core WEB programming

Network Programming: Servers

Agenda

- **Steps for creating a server**
  1. Create a ServerSocket object
  2. Create a Socket object from ServerSocket
  3. Create an input stream
  4. Create an output stream
  5. Do I/O with input and output streams
  6. Close the socket
- **A generic network server**
- **Accepting connections from browsers**
- **Creating an HTTP server**
- **Adding multithreading to an HTTP server**

Steps for Implementing a Server

1. **Create a ServerSocket object**

```
ServerSocket listenSocket =
  new ServerSocket(portNumber);
```

2. **Create a Socket object from ServerSocket**

```
while(someCondition) {
  Socket server = listenSocket.accept();
  doSomethingWith(server);
}
```

   - Note that it is quite common to have doSomethingWith spin off a separate thread

3. **Create an input stream to read client input**

```
BufferedReader in =
 new BufferedReader
  (new InputStreamReader(server.getInputStream()));
```

Steps for Implementing a Server

4. **Create an output stream that can be used to send info back to the client.**

```
// Last arg of true means autoflush stream
// when println is called
PrintWriter out =
  new PrintWriter(server.getOutputStream(), true)
```

5. **Do I/O with input and output Streams**
   - Most common input: readLine
   - Most common output: println
6. **Close the socket when done**

```
server.close();
```

   - This closes the associated input and output streams.

A Generic Network Server

```
import java.net.*;
import java.io.*;

/** A starting point for network servers. */

public class NetworkServer {
  protected int port, maxConnections;

  /** Build a server on specified port. It will continue
   *  to accept connections (passing each to
   *  handleConnection) until an explicit exit
   *  command is sent (e.g. System.exit) or the
   *  maximum number of connections is reached. Specify
   *  0 for maxConnections if you want the server
   *  to run indefinitely.
   */

  public NetworkServer(int port, int maxConnections) {
    this.port = port;
    this.maxConnections = maxConnections;
  }
  ...
```

A Generic Network Server (Continued)

```
/** Monitor a port for connections. Each time one
 *  is established, pass resulting Socket to
 *  handleConnection.
 */

public void listen() {
  int i=0;
  try {
    ServerSocket listener = new ServerSocket(port);
    Socket server;
    while((i++ < maxConnections) ||
          (maxConnections == 0)) {
      server = listener.accept();
      handleConnection(server);
    }
  } catch (IOException ioe) {
    System.out.println("IOException: " + ioe);
    ioe.printStackTrace();
  }
}
```

A Generic Network Server (Continued)

```
  ...
  protected void handleConnection(Socket server)
      throws IOException{
    BufferedReader in =
      SocketUtil.getBufferedReader(server);
    PrintWriter out =
      SocketUtil.getPrintWriter(server);
    System.out.println
      ("Generic Network Server:\n" +
       "got connection from " +
       server.getInetAddress().getHostName() + "\n" +
       "with first line '" +
       in.readLine() + "'");
    out.println("Generic Network Server");
    server.close();
  }
}
```

- Override handleConnection to give *your* server the behavior you want.

Using Network Server

```
public class NetworkServerTest {
  public static void main(String[] args) {
    int port = 8088;
    if (args.length > 0) {
      port = Integer.parseInt(args[0]);
    }
    NetworkServer server = new NetworkServer(port, 1);
    server.listen();
  }
}
```

Network Server: Results

- **Accepting a Connection from a WWW Browser**
  - Suppose the above test program is started up on port 8088 of `server.com`:

```
server> java NetworkServerTest
```

  - Then, a standard Web browser on `client.com` requests `http://server.com:8088/foo/`, yielding the following back on `server.com`:

```
Generic Network Server:
got connection from client.com
with first line 'GET /foo/ HTTP/1.0'
```

HTTP Requests and Responses

- **Request**

```
GET /~gates/ HTTP/1.0
Header1: …
Header2: …
…
HeaderN: …
Blank Line
```

  - All request headers are optional except for `Host` (required only for HTTP/1.1 requests)
  - If you send `HEAD` instead of `GET`, the server returns the same HTTP headers, but no document

- **Response**

```
HTTP/1.0 200 OK
Content-Type: text/html
Header2: …
…
HeaderN: …
Blank Line
<!DOCTYPE …>
<HTML>
…
</HTML>
```

  - All response headers are optional except for `Content-Type`

A Simple HTTP Server

- **Idea**
  1. Read all the lines sent by the browser, storing them in an array
     - Use readLine a line at a time until an empty line
       - Exception: with POST requests you have to read some extra data
  2. Send an HTTP response line (e.g. "HTTP/1.0 200 OK")
  3. Send a Content-Type line then a blank line
     - This indicates the file type being returned (HTML in this case)
  4. Send an HTML file showing the lines that were sent
  5. Close the connection

EchoServer

```
import java.net.*;
import java.io.*;
import java.util.StringTokenizer;

 /** A simple HTTP server that generates a Web page
  *  showing all of the data that it received from
  *  the Web client (usually a browser). */

public class EchoServer extends NetworkServer {
  protected int maxInputLines = 25;
  protected String serverName = "EchoServer 1.0";

  public static void main(String[] args) {
    int port = 8088;
    if (args.length > 0)
      port = Integer.parseInt(args[0]);
    EchoServer echoServer = new EchoServer(port, 0);
    echoServer.listen();
  }

  public EchoServer(int port, int maxConnections) {
    super(port, maxConnections);
  }
```

EchoServer (Continued)

```
public void handleConnection(Socket server)
    throws IOException{
  System.out.println(serverName + ": got connection from " +
      server.getInetAddress().getHostName());
  BufferedReader in = SocketUtil.getBufferedReader(server);
  PrintWriter out = SocketUtil.getPrintWriter(server);
  String[] inputLines = new String[maxInputLines];
  int i;
  for (i=0; i<maxInputLines; i++) {
    inputLines[i] = in.readLine();
    if (inputLines[i] == null) // Client closes connection
      break;
    if (inputLines[i].length() == 0) { // Blank line
      if (usingPost(inputLines)) {
        readPostData(inputLines, i, in);
        i = i + 2;
      }
      break;
    }
  }
  ...
```

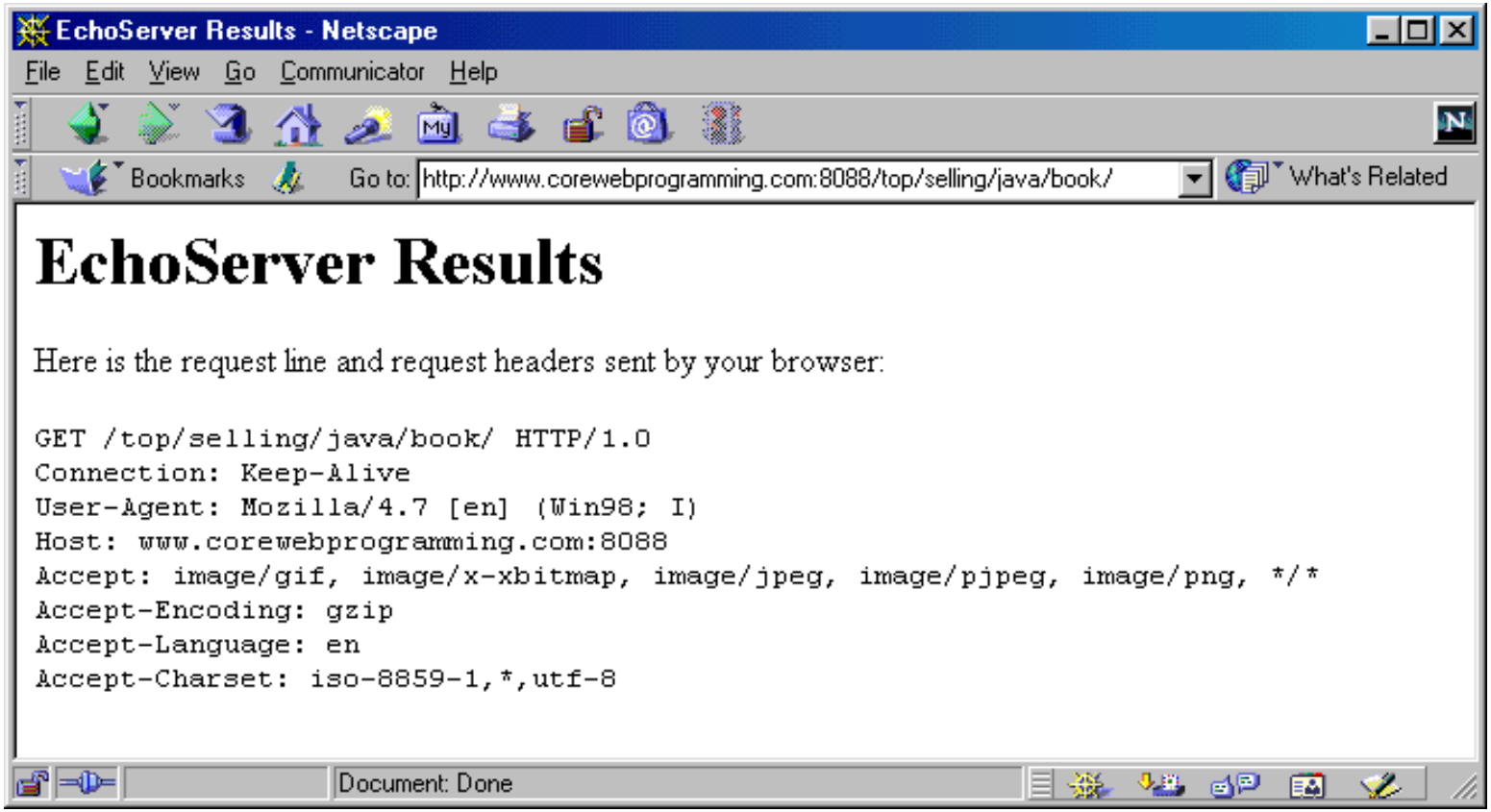
EchoServer (Continued)

```
      printHeader(out);
      for (int j=0; j<i; j++)
        out.println(inputLines[j]);
      printTrailer(out);
      server.close();
    }

    private void printHeader(PrintWriter out) {
      out.println("HTTP/1.0 200 Document follows\r\n" +
                  "Server: " + serverName + "\r\n" +
                  "Content-Type: text/html\r\n" +
                  "\r\n" +
                  "<!DOCTYPE HTML PUBLIC " +
                      "\"-//W3C//DTD HTML 4.0//EN\">\n" +
                  "<HTML>\n" +

                  ...
                  "</HEAD>\n");
    }
    ...
}
```

EchoServer in Action



EchoServer shows data sent by the browser

Adding Multithreading

```
import java.net.*;
import java.io.*;

/** A multithreaded variation of EchoServer. */

public class ThreadedEchoServer extends EchoServer
                                implements Runnable {
  public static void main(String[] args) {
    int port = 8088;
    if (args.length > 0)
      port = Integer.parseInt(args[0]);
    ThreadedEchoServer echoServer =
      new ThreadedEchoServer(port, 0);
    echoServer.serverName = "Threaded Echo Server 1.0";
    echoServer.listen();
  }

  public ThreadedEchoServer(int port, int connections) {
    super(port, connections);
  }
```

Adding Multithreading (Continued)

```
  public void handleConnection(Socket server) {
    Connection connectionThread =
      new Connection(this, server);
    connectionThread.start();
  }

  public void run() {
    Connection currentThread =
      (Connection)Thread.currentThread();
    try {
      super.handleConnection(currentThread.serverSocket);
    } catch(IOException ioe) {
      System.out.println("IOException: " + ioe);
      ioe.printStackTrace();
    }
  }
}
```

Adding Multithreading (Continued)

```
/** This is just a Thread with a field to store a
 *  Socket object. Used as a thread-safe means to pass
 *  the Socket from handleConnection to run.
 */

class Connection extends Thread {
  protected Socket serverSocket;

  public Connection(Runnable serverObject,
                    Socket serverSocket) {
    super(serverObject);
    this.serverSocket = serverSocket;
  }
}
```

Summary

- **Create a ServerSocket; specify port number**
- **Call `accept` to wait for a client connection**
  - Once a connection is established, a Socket object is created to communicate with client
- **Browser requests consist of a GET, POST, or HEAD line followed by a set of request headers and a blank line**
- **For the HTTP server response, send the status line (HTTP/1.0 200 OK), Content-Type, blank line, and document**
- **For improved performance, process each request in a separate thread**

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Questions?