Advanced Web Programming

MCS 275 Lecture 33
Programming Tools and File Management
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Advanced Web Programming

Plan of the Course

since the first midterm

In the four weeks after the midterm exam
we covered:

1. CGI programming: handling forms
2. database programming: MySQL and MySQLdb
3. network programming: using sockets
4. multithreaded programming

Anything left to cover?

Advanced Web Programming
$\rightarrow$ gluing various programming tools

Advanced Web Programming

The SocketServer Module

simplified development of network servers

With the `SocketServer` module we do not need to import the `socket` module for the server script.

Follow these steps:

1. `from socketserver import StreamRequestHandler`
   `from socketserver import TCPServer`
2. Inheriting from `StreamRequestHandler`
   define a request handler class. Override `handle()`.
   → `handle()` processes incoming requests
3. Instantiate `TCPServer` with `(address, port)`
   and an instance of the request handler class.
   → this returns a server object
4. Apply the method `handle_request()` or `serve_forever()`
   to the server object.

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1. Advanced Web Programming
   - what we have covered so far
2. The SocketServer Module
   - simplified development of network servers
   - a server tells clients the time
3. A Forking Server
   - instead of threads use processes
   - process to handle a client
4. The BaseHTTPServer Module
   - creating a very simple HTTP server
   - code for the simple HTTP web server

a server to tell the time with `SocketServer`

In the window running the server:

```
$ python clockserver.py
server is listening to 12091
connected at ('127.0.0.1', 49142)
read "What is the time?          " from client
writing "Sun Apr  4 18:16:14 2010" to client
```

In the window running the client:

```
$ python clockclient.py
client is connected
Sun Apr  4 18:16:14 2010
```

code for the client in file `clockclient.py`

```
from socket import socket as Socket
from socket import AF_INET, SOCK_STREAM

HOSTNAME = 'localhost'   # on same host
PORTNUMBER = 12091       # same port number
BUFFER = 25              # size of the buffer

SERVER_ADDRESS = (HOSTNAME, PORTNUMBER)
CLIENT = Socket(AF_INET, SOCK_STREAM)
CLIENT.connect(SERVER_ADDRESS)

print('client is connected')
QUESTION = 'What is the time?'
DATA = QUESTION + (BUFFER-len(QUESTION))*' '
CLIENT.send(DATA.encode())
DATA = CLIENT.recv(BUFFER)
print(DATA.decode())

CLIENT.close()
```

code for the server in the file `clockserver.py`

```
from socketserver import StreamRequestHandler
from socketserver import TCPServer
from time import ctime

PORT = 12091

class ServerClock(StreamRequestHandler):
    """
    The server tells the clients the time.
    """
    def handle(self):
        """
        Handler sends time to client.
        """

def main():
    """
    Starts the server and serves requests.
    """
```

code for the handler

```
def handle(self):
    """
    Handler sends time to client.
    """
    print("connected at", self.client_address)
    message = self.rfile.read(25)
    data = message.decode()
    print('read \"' + data + '\" from client')
    now = ctime()
    print('writing \"' + now + '\" to client')
    self.wfile.write(now.encode())
```

code for the main function

```
def main():
    """
    Starts the server and serves requests.
    """
    ss = TCPServer(('', PORT), ServerClock)
    print('server is listening to', PORT)
    try:
        print('press ctrl c to stop server')
        ss.serve_forever()
    except KeyboardInterrupt:
        print(' ctrl c pressed, closing server')
        ss.socket.close()

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

About `rfile` and `wfile`

attributes in the class `StreamRequestHandler`

- **rfile** contains input stream to read data from client

  example: `data = self.rfile.read(25)`
  client must send exactly 25 characters!

- **wfile** contains output stream to write data to client

  example: `self.wfile.write(data)`
  all data are strings of characters!

alternatives to the simple example

Instead of `StreamRequestHandler`,
we can use `DatagramRequestHandler`.

Instead of `TCPServer`, we can use `UDPServer`,
if we want UDP instead of TCP protocol.
On Unix (instead of `TCPServer`): `UnixStreamServer` or
`UnixDatagramServer`.

Choice between

1. `handle_request()`: handle one single request, or
2. `serve_forever()`: indefinitely many requests.

using `serve_forever()`

With `serve_forever()`, we can

1. serve indefinitely many requests,
2. simultaneously from multiple clients.

```
ss = TCPServer(('',port),ServerClock)
print 'server is listening to', port
try:
   print 'press ctrl c to stop server'
   ss.serve_forever()
except KeyboardInterrupt:
   print ' ctrl c pressed, closing server'
   ss.socket.close()
```

Advanced Web Programming

a forking server

Threads in Python are not mapped to cores.

For computationally intensive request,
we want to spawn a new process.

```
>>> import os
>>> help(os.fork)
Help on built-in function fork in module posix:

fork(...)
    fork() -> pid

    Fork a child process.
    Return 0 to child process
      and PID of child to parent process.
```

illustration of a fork

The child process will just print `hello`.

```
import os

def child():
    """
    The code executed by the forked process.
    """
    print('hello from child', os.getpid())
    os._exit(0) # go back to parent loop
```

code for the `parent()` function

```
def parent():
    """
    Code executed by the forking process.
    Type q to quit this process.
    """
    while True:
        newpid = os.fork()
        if newpid == 0:
            child()
        else:
            print('hello from parent',\
                os.getpid(), newpid)
        if input() == 'q':
            break

parent()
```

running fork.py

```
$ python fork.py
hello from parent 854 855
hello from child 855
```

In another terminal window:

```
$ ps -e | grep "Python"
  854 ttys000    0:00.03 /Library/Frameworks/Python.fr
  855 ttys000    0:00.00 (Python)
  895 ttys001    0:00.00 grep Python
```

Then we type `q` in the first terminal window to quit the parent process.

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Are we there yet?

Consider the following simulation:

- Any number of clients connect from time to time and they ask for the current time.

Are we there yet?!

- For every request, the server forks a process. The child process exits when the client stops.

Two advantage of forking processes over threads:

1. We have parallelism, as long as there are enough cores.
2. Unlike threads, processes can be killed explicitly.

clockforkclient.py

We have the same start as in `clockclient.py`

```
print('client is connected')
data = 'What is the time?'

while True:
    message = data + (buffer-len(data))*' '
    client.send(message.encode())
    data = client.recv(buffer).decode()
    print(data)
    nbr = randint(3, 10)
    print('client sleeps for %d seconds' % nbr)
    sleep(nbr)

client.close()
```

process handling a client

```
def handle_client(sck):
    """
    Handling a client via the socket sck.
    """
    print("client is blocked for ten seconds ...")
    sleep(10)
    print("handling a client ...")
    while True:
        data = sck.recv(buffer).decode()
        if not data:
            break
        print('received \"' + data + '\" from client')
        now = ctime()
        print('sending \"' + now + '\" to client')
        sck.send(now.encode())
    print('closing client socket, exiting child process')
    sck.close()
    os._exit(0)
```

killing the handling child processes

With the `os` module, we can kill a process,
once with have its process id.

```
import os

active_processes = []

def kill_processes():
    """
    kills handler processes
    """
    while len(active_processes) > 0:
        pid = active_processes.pop(0)
        print('-> killing process %d' % pid)
        os.system('kill -9 %d' % pid)
```

the `main()` in the server

```
def main():
    """
    Listen for connecting clients.
    """
    try:
        print('press ctrl c to stop server')
        while True:
            client, address = server.accept()
            print('server connected at', address)
            child_pid = os.fork()
            if child_pid == 0:
                handle_client(client)
            else:
                print('appending PID', child_pid)
                active_processes.append(child_pid)
```

shutting down the server

Before closing the server socket,
all active child processes are killed.

```
    except:
        print('ctrl c pressed, closing server')
        print('active processes :', active_processes)
        kill_processes()
        server.close()

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

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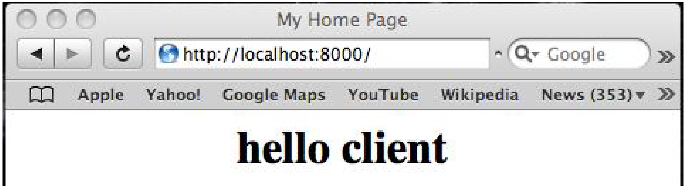
Client Accesses the HTTP Server

The client is the web browser.

Working offline, with URL `http://localhost:8000/`



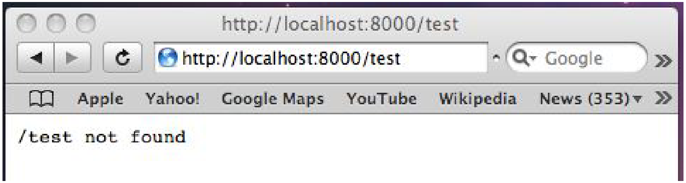
hello client

This is the default page displayed
in response to a GET request.

Not Serving Files

For now, our server does not make files available.

If a user requests a file, e.g.: `test`,
then the server answers:



```
/test not found
```

running the web server in `ourwebserver.py`

Recall the script `myserver.py` which allowed us to do server side Python scripting without Apache.

We can also serve html pages without Apache:

```
$ python3 ourwebserver.py
welcome to our web server
press ctrl c to stop server
127.0.0.1 - - [04/Apr/2016 09:20:55] "GET / HTTP/1.1"
^C ctrl c pressed, shutting down
$
```

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The BaseHTTPServer Module

writing code for a web server

Using the `BaseHTTPServer` module
is similar to using `SocketServer`.

Execute these steps:

1. Import the following:
   ```
   from BaseHTTPServer import BaseHTTPRequestHandler
   from BaseHTTPServer import HTTPServer
   ```
2. Inheriting from `BaseHTTPRequestHandler`
   define request handler class. Override `do_GET()`.
   $\rightarrow$ `do_GET()` defines how to serve GET requests
3. Instantiate `HTTPServer` with `(address, port)`
   and an instance of the request handler class.
   $\rightarrow$ this returns a server object
4. Apply `serve_forever()` to server object.

part I of `ourwebserver.py`

```
from http.server import BaseHTTPRequestHandler
from http.server import HTTPServer

dynhtml = """
<HTML>
<HEAD><TITLE>My Home Page</TITLE></HEAD>
<BODY> <CENTER>
<H1> hello client </H1>
</CENTER> </BODY>
</HTML>"""
```

This defines the HTML code we display.

part II of ourwebserver.py

```
class WebServer(BaseHTTPRequestHandler):
    """
    Illustration to set up a web server.
    """
    def do_GET(self):
        """
        Defines what server must do when
        it receives a GET request.
        """
        if self.path == '/':
            self.send_response(200)
            self.send_header('Content-type','text/html')
            self.end_headers()
            self.wfile.write(dynhtml.encode())
        else:
            message = self.path + ' not found'
            self.wfile.write(message.encode())
```

the `main()` in `ourwebserver.py`

```
def main():
    """
    a simple web server
    """
    try:
        ws = HTTPServer(('', 8000), WebServer)
        print('welcome to our web server')
        print('press ctrl c to stop server')
        ws.serve_forever()
    except KeyboardInterrupt:
        print(' ctrl c pressed, shutting down')
        ws.socket.close()
```

Summary + Assignments

Assignments:

1. Use the `SocketServer` module to implement a server to swap one data string between two clients. Clients A and B send a string to the server, client B receives what A sent and A receives what B sent.
2. Implement a server which generates a secret number. Clients connect to the server sending their guess for the secret. In response, the server sends one of these three messages: (1) wrong, (2) right, or (3) secret found. If a client has sent the right answer, all future clients must get reply (3).
3. Consider the previous exercise and set up a simple web server to guess a secret word. The word is the name typed in after `localhost:8000/` in the URL.