is:

```
urljoin(baseurl, newurl, allowFrag=None)
```

`urljoin()` takes *baseurl* and joins its base path (*net_loc* plus the full path up to, but not including, a file at the end) with *newurl*. For example:

```
>>> urlparse.urljoin('http://www.python.org/doc/FAQ.html', \
... 'current/lib/lib.htm')
'http://www.python.org/doc/current/lib/lib.html'
```

A summary of the functions in `urlparse` can be found in [Table 20.3](#).

Table 20.3. Core `urlparse` Module Functions

<code>urlparse</code> Functions	Description
<code>urlparse(urlstr, defProtSch=None, allowFrag=None)</code>	Parses <i>urlstr</i> into separate components, using <i>defProtSch</i> if the protocol or scheme is not given in <i>urlstr</i> ; <i>allowFrag</i> determines whether a URL fragment is allowed


```
urlunparse(urltup)
```

Unparses a tuple of URL data (*urltup*) into a single URL string

```
urljoin(baseurl,newurl,allowFrag=None)
```

Merges the base part of the *baseurl* URL with *newurl* to form a complete URL; *allowFrag* is the same as for `urlparse()`

20.2.3. urllib Module

Core Module: urllib



*Unless you are planning on writing a more lower-level network client, the `urllib` module provides all the functionality you need. `urllib` provides a high-level Web communication library, supporting the basic Web protocols, HTTP, FTP, and Gopher, as well as providing access to local files. Specifically, the functions of the `urllib` module are designed to download data (from the Internet, local network, or local host) using the aforementioned protocols. Use of this module generally obviates the need for using the `httplib`, `ftplib`, and `gopherlib` modules unless you desire their lower-level functionality. In those cases, such modules can be considered as alternatives. (Note: Most modules named **lib* are generally for developing clients of the corresponding protocols. This is not always the case, however, as perhaps `urllib` should then be renamed "internetlib" or something similar!)*

The `urllib` module provides functions to download data from given URLs as well as encoding and decoding strings to make them suitable for including as part of valid URL strings. The functions we will be looking at in this upcoming section include: `urlopen()`, `urlretrieve()`, `quote()`, `unquote()`, `quote_plus()`, `unquote_plus()`, and `urlencode()`. We will also look at some of the methods available to the file-like object returned by `urlopen()`. They will be familiar to you because you have already learned to work with files back in [Chapter 9](#).

`urllib.urlopen()`

`urlopen()` opens a Web connection to the given URL string and returns a file-like object. It has the following syntax:

```
urlopen(urlstr, postData=None)
```

`urlopen()` opens the URL pointed to by *urlstr*. If no protocol or download scheme is given, or if a "file" scheme is passed in, `urlopen()` will open a local file.

For all HTTP requests, the normal request type is "GET." In these cases, the query string provided to the Web server (key-value pairs encoded or "quoted," such as the string output of the `urlencode()` function [see below]), should be given as part of *urlstr*.

If the "POST" request method is desired, then the query string (again encoded) should be placed in the `postQueryData` variable. (For more information regarding the GET and POST request methods, refer to any general documentation or texts on programming CGI applications which we will also discuss below. GET and POST requests are the two ways to "upload" data to a Web server.

When a successful connection is made, `urlopen()` returns a file-like object as if the destination was a file opened in read mode. If our file object is `f`, for example, then our "handle" would support the expected read methods such as `f.read()`, `f.readline()`, `f.readlines()`, `f.close()`, and `f.fileno()`.

In addition, a `f.info()` method is available which returns the *MIME* (Multipurpose Internet Mail Extension) headers. Such headers give the browser information regarding which application can view returned file types. For example, the browser itself can view *HTML* (HyperText Markup Language), plain text files, and render *PNG* (Portable Network Graphics) and *JPEG* (Joint Photographic Experts Group) or the old *GIF* (Graphics Interchange Format) graphics files. Other files such as multimedia or specific document types require external applications in order to view.

Finally, a `geturl()` method exists to obtain the true URL of the final opened destination, taking into consideration any redirection that may have occurred. A summary of these file-like object methods is given in [Table 20.4](#).

Table 20.4. `urllib.urlopen()` File-like Object Methods

<code>urlopen()</code> Object Methods	Description
<code>f.read([bytes])</code>	Reads all or <code>bytes</code> bytes from <code>f</code>
<code>f.readline()</code>	Reads a single line from <code>f</code>
<code>f.readlines()</code>	Reads all lines from <code>f</code> into a list
<code>f.close()</code>	Closes URL connection for <code>f</code>
<code>f.fileno()</code>	Returns file number of <code>f</code>
<code>f.info()</code>	Gets MIME headers of <code>f</code>
<code>f.geturl()</code>	Returns true URL opened for <code>f</code>

If you expect to be accessing more complex URLs or want to be able to handle more complex situations such as basic and digest authentication, redirections, cookies, etc., then we suggest using the `urllib2` module, introduced back in the 1.6 days (mostly as an experimental module). It too, has a `urlopen()` function, but also provides other functions and classes for opening a variety of URLs. For more on `urllib2`, see the next section of this chapter.

`urllib.urlretrieve()`

`urlretrieve()` will do some quick and dirty work for you if you are interested in working with a URL document as a whole. Here is the syntax for `urlretrieve()`:

```
urlretrieve(urlstr, localfile=None, downloadSta-
tusHook=None)
```

Rather than reading from the URL like `urlopen()` does, `urlretrieve()` will simply download the entire HTML file located at `urlstr` to your local disk. It will store the downloaded data into `localfile` if given or a temporary file if not. If the file has already been copied from the Internet or if the file is local, no subsequent downloading will occur.

The `downloadStatusHook`, if provided, is a function that is called after each block of data has been downloaded and delivered. It is called with the following three arguments: number of blocks read so far, the block size in bytes, and the total (byte) size of the file. This is very useful if you are implementing "download status" information to the user in a text-based or graphical display.

`urlretrieve()` returns a 2-tuple, `(filename, mime_hdrs)`. `filename` is the name of the local file containing the downloaded data. `mime_hdrs` is the set of MIME headers returned by the responding Web server. For more information, see the `Message` class of the `mimertools` module. `mime_hdrs` is `None` for local files.

For a simple example using `urlretrieve()`, take a look at [Example 11.4](#) (`grabweb.py`). A larger piece of code using `urlretrieve()` can be found later in this chapter in [Example 20.2](#).

Example 20.2. Advanced Web Client: a Web Crawler (`crawl.py`)

The crawler consists of two classes, one to manage the entire crawling process (`Crawler`), and one to retrieve and parse each downloaded Web page (`Retriever`).

```
1      #!/usr/bin/env python
2
3      from sys import argv
4      from os import makedirs, unlink, sep
5      from os.path import dirname, exists, isdir, splitext
6      from string import replace, find, lower
7      from htmllib import HTMLParser
8      from urllib import urlretrieve
9      from urlparse import urlparse, urljoin
10     from formatter import DumbWriter, AbstractFormatter
11     from cStringIO import StringIO
12
13     class Retriever(object):# download Web pages
14
15         def __init__(self, url):
16             self.url = url
17             self.file = self.filename(url)
18
19         def filename(self, url, deffile='index.htm'):
20             parsedurl = urlparse(url, 'http:', 0) ## parse path
21             path = parsedurl[1] + parsedurl[2]
22             ext = splitext(path)
23             if ext[1] == '':                # no file, use default
24                 if path[-1] == '/':
25                     path += deffile
26             else:
27                 path += '/' + deffile
```

```

28         ldir = dirname(path)    # local directory
29         if sep != '/':          # os-indep. path separator
30             ldir = replace(ldir, '/', sep)
31         if not isdir(ldir):      # create archive dir if nec
32             if exists(ldir): unlink(ldir)
33             makedirs(ldir)
34         return path
35
36     def download(self):          # download Web page
37         try:
38             retval = urlretrieve(self.url, self.file)
39         except IOError:
40             retval = ('*** ERROR: invalid URL "%s"' % \
41                     self.url,)
42         return retval
43
44     def parseAndGetLinks(self): # parse HTML, save links
45         self.parser = HTMLParser(AbstractFormatter(\
46             DumbWriter(StringIO()))
47         self.parser.feed(open(self.file).read())
48         self.parser.close()
49         return self.parser.anchorlist
50
51 class Crawler(object): # manage entire crawling process
52
53     count = 0            # static downloaded page counter
54
55     def __init__(self, url):
56         self.q = [url]
57         self.seen = []
58         self.dom = urlparse(url)[1]
59
60     def getPage(self, url):
61         r = Retriever(url)
62         retval = r.download()
63         if retval[0] == '*': # error situation, do not parse
64             print retval, '... skipping parse'
65             return
66         Crawler.count += 1
67         print '\n(', Crawler.count, ')'
68         print 'URL:', url
69         print 'FILE:', retval[0]
70         self.seen.append(url)
71
72         links = r.parseAndGetLinks() # get and process links
73         for eachLink in links:
74             if eachLink[:4] != 'http' and \
75                 find(eachLink, '://') == -1:
76                 eachLink = urljoin(url, eachLink)
77             print '* ', eachLink,
78
79             if find(lower(eachLink), 'mailto:') != -1:
80                 print '... discarded, mailto link'
81                 continue
82
83             if eachLink not in self.seen:
84                 if find(eachLink, self.dom) == -1:
85                     print '... discarded, not in domain'
86                 else:

```

```

87         if eachLink not in self.q:
88             self.q.append(eachLink)
89             print '... new, added to Q'
90         else:
91             print '... discarded, already in Q'
92     else:
93         print '... discarded, already processed'
94
95     def go(self):# process links in queue
96         while self.q:
97             url = self.q.pop()
98             self.getPage(url)
99
100     def main():
101         if len(argv) > 1:
102             url = argv[1]
103         else:
104             try:
105                 url = raw_input('Enter starting URL: ')
106             except (KeyboardInterrupt, EOFError):
107                 url = ''
108
109         if not url: return
110         robot = Crawler(url)
111         robot.go()
112
113     if __name__ == '__main__':
114         main()

```

urllib.quote() and urllib.quote_plus()

The `quote*()` functions take URL data and "encodes" them so that they are "fit" for inclusion as part of a URL string. In particular, certain special characters that are unprintable or cannot be part of valid URLs acceptable to a Web server must be converted. This is what the `quote*()` functions do for you. Both `quote*()` functions have the following syntax:

```
quote(urldata, safe='/')
```

Characters that are never converted include commas, underscores, periods, and dashes, as well as alphanumerics. All others are subject to conversion. In particular, the disallowed characters are changed to their hexadecimal ordinal equivalents prepended with a percent sign (%), i.e., "%xx" where "xx" is the hexadecimal representation of a character's ASCII value. When calling `quote*()`, the `urldata` string is converted to an equivalent string that can be part of a URL string. The `safe` string should contain a set of characters which should also *not* be converted. The default is the slash (/).

`quote_plus()` is similar to `quote()` except that it also encodes spaces to plus signs (+). Here is an example using `quote()` vs. `quote_plus()`:

```

>>> name = 'joe mama'
>>> number = 6
>>> base = 'http://www/~foo/cgi-bin/s.py'

```

```
>>> final = '%s?name=%s&num=%d' % (base, name, number)
>>> final
'http://www/~foo/cgi-bin/s.py?name=joe mama&num=6'
>>>
>>> urllib.quote(final)
'http:%3a//www/%7efoo/cgi-bin/s.py%3fname%3djoe%20mama%26num%3d6'
>>>
>>> urllib.quote_plus(final)
'http:%3a//www/%7efoo/cgi-bin/s.py%3fname%3djoe+mama%26num%3d6'
```

urllib.unquote() and urllib.unquote_plus()

As you have probably guessed, the `unquote*()` functions do the exact opposite of the `quote*()` functions; they convert all characters encoded in the "%xx" fashion to their ASCII equivalents. The syntax of `unquote*()` is as follows:

```
unquote*(urldata)
```

Calling `unquote()` will decode all URL-encoded characters in `urldata` and return the resulting string. `unquote_plus()` will also convert plus signs back to space characters.

urllib.urlencode()

`urlencode()`, added to Python back in 1.5.2, takes a dictionary of key-value pairs and encodes them to be included as part of a query in a CGI request URL string. The pairs are in "key=value" format and are delimited by ampersands (&). Furthermore, the keys and their values are sent to `quote_plus()` for proper encoding. Here is an example output from `urlencode()`:

```
>>> aDict = { 'name': 'Georgina Garcia', 'hmdir': '~ggarcia' }
>>> urllib.urlencode(aDict)
'name=Georgina+Garcia&hmdir=%7eggarcia'
```

There are other functions in `urllib` and `urlparse` which we did not have the opportunity to cover here. Refer to the documentation for more information.

Secure Socket Layer support

The `urllib` module was given support for opening HTTP connections using the Secure Socket Layer (SSL) in 1.6. The core change to add SSL is implemented in the `socket` module. Consequently, the `urllib` and `httpplib` modules were updated to support URLs using the "https" connection scheme. In addition to those two modules, other protocol client modules with SSL support include: `imaplib`, `poplib`, and `smtplib`.

A summary of the `urllib` functions discussed in this section can be found in [Table 20.5](#).

Table 20.5. Core `urllib` Module Functions

urllib Functions

Description

`urlopen(urlstr, postData=None)`

Opens the URL *urlstr*, sending the query data in *postData* if a POST request

`urlretrieve(urlstr, localfile=None, downloadStatusHook=None)`

Downloads the file located at the *urlstr* URL to *localfile* or a temporary file if *localfile* not given; if present, *downloadStatusHook* is a function that can receive download statistics

`quote(urldata, safe='/')`

Encodes invalid URL characters of *urldata*; characters in *safe* string are *not* encoded

`quote_plus(urldata, safe='/')`

Same as `quote()` except encodes spaces as plus (+) signs (rather than as %20)

`unquote(urldata)`

Decodes encoded characters of *urldata*

`unquote_plus(urldata)`

Same as `unquote()` but converts plus signs to spaces

`urlencode(dict)`

Encodes the key-value pairs of *dict* into a valid string for CGI queries and encodes the key and value strings with `quote_plus()`

20.2.4. urllib2 Module

As mentioned in the previous section, `urllib2` can handle more complex URL opening. One example is for Web sites with basic authentication (login and password) requirements. The most straightforward solution to "getting past security" is to use the extended `net_loc` URL component as described earlier in this chapter, i.e., `http://user:passwd@www.python.org`. The problem with this solution is that it is not programmatic. Using `urllib2`, however, we can tackle this problem in two different ways.

We can create a basic authentication handler (`urllib2.HTTPBasicAuthHandler`) and "register" a login password given the base URL and perhaps a *realm*, meaning a string defining the secure area of the Web site. (For more on realms, see RFC 2617 [HTTP Authentication: Basic and Digest Access Authentication]). Once this is done, you can "install" a URL-opener with this handler so that all URLs opened will use our handler.

The other alternative is to simulate typing the username and password when prompted by a browser and that is to send an HTTP client request with the appropriate authorization headers. In [Example 20.1](#) we can easily identify each of these two methods.

Example 20.1. HTTP Auth Client (`urlopen-auth.py`)

This script uses both techniques described above for basic authentication.

```
1      #!/usr/bin/env python
2
3      import urllib2
4
5      LOGIN = 'wesc'
6      PASSWD = "you'llNeverGuess"
7      URL = 'http://localhost'
8
9      def handler_version(url):
10         from urlparse import urlparse as up
11         hdlr = urllib2.HTTPBasicAuthHandler()
12         hdlr.add_password('Archives', up(url)[1], LOGIN, PASSWD)
13         opener = urllib2.build_opener(hdlr)
14         urllib2.install_opener(opener)
15         return url
16
17     def request_version(url):
18         from base64 import encodestring
19         req = urllib2.Request(url)
20         b64str = encodestring('%s:%s' % (LOGIN, PASSWD))[:-1]
21         req.add_header("Authorization", "Basic %s" % b64str)
22         return req
23
24     for funcType in ('handler', 'request'):
25         print '*** Using %s:' % funcType.upper()
26         url = eval('%s_version')(URL)
27         f = urllib2.urlopen(url)
28         print f.readline()
29         f.close()
```

Line-by-Line Explanation

Lines 17

The usual setup plus some constants for the rest of the script to use.

Lines 915

The "handler" version of the code allocates a basic handler class as described earlier, then adds the authentication information. The handler is then used to create a URL-opener that is then installed so that all URLs opened will use the given authentication. This code was adapted from the official Python documentation for the `urllib2` module.

Lines 1722

The "request" version of our code just builds a `Request` object and adds the simple base64-encoded authentication header into our HTTP request. This request is then used to substitute the URL string when calling `urlopen()` upon returning back to "main." Note that the original URL was built into the Request object, hence the reason why it was not a problem to replace it in the subsequent call to `urllib2.urlopen`

(). This code was inspired by Mike Foord's and Lee Harr's recipes in the Python Cookbook located at:

<http://aspn.activestate.com/ASPN/Cookbook/Python/Recipe/305288>

<http://aspn.activestate.com/ASPN/Cookbook/Python/Recipe/267197>

It would have been great to have been able to use Harr's `HTTPRealmFinder` class so that we do not need to hardcode it in our example.

Lines 2429

The rest of this script just opens the given URL using both techniques and displays the first line (dumping the others) of the resulting HTML page returned by the server once authentication has been validated. Note that an HTTP error (and no HTML) would be returned if the authentication information is invalid.

The output should look something like this:

```
$ python urlopen-auth.py
Using handler:
<html>

Using request:
<html>
```

In addition to the official Python documentation for `urllib2`, you may find this companion piece useful: <http://www.voidspace.org.uk/python/articles/urllib2.shtml>.

20.3. Advanced Web Clients

Web browsers are basic Web clients. They are used primarily for searching and downloading documents from the Web. Advanced clients of the Web are those applications that do more than download single documents from the Internet.

One example of an advanced Web client is a *crawler* (aka *spider*, *robot*). These are programs that explore and download pages from the Internet for different reasons, some of which include:

- Indexing into a large search engine such as Google or Yahoo!
- Offline browsing/downloading documents onto a local hard disk and rearranging hyperlinks to create almost a mirror image for local browsing
- Downloading and storing for historical or archival purposes, or
- Web page caching to save superfluous downloading time on Web site revisits.

The crawler we present below, `crawl.py`, takes a starting Web address (URL), downloads that page and all other pages whose links appear in succeeding pages, but only those that are in the same domain as the starting page. Without such limitations, you will run out of disk space! The source for `crawl.py` appears in [Example 20.2](#).

Line-by-Line (Class-by-Class) Explanation

Lines 111

The top part of the script consists of the standard Python Unix start-up line and the importation of various module attributes that are employed in this application.

Lines 1349

The `Retriever` class has the responsibility of downloading pages from the Web and parsing the links located within each document, adding them to the "to-do" queue if necessary. A `Retriever` instance object is created for each page that is downloaded from the net. `Retriever` consists of several methods to aid in its functionality: a constructor (`__init__()`), `filename()`, `download()`, and `parseAndGetLinks()`.

The `filename()` method takes the given URL and comes up with a safe and sane corresponding filename to store locally. Basically, it removes the "http://" prefix from the URL and uses the remaining part as the filename, creating any directory paths necessary. URLs without trailing file-names will be given a default filename of "index.htm". (This name can be overridden in the call to `filename()`).

The constructor instantiates a `Retriever` object and stores both the URL string and the corresponding file name returned by `filename()` as local attributes.

The `download()` method, as you may imagine, actually goes out to the net to download the page with the given link. It calls `urllib.urlretrieve()` with the URL and saves it to the filename (the one returned by `filename()`). If the download was successful, the `parse()` method is called to parse the page just copied from the network; otherwise an error string is returned.

If the `Crawler` determines that no error has occurred, it will invoke the `parseAndGetLinks()` method to

parse the newly downloaded page and determine the course of action for each link located on that page.

Lines 5198

The `Crawler` class is the "star" of the show, managing the entire crawling process for one Web site. If we added threading to our application, we would create separate instances for each site crawled. The `Crawler` consists of three items stored by the constructor during the instantiation phase, the first of which is `q`, a queue of links to download. Such a list will fluctuate during execution, shrinking as each page is processed and grown as new links are discovered within each downloaded page.

The other two data values for the `Crawler` include `seen`, a list of all the links that "we have seen" (downloaded) already. And finally, we store the domain name for the main link, `dom`, and use that value to determine whether any succeeding links are part of the same domain.

`Crawler` also has a static data item named `count`. The purpose of this counter is just to keep track of the number of objects we have downloaded from the net. It is incremented for every page successfully download.

`Crawler` has a pair of other methods in addition to its constructor, `getPage()` and `go()`. `go()` is simply the method that is used to start the `Crawler` and is called from the main body of code. `go()` consists of a loop that will continue to execute as long as there are new links in the queue that need to be downloaded. The workhorse of this class, though, is the `getPage()` method.

`getPage()` instantiates a `Retriever` object with the first link and lets it go off to the races. If the page was downloaded successfully, the counter is incremented and the link added to the "already seen" list. It looks recursively at all the links featured inside each downloaded page and determines whether any more links should be added to the queue. The main loop in `go()` will continue to process links until the queue is empty, at which time victory is declared.

Links that are part of another domain, have already been downloaded, are already in the queue waiting to be processed, or are "`mailto:`" links are ignored and not added to the queue.

Lines 100114

`main()` is executed if this script is invoked directly and is the starting point of execution. Other modules that import `crawl.py` will need to invoke `main()` to begin processing. `main()` needs a URL to begin processing. If one is given on the command line (for example, when this script is invoked directly), it will just go with the one given. Otherwise, the script enters interactive mode, prompting the user for a starting URL. With a starting link in hand, the `Crawler` is instantiated and away we go.

One sample invocation of `crawl.py` may look like this:

```
% crawl.py
Enter starting URL: http://www.null.com/home/index.html

( 1 )
URL: http://www.null.com/home/index.html
FILE: www.null.com/home/index.html
* http://www.null.com/home/overview.html ... new, added to Q
* http://www.null.com/home/synopsis.html ... new, added to Q
* http://www.null.com/home/order.html ... new, added to Q
* mailto:postmaster@null.com ... discarded, mailto link
```

```
* http://www.null.com/home/overview.html ... discarded, already in Q
* http://www.null.com/home/synopsis.html ... discarded, already in Q
* http://www.null.com/home/order.html ... discarded, already in Q
* mailto:postmaster@null.com ... discarded, mailto link
* http://bogus.com/index.html ... discarded, not in domain
```

(2)

URL: http://www.null.com/home/order.html

FILE: www.null.com/home/order.html

```
* mailto:postmaster@null.com ... discarded, mailto link
* http://www.null.com/home/index.html ... discarded, already processed
* http://www.null.com/home/synopsis.html ... discarded, already in Q
* http://www.null.com/home/overview.html ... discarded, already in Q
```

(3)

URL: http://www.null.com/home/synopsis.html

FILE: www.null.com/home/synopsis.html

```
* http://www.null.com/home/index.html ... discarded, already processed
* http://www.null.com/home/order.html ... discarded, already processed
* http://www.null.com/home/overview.html ... discarded, already in Q
```

(4)

URL: http://www.null.com/home/overview.html

FILE: www.null.com/home/overview.html

```
* http://www.null.com/home/synopsis.html ... discarded, already processed
* http://www.null.com/home/index.html ... discarded, already processed
* http://www.null.com/home/synopsis.html ... discarded, already processed
* http://www.null.com/home/order.html ... discarded, already processed
```

After execution, a www.null.com directory would be created in the local file system, with a `home` subdirectory. Within `home`, all the HTML files processed will be found.

20.4. CGI: Helping Web Servers Process Client Data

20.4.1. Introduction to CGI

The Web was initially developed to be a global online repository or archive of (mostly educational and research-oriented) documents. Such pieces of information generally come in the form of static text and usually in HTML.

HTML is not as much a *language* as it is a text formatter, indicating changes in font types, sizes, and styles. The main feature of HTML is in its hypertext capability, text that is in one way or another highlighted to point to another document in a related context to the original. Such a document can be accessed by a mouse click or other user selection mechanism. These (static) HTML documents live on the Web server and are sent to clients when and if requested.

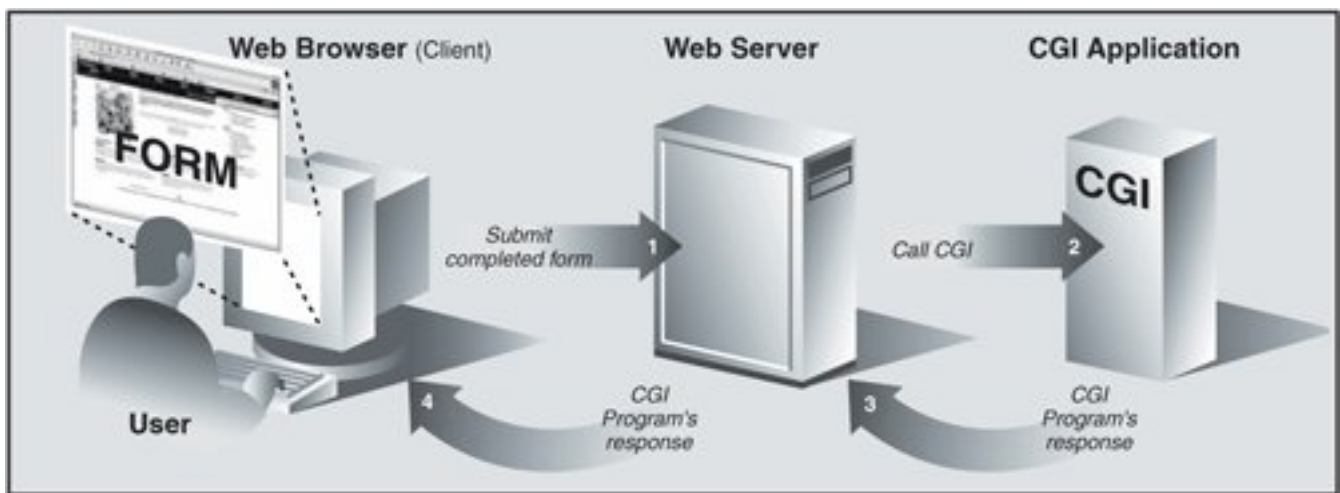
As the Internet and Web services evolved, there grew a need to process user input. Online retailers needed to be able to take individual orders, and online banks and search engine portals needed to create accounts for individual users. Thus fill-out forms were invented, and became the only way a Web site can get specific information from users (until Java applets came along). This, in turn, required the HTML now be generated on the fly, for each client submitting user-specific data.

Now, Web servers are only really good at one thing, getting a user request for a file and returning that file (i.e., an HTML file) to the client. They do not have the "brains" to be able to deal with user-specific data such as those which come from fields. Not being their responsibility, Web servers farm out such requests to external applications which create the dynamically generated HTML that is returned to the client.

The entire process begins when the Web server receives a client request (i.e., GET or POST) and calls the appropriate application. It then waits for the resulting HTML meanwhile, the client also waits. Once the application has completed, it passes the dynamically generated HTML back to the server, who then (finally) forwards it back to the user. This process of the server receiving a form, contacting an external application, and receiving and returning the newly-generated HTML takes place through what is called the Web server's *CGI* (Common Gateway Interface). An overview of how CGI works is illustrated in [Figure 20-3](#), which shows you the execution and data flow, step-by-step, from when a user submits a form until the resulting Web page is returned.

Figure 20-3. Overview of how CGI works. CGI represents the interaction between a Web server and the application that is required to process a user's form and generate the dynamic HTML that is eventually returned.

[\[View full size image\]](#)



Forms input from the client sent to a Web server may include processing and perhaps some form of storage in a backend database. Just keep in mind that any time there are any user-filled fields and/or a Submit button or image, it most likely involves some sort of CGI activity.

CGI applications that create the HTML are usually written in one of many higher-level programming languages that have the ability to accept user data, process it, and return HTML back to the server. Currently used programming languages include Perl, PHP, C/C++, or Python, to name a few. Before we take a look at CGI, we have to provide the caveat that the typical production Web application is no longer being done in CGI anymore.

Because of its significant limitations and limited ability to allow Web servers to process an abundant number of simultaneous clients, CGI is a dinosaur. Mission-critical Web services rely on compiled languages like C/C++ to scale. A modern-day Web server is typically composed of Apache and integrated components for database access (MySQL or PostgreSQL), Java (Tomcat), PHP, and various modules for Perl, Python, and SSL/security. However, if you are working on small personal Web sites or ones for small organizations and do not need the power and complexity required by mission critical Web services, CGI is the perfect tool for your simple Web sites.

Furthermore, there are a good number of Web application development frameworks out there as well as content management systems, all of which make building CGI a relic of past. However, beneath all the fluff and abstraction, they must still, in the end, follow the same model that CGI originally provided, and that is being able to take user input, execute code based on that input, and provide valid HTML as its final output for the client. Therefore, the exercise in learning CGI is well worth it in terms of understanding the fundamentals in order to develop effective Web services.

In this next section, we will look at how to create CGI applications in Python, with the help of the `cgi` module.

20.4.2. CGI Applications

A CGI application is slightly different from a typical program. The primary differences are in the input, output, and user interaction aspects of a computer program. When a CGI script starts, it needs to retrieve the user-supplied form data, but it has to obtain this data from the Web client, not a user on the server machine nor a disk file.

The output differs in that any data sent to standard output will be sent back to the connected Web client rather than to the screen, GUI window, or disk file. The data sent back must be a set of valid headers followed by HTML. If it is not and the Web client is a browser, an error (specifically, an Internal Server Error) will occur because Web clients such as browsers understand only valid HTTP data (i.e., MIME headers and HTML).

Finally, as you can probably guess, there is no user interaction with the script. All communication occurs among the Web client (on behalf of a user), the Web server, and the CGI application.

20.4.3. `cgi` Module

There is one primary class in the `cgi` module that does all the work: the `FieldStorage` class. This class should be instantiated when a Python CGI script begins, as it will read in all the pertinent user information from the Web client (via the Web server). Once this object has been instantiated, it will consist of a dictionary-like object that has a set of key-value pairs. The keys are the names of the form items that were passed in through the form while the values contain the corresponding data.

These values themselves can be one of three objects. They can be `FieldStorage` objects (instances) as well as instances of a similar class called `MiniFieldStorage`, which is used in cases where no file uploads or multiple-part form data is involved. `MiniFieldStorage` instances contain only the key-value pair of the name and the data. Lastly, they can be a list of such objects. This occurs when a form contains more than one input item with the same field name.

For simple Web forms, you will usually find all `MiniFieldStorage` instances. All of our examples below pertain only to this general case.



20.5. Building CGI Applications

20.5.1. Setting Up a Web Server

In order to play around with CGI development in Python, you need to first install a Web server, configure it for handling Python CGI requests, and then give the Web server access to your CGI scripts. Some of these tasks may require assistance from your system administrator.

If you want a real Web server, you will likely download and install Apache. There are Apache plug-ins or modules for handling Python CGI, but they are not required for our examples. You may wish to install those if you are planning on "going live" to the world with your service. Even this may be overkill.

For learning purposes or for simple Web sites, it may suffice to just use the Web servers that come with Python. In [Section 20.8](#), you will actually learn how to build and configure simple Python-based Web servers. You may read ahead now if you wish to find out more about it at this stage. However, that is not what this section is about.

If you want to just start up the most basic Web server, just execute it directly with Python:

```
$ python -m CGIHTTPServer
```

The `-m` option is new in 2.4, so if you are using an older version of Python or want to see alternative ways of running it, see [section 14.4.3](#). Anyway, if you eventually get it working. ...

This will start a Web server on port 8000 on your current machine from the current directory. Then you can just create a `Cgi-bin` right underneath the directory from which you started the server and put your Python CGI scripts in there. Put some HTML files in that directory and perhaps some `.py` CGI scripts in `Cgi-bin`, and you are ready to "surf" directly to this Web site with addresses looking something like these:

```
http://localhost:8000/friends.htm
```

```
http://localhost:8000/cgi-bin/friends2.py
```

20.5.2. Creating the Form Page

In [Example 20.3](#), we present the code for a simple Web form, `friends.htm`.

Example 20.3. Static Form Web Page (`friends.htm`)

This HTML file presents a form to the user with an empty field for the user's name and a set of radio buttons for the user to choose from.

```
1  <HTML><HEAD><TITLE>
2  Friends CGI Demo (static screen)
3  </TITLE></HEAD>
4  <BODY><H3>Friends list for: <I>NEW USER</I></H3>
5  <FORM ACTION="/cgi-bin/friends1.py">
6  <B>Enter your Name:</B>
7  <INPUT TYPE=text NAME=person VALUE="NEW USER" SIZE=15>
8  <P><B>How many friends do you have?</B>
9  <INPUT TYPE=radio NAME=howmany VALUE="0" CHECKED> 0
10 <INPUT TYPE=radio NAME=howmany VALUE="10"> 10
11 <INPUT TYPE=radio NAME=howmany VALUE="25"> 25
12 <INPUT TYPE=radio NAME=howmany VALUE="50"> 50
13 <INPUT TYPE=radio NAME=howmany VALUE="100"> 100
14 <P><INPUT TYPE=submit></FORM></BODY></HTML>
```

As you can see in the code, the form contains two input variables: `person` and `howmany`. The values of these two fields will be passed to our CGI script, `friends1.py`.

You will notice in our example that we install our CGI script into the default `cgi-bin` directory (see the "Action" link) on the local host. (If this information does not correspond with your development environment, update the form action before attempting to test the Web page and CGI script.) Also, because a METHOD subtag is missing from the form action all requests will be of the default type, GET. We choose the GET method because we do not have very many form fields, and also, we want our query string to show up in the "Location" (aka "Address", "Go To") bar so that you can see what URL is sent to the server.

Let us take a look at the screen that is rendered by `friends.htm` in a client (see [Figure 20-4](#) for Safari on MacOS and [Figure 20-5](#) for IE6). Throughout this chapter, we will feature screenshots from various Web browsers and operating systems over the past few years.

Figure 20-4. Friends form page in Safari on MacOS X (`friends.htm`)

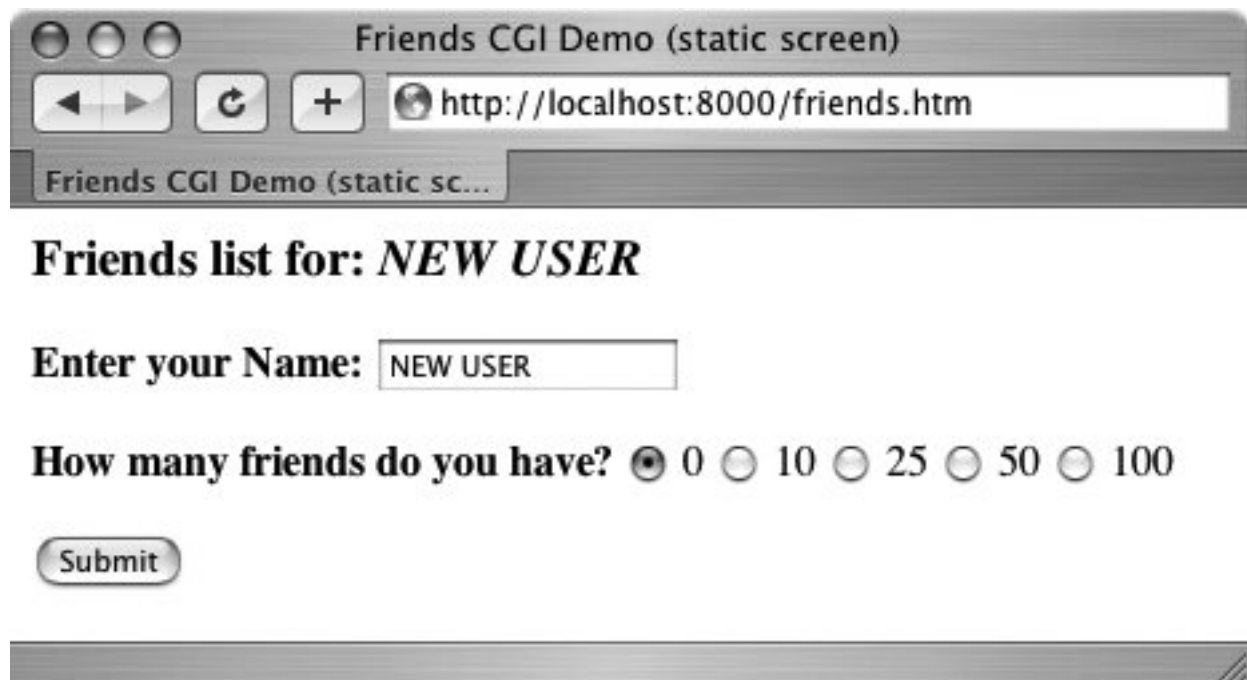
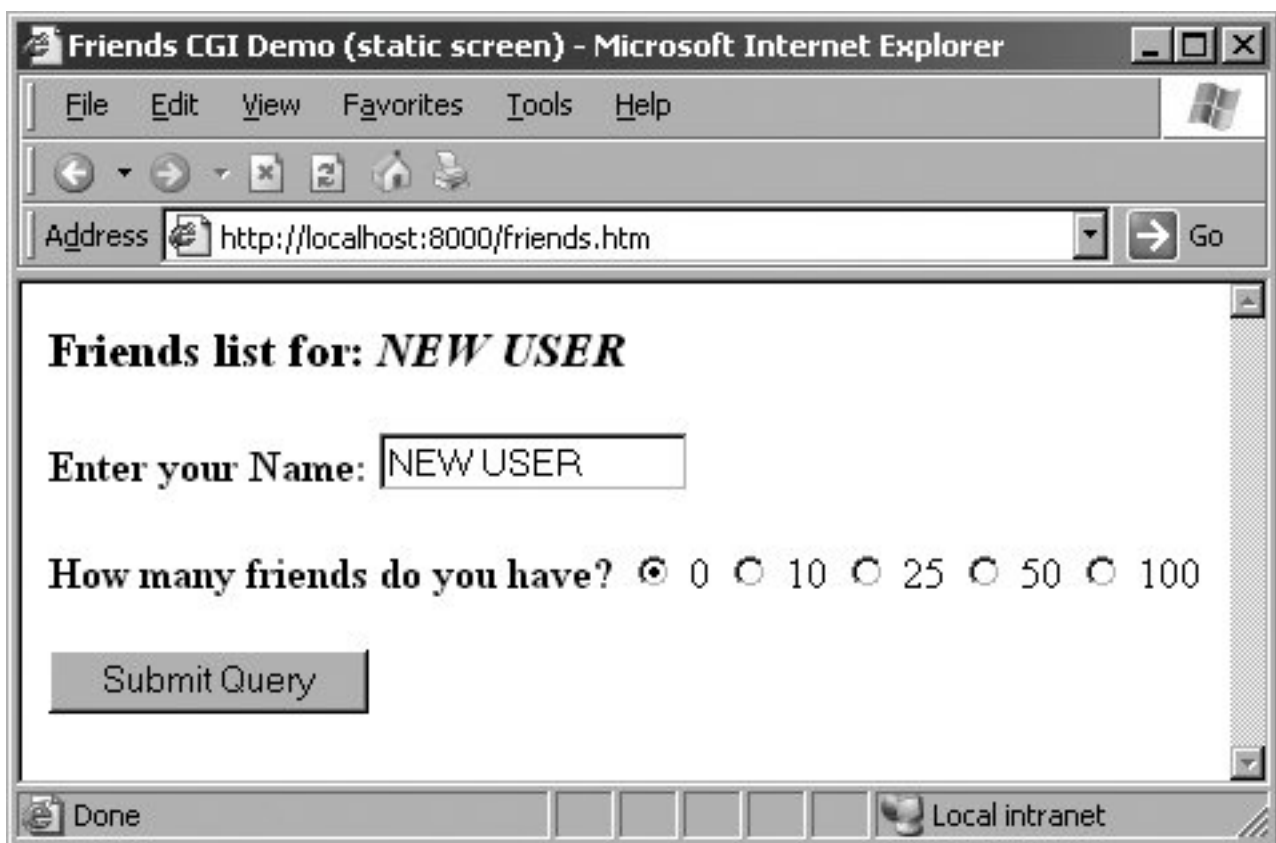


Figure 20-5. Friends form page in IE6 on Win32 (*friends.htm*)



20.5.3. Generating the Results Page

The input is entered by the user and the "Submit" button is pressed. (Alternatively, the user can also press the RETURN or Enter key within the text field to cause a similar effect.) When this occurs, the script in [Example 20.4](#), *friends1.py*, is executed via CGI.

Example 20.4. Results Screen CGI code (`friends1.py`)

This CGI script grabs the `person` and `howmany` fields from the form and uses that data to create the dynamically generated results screen.

```
1  #!/usr/bin/env python
2
3  import cgi
4
5  reshtml = '''Content-Type: text/html\n
6  <HTML><HEAD><TITLE>
7  Friends CGI Demo (dynamic screen)
8  </TITLE></HEAD>
9  <BODY><H3>Friends list for: <I>%s</I></H3>
10 Your name is: <B>%s</B><P>
11 You have <B>%s</B> friends.
12 </BODY></HTML>'''
13
14 form = cgi.FieldStorage()
15 who = form['person'].value
16 howmany = form['howmany'].value
17 print reshtml % (who, who, howmany)
```

This script contains all the programming power to read the form input and process it, as well as return the resulting HTML page back to the user. All the "real" work in this script takes place in only four lines of Python code (Lines 14-17).

The form variable is our `FieldStorage` instance, containing the values of the `person` and `howmany` fields. We read these into the Python `who` and `howmany` variables, respectively. The `reshtml` variable contains the general body of HTML text to return, with a few fields filled in dynamically, the data just read in from the form.

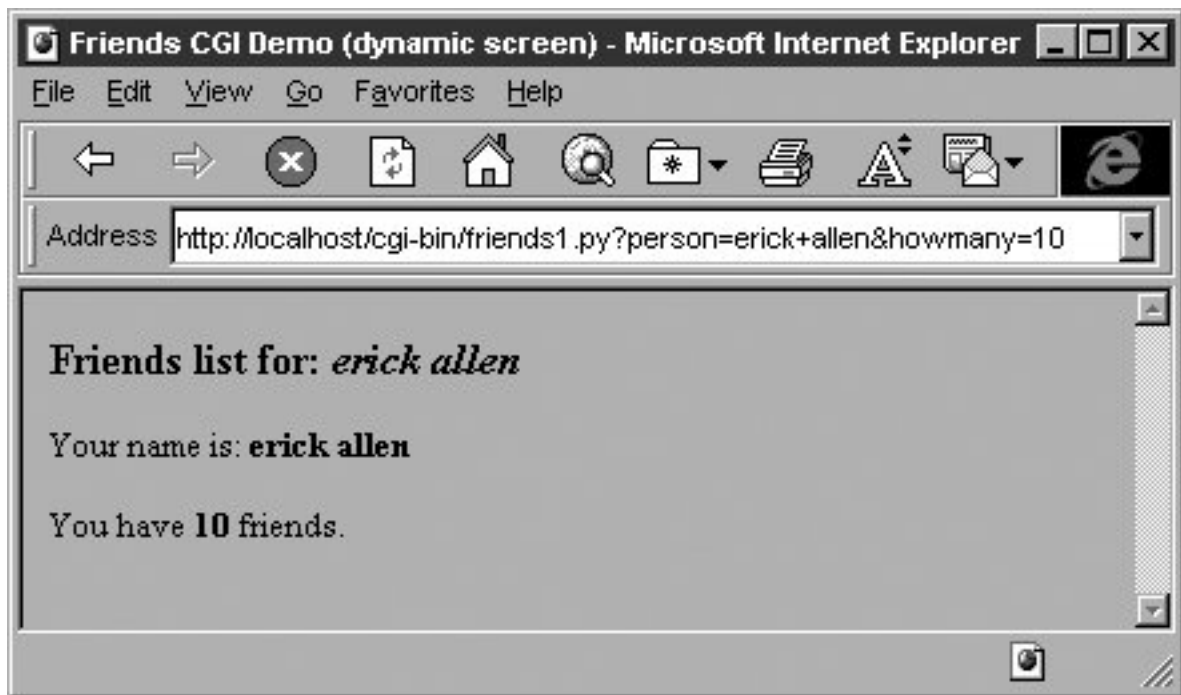
Core Tip: HTTP headers separate from HTML



One thing that always nails CGI beginners is that when sending results back to a CGI script, it must return the appropriate HTTP headers first before any HTML. Furthermore, to distinguish between these headers and the resulting HTML, several NEWLINE characters must be inserted between both sets of data, as in line 5 of our `friends1.py` example, as well as for the code in the remaining part of the chapter.

One possible resulting screen appears in [Figure 20-6](#), assuming the user typed in "erick allen" as the name and clicked on the "10 friends" radio button. The screen snapshot this time is represented by the older IE3 browser in a Windows environment.

Figure 20-6. Friends results page in IE3 on Win32



If you are a Web site producer, you may be thinking, "Gee, wouldn't it be nice if I could automatically capitalize this person's name, especially if they forgot?" This can easily be accomplished using Python CGI. (And we shall do so soon!)

Notice how on a GET request that our form variables and their values are added to the form action URL in the "Address" bar. Also, did you observe that the title for the `friends.htm` page has the word "static" in it while the output screen from `friends.py` has the word "dynamic" in *its* title? We did that for a reason: to indicate that the `friends.htm` file is a static text file while the results page is dynamically generated. In other words, the HTML for the results page did not exist on disk as a text file; rather, it was generated by our CGI script, which returned it as if it *was* a local file.

In our next example, we will bypass static files altogether by updating our CGI script to be somewhat more multifaceted.

20.5.4. Generating Form and Results Pages

We obsolete `friends.html` and merge it into `friends2.py`. The script will now generate both the form page as well as the results page. But how can we tell which page to generate? Well, if there is form data being sent to us, that means that we should be creating a results page. If we do not get any information at all, that tells us that we should generate a form page for the user to enter his or her data.

Our new `friends2.py` script is shown in [Example 20.5](#).

Example 20.5. Generating Form and Results Pages (`friends2.py`)

Both *friends.html* and *friends1.py* are merged together as *friends2.py*. The resulting script can now output both form and results pages as dynamically generated HTML and has the smarts to know which page to output.

```
1  #!/usr/bin/env python
2
3  import cgi
4
5  header = 'Content-Type: text/html\n\n'
6
7  formhtml = '''<HTML><HEAD><TITLE>
8  Friends CGI Demo</TITLE></HEAD>
9  <BODY><H3>Friends list for: <I>NEW USER</I></H3>
10 <FORM ACTION="/cgi-bin/friends2.py">
11 <B>Enter your Name:</B>
12 <INPUT TYPE=hidden NAME=action VALUE=edit>
13 <INPUT TYPE=text NAME=person VALUE="NEW USER" SIZE=15>
14 <P><B>How many friends do you have?</B>
15 %s
16 <P><INPUT TYPE=submit></FORM></BODY></HTML>'''
17
18 fradio = '<INPUT TYPE=radio NAME=howmany VALUE="%s" %s> %s\n'
19
20 def showForm():
21     friends = ''
22     for i in [0, 10, 25, 50, 100]:
23         checked = ''
24         if i == 0:
25             checked = 'CHECKED'
26         friends = friends + fradio % \
27             (str(i), checked, str(i))
28
29     print header + formhtml % (friends)
30
31 reshtml = '''<HTML><HEAD><TITLE>
32 Friends CGI Demo</TITLE></HEAD>
33 <BODY><H3>Friends list for: <I>%s</I></H3>
34 Your name is: <B>%s</B><P>
35 You have <B>%s</B> friends.
36 </BODY></HTML>'''
37
38 def doResults(who, howmany):
39     print header + reshtml % (who, who, howmany)
40
41 def process():
42     form = cgi.FieldStorage()
43     if form.has_key('person'):
44         who = form['person'].value
45     else:
46         who = 'NEW USER'
47
48     if form.has_key('howmany'):
49         howmany = form['howmany'].value
50     else:
51         howmany = 0
52
53     if form.has_key('action'):
54         doResults(who, howmany)
```

```
55         else:
56             showForm( )
57
58     if __name__ == '__main__':
59         process( )
```

So what did we change in our script? Let's take a look at some of the blocks of code in this script.

Line-by-Line Explanation

Lines 15

In addition to the usual startup and module import lines, we separate the HTTP MIME header from the rest of the HTML body because we will use it for both types of pages (form page and results page) returned and we don't want to duplicate the text. We will add this header string to the corresponding HTML body when it comes time for output to occur.

Lines 729

All of this code is related to the now-integrated `friends.htm` form page in our CGI script. We have a variable for the form page text, `formhtml`, and we also have a string to build the list of radio buttons, `fradio`. We could have duplicated this radio button HTML text as it is in `friends.htm`, but we wanted to show how we could use Python to generate more dynamic outputsee the `for`-loop on Lines 2227.

The `showForm()` function has the responsibility of generating a form for user input. It builds a set of text for the radio buttons, merges those lines of HTML into the main body of `formhtml`, prepends the header to the form, and then returns the entire wad of data back to the client by sending the entire string to standard output.

There are a couple of interesting things to note about this code. The first is the "hidden" variable in the form called `action`, containing the value "edit" on line 12. This field is the only way we can tell which screen to display (i.e., the form page or the results page). We will see this field come into play in Lines 5356.

Also, observe that we set the 0 radio button as the default by "checking" it within the loop that generates all the buttons. This will also allow us to update the layout of the radio buttons and/or their values on a single line of code (line 18) rather than over multiple lines of text. It will also offer some more flexibility in letting the logic determine which radio button is checkedsee the next update to our script, `friends3.py` coming up.

Now you may be thinking, "Why do we need an `action` variable when I could just as well be checking for the presence of `person` or `howmany`?" That is a valid question because yes, you could have just used `person` or `howmany` in this situation.

However, the `action` variable is a more conspicuous presence, insofar as its name as well as what it doesthe code is easier to understand. The `person` and `howmany` variables are used for their values while the `action` variable is used as a flag.

The other reason for creating `action` is that we will be using it again to help us determine which page to generate. In particular, we will need to display a form *with* the presence of a `person` variable (rather than a results page) this will break your code if you are solely relying on there being a `person` variable.

Lines 3139

The code to display the results page is practically identical to that of `friends1.py`.

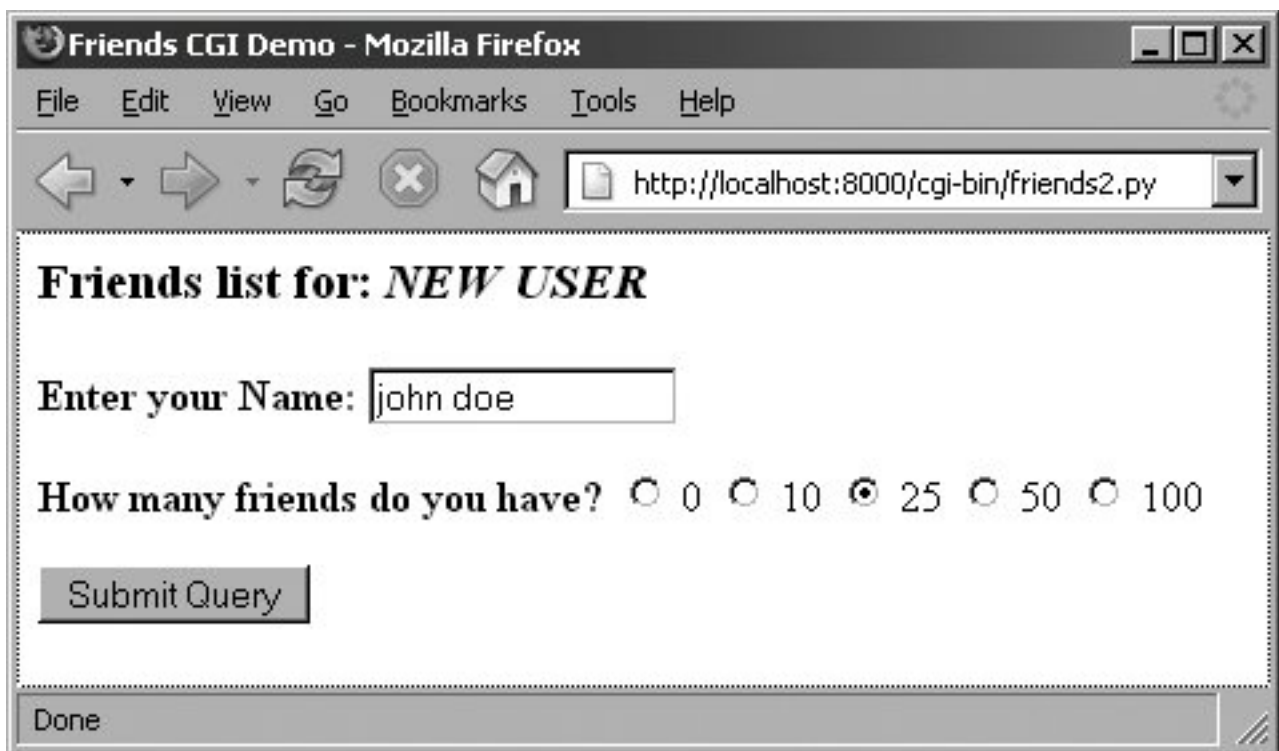
Lines 4156

Since there are different pages that can result from this one script, we created an overall `process()` function to get the form data and decide which action to take. The main portion of `process()` will also look familiar to the main body of code in `friends1.py`. There are two major differences, however.

Since the script may or may not be getting the expected fields (invoking the script the first time to generate a form page, for example, will not pass any fields to the server), we need to "bracket" our retrieval of the form fields with `if` statements to check if they are even there. Also, we mentioned the `action` field above, which helps us decide which page to bring up. The code that performs this determination is in Lines 5356.

In [Figures 20-7](#) and [20-8](#), you will see first the form screen generated by our script (with a name entered and radio button chosen), followed by the results page, also generated by our script.

Figure 20-7. Friends form page in Firefox 1.x on Win32 (`friends2.py`)



The screenshot shows a Mozilla Firefox browser window titled "Friends CGI Demo - Mozilla Firefox". The address bar displays "http://localhost:8000/cgi-bin/friends2.py". The main content area contains the following form:

Friends list for: *NEW USER*

Enter your Name:

How many friends do you have? ☐ 0 ☐ 10 ☒ 25 ☐ 50 ☐ 100

The status bar at the bottom shows "Done".

Figure 20-8. Friends results page in Firefox on Win32 (`friends2.py`)



If you look at the location or "Go to" bar, you will not see a URL referring to a static `friends.htm` file as you did in [Figure 20-4](#) or [Figure 20-5](#).

20.5.5. Fully Interactive Web sites

Our final example will complete the circle. As in the past, a user enters his or her information from the form page. We then process the data and output a results page. Now we will add a link to the results page that will allow the user to go *back* to the form page, but rather than presenting a blank form, we will fill in the data that the user has already provided. We will also add some error processing to give you an example of how it can be accomplished.

We now present our final update, `friends3.py` in [Example 20.6](#).

Example 20.6. Full User Interaction and Error Processing (`friends3.py`)

By adding a link to return to the form page with information already provided, we have come "full circle," giving the user a fully interactive Web surfing experience. Our application also now performs simple error checking, which notifies the user if no radio button was selected.

```
1  #!/usr/bin/env python
2
3  import cgi
4  from urllib import quote_plus
5  from string import capwords
6
7  header = 'Content-Type: text/html\n\n'
8  url = '/cgi-bin/friends3.py'
9
10 errhtml = '''<HTML><HEAD><TITLE>
11 Friends CGI Demo</TITLE></HEAD>
```



```

12 <BODY><H3>ERROR</H3>
13 <B>%s</B><P>
14 <FORM><INPUT TYPE=button VALUE=Back
15 ONCLICK="window.history.back()"></FORM>
16 </BODY></HTML>'''
17
18 def showError(error_str):
19     print header + errhtml % (error_str)
20
21 formhtml = '''<HTML><HEAD><TITLE>
22 Friends CGI Demo</TITLE></HEAD>
23 <BODY><H3>Friends list for: <I>%s</I></H3>
24 <FORM ACTION="%s">
25 <B>Your Name:</B>
26 <INPUT TYPE=hidden NAME=action VALUE=edit>
27 <INPUT TYPE=text NAME=person VALUE="%s" SIZE=15>
28 <P><B>How many friends do you have?</B>
29 %s
30 <P><INPUT TYPE=submit></FORM></BODY></HTML>'''
31
32 fradio = '<INPUT TYPE=radio NAME=howmany VALUE="%s" %s> %s\n'
33
34 def showForm(who, howmany):
35     friends = ''
36     for i in [0, 10, 25, 50, 100]:
37         checked = ''
38         if str(i) == howmany:
39             checked = 'CHECKED'
40         friends = friends + fradio % \
41             (str(i), checked, str(i))
42     print header + formhtml % (who, url, who, friends)
43
44 reshtml = '''<HTML><HEAD><TITLE>
45 Friends CGI Demo</TITLE></HEAD>
46 <BODY><H3>Friends list for: <I>%s</I></H3>
47 Your name is: <B>%s</B><P>
48 You have <B>%s</B> friends.
49 <P>Click <A HREF="%s">here</A> to edit your data again.
50 </BODY></HTML>'''
51
52 def doResults(who, howmany):
53     newurl = url + '?action=reedit&person=%s&howmany=%s'%\
54         (quote_plus(who), howmany)
55     print header + reshtml % (who, who, howmany, newurl)
56
57 def process():
58     error = ''
59     form = cgi.FieldStorage()
60
61     if form.has_key('person'):
62         who = capwords(form['person'].value)
63     else:
64         who = 'NEW USER'
65
66     if form.has_key('howmany'):
67         howmany = form['howmany'].value
68     else:
69         if form.has_key('action') and \
70             form['action'].value == 'edit':

```

```

71         error = 'Please select number of friends.'
72     else:
73         howmany = 0
74
75     if not error:
76         if form.has_key('action') and \
77             form['action'].value != 'reedit':
78             doResults(who, howmany)
79         else:
80             showForm(who, howmany)
81     else:
82         showError(error)
83
84 if __name__ == '__main__':
85     process()

```

`friends3.py` is not too unlike `friends2.py`. We invite the reader to compare the differences; we present a brief summary of the major changes for you here.

Abridged Line-by-Line Explanation

Line 8

We take the URL out of the form because we now need it in two places, the results page being the new customer.

Lines 1019, 6971, 7582

All of these lines deal with the new feature of having an error screen. If the user does not select a radio button indicating the number of friends, the `howmany` field is not passed to the server. In such a case, the `show-Error()` function returns the error page to the user.

The error page also features a JavaScript "Back" button. Because buttons are input types, we need a form, but no action is needed because we are simply just going back one page in the browsing history. Although our script currently supports (aka detects, tests for) only one type of error, we still use a generic `error` variable in case we wanted to continue development of this script to add more error detection in the future.

Lines 27, 38-41, 49, and 52-55

One goal for this script is to create a meaningful link back to the form page from the results page. This is implemented as a link to give the user the ability to return to a form page to update the data he or she entered, in case it was erroneous. The new form page makes sense only if it contains information pertaining to the data that have already been entered by the user. (It is frustrating for users to reenter their information from scratch!)

To accomplish this, we need to embed the current values into the updated form. In line 27, we add a value for the name. This value will be inserted into the name field, if given. Obviously, it will be blank on the initial form page. In Lines 38-41, we set the radio box corresponding to the number of friends currently chosen. Finally, on lines 49 and the updated `doResults()` function on lines 52-55, we create the

link with all the existing information, which "returns" the user to our modified form page.

Line 62

Finally, we added a simple feature that we thought would be a nice aesthetic touch. In the screens for `friends1.py` and `friends2.py`, the text entered by the user as his or her name is taken verbatim. You will notice in the screens above that if the user does not capitalize his or her names, that is reflected in the results page. We added a call to the `string.capwords()` function to automatically capitalize a user's name. The `capwords()` function will capitalize the first letter of each word in the string that is passed in. This may or may not be a desired feature, but we thought that we would share it with you so that you know that such functionality exists.

We will now present four screens that show the progression of user interaction with this CGI form and script.

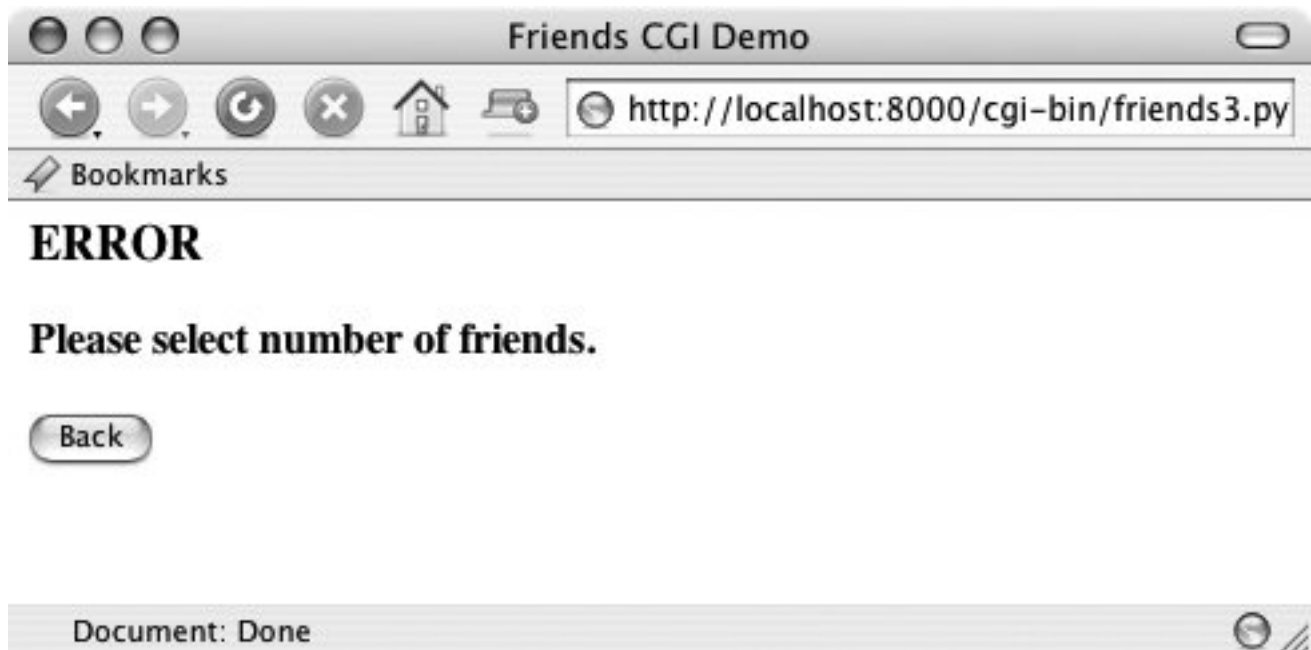
In the first screen, shown in [Figure 20-9](#), we invoke `friends3.py` to bring up the now-familiar form page. We enter a name "foo bar," but deliberately avoid checking any of the radio buttons. The resulting error after submitting the form can be seen in the second screen ([Figure 20-10](#)).

Figure 20-9. Friends initial form page in Camino on MacOS X (`friends3.py`)



The screenshot shows a web browser window titled "Friends CGI Demo". The address bar displays the URL `http://localhost:8000/cgi-bin/friends3.py`. Below the address bar is a "Bookmarks" section. The main content area displays the text "Friends list for: *NEW USER*". Below this, there is a form with two fields. The first field is labeled "Your Name:" and contains the text "foo bar". The second field is labeled "How many friends do you have?" and contains a series of radio buttons with labels 0, 10, 25, 50, and 100. Below the form is a "Submit Query" button. At the bottom of the window, the status bar shows "Document: Done".

Figure 20-10. Friends error page (invalid user input), also in Camino (`friends3.py`)

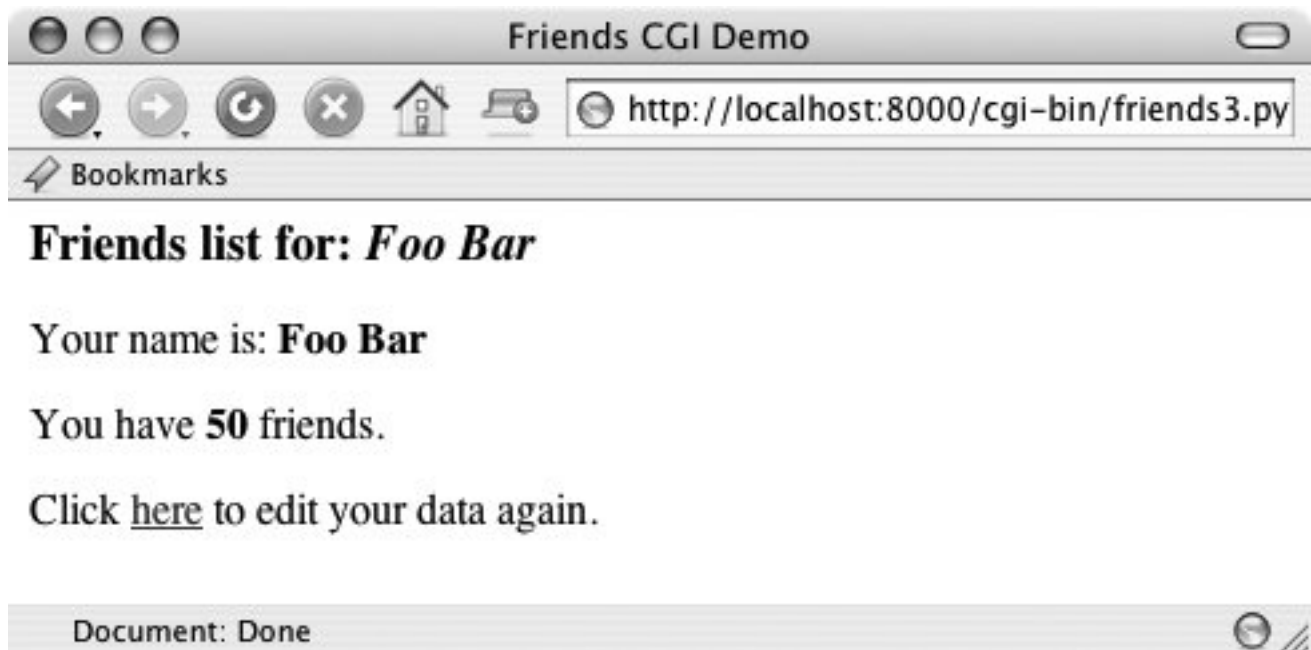


We click on the "Back" button, check the "50" radio button, and resubmit our form. The results page, shown in [Figure 20-11](#), is also familiar, but now has an extra link at the bottom. This link will take us back to the form page. The only difference between the new form page and our original is that all the data filled in by the user are now set as the "default" settings, meaning that the values are already available in the form. We can see this in [Figure 20-12](#).

Figure 20-11. Friends updated form page with current information



Figure 20-12. Friends results page (valid input) (`friends3.py`)



Now the user is able to make changes to either of the fields and resubmit his or her form.

You will no doubt begin to notice that as our forms and data get more complicated, so does the generated HTML, especially for complex results pages. If you ever get to a point where generating the HTML text is interfering with your application, you may consider connecting with a Python module such as [HTMLgen](#), an external Python module which specializes in HTML generation.

◀ PREV

NEXT ▶

20.6. Using Unicode with CGI

In [Chapter 6](#), "Sequences," we introduced the use of Unicode strings. In [Section 6.8.5](#), we gave a simple example of a script that takes a Unicode string, writing it out to a file and reading it back in. In this section, we will demonstrate a simple CGI script that has Unicode output and how to give your browser enough clues to be able to render the characters properly. The one requirement is that you must have East Asian fonts installed on your computer so that the browser can display them.

To see Unicode in action we will build a CGI script to generate a multilingual Web page. First of all we define the message in a Unicode string. We assume your text editor can only enter ASCII. Therefore the non-ASCII characters are input using the `\u` escape. In practice the message can also be read from a file or from database.

```
# Greeting in English, Spanish,  
# Chinese and Japanese.  
UNICODE_HELLO = u""  
Hello!  
\u00A1Hola!  
\u4F60\u597D!  
\u3053\u3093\u306B\u3061\u306F!  
""
```

The first output the CGI generates is the content-type HTTP header. It is very important to declare here that the content is transmitted in the UTF-8 encoding so that the browser can correctly interpret it.

```
print 'Content-type: text/html; charset=UTF-8\r'  
print '\r'
```

Then output the actual message. Use the string's `encode()` method to translate the string into UTF-8 sequences first.

```
print UNICODE_HELLO.encode('UTF-8')
```

[Example 20.7](#) shows the complete program.

Example 20.7. Simple Unicode CGI Example (`uniCGI.py`)

This script outputs Unicode strings to your Web browser.

```
1  #!/usr/bin/env python
2
3  CODEC = 'UTF-8'
4  UNICODE_HELLO = u'''
5  Hello!
6  \u00A1Hola!
7  \u4F60\u597D!
8  \u3053\u3093\u306B\u3061\u306F!
9  '''
10
11  print 'Content-Type: text/html; charset=%s\r' % CODEC
12  print '\r'13print '<HTML><HEAD><TITLE>Unicode CGI Demo</TITLE></HEAD>'
14  print '<BODY>'
15  print UNICODE_HELLO.encode(CODEC)
16  print '</BODY></HTML>'
```

If you run the CGI code from your browser, you will get output like that shown in [Figure 20-13](#).

Figure 20-13. Simple Unicode CGI demo output in Firefox (`uniCGI.py`)

[\[View full size image\]](#)



20.7. Advanced CGI

We will now take a look at some of the more advanced aspects of CGI programming. These include the use of *cookies* cached data saved on the client side multiple values for the same CGI field and file upload using multipart form submissions. To save space, we will show you all three of these features with a single application. Let's take a look at multipart submissions first.

20.7.1. Multipart Form Submission and File Uploading

Currently, the CGI specifications only allow two types of form encodings, "application/x-www-form-urlencoded" and "multipart/form-data." Because the former is the default, there is never a need to state the encoding in the FORM tag like this:

```
<FORM enctype="application/x-www-form-urlencoded" ...>
```

But for multipart forms, you must explicitly give the encoding as:

```
<FORM enctype="multipart/form-data" ...>
```

You can use either type of encoding for form submissions, but at this time, file uploads can only be performed with the multipart encoding. Multipart encoding was invented by Netscape in the early days but has since been adopted by Microsoft (starting with version 4 of Internet Explorer) as well as other browsers.

File uploads are accomplished using the file input type:

```
<INPUT type=file name=...>
```

This directive presents an empty text field with a button on the side which allows you to browse your file directory structure for a file to upload. When using multipart, your Web client's form submission to the server will look amazingly like (multipart) e-mail messages with attachments. A separate encoding was needed because it just would not be necessarily wise to "urlencode" a file, especially a binary file. The information still gets to the server, but it is just "packaged" in a different way.

Regardless of whether you use the default encoding or the multipart, the `cgi` module will process them in the same manner, providing keys and corresponding values in the form submission. You will simply access the data through your `FieldStorage` instance as before.

20.7.2. Multivalued Fields

In addition to file uploads, we are going to show you how to process fields with multiple values. The most common case is when you have a set of checkboxes allowing a user to select from various choices. Each of the checkboxes is labeled with the same field name, but to differentiate them, each will have a different value associated with a particular checkbox.

As you know, the data from the user are sent to the server in key-value pairs during form submission.

When more than one checkbox is submitted, you will have multiple values associated with the same key. In these cases, rather than being given a single `MiniFieldStorage` instance for your data, the `cgi` module will create a list of such instances that you will iterate over to obtain the different values. Not too painful at all.

20.7.3. Cookies

Finally, we will use cookies in our example. If you are not familiar with cookies, they are just bits of data information which a server at a Web site will request to be saved on the client side, e.g., the browser.

Because HTTP is a "stateless" protocol, information that has to be carried from one page to another can be accomplished by using key-value pairs in the request as you have seen in the GET requests and screens earlier in this chapter. Another way of doing it, as we have also seen before, is using hidden form fields, such as the action variable in some of the later `friends*.py` scripts. These variables and their values are managed by the server because the pages they return to the client must embed these in generated pages.

One alternative to maintaining persistency in state across multiple page views is to save the data on the client side instead. This is where cookies come in. Rather than embedding data to be saved in the returned Web pages, a server will make a request to the client to save a cookie. The cookie is linked to the domain of the originating server (so a server cannot set or override cookies from other Web sites) and has an expiration date (so your browser doesn't become cluttered with cookies).

These two characteristics are tied to a cookie along with the key-value pair representing the data item of interest. There are other attributes of cookies such as a domain subpath or a request that a cookie should only be delivered in a secure environment.

By using cookies, we no longer have to pass the data from page to page to track a user. Although they have been subject to a good amount of controversy over the privacy issue, most Web sites use cookies responsibly. To prepare you for the code, a Web server requests a client store a cookie by sending the "Set-Cookie" header immediately before the requested file.

Once cookies are set on the client side, requests to the server will automatically have those cookies sent to the server using the `HTTP_COOKIE` environment variable. The cookies are delimited by semicolons and come in "key=value" pairs. All your application needs to do to access the data values is to split the string several times (i.e., using `string.split()` or manual parsing). The cookies are delimited by semicolons (;), and each key-value pair is separated by equal signs (=).

Like multipart encoding, cookies originated from Netscape, which implemented cookies and wrote up the first specification, which is still valid today. You can access this document at the following Web site:

http://www.netscape.com/newsref/std/cookie_spec.html

Once cookies are standardized and this document finally obsoleted, you will be able to get more current information from Request for Comment documents (RFCs). The most current one for cookies at the time of publication is RFC 2109.

20.7.4. Using Advanced CGI

We now present our CGI application, `advcgi.py`, which has code and functionality not too unlike the `friends3.py` script seen earlier in this chapter. The default first page is a user fill-out form consisting of four main parts: user-set cookie string, name field, checkbox list of programming languages, and file submission box. An image of this screen can be seen in [Figure 20-14](#).

Figure 20-14. Upload and multivalue form page in IE5 on MacOS X

[\[View full size image\]](#)

The screenshot shows a web browser window titled "Advanced CGI Demo". The address bar displays "http://localhost:8000/cgi-bin/advcgi.py". The browser's toolbar includes buttons for Back, Forward, Stop, Refresh, Home, AutoFill, and Print. The main content area features the title "Advanced CGI Demo Form" and a section "My Cookie Setting". Below this, a message states "CPPuser = (cookie has not been set yet)". There are two input fields: "Enter cookie value" (optional) and "Enter your name" (required). A section titled "What languages can you program in? (at least one required)" contains checkboxes for Python (checked), PERL, Java, C++, PHP, C, and JavaScript. Below this is an "Enter file to upload" section with a text input field and a "Browse..." button. At the bottom left is a "Submit" button. The status bar at the bottom indicates "Local machine zone".

Advanced CGI Demo Form

My Cookie Setting

• CPPuser = (cookie has not been set yet)

Enter cookie value
 (optional)

Enter your name
 (required)

What languages can you program in? (at least one required)

☒ Python ☐ PERL ☐ Java ☐ C++ ☐ PHP ☐ C ☐ JavaScript

Enter file to upload

Local machine zone

[Figure 20-15](#) shows another look at the form from another browser. From this form, we can enter our information, such as the sample data given in [Figure 20-16](#). Notice how the text in the button to search for files differs between browsers, i.e., "Browse ...", "Choose", "...", etc.

Figure 20-15. The same advanced CGI form but in Netscape4 on Linux

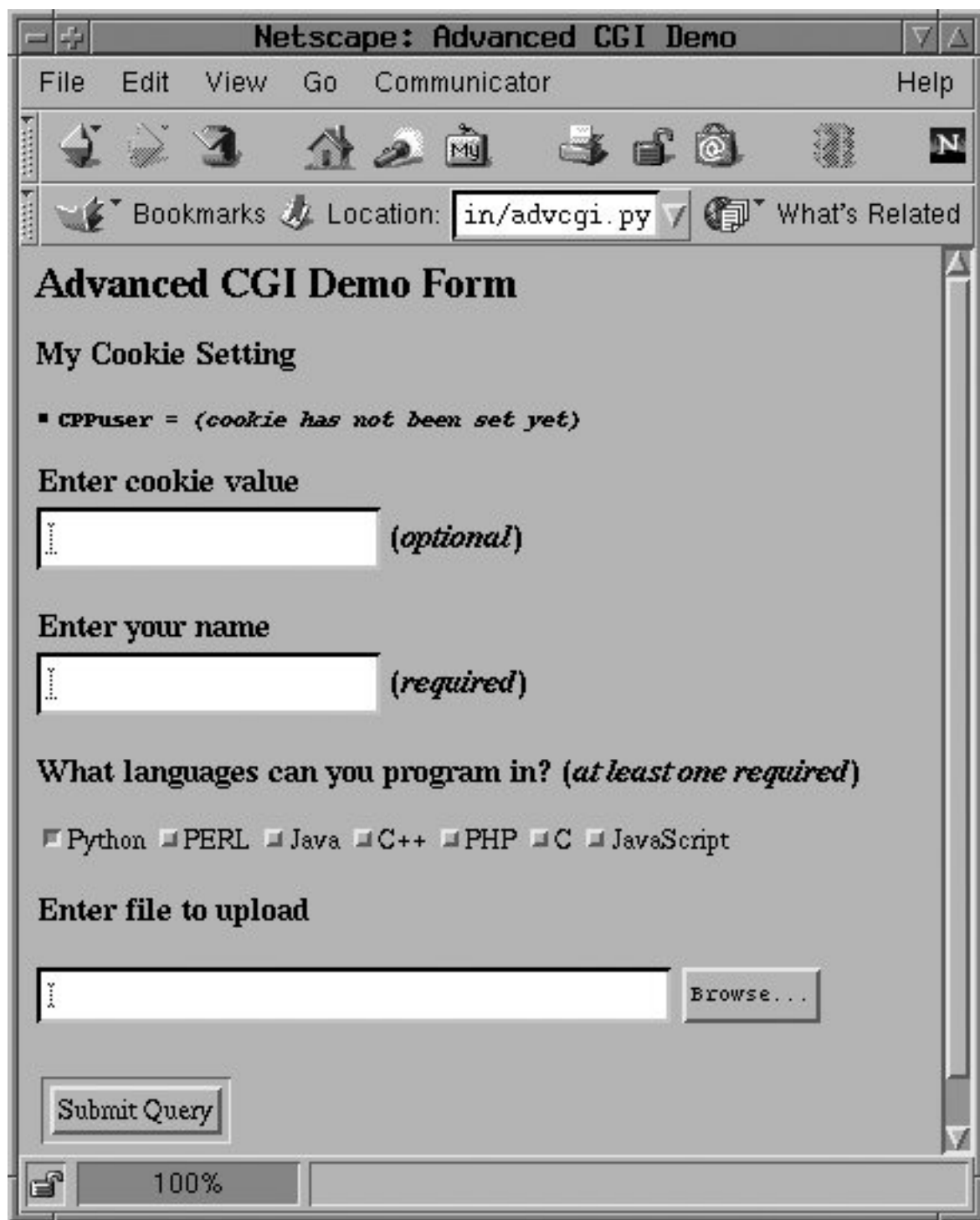


Figure 20-16. Submitting our advanced CGI demo form in Opera8 on Win32

[\[View full size image\]](#)

The screenshot shows a web browser window titled "Advanced CGI Demo - Opera". The address bar displays "http://localhost:8000/cgi-bin/ad". The page content includes a title "Advanced CGI Demo Form", a section "My Cookie Setting" with a message "• CPPuser = (cookie has not been set yet)", a form field "Enter cookie value" with the text "Oh look mom, a cookie (optional)", another form field "Enter your name" with the text "steven alistair kirk (required)", a section "What languages can you program in? (at least one required)" with checkboxes for Python, PERL, Java, C++, PHP, C, and JavaScript, and a section "Enter file to upload" with a text field containing "C:\comments.txt" and a "Choose" button. At the bottom is a "Submit" button.

Advanced CGI Demo - Opera

File Edit View Bookmarks Tools Help

http://localhost:8000/cgi-bin/ad Document: 0 B

Advanced CGI Demo Form

My Cookie Setting

- CPPuser = (cookie has not been set yet)

Enter cookie value

Oh look mom, a cookie (optional)

Enter your name

steven alistair kirk (required)

What languages can you program in? (at least one required)

☒ Python ☐ PERL ☒ Java ☐ C++ ☐ PHP ☒ C ☐ JavaScript

Enter file to upload

"C:\comments.txt" Choose

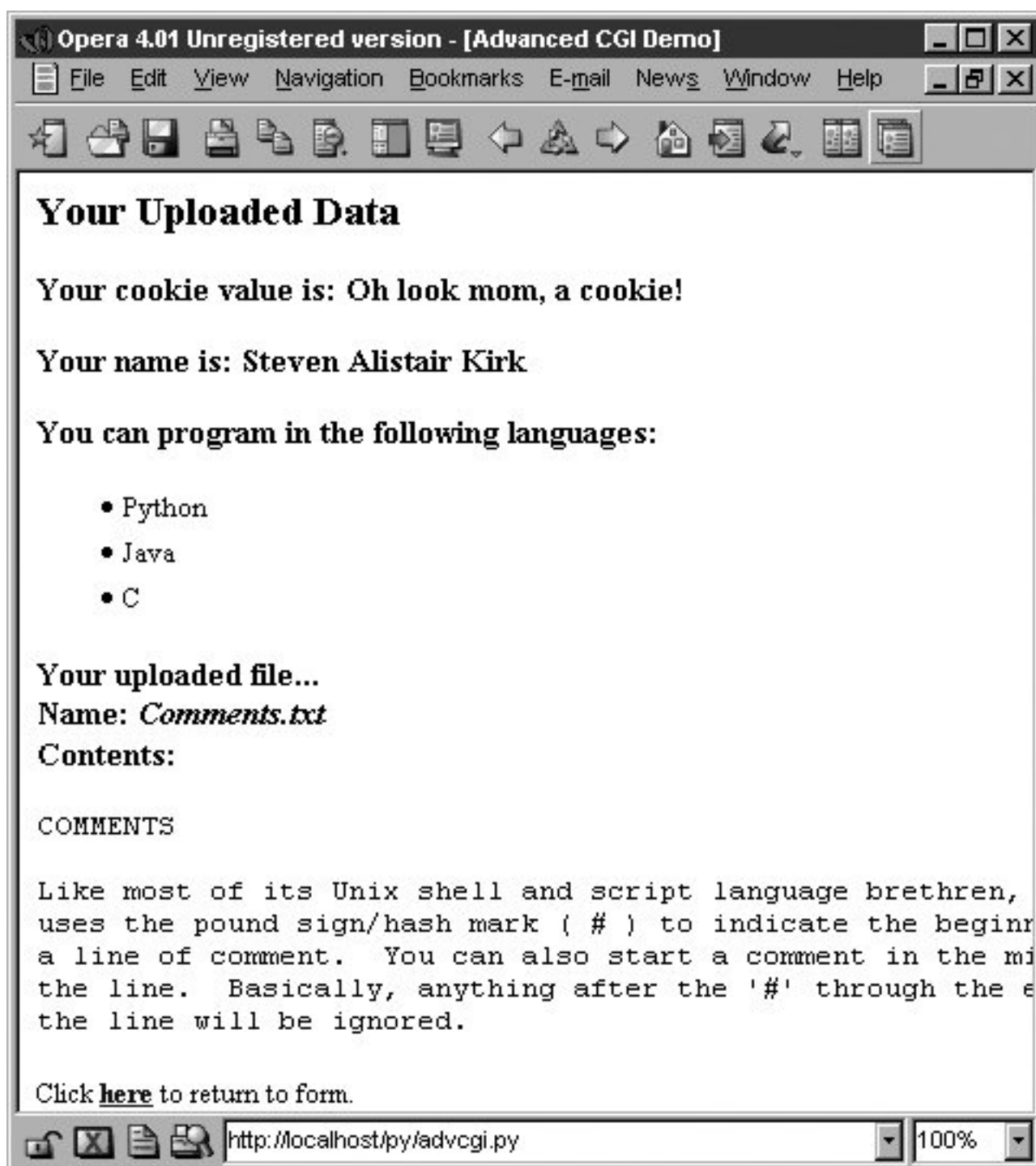
Submit

The data are submitted to the server using multipart encoding and retrieved in the same manner on the server side using the `FieldStorage` instance. The only tricky part is in retrieving the uploaded file. In our application, we choose to iterate over the file, reading it line by line. It is also possible to read in the entire contents of the file if you are not wary of its size.

Since this is the first occasion data are received by the server, it is at this time, when returning the results page back to the client, that we use the "Set-Cookie:" header to cache our data in browser cookies.

In [Figure 20-17](#), you will see the results after submitting our form data. All the fields the user entered are shown on the page. The given file in the final dialog box was uploaded to the server and displayed as well.

Figure 20-17. Results page generated and returned by the Web server in Opera4 on Win32



You will also notice the link at the bottom of the results page, which returns us to the form page, again using the same CGI script.

If we click on that link at the bottom, no form data is submitted to our script, causing a form page to be displayed. Yet, as you can see from [Figure 20-17](#), what shows up is anything but an empty form! Information previously entered by the user shows up! How did we accomplish this with no form data (either hidden or as query arguments in the URL)? The secret is that the data are stored on the client side in cookies, two in fact.

The user cookie holds the string of data typed in by the user in the "Enter cookie value" form field, and the user's name, languages they are familiar with, and uploaded files are stored in the info cookie.

When the script detects no form data, it shows the form page, but before the form page has been created, it grabs the cookies from the client (which are automatically transmitted by the client when the user clicks on the link) and fills out the form accordingly. So when the form is finally displayed, all the previously entered information appears to the user like magic (see [Figure 20-18](#)).

Figure 20-18. Form page with data loaded from the Client cookies

Opera 4.01 Unregistered version - [Advanced CGI Demo]

File Edit View Navigation Bookmarks E-mail News Window Help

Advanced CGI Demo Form

My Cookie Setting

- CPPuser = Oh look mom, a cookie!

Enter cookie value

Oh look mom, a cookie! (optional)

Enter your name

Steven Alistair Kirk (required)

What languages can you program in? (at least one required)

☒ Python ☐ PERL ☒ Java ☐ C++ ☐ PHP ☒ C ☐ JavaScript

Enter file to upload

Comments.txt ...

Submit

http://localhost/py/advcgi.py 100%

We are certain you are eager to take a look at this application, so here it is, in [Example 20.8](#).

Example 20.8. Advanced CGI Application (advcgi.py)

*This script has one main class that does everything, **AdvCGI**. It has methods to show either form, error, or results pages as well as those that read or write cookies from/to the client (a Web browser).*

```
1      #!/usr/bin/env python
2
3      from cgi import FieldStorage
4      from os import environ
5      from cStringIO import StringIO
6      from urllib import quote, unquote
7      from string import capwords, strip, split, join
8
9      class AdvCGI(object):
10
11          header = 'Content-Type: text/html\n\n'
12          url = '/py/advcgi.py'
13
14          formhtml = '''<HTML><HEAD><TITLE>
Advanced CGI Demo</TITLE></HEAD>
<BODY><H2>Advanced CGI Demo Form</H2>
<FORM METHOD=post ACTION="%s" ENCTYPE="multipart/form-data">
<H3>My Cookie Setting</H3>
<LI> <CODE><B>CPPuser = %s</B></CODE>
<H3>Enter cookie value<BR>
<INPUT NAME=cookie value="%s"> (<I>optional</I></H3>
<H3>Enter your name<BR>
<INPUT NAME=person VALUE="%s"> (<I>required</I></H3>
<H3>What languages can you program in?
(<I>at least one required</I></H3>
%s
<H3>Enter file to upload</H3>
<INPUT TYPE=file NAME=upfile VALUE="%s" SIZE=45>
<P><INPUT TYPE=submit>
</FORM></BODY></HTML>'''
15
16          langSet = ('Python', 'PERL', 'Java', 'C++', 'PHP',
17                    'C', 'JavaScript')
18          langItem = \
19              '<INPUT TYPE=checkbox NAME=lang VALUE="%s"%s> %s\n'
20
21          def getCPPCookies(self): # read cookies from client
22              if environ.has_key('HTTP_COOKIE'):
23                  for eachCookie in map(strip, \
24                                         split(environ['HTTP_COOKIE'], ';')):
25                      if len(eachCookie) > 6 and \
26                          eachCookie[:3] == 'CPP':
27                          tag = eachCookie[3:7]
28                          try:
29                              self.cookies[tag] = \
30                                  eval(unquote(eachCookie[8:]))
31                          except (NameError, SyntaxError):
32                              self.cookies[tag] = \
33                                  unquote(eachCookie[8:])
34              else:
35                  self.cookies['info'] = self.cookies['user'] = ''
36
37          if self.cookies['info'] != '':
38              self.who, langStr, self.fn = \
```

```

55         split(self.cookies['info'], ':')
56         self.langs = split(langStr, ',')
57     else:
58         self.who = self.fn = ' '
59         self.langs = ['Python']
60
61     def showForm(self):    # show fill-out form
62         self.getCPPCookies()
63         langStr = ''
64         for eachLang in AdvCGI.langSet:
65             if eachLang in self.langs:
66                 langStr += AdvCGI.langItem % \
67                     (eachLang, ' CHECKED', eachLang)
68             else:
69                 langStr += AdvCGI.langItem % \
70                     (eachLang, ' ', eachLang)
71
72         if not self.cookies.has_key('user') or \
73             self.cookies['user'] == '':
74             cookStatus = '<I>(cookie has not been set yet)</I>'
75             userCook = ''
76         else:
77             userCook = cookStatus = self.cookies['user']
78
79         print AdvCGI.header + AdvCGI.formhtml % (AdvCGI.url,
80             cookStatus, userCook, self.who, langStr, self.fn)
81
82     errhtml = '''<HTML><HEAD><TITLE>
83 Advanced CGI Demo</TITLE></HEAD>
84 <BODY><H3>ERROR</H3>
85 <B>%s</B><P>
86 <FORM><INPUT TYPE=button VALUE=Back
87 ONCLICK="window.history.back()"></FORM>
88 </BODY></HTML>'''
89
90     def showError(self):
91         print AdvCGI.header + AdvCGI.errhtml % (self.error)
92
93     reshtml = '''<HTML><HEAD><TITLE>
94 Advanced CGI Demo</TITLE></HEAD>
95 <BODY><H2>Your Uploaded Data</H2>
96 <H3>Your cookie value is: <B>%s</B></H3>
97 <H3>Your name is: <B>%s</B></H3>
98 <H3>You can program in the following languages:</H3>
99 <UL>%s</UL>
100 <H3>Your uploaded file...<BR>
101 Name: <I>%s</I><BR>
102 Contents:</H3>
103 <PRE>%s</PRE>
104 Click <A HREF="%s"><B>here</B></A> to return to form.
105 </BODY></HTML>'''
106
107     def setCPPCookies(self): # tell client to store cookies
108         for eachCookie in self.cookies.keys():
109             print 'Set-Cookie: CPP%s=%s; path=/' % \
110                 (eachCookie, quote(self.cookies[eachCookie]))
111
112     def doResults(self):# display results page

```



```

113 MAXBYTES = 1024
114 langlist = ''
115 for eachLang in self.langs:
116     langlist = langlist + '<LI>%s<BR>' % eachLang
117
118 filedata = ''
119 while len(filedata) < MAXBYTES:# read file chunks
120     data = self.fp.readline()
121     if data == '': break
122     filedata += data
123 else:                                     # truncate if too long
124     filedata += \
125         '... <B><I>(file truncated due to size)</I></B>'
126 self.fp.close()
127 if filedata == '':
128     filedata = \
129     <B><I>(file upload error or file not given)</I></B>'
130 filename = self.fn
131
132 if not self.cookies.has_key('user') or \
133     self.cookies['user'] == '':
134     cookStatus = '<I>(cookie has not been set yet)</I>'
135     userCook = ''
136 else:
137     userCook = cookStatus = self.cookies['user']
138
139 self.cookies['info'] = join([self.who, \
140     join(self.langs, ','), filename], ':')
141 self.setCPPCookies()
142 print AdvCGI.header + AdvCGI.reshtml % \
143     (cookStatus, self.who, langlist,
144     filename, filedata, AdvCGI.url)
145
146 def go(self):                             # determine which page to return
147     self.cookies = {}
148     self.error = ''
149     form = FieldStorage()
150     if form.keys() == []:
151         self.showForm()
152         return
153
154     if form.has_key('person'):
155         self.who = capwords(strip(form['person'].value))
156         if self.who == '':
157             self.error = 'Your name is required. (blank)'
158     else:
159         self.error = 'Your name is required. (missing)'
160
161     if form.has_key('cookie'):
162         self.cookies['user'] = unquote(strip(\
163             form['cookie'].value))
164     else:
165         self.cookies['user'] = ''
166
167     self.langs = []
168 if form.has_key('lang'):
169     langdata = form['lang']
170     if type(langdata) == type([]):
171         for eachLang in langdata:

```

```

172         self.langs.append(eachLang.value)
173     else:
174         self.langs.append(langdata.value)
175 else:
176     self.error = 'At least one language required.'
177
178     if form.has_key('upfile'):
179         upfile = form["upfile"]
180         self.fn = upfile.filename or ''
181         if upfile.file:
182             self.fp = upfile.file
183         else:
184             self.fp = StringIO('(no data)')
185     else:
186         self.fp = StringIO('(no file)')
187         self.fn = ''
188
189     if not self.error:
190         self.doResults()
191     else:
192         self.showError()
193
194 if __name__ == '__main__':
195     page = AdvCGI()
196     page.go()

```

`advcgi.py` looks strikingly similar to our `friends3.py` CGI scripts seen earlier in this chapter. It has a form, results, and error pages to return. In addition to all of the advanced CGI features that are part of our new script, we are also using more of an object-oriented feel to our script by using a class with methods instead of just a set of functions. The HTML text for our pages is now static data for our class, meaning that they will remain constant across all instances even though there is actually only one instance in our case.

Line-by-Line (Block-by-Block) Explanation

Lines 17

The usual startup and import lines appear here. The only module you may not be familiar with is `cStringIO`, which we briefly introduced at the end of [Chapter 10](#) and also used in [Example 20.1](#). `cStringIO.StringIO()` creates a file-like object out of a string so that access to the string is similar to opening a file and using the handle to access the data.

Lines 912

After the `AdvCGI` class is declared, the `header` and `url` (static class) variables are created for use by the methods displaying all the different pages.

Lines 1480

All the code in this block is used to generate and display the form page. The data attributes speak for themselves. `getCPPOokies()` obtains cookie information sent by the Web client, and `showForm()` collates

all the information and sends the form page back to the client.

Lines 8291

This block of code is responsible for the error page.

Lines 93144

The results page is created using this block of code. The `setCPPCookies()` method requests that a client store the cookies for our application, and the `doResults()` method puts together all the data and sends the output back to the client.

Lines 146196

The script begins by instantiating an `AdvCGI` page object, then calls its `go()` method to start the ball rolling, in contrast to a strictly procedural programming process. The `go()` method contains the logic that reads all incoming data and decides which page to show.

The error page will be displayed if no name was given or if no languages were checked. The `showForm()` method is called to output the form if no input data were received, and the `doResults()` method is invoked otherwise to display the results page. Error situations are created by setting the `self.error` variable, which serves two purposes. It lets you set an error reason as a string and also serves as a flag to indicate that an error has occurred. If this value is not blank, the user will be forwarded to the error page.

Handling the person field (lines 154159) is the same as we have seen in the past, a single key-value pair; however, collecting the language information is a bit trickier since we must check for either a (`Mini`) `FieldStorage` instance or a list of such instances. We will employ the familiar `type()` built-in function for this purpose. In the end, we will have a list of a single language name or many, depending on the user's selections.

The use of cookies (lines 161165) to contain data illustrates how they can be used to avoid using any kind of CGI field pass-through. You will notice in the code that obtains such data that no CGI processing is invoked, meaning that the data do not come from the `FieldStorage` object. The data are passed to us by the Web client with each request and the values (user's chosen data as well as information to fill in a succeeding form with pre-existing information) are obtained from cookies.

Because the `showResults()` method receives the new input from the user, it has the responsibility of setting the cookies, i.e., by calling `setCPPCookies()`. `showForm()`, however, must read in the cookies' values in order to display a form page with the current user selections. This is done by its invocation of the `getCPPCookies()` method.

Finally, we get to the file upload processing (lines 178187). Regardless of whether a file was actually uploaded, `FieldStorage` is given a file handle in the file attribute. On line 180, if there was no filename given, then we just set it to a blank string. If the value attribute is accessed, the entire contents of the file will be placed into value. As a better alternative, you can access the file pointerthe file attributeand perhaps read only one line at a time or other kind of slower processing.

In our case, file uploads are only part of user submissions, so we simply pass on the file pointer to the `doResults()` function to extract the data from the file. `doResults()` will display only the first 1K of the file for space reasons and to show you that it is not necessary (or necessarily productive/useful) to display a

four-megabyte binary file.



20.8. Web (HTTP) Servers

Until now, we have been discussing the use of Python in creating Web clients and performing tasks to aid Web servers in CGI request processing. We know (and saw earlier in [Sections 20.2](#) and [20.3](#)) that Python can be used to create both simple and complex Web clients. Complexity of CGI requests goes without saying.

However, we have yet to explore the creation of Web *servers*, and that is the focus of this section. If the Firefox, Mozilla, IE, Opera, Netscape, AOL, Safari, Camino, Epiphany, Galeon, and Lynx browsers are among the most popular Web clients, then what are the most common Web servers? They are Apache, Netscape, IIS, thttpd, Zeus, and Zope. In situations where these servers may be overkill for your desired application, Python can be used to create simple yet useful Web servers.

20.8.1. Creating Web Servers in Python

Since you have decided on building such an application, you will naturally be creating all the custom stuff, but all the base code you will need is already available in the Python Standard Library. To create a Web server, a base server and a "handler" are required.

The base (Web) server is a boilerplate item, a must have. Its role is to perform the necessary HTTP communication between client and server. The base server class is (appropriately) named `HTTPServer` and is found in the `BaseHTTPServer` module.

The handler is the piece of software that does the majority of the "Web serving." It processes the client request and returns the appropriate file, whether static or dynamically generated by CGI. The complexity of the handler determines the complexity of your Web server. The Python standard library provides three different handlers.

The most basic, plain, vanilla handler, named `BaseHTTPRequestHandler`, is found in the `BaseHTTPServer` module, along with the base Web server. Other than taking a client request, no other handling is implemented at all, so you have to do it all yourself, such as in our `myhttpd.py` server coming up.

The `SimpleHTTPRequestHandler`, available in the `SimpleHTTP-Server` module, builds on `BaseHTTPRequestHandler` by implementing the standard GET and HEAD requests in a fairly straightforward manner. Still nothing sexy, but it gets the simple jobs done.

Finally, we have the `CGIHTTPRequestHandler`, available in the `CGIHTTPServer` module, which takes the `SimpleHTTPRequestHandler` and adds support for POST requests. It has the ability to call CGI scripts to perform the requested processing and can send the generated HTML back to the client.

The three modules and their classes are summarized in [Table 20.6](#).

Table 20.6. Web Server Modules and Classes

Module	Description
<code>BaseHTTPServer</code>	Provides the base Web server and base handler classes, <code>HTTPServer</code> and <code>BaseHTTPRequestHandler</code> , respectively
<code>SimpleHTTPServer</code>	Contains the <code>SimpleHTTPRequestHandler</code> class to perform GET and HEAD requests
<code>CGIHTTPServer</code>	Contains the <code>CGIHTTPRequestHandler</code> class to process POST requests and perform CGI execution

To be able to understand how the more advanced handlers found in the `SimpleHTTPServer` and `CGIHTTPServer` modules work, we will implement simple GET processing for a `BaseHTTPRequestHandler`.

In [Example 20.9](#), we present the code for a fully working Web server, `myhttpd.py`.

Example 20.9. Simple Web Server (`myhttpd.py`)

This simple Web server can read GET requests, fetch a Web page (.html file) and return it to the calling client. It uses the `BaseHTTPRequestHandler` found in `BaseHTTPServer` and implements the `do_GET()` method to enable processing of GET requests.

```

1  #!/usr/bin/env python
2
3  from os import curdir, sep
4  from BaseHTTPServer import \
5      BaseHTTPRequestHandler, HTTPServer
6
7  class MyHandler(BaseHTTPRequestHandler):
8
9      def do_GET(self):
10         try:
11             f = open(curdir + sep + self.path)
12             self.send_response(200)
13             self.send_header('Content-type',
14                             'text/html')
15             self.end_headers()
16             self.wfile.write(f.read())
17             f.close()
18         except IOError:
19             self.send_error(404,
20                             'File Not Found: %s' % self.path)
21
22  def main():
23      try:
24          server = HTTPServer(('', 80), MyHandler)
25          print 'Welcome to the machine...'
26          print 'Press ^C once or twice to quit.'
27          server.serve_forever()
28      except KeyboardInterrupt:
29          print '^C received, shutting down server'
30          server.socket.close()
31
32  if __name__ == '__main__':

```

This server subclasses `BaseHTTPRequestHandler` and consists of a single `do_GET()` method, which is called when the base server receives a GET request. We attempt to open the path passed in by the client and if present, return an "OK" status (200) and forward the downloaded Web page. If the file was not found, it returns a 404 status.

The `main()` function simply instantiates our Web server class and invokes it to run our familiar infinite server loop, shutting it down if interrupted by `^C` or similar keystroke. If you have appropriate access and can run this server, you will notice that it displays loggable output, which will look something like this:

```
# myhttpd.py
Welcome to the machine... Press ^C once or twice to quit
localhost - - [26/Aug/2000 03:01:35] "GET /index.html HTTP/1.0" 200 -
localhost - - [26/Aug/2000 03:01:29] code 404, message File Not Found: /x.html
localhost - - [26/Aug/2000 03:01:29] "GET /dummy.html HTTP/1.0" 404 -
localhost - - [26/Aug/2000 03:02:03] "GET /hotlist.htm HTTP/1.0" 200 -
```

Of course, our simple little Web server is so simple, it cannot even process plain text files. We leave that as an exercise for the reader, which can be found at the end of the chapter.

As you can see, it doesn't take much to have a Web server up and running in pure Python. There is plenty more you can do to enhance the handlers to customize it to your specific application. Please review the Library Reference for more information on the modules (and their classes) discussed in this section.

20.9. Related Modules

In [Table 20.7](#), we present a list of modules which you may find useful for Web development. You may also wish to look at the Internet Client Programming in [Chapter 17](#), as well as the Web services section of [Chapter 23](#) for other modules that may be useful for Web applications.

Table 20.7. Web Programming Related Modules

Module/Package	Description
Web Applications	
<code>cgi</code>	Gets Common Gateway Interface (CGI) form data
<code>cgitb</code> [c]	Handles CGI tracebacks
<code>htmllib</code>	Older HTML parser for simple HTML files; <code>HTML-Parser</code> class extends from <code>sgmlib.SGMLParser</code>
<code>HTMLparser</code> [c]	Newer non-SGML-based parser for HTML and XHTML
<code>htmlentitydefs</code>	HTML general entity definitions
<code>Cookie</code>	Server-side cookies for HTTP state management
<code>cookielib</code> [e]	Cookie-handling classes for HTTP clients
<code>webbrowser</code> [b]	Controller: launches Web documents in a browser
<code>sgmlib</code>	Parses simple SGML files
<code>robotparser</code> [a]	Parses <code>robots.txt</code> files for URL "fetchability" analysis
<code>httplib</code> [a]	Used to create HTTP clients
XML Processing	
<code>xmllib</code>	(Outdated/deprecated) original simple XML parser
<code>xml</code> [b]	XML package featuring various parsers (some below)
<code>xml.sax</code> [b]	Simple API for XML (SAX) SAX2-compliant XML parser
<code>xml.dom</code> [b]	Document Object Model [DOM] XML parser
<code>xml.etree</code> [f]	Tree-oriented XML parser based on the Element flexible container object

<code>xml.parsers.expat</code> [b]	Interface to the non-validating Expat XML parser
<code>xmlrpclib</code> [c]	Client support for XML Remote Procedure Call (RPC) via HTTP

XML Processing

<code>SimpleXMLRPCServer</code> [c]	Basic framework for Python XML-RPC servers
<code>DocXMLRPCServer</code> [d]	Framework for self-documenting XML-RPC servers

Web Servers

<code>BaseHTTPServer</code>	Abstract class with which to develop Web servers
<code>SimpleHTTPServer</code>	Serve the simplest HTTP requests (HEAD and GET)
<code>CGIHTTPServer</code>	In addition to serving Web files like <code>SimpleHTTPServer</code> s, can also process CGI (HTTP POST) requests
<code>wsgiref</code> [f]	Standard interface between Web servers and Python Web application

3rd party packages (not in standard library)

<code>HTMLgen</code>	CGI helper converts Python objects into valid HTML http://starship.python.net/crew/friedrich/HTMLgen/html/main.html
<code>BeautifulSoup</code>	HTML and XML parser and screen-scraper http://crummy.com/software/BeautifulSoup

Mail Client Protocols

<code>poplib</code>	Use to create POP3 clients
<code>imaplib</code>	Use to create IMAP4 clients

Mail and MIME Processing and Data Encoding Formats

<code>email</code> [c]	Package for managing e-mail messages, including MIME and other RFC2822-based message
<code>mailbox</code>	Classes for mailboxes of e-mail messages
<code>mailcap</code>	Parses mailcap files to obtain MIME application delegations

Mail and MIME Processing and Data Encoding Formats

<code>mimetools</code>	Provides functions for manipulating MIME-encoded messages
<code>mimetypes</code>	Provides MIME-type associations
<code>MimeWriter</code>	Generates MIME-encoded multipart files
<code>multifile</code>	Can parse multipart MIME-encoded files
<code>quopri</code>	En-/decodes data using quoted-printable encoding
<code>rfc822</code>	Parses RFC822-compliant e-mail headers
<code>smtplib</code>	Uses to create SMTP (Simple Mail Transfer Protocol) clients
<code>base64</code>	En-/decodes data using base64 encoding

<code>binascii</code>	En-/decodes data using base64, binhex, or uu (modules)
<code>binhex</code>	En-/decodes data using binhex4 encoding
<code>uu</code>	En-/decodes data using uuencode encoding

Internet Protocols

<code>httplib</code> ^[a]	Used to create HTTP clients
<code>ftplib</code>	Used to create FTP (File Transfer Protocol) clients
<code>gopherlib</code>	Used to create Gopher clients
<code>telnetlib</code>	Used to create Telnet clients
<code>nntplib</code>	Used to create NNTP (Network News Transfer Protocol [Usenet]) clients

^[c] New in [Python 2.2](#).

^[e] New in [Python 2.4](#).

^[b] New in Python 2.0.

^[a] New in Python 1.6.

^[f] New in Python 2.5.

^[d] New in [Python 2.3](#).

20.10. Exercises

- 20-1.** *urllib Module and Files.* Update the `friends3.py` script so that it stores names and corresponding number of friends into a two-column text file on disk and continues to add names each time the script is run.
- Extra Credit: Add code to dump the contents of such a file to the Web browser (in HTML format). Additional Extra Credit: Create a link that clears all the names in this file.
- 20-2.** *urllib Module.* Write a program that takes a user-input URL (either a Web page or an FTP file, i.e., `http://python.org` or `ftp://ftp.python.org/pub/python/README`), and downloads it to your machine with the same filename (or modified name similar to the original if it is invalid on your system). Web pages (HTTP) should be saved as `.htm` or `.html` files, and FTP'd files should retain their extension.
- 20-3.** *urllib Module.* Rewrite the `grabWeb.py` script of Example 11.,4, which downloads a Web page and displays the first and last non-blank lines of the resulting HTML file so that you use `urlopen()` instead of `urlretrieve()` to process the data directly (as opposed to downloading the entire file first before processing it).
- 20-4.** *URLs and Regular Expressions.* Your browser may save your favorite Web site URLs as a "bookmarks" HTML file (Mozilla-flavored browsers do this) or as a set of `.URL` files in a "favorites" directory (IE does this). Find your browser's method of recording your "hot links" and the location of where and how they stored. Without altering any of the files, strip the URLs and names of the corresponding Web sites (if given) and produce a two-column list of names and links as output, and storing this data into a disk file. Truncate site names or URLs to keep each line of output within 80 columns in size.
- 20-5.** *URLs, urllib Module, Exceptions, and REs.* As a follow-up problem to the previous one, add code to your script to test each of your favorite links. Report back a list of dead links (and their names), i.e., Web sites that are no longer active or a Web page that has been removed. Only output and save to disk the still-valid links.
- 20-6.** *Error Checking.* The `friends3.py` script reports an error if no radio button was selected to indicate the number of friends. Update the CGI script to also report an error if no name (e.g., blank or whitespace) is entered.

Extra Credit: We have so far explored only server-side error checking. Explore JavaScript programming and implement client-side error checking by creating JavaScript code to check for both error situations so that these errors are stopped before they reach the server.

Problems 20-7 to 20-10 below pertain to *Web server access log files and regular expressions*. Web servers (and their administrators) generally have to maintain an access log file (usually `logs/access_log` from the main Web, server directory) which tracks requests file. Over a period of time, such files get large and either need to be stored or truncated. Why not save only the pertinent information and delete the files to conserve disk space? The exercises below are designed to give you some exercise with REs and how they can be used to help archive and analyze Web server data.

- 20-7.** Count how many of each type of request (GET versus POST) exist in the log file.
- 20-8.** Count the successful page/data downloads: Display all links that resulted in a return code of 200 (OK [no error]) and how many times each link was accessed.
- 20-9.** Count the errors: Show all links that resulted in errors (return codes in the 400s or 500s) and how many times each link was accessed.
- 20-10.** Track IP addresses: For each IP address, output a list of each page/data downloaded and how many times that link was accessed.
- 20-11.** *Simple CGI.* Create a "Comments" or "Feedback" page for a Web site. Take user feedback via a form, process the data in your script, and return a "thank you" screen.
- 20-12.** *Simple CGI.* Create a Web guestbook. Accept a name, an e-mail address, and a journal entry from a user and log it to a file (format of your choice). Like the previous problem, return a "thanks for filling out a guestbook entry" page. Also provide a link that allows users to view guestbooks.
- 20-13.** *Web Browser Cookies and Web site Registration.* Update your solution to [Exercise 20-4](#). So your user-password information should now pertain to Web site registration instead of a simple text-based menu system.
- Extra Credit: familiarize yourself with setting Web browser cookies and maintain a login session for 4 hours from the last successful login.
- 20-14.** *Web Clients.* Port [Example 20.1](#), `crawl.py`, the Web crawler, to using the `HTMLParser` module or the BeautifulSoup parsing system.
- 20-15.** *Errors.* What happens when a CGI script crashses? How can the `cgitb` module be helpful?
- 20-16.** *CGI, File Updates, and Zip Files.* Create a CGI application that not only saves files to the server's disk, but also intelligently unpacks Zip files (or other archive) into a subdirectory named after the archive file.
- 20-17.** *Zope, Plone, TurboGears, Django.* Investigate each of these complex Web development platforms and create one simple application in each.
- 20-18.** *Web Database Application.* Think of a database schema you want to provide as part of a Web database application. For this multi-user application, you want to provide everyone read access to the entire contents of the database, but perhaps only write access to each individual. One example may be an "address book" for your family and relatives. Each family member, once successfully logged in, is presented with a Web page with several options, add an entry, view my entry, update my entry, remove or delete my entry, and view all entries (entire database).

Design a `UserEntry` class and create a database entry for each instance of this class. You may use any solution created for any previous problem to implement the registration framework. Finally, you may use any type of storage mechanism for your database, either a relational database such as MySQL or some of the simpler Python persistent storage modules such as `anydbm` or `shelve`.

20-19. *Electronic Commerce Engine.* Use the classes created for your solution to [Exercise 13-11](#) and add some product inventory to create a potential electronic commerce Web site. Be sure your Web application also supports multiple customers and provides registration for each user.

20-20. *Dictionaries and `cgi` module.* As you know, the `cgi.FieldStorage()` method returns a dictionary-like object containing the key-value pairs of the submitted CGI variables. You can use methods such as `keys()` and `has_key()` for such objects. In Python 1.5, a `get()` method was added to dictionaries which returned the value of the requested key, or the default value for a non-existent key. `FieldStorage` objects do not have such a method. Let's say we grab the form in the usual manner of:

```
form = cgi.FieldStorage()
```

Add a similar `get()` method to class definition in `cgi.py` (you can rename it to `mycgi.py` or something like that) such that code that looks like this:

```
if form.has_key('who'):
    who = form['who'].value
else:
    who = '(no name submitted)'
```

... can be replaced by a single line which makes forms even more like a dictionary:

```
howmany = form.get('who', '(no name submitted)')
```

20-21. *Creating Web Servers.* Our code for `myhttpd.py` in [Section 20.7](#) is only able to read HTML files and return them to the calling client. Add support for plain text files with the `.txt` ending. Be sure that you return the correct MIME type of "text/plain."

Extra credit: add support for JPEG files ending with either `.jpg` or `.jpeg` and having a MIME type of "image/jpeg."

20-22. *Advanced Web Clients.* URLs given as input to `crawl.py` must have the leading "http://" protocol indicator and top-level URLs must contain a trailing slash, i.e., <http://www.prenhallprofessional.com/>. Make `crawl.py` more robust by allowing the user to input just the hostname (without the protocol part [make it assume HTTP]) and also make the trailing slash optional. For example, www.prenhallprofessional.com should now be acceptable input.

20-23. *Advanced Web Clients.* Update the `crawl.py` script in [Section 20.3](#) to also download links that use the "ftp:" scheme. All "mailto:" links are ignored by `crawl.py`. Add support to ensure that it also ignores "telnet:", "news:", "gopher:", and "about:" links.

20-24. *Advanced Web Clients.* The `crawl.py` script in [Section 20.3](#) only downloads `.html` files via links found in Web pages at the same site and does not handle/save images that are also valid "files" for those pages. It also does not handle servers that are susceptible to URLs that are missing the trailing slash (`/`). Add a pair of classes to `crawl.py` to deal with these problems.

A `My404UrlOpener` class should subclass `urllib.FancyURLOpener` and consist of a single method, `http_error_404()` which determines if a 404 error was reached using a URL without a trailing slash. If so, it adds the slash and retries the request again (and only once). If it still fails, return a real 404 error. You must set `urllib._urlopener` with an instance of this class so that `urllib` uses it.

Create another class called `LinkImageParser`, which derives from `htmllib.HTMLParser`. This class should contain a constructor to call the base class constructor as well as initialize a list for the image files parsed from Web pages. The `handle_image()` method should be overridden to add image filenames to the image list (instead of discarding them like the current base class method does).