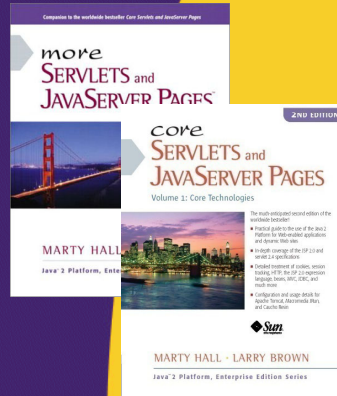




Network Programming: Servers

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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**
 - Single threaded
 - Multithreaded
- **Accepting connections from browsers**
- **A simple HTTP server**

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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()));
```

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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
- Again you can use ObjectInputStream and ObjectOutputStream for Java-to-Java communication

6. Close the socket when done

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

- This closes the associated input and output streams.

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A Generic Single-Threaded Network Server

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

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

public abstract class NetworkServer {
    private int port;

    /** Build a server on specified port. It will continue to
     *  accept connections, passing each to handleConnection until
     *  the server is killed (e.g., Control-C in the startup window)
     *  or System.exit() from handleConnection of elsewhere
     *  in the Java code).
     */

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

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A Generic Network Server (Continued)

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

public void listen() {
    try {
        ServerSocket listener = new ServerSocket(port);
        Socket socket;
        while(true) { // Run until killed
            socket = listener.accept();
            handleConnection(socket);
        }
    } catch (IOException ioe) {
        System.out.println("IOException: " + ioe);
        ioe.printStackTrace();
    }
}
```

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A Generic Network Server (Continued)

```
/** This is the method that provides the behavior to the
 * server, since it determines what is done with the
 * resulting socket. <B>Override this method in servers
 * you write.</B>
 */

protected abstract void handleConnection(Socket socket)
    throws IOException;

/** Gets port on which server is listening. */

public int getPort() {
    return(port);
}
}
```

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Using Network Server

```
public class NetworkServerTest extends NetworkServer {
    public NetworkServerTest(int port) {
        super(port);
    }

    protected void handleConnection(Socket socket)
        throws IOException{
        PrintWriter out = SocketUtil.getWriter(socket);
        BufferedReader in = SocketUtil.getReader(socket);
        System.out.printf
            ("Generic Server: got connection from %s%n" +
             "with first line '%s'.%n",
             socket.getInetAddress().getHostName(),
             in.readLine());
        out.println("Generic Server");
        socket.close();
    }
}
```

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Using Network Server (Continued)

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

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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'
```

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Template for a Multithreaded Network Server

```
import java.net.*;  
import java.util.concurrent.*;  
import java.io.*;  
  
public class MultithreadedServer {  
    private int port;  
  
    public MultithreadedServer(int port) {  
        this.port = port;  
    }  
  
    public int getPort() {  
        return (port);  
    }  
}
```

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MultithreadedServer.java (Continued)

```
public void listen() {
    int poolSize =
        50 * Runtime.getRuntime().availableProcessors();
    ExecutorService tasks =
        Executors.newFixedThreadPool(poolSize);
    try {
        ServerSocket listener = new ServerSocket(port);
        Socket socket;
        while(true) { // Run until killed
            socket = listener.accept();
            tasks.execute(new ConnectionHandler(socket));
        }
    } catch (IOException ioe) {
        System.err.println("IOException: " + ioe);
        ioe.printStackTrace();
    }
}}
```

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The upcoming EchoServer will apply this template to making an HTTP server.

ConnectionHandler.java

```
public class ConnectionHandler implements Runnable {
    private Socket socket;

    public ConnectionHandler(Socket socket) {
        this.socket = socket;
    }

    public void run() {
        try {
            handleConnection(socket);
        } catch (IOException ioe) {
            System.err.println("IOException: " + ioe);
            ioe.printStackTrace();
        }
    }

    public void handleConnection(Socket socket)
        throws IOException{
        // Do something with socket
    }
}
```

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HTTP Requests and Responses

- **Request**

```
GET /~gates/ HTTP/1.1
Host: www.mainhost.com
Connection: close
Header3: ...
...
HeaderN: ...
Blank Line
```

- All request headers are optional except for Host (required only for HTTP/1.1)
- 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

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A Simple HTTP Server

- **Idea**

1. Read lines sent by the browser, storing them in a List
 - Use readLine a line at a time until an empty line
 - Exception: with POST requests you have to read extra line
2. Send an HTTP response line (e.g. "HTTP/1.1 200 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
 - Put the input in a PRE section inside the BODY
5. Close the connection

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EchoServer.java

```
/** 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 {
    private int port;

    public EchoServer(int port) {
        this.port = port;
    }

    public static void main(String[] args) {
        int port = 8088;
        if (args.length > 0) {
            try {
                port = Integer.parseInt(args[0]);
            } catch (NumberFormatException nfe) {}
        }
        EchoServer server = new EchoServer(port);
        server.listen();
    }
}
```

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EchoServer.java (Continued)

```
public void listen() {
    int poolSize =
        50 * Runtime.getRuntime().availableProcessors();
    ExecutorService tasks =
        Executors.newFixedThreadPool(poolSize);
    try {
        ServerSocket listener = new ServerSocket(port);
        Socket socket;
        while(true) { // Run until killed
            socket = listener.accept();
            tasks.execute(new EchoHandler(socket));
        }
    } catch (IOException ioe) {
        System.out.println("IOException: " + ioe);
        ioe.printStackTrace();
    }
}
```

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EchoHandler.java

```
public class EchoHandler implements Runnable {
    private Socket socket;

    public EchoHandler(Socket socket) {
        this.socket = socket;
    }

    public void run() {
        try {
            handleConnection(socket);
        } catch (IOException ioe) {
            System.err.println("IOException: " + ioe);
            ioe.printStackTrace();
        }
    }
}
```

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EchoHandler.java (Continued)

```
public void handleConnection(Socket socket)
    throws IOException{
    PrintWriter out = SocketUtil.getWriter(socket);
    BufferedReader in = SocketUtil.getReader(socket);
    List<String> inputLines = new ArrayList<String>();
    String line;
    while((line = in.readLine()) != null) {
        inputLines.add(line);
        if (line.length() == 0) { // Blank line.
            if (usingPost(inputLines)) { // One more line if POST
                ...
            }
            break;
        }
    }
    printHeader(out);
    for (String inputLine: inputLines) {
        out.println(inputLine);
    }
    printTrailer(out);
    socket.close();
}
```

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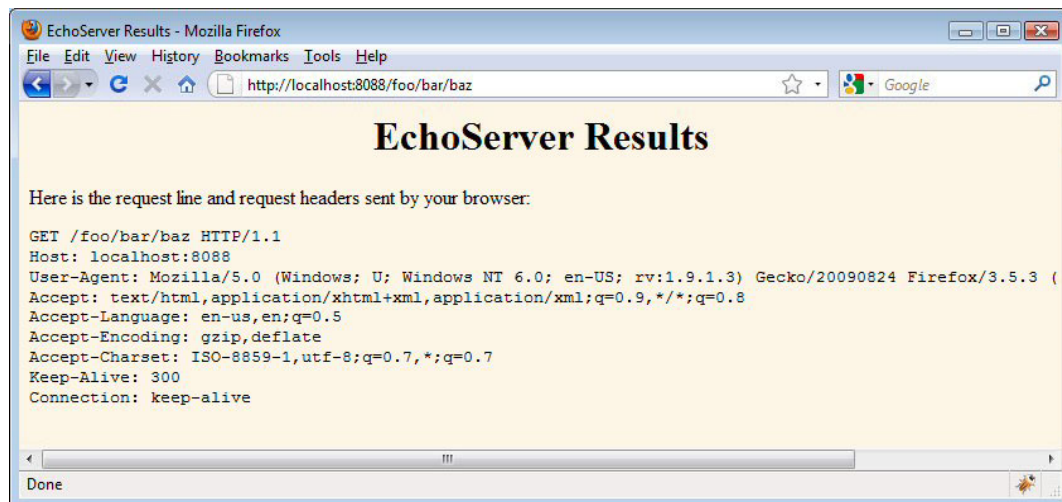
EchoHandler.java (Continued)

```
private void printHeader(PrintWriter out) {
    String serverName = "EchoServer";
    out.println
        ("HTTP/1.1 200 OK\r\n" +
         "Server: " + serverName + "\r\n" +
         "Content-Type: text/html\r\n" +
         "\r\n" +
         "<!DOCTYPE HTML PUBLIC " +
          "\"-//W3C//DTD HTML 4.0 Transitional//EN\">\n" +
         ...
         "<PRE>");
}

private void printTrailer(PrintWriter out) {
    out.println
        ("</PRE></BODY></HTML>\n");
}
```

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EchoServer in Action



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Summary

- **Create a ServerSocket; specify port number**
 - Call accept to wait for a client connection
 - accept returns a Socket object (just as in last lecture)
- **Browser requests:**
 - GET, POST, or HEAD line
 - 0 or more request headers
 - blank line
 - One additional line (query data) for POST requests only
- **HTTP server response:**
 - Status line (HTTP/1.0 200 OK),
 - Content-Type (and, optionally, other response headers)
 - Blank line
 - Document
- **For improved performance**
 - Make multithreaded task queue to handle connections

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