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Chapter 19. Server-Side Java: Servlets

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Servlets are java technology's answer to Common Gateway Interface (CGI) programming. They are programs that run on a web server, acting as a middle layer between a request coming from a web browser or other http client and databases or applications on the http server. Their job is to:

1. **Read any data sent by the user.** This data is usually entered in a form on a Web page but could also come from an applet or a custom HTTP client program.

2. **Look up any other information about the request that is embedded in the HTTP request.** This information includes details about browser capabilities, cookies, the host name of the requesting client, and so forth.

3. **Generate the results.** This process may require talking to a database, executing an RMI or CORBA call, invoking a legacy application, or computing the response directly.

4. **Format the results inside a document.** In most cases, this involves embedding the information inside an HTML document.

5. **Set the appropriate HTTP response parameters.** This means telling the browser what type of document is being returned (e.g., HTML), setting cookies and caching parameters, and other such tasks.

6. **Send the document back to the client.** This document can be sent in text format (HTML), binary format (GIF images), or even in a compressed format like gzip that is layered on top of some other underlying format.

Many client requests can be satisfied by prebuilt documents, and the server would handle these requests without invoking servlets. In many cases, however, a static result is not sufficient, and a page needs to be generated for each request. There are a number of reasons why Web pages need to be built on-the-fly like this:

- **The Web page is based on data submitted by the user.** For instance, the results page from search engines and order-confirmation pages at on-line stores are specific to particular user requests.

- **The Web page is derived from data that changes frequently.** For example, a weather report or news headlines site might build the pages dynamically, perhaps returning a previously built page if it is still up to date.

- **The Web page uses information from corporate databases or other server-side sources.** For example, an e-commerce site could use a servlet to build a Web page that lists the current price and availability of each sale item.

In principle, servlets are not restricted to Web or application servers that handle HTTP requests but can be used for other types of servers as well. For example, servlets could be embedded in FTP or mail servers to extend their functionality. In practice, however, this use of servlets has not caught on, and we'll only be discussing HTTP servlets.

19.1 The Advantages of Servlets Over "Traditional" CGI

Java servlets are more efficient, easier to use, more powerful, more portable, safer, and cheaper than traditional CGI and many alternative CGI-like technologies.

Efficient

With traditional CGI, a new process is started for each HTTP request. If the CGI program itself is relatively short, the overhead of starting the process can dominate the execution time. With servlets, the Java Virtual Machine stays running and handles each request with a lightweight Java thread, not a heavyweight operating system process. Similarly, in traditional CGI, if there are *N* simultaneous requests to the same CGI program, the code for the CGI program is loaded into memory *N* times. With servlets, however, there would be *N* threads but only a single copy of the servlet class. Finally, when a CGI program finishes handling a request, the program terminates. This approach makes it difficult to cache computations, keep database connections open, and perform other optimizations that rely on persistent data. Servlets, however, remain in memory even after they complete a response, so it is straightforward to store arbitrarily complex data between client requests.

Convenient

Servlets have an extensive infrastructure for automatically parsing and decoding HTML form data, reading and setting HTTP headers, handling cookies, tracking sessions, and many other such high-level utilities. Besides, you already know the Java programming language. Why learn Perl too? You're already convinced that Java technology makes for more reliable and reusable code than does C++. Why go back to C++ for server-side programming?

Powerful

Servlets support several capabilities that are difficult or impossible to accomplish with regular CGI. Servlets can talk directly to the Web server, whereas regular CGI programs cannot, at least not without using a server-specific API. Communicating with the Web server makes it easier to translate relative URLs into concrete path names, for instance. Multiple servlets can also share data, making it easy to implement database connection pooling and similar resource-sharing optimizations. Servlets can also maintain information from request to request, simplifying techniques like session tracking and caching of previous computations.

Portable

Servlets are written in the Java programming language and follow a standard API. Consequently, servlets written for, say, iPlanet Enterprise Server can run virtually unchanged on Apache, Microsoft Internet Information Server (IIS), IBM WebSphere, or StarNine WebStar. In fact, servlets are supported directly or by a plug-in on virtually *every* major Web server. They are now part of the Java 2 Platform, Enterprise Edition (J2EE; see http://java.sun.com/j2ee/), so industry support for servlets is becoming even more pervasive.

Secure

One of the main sources of vulnerabilities in traditional CGI programs stems from the fact that they are often executed by general-purpose operating system shells. So, the CGI programmer must be careful to filter out characters such as backquotes and semicolons that are treated specially by the shell. Implementing this precaution is harder than one might think, and weaknesses stemming from this problem are constantly being uncovered in widely used CGI libraries.

A second source of problems is the fact that some CGI programs are processed by languages that do not automatically check array or string bounds. For example, in C and C++ it is perfectly legal to allocate a 100-element array then write into the 999th "element," which is really some random part of program memory. So, programmers who forget to perform this check open up their system to deliberate or accidental buffer overflow attacks. Servlets suffer from neither of these problems. Even if a servlet executes a remote system call to invoke a program on the local operating system, it does not use a shell to do so. And, of course, array bounds checking and other memory protection features are a central part of the Java programming language.

Inexpensive

A number of free or very inexpensive Web servers are available that are good for personal use or low-volume Web sites. However, with the major exception of Apache, which is free, most commercial-quality Web servers are relatively expensive. Nevertheless, once you have a Web server, no matter its cost, adding servlet support to it (if it doesn't come preconfigured to support servlets) costs very little extra. This is in contrast to many of the other CGI alternatives, which require a significant initial investment to purchase a proprietary package.

19.2 Server Installation and Setup

Before you can get started, you have to download the servlet software you need and configure your system to take advantage of it. Here's an outline of the steps involved. Please note, however, that although your servlet code will follow a standard API, there is no standard for downloading and configuring Web or application servers. Thus, unlike most sections of this book, the methods described here vary significantly from server to server, and the examples in this section should be taken only as representative samples. Check your server's documentation for authoritative instructions.

Obtain Servlet and JSP Software

Your first step is to download software that implements the Java Servlet 2.1 or 2.2 and JavaServer Pages 1.0 or 1.1 specifications. If you are using an up-to-date Web or application server, there is a good chance that it already has everything you need. Check your server documentation or see the latest list of servers that support servlets at http://java.sun.com/products/servlet/industry.html. Although you'll eventually want to deploy in a commercial-quality server, it is useful to have a free system that you can install on your desktop machine for development and testing. Here are some of the most popular options:

- **Apache Tomcat.** Tomcat is the official reference implementation of the servlet 2.2 and JSP 1.1 specifications. It can be used as a small stand-alone server for testing servlets and JSP pages or can be integrated into the Apache Web server. It runs on almost any operating system that supports the Java 2 platform. For details, see http://jakarta.apache.org/tomcat/.

- **Allaire JRun.** JRun is a servlet 2.2 and JSP 1.1 engine that can be plugged into Netscape Enterprise or FastTrack servers, IIS, Microsoft Personal Web Server, Apache, O'Reilly's WebSite, or StarNine WebStar. It is free for desktop development, but not for deployment. For details, see http://www.allaire.com/products/jrun/.

- **Unify eWave ServletExec.** ServletExec is a servlet 2.2 and JSP 1.1 engine that can be plugged into most popular Web servers for Solaris, Windows, MacOS, HP-UX, and Linux. You can download and use it for free, but some of the advanced features and administration utilities are disabled until you purchase a license. For details, see http://www.servletexec.com/.

- **LiteWebServer (LWS) from Gefion Software.** LWS is a small free Web server derived from Tomcat. It supports servlets version 2.2 and JSP 1.1. Gefion also has a free plug-in called WAICoolRunner that adds servlet 2.2 and JSP 1.1 support to Netscape FastTrack and Enterprise servers. For details, see http://www.gefionsoftware.com/.

- **Caucho's Resin.** Resin is a fast servlet 2.2 and JSP 1.1 engine that also supports load balancing. It is free for development and non-commercial deployment purposes. For details, see http://www.caucho.com/products/resin/.

- **JavaServer Web Development Kit (JSWDK).** The JSWDK is the official reference implementation of the servlet 2.1 and JSP 1.0 specifications. It is used as a small stand-alone server for testing servlets and JSP pages before they are deployed to a full Web server that supports these technologies. For details, see http://java.sun.com/products/servlet/download.html.

Bookmark or Install the Servlet and JSP API Documentation

Just as no serious programmer should develop general-purpose Java applications without access to the JDK 1.1 or 1.3 API documentation, no serious programmer should develop servlets or JSP pages without access to the API for classes in the `javax.servlet` packages. Here is a summary of where to find the API:

- http://java.sun.com/products/jsp/download.html This site lets you download either the 2.1/1.0 API or the 2.2/1.1 API to your local system. You may have to download the entire reference implementation and then extract the documentation.

- http://java.sun.com/products/servlet/2.2/javadoc/ This site lets you browse the servlet 2.2 and JSP 1.1 API on-line.

- http://www.java.sun.com/j2ee/j2sdkee/techdocs/api/ This address lets you browse the complete API for the Java 2 Platform, Enterprise Edition (J2EE), which includes the servlet 2.2 and JSP 1.1 packages.

Identify the Classes to the Java Compiler

Once you've obtained the necessary software, you need to tell the Java compiler (`javac`) where to find the servlet and JSP class files when it compiles your servlets. Check the documentation of your particular system for definitive details, but the necessary class files are usually in the `lib` subdirectory of the server's installation directory, with the servlet classes in `servlet.jar` and the JSP classes in `jsp.jar`, `jspengine.jar`, or `jasper.jar`. There are a couple of different ways to tell `javac` about these classes, the easiest of which is to put the JAR files in your `CLASSPATH`. If you've never dealt with the `CLASSPATH` before, it is the variable that specifies where `javac` looks for classes when compiling. If the variable is unspecified, `javac` looks in the current directory and the standard system libraries. If you set `CLASSPATH` yourself, be sure to include ".", signifying the current directory. See Section 7.10 (Packages, Classpath, and JAR Archives) for details.

Package Your Classes

As you'll see in the next sections, you probably want to put your servlets into packages to avoid name conflicts with servlets other people write for the same Web or application server. In that case, you may find it convenient to add the top-level directory of your package hierarchy to the `CLASSPATH` as well.

Configure the Server

Before you start the server, you may want to designate parameters like the port on which the server listens, the directories in which it looks for HTML files, and so forth. This process is server specific, and for commercial-quality Web servers should be clearly documented in the installation notes.

DOS Memory Setting

If you start Tomcat or the JSWDK server from Windows 95 or 98, you probably have to modify the amount of memory DOS allocates for environment variables. To do this, start a fresh DOS window, click on the MS-DOS icon in the top-left corner of the window, and select `Properties`. From there, choose the Memory tab, go to the Initial Environment setting, and change the value from Auto to 2816. This configuration only needs to be done once.

Compile and Install Your Servlets

Once you've properly set your `CLASSPATH`, as described earlier in this section, just use `javac ServletName.java` to compile a servlet. The resultant class file needs to go in a location that the server knows to check during execution. As you might expect, this location varies from server to server. Check your server's documentation for details. Following is a quick summary of the locations used by the latest releases of Tomcat and the JSWDK. In both cases, assume `install_dir` is the server's main installation directory.

Tomcat 3

- **`install_dir/`*`webapps/ROOT/WEB-INF/classes`*** Standard location for servlet classes. Note that all servers that support servlets 2.2 and JSP 1.1 will have a an installation directory that looks like `.../WEB-INF/classes`. For example, the default location for Allaire JRun is *`install_dir/servers/default/ default-app/WEB-INF/classes`*.

- **`install_dir/`*`lib`*** Location for JAR files containing classes.

- **`install_dir/`*`webapps/ROOT`*** Location for HTML files, images, and JSP pages. Again, the pattern is similar for other 2.2-compatible servers. For example, Allaire JRun uses *`install_dir/servers/default/default-app/`* for HTML, JSP, and image files in its default Web application.

The JSWDK 1.0.1

- **`install_dir/webpages/WEB-INF/servlets`** Standard location for servlet classes.
- **`install_dir/lib`** Location for JAR files containing classes.
- **`install_dir/webpages`** Location for HTML files, images, and JSP pages.

Invoke Your Servlets

Most servers let you register names for servlets, so a servlet can be invoked by `http://host/any-path/any-file`. The process for doing this is serverspecific; check your server's documentation for details. However, there is a common default way to invoke servlets: use a URL of the form `http://host/servlet/ServletName`. Note that the URL refers to `servlet`, singular, even if the real directory containing the servlet code is called `servlets`, plural, or has an unrelated name like `classes` or `lib`.

There are two variations of this default URL. First, since servlets are typically placed in packages to avoid name conflicts with other servlets, the package name must appear in the URL. You would use a URL of the form `http://host/servlet/packageName.ServletName` in such a case. Second, many modern Web servers let you define multiple separate *Web applications*—collections of servlets and JSP files (and associated images, HTML documents, etc.). In such a case, the default URL for accessing servlets would be of the form `http://host/webApplicationPath/servlet/packageName.ServletName`. Again, most Web servers let you define custom URL-to-servlet mappings, regardless of whether packages or Web applications are being used.

19.3 Basic Servlet Structure

Listing 19.1 outlines a basic servlet that handles `GET` requests. `GET` requests, for those unfamiliar with HTTP, are the usual type of browser requests for Web pages. A browser generates this request when the user enters a URL on the address line, follows a link from a Web page, or submits an HTML form that either does not specify a `METHOD` or specifies `METHOD="GET"`. Servlets can also very easily handle `POST` requests, which are generated when someone submits an HTML form that specifies `METHOD="POST"`. For details on using HTML forms, see Chapter 18.

Listing 19.1 `ServletTemplate.java`

```
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

public class ServletTemplate extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {

    // Use "request" to read incoming HTTP headers
    // (e.g., cookies) and query data from HTML forms.

    // Use "response" to specify the HTTP response status
    // code and headers (e.g. the content type, cookies).

    PrintWriter out = response.getWriter();
    // Use "out" to send content to browser.
  }
}
```

To be a servlet, a class should extend `HttpServlet` and override `doGet` or `doPost`, depending on whether the data is being sent by `GET` or by `POST`. If you want a servlet to take the same action for both `GET` and `POST` requests, simply have `doGet` call `doPost`, or vice versa.

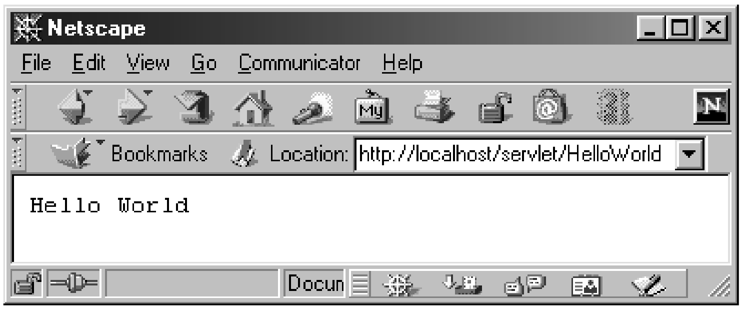
Both of these methods take two arguments: an `HttpServletRequest` and an `HttpServletResponse`. The `HttpServletRequest` has methods by which you can find out about incoming information such as form (query) data, HTTP request headers, and the client's hostname. The `HttpServletResponse` lets you specify outgoing information such as HTTP status codes (200, 404, etc.) and response headers (`Content-Type`, `Set-Cookie`, etc.). Most importantly, it lets you obtain a `PrintWriter` with which you send the document content back to the client. For simple servlets, most of the effort is spent in `println` statements that generate the desired page. Form data, HTTP request headers, HTTP responses, and cookies are all discussed in the following sections.

Since `doGet` and `doPost` throw two exceptions, you are required to include them in the declaration. Finally, you must import classes in `java.io` (for `PrintWriter`, etc.), `javax.servlet` (for `HttpServlet`, etc.), and `javax.servlet.http` (for `HttpServletRequest` and `HttpServletResponse`).

A Servlet That Generates Plain Text

Listing 19.2 shows a simple servlet that outputs plain text, with the output shown in Figure 19-1. Listing 19.3 shows the more usual case where HTML is generated. However, before we move, it is worth spending some time going through the process of installing, compiling, and running this simple servlet.

Figure 19-1. Result of Listing 19.2 (`HelloWorld.java`).


Netscape
File Edit View Go Communicator Help
Bookmarks
Location: http://localhost/servlet/HelloWorld
Docun

```
Hello World
```

First, be sure that your server is set up properly and that your `CLASSPATH` refers to the JAR file containing the `javax.servlet` classes, as described in Section 19.2 (Server Installation and Setup). Second, type `javac HelloWorld.java` (or click "build" in your IDE). Third, move `HelloWorld.class` to the directory that your server uses to store servlets (usually *`install_dir`*`/.../WEB-INF/classes`). Alternatively, you can use the `-D` option of `javac` to automatically place the `.class` files in the appropriate location. Finally, invoke your servlet. This last step involves either the default URL of `http://`*`host`*`/servlet/`*`ServletName`* or a custom URL defined in a server-specific manner. Figure 19-1 shows the servlet being accessed by means of the default URL, with the server running on the local machine.

Listing 19.2 `HelloWorld.java`

```
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

public class HelloWorld extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    PrintWriter out = response.getWriter();
    out.println("Hello World");
  }
}
```

A Servlet That Generates HTML

Most servlets generate HTML, not plain text as in the previous example. To build HTML, you need two additional steps:

1. Tell the browser that you're sending back HTML.

2. Modify the `println` statements to build a legal Web page.

You accomplish the first step by setting the HTTP `Content-Type` response header. In general, headers are set by the `setHeader` method of `HttpServletResponse`, but setting the content type is such a common task that there is also a special `setContentType` method just for this purpose. The way to designate HTML is with a type of `text/html`, so the code would look like this:

```
response.setContentType("text/html");
```

Although HTML is the most common type of document servlets create, it is not unusual to create other document types. For example, it is quite common to use servlets to generate GIF images (content type `image/gif`) and Excel spreadsheets (content type `application/vnd.ms-excel`).

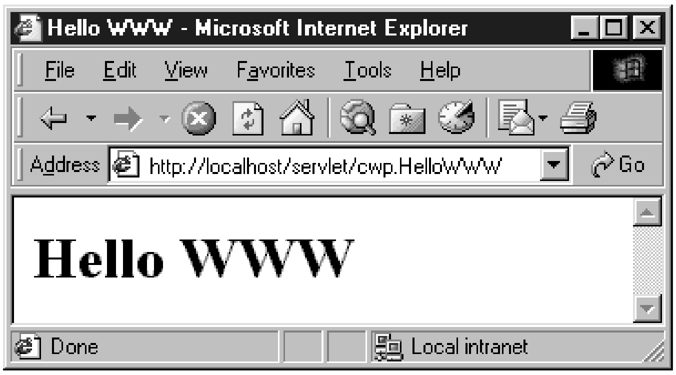
Don't be concerned if you are not yet familiar with HTTP response headers; they are discussed in Section 19.10. Note that you need to set response headers *before* actually returning any of the content with the `PrintWriter`. That's because an HTTP response consists of the status line, one or more headers, a blank line, and the actual document, *in that order.* The headers can appear in any order, and servlets buffer the headers and send them all at once, so it is legal to set the status code (part of the first line returned) even after setting headers. But servlets do not necessarily buffer the document itself, since users might want to see partial results for long pages. In version 2.1 of the servlet specification, the `PrintWriter` output is not buffered at all, so the first time you use the `PrintWriter`, it is too late to go back and set headers. In version 2.2, servlet engines are permitted to partially buffer the output, but the size of the buffer is left unspecified. You can use the `getBufferSize` method of `HttpServletResponse` to determine the size or use `setBufferSize` to specify it. In version 2.2 with buffering enabled, you can set headers until the buffer fills up and is actually sent to the client. If you aren't sure if the buffer has been sent, you can use the `isCommitted` method to check.

Core Approach

*Always set the content type **before** transmitting the actual document.*

The second step in writing a servlet that builds an HTML document is to have your `println` statements output HTML, not plain text. The structure of HTML documents is discussed in Part 1 of this book. Listing 19.3 gives an example servlet that is placed in the cwp package; Figure 19-2 shows the result. Remember that, to use packages, you need to place your code in a directory corresponding to the package name and your CLASSPATH needs to refer to the top-level directory (i.e., the one containing your package-specific directory, cwp in this case).

Figure 19-2. Result of Listing 19.3 (HelloWWW.java).


Hello WWW - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://localhost/servlet/cwp.HelloWWW
Go
Hello WWW
Done
Local intranet

Listing 19.3 HelloWWW.java

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

public class HelloWWW extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String docType =
      "<!DOCTYPE HTML PUBLIC \"-//W3C//DTD HTML 4.0 " +
      "Transitional//EN\">\n";
    out.println(docType +
                "<HTML>\n" +
                "<HEAD><TITLE>Hello WWW</TITLE></HEAD>\n" +
                "<BODY>\n" +
                "<H1>Hello WWW</H1>\n" +
                "</BODY></HTML>");
  }
}
```

Simple HTML-Building Utilities

As you know from Part 1 of the book, an HTML document is structured as follows:

```
<!DOCTYPE ...>
<HTML>
<HEAD><TITLE>...</TITLE>...</HEAD>
```

```
<BODY ...>...</BODY>
</HTML>
```

When using servlets to build the HTML, you might be tempted to omit part of this structure, especially the DOCTYPE line, noting that virtually all major browsers ignore it even though the HTML 3.2 and 4.0 specifications require it. We strongly discourage this practice. The advantage of the DOCTYPE line is that it tells HTML validators which version of HTML you are using, so they know which specification to check your document against. These validators are valuable debugging services, helping you catch HTML syntax errors that your browser guesses well on but that other browsers will have trouble displaying. The two most popular on-line validators are the ones from the World Wide Web Consortium (http://validator.w3.org/) and from the Web Design Group (http://www.htmlhelp.com/tools/validator/). They let you submit a URL, then they retrieve the page, check the syntax against the formal HTML specification, and report any errors to you. Since a servlet that generates HTML looks like a regular Web page to visitors, it can be validated in the normal manner unless it requires POST data to return its result. Remember that GET data is attached to the URL, so you can send the validators a URL that includes GET data.

Core Approach

Use an HTML validator to check the syntax of pages that your servlets generate.

Admittedly, it is a bit cumbersome to generate HTML with println statements, especially long tedious lines like the DOCTYPE declaration. Some people address this problem by writing detailed HTML generation utilities in Java, then use them throughout their servlets. We're skeptical of the utility of such an extensive library. First and foremost, the inconvenience of generating HTML programmatically is one of the main problems addressed by JavaServer Pages (discussed in the next chapter). Second, HTML generation routines can be cumbersome and tend not to support the full range of HTML attributes (CLASS and ID for style sheets, JavaScript event handlers, table cell background colors, and so forth). Despite the questionable value of a full-blown HTML generation library, if you find you're repeating the same constructs many times, you might as well create a simple utility file that simplifies those constructs. For standard servlets, there are two parts of the Web page (DOCTYPE and HEAD) that are unlikely to change and thus could benefit from being incorporated into a simple utility file. These are shown in Listing 19.4, with Listing 19.5 showing a variation of HelloWWW that makes use of this utility. We'll add a few more utilities throughout the chapter.

Listing 19.4 ServletUtilities.java

```
package cwp;

/** Some simple time savers. Note that most are static methods. */

public class ServletUtilities {
  public static final String DOCTYPE =
    "<!DOCTYPE HTML PUBLIC \"-//W3C//DTD HTML 4.0 " +
    "Transitional//EN\">";

  public static String headWithTitle(String title) {
    return(DOCTYPE + "\n" +
           "<HTML>\n" +
           "<HEAD><TITLE>" + title + "</TITLE></HEAD>\n");
  }
  // Rest of ServletUtilities omitted
}
```

Listing 19.5 **SimplerHelloWWW.java**

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

/** Simple servlet that generates HTML. This variation of
 *  HelloWWW uses the ServletUtilities utility class
 *  to generate the DOCTYPE, HEAD, and TITLE.
 */

public class SimplerHelloWWW extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    out.println(ServletUtilities.headWithTitle("Hello WWW") +
                "<BODY>\n" +
                "<H1>Hello WWW</H1>\n" +
                "</BODY></HTML>");
  }
}
```

19.4 The Servlet Life Cycle

Earlier in this chapter, we vaguely referred to the fact that only a single instance of a servlet gets created, with each user request resulting in a new thread that is handed off to doGet or doPost as appropriate. We'll now be more specific about how servlets are created and destroyed, and how and when the various methods are invoked. We give a quick summary here, then elaborate in the following subsections.

When the servlet is first created, its init method is invoked, so that is where you put one-time setup code. After this, each user request results in a thread that calls the service method of the previously created instance. Multiple concurrent requests normally result in multiple threads calling service simultaneously, although your servlet can implement a special interface (SingleThreadModel) that stipulates that only a single thread is permitted to run at any one time. The service method then calls doGet, doPost, or another do*Xxx* method, depending on the type of HTTP request it received. Finally, when the server decides to unload a servlet, it first calls the servlet's destroy method.

The init Method

The init method is called when the servlet is first created and is *not* called again for each user request. So, it is used for one-time initializations, just as with the init method of applets. The servlet can be created when a user first invokes a URL corresponding to the servlet or when the server is first started, depending on how you have registered the servlet with the Web server. The servlet will be created for the first user request if it is not explicitly registered but is instead just placed in one of the standard server directories. See the discussion of Section 19.2 (Server

Installation and Setup) for details on these directories.

The `init` method definition looks like this:

```
public void init() throws ServletException {
  // Initialization code...
}
```

One of the most common tasks that `init` performs is reading server-specific initialization parameters. For example, the servlet might need to know about database settings, password files, server-specific performance parameters, hit count files, or serialized cookie data from previous requests. To accomplish this task, you obtain a `ServletConfig` object by means of `getServletConfig`, then call `getInitParameter` on the result. Here is an example:

```
public void init() throws ServletException {
  ServletConfig config = getServletConfig();
  String param1 = config.getInitParameter("SomeParameter");
}
```

Notice two things about this code. First, the `init` method uses `getServletConfig` to obtain a reference to the `ServletConfig` object. Second, `ServletConfig` has a `getInitParameter` method with which you can look up initialization parameters associated with the servlet. Just as with the `getParameter` method used in the `init` method of applets, both the input (the parameter name) and the output (the parameter value) are strings. For an example of the use of initialization parameters, see Section 19.5 (An Example Using Initialization Parameters). Note that although you *look up* parameters in a portable manner, you *set* them in a server-specific way. For example, with Tomcat and servers compliant with servlets 2.2, you embed servlet properties in a file called `web.xml`; with the JSWDK, you use `servlets.properties`; and with the Java Web Server, you set the properties interactively with the administration console.

The service Method

Each time the server receives a request for a servlet, the server spawns a new thread and calls `service`. The `service` method checks the HTTP request type (`GET`, `POST`, `PUT`, `DELETE`, etc.) and calls `doGet`, `doPost`, `doPut`, `doDelete`, etc., as appropriate. Now, if you have a servlet that needs to handle both `POST` and `GET` requests identically, you may be tempted to override `service` directly, rather than implementing both `doGet` and `doPost`. This is not a good idea. Instead, just have `doPost` call `doGet` (or vice versa), as below.

```
public void doGet(HttpServletRequest request,
                  HttpServletResponse response)
    throws ServletException, IOException {
  // Servlet Code
}

public void doPost(HttpServletRequest request,
                   HttpServletResponse response)
    throws ServletException, IOException {
  doGet(request, response);
}
```

Although this approach takes a couple of extra lines of code, it has several advantages over directly overriding `service`. First, you can later add support for other HTTP request methods by adding `doPut`, `doTrace`, etc., perhaps in a subclass. Overriding `service` directly precludes this possibility. Second, you can add support for modification dates by adding a `getLastModified` method. Since `getLastModified` is invoked by the default `service` method, overriding `service` eliminates this option. Finally, you get automatic support for `HEAD`, `OPTION`, and `TRACE` requests.

Core Tip

If your servlet needs to handle both `GET` and `POST` identically, have your `doPost` method call `doGet`, or vice versa. Don't override `service`.

The doGet, doPost, and doXxx Methods

These methods contain the real meat of your servlet. Ninety-nine percent of the time, you only care about `GET` or `POST` requests, so you override `doGet` and/or `doPost`. However, if you want to, you can also override `doDelete` for `DELETE` requests, `doPut` for `PUT`, `doOptions` for `OPTIONS`, and `doTrace` for `TRACE`. Recall, however, that you have automatic support for `OPTIONS` and `TRACE`. Note that there is no `doHead` method. That's because the system automatically uses the status line and header settings of `doGet` to answer `HEAD` requests.

The SingleThreadModel Interface

Normally, the system makes a single instance of your servlet and then creates a new thread for each user request, with multiple simultaneous threads running if a new request comes in while a previous request is still executing. This means that your `doGet` and `doPost` methods must be careful to synchronize access to fields and other shared data, since multiple threads may access the data simultaneously. If you want to prevent this multithreaded access, you can have your servlet implement the `SingleThreadModel` interface, as below.

```
public class YourServlet extends HttpServlet
                           implements SingleThreadModel {
                           ...
}
```

If you implement this interface, the system guarantees that there is never more than one request thread accessing a single instance of your servlet. It does so either by queuing up all the requests and passing them one at a time to a single servlet instance or by creating a pool of multiple instances, each of which handles one request at a time. This means that you don't have to worry about simultaneous access to regular fields (instance variables) of the servlet. You *do,* however, still have to synchronize access to class variables (`static` fields) or shared data stored outside the servlet.

Synchronous access to your servlets can significantly hurt performance (latency) if your servlet is accessed frequently. So think twice before using the `SingleThreadModel` approach.

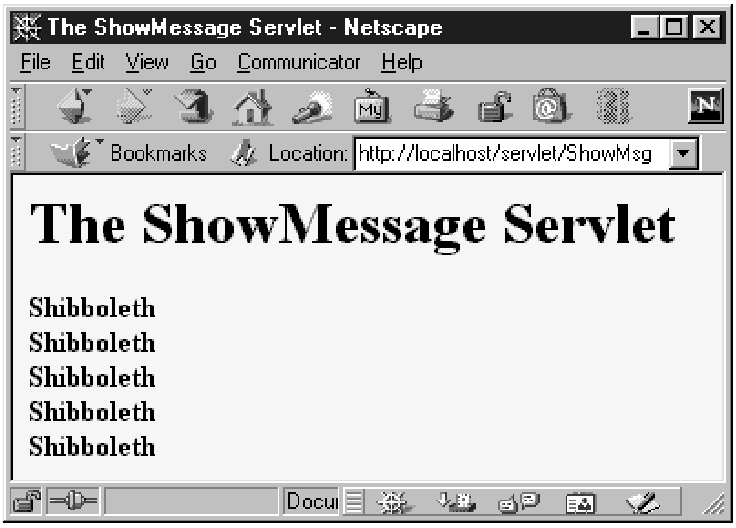
The destroy Method

The server may decide to remove a previously loaded servlet instance, perhaps because it is explicitly asked to do so by the server administrator, or perhaps because the servlet is idle for a long time. Before it does, however, it calls the servlet's `destroy` method. This method gives your servlet a chance to close database connections, halt background threads, write cookie lists or hit counts to disk, and perform other such cleanup activities. Be aware, however, that it is possible for the Web server to crash. So, don't count on `destroy` as the only mechanism for saving state to disk. Activities like hit counting or accumulating lists of cookie values that indicate special access should also proactively write their state to disk periodically.

19.5 An Example Using Initialization Parameters

Listing 19.6 shows a servlet that, when initialized, reads the `message` and `repeats` initialization parameters. Figure 19-3 shows the result when `message` is `Shibboleth`, `repeats` is `5`, and the servlet is registered under the name `ShowMsg`. Listing 19.7 shows the XML configuration file used with Tomcat 3 to obtain the result of Figure 19-3, and Listing 19.8 shows the configuration file used with the JSWDK. Servers compliant with the 2.2 servlet specification use the same file format (`web.xml`) as Tomcat, albeit sometimes with a graphical user interface to generate it.

Figure 19-3. The `ShowMessage` servlet, registered under the name `ShowMsg` and supplied with server-specific initialization parameters.


The ShowMessage Servlet - Netscape
File Edit View Go Communicator Help
Bookmarks
Location:
Docu

http://localhost/servlet/ShowMsg

The ShowMessage Servlet

Shibboleth
Shibboleth
Shibboleth
Shibboleth
Shibboleth

It is a good idea to minimize the number of separate initialization entries that have to be specified. Doing so will limit the work you need to do when moving servlets that use init parameters from one server to another. If you need to read a large amount of data, we recommend that the init parameter itself merely give the location of a parameter file and that the real data go in that file.

Core Approach

For complex initializations, store the data in a separate file and use the init parameters to give the location of that file.

Listing 19.6 `ShowMessage.java`

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

/** Example using servlet initialization. Here, the message
 *  to print and the number of times the message should be
 *  repeated is taken from the init parameters.
 */

public class ShowMessage extends HttpServlet {
  private String message;
  private String defaultMessage = "No message.";
  private int repeats = 1;

  public void init() throws ServletException {
    ServletConfig config = getServletConfig();
    message = config.getInitParameter("message");
    if (message == null) {
      message = defaultMessage;
    }
    try {
      String repeatString = config.getInitParameter("repeats");
      repeats = Integer.parseInt(repeatString);
    } catch(NumberFormatException nfe) {
      // NumberFormatException handles case where repeatString
      // is null *and* case where it is in an illegal format.
    }
  }

  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String title = "The ShowMessage Servlet";
    out.println(ServletUtilities.headWithTitle(title) +
                "<BODY BGCOLOR=\"#FDF5E6\">\n" +
                "<H1 ALIGN=\"CENTER\">" + title + "</H1>");
    for(int i=0; i<repeats; i++) {
      out.println("<B>" + message + "</B><BR>");
    }
    out.println("</BODY></HTML>");
  }
}
```

Listing 19.7 `web.xml` (for Tomcat 3)

```
<?xml version="1.0" encoding="ISO-8859-1"?>

<!DOCTYPE web-app PUBLIC
    "-//Sun Microsystems, Inc.//DTD Web Application 2.2//EN"
    "http://java.sun.com/j2ee/dtds/web-app_2.2.dtd">

<web-app>
  <servlet>
    <servlet-name>ShowMsg</servlet-name>
    <servlet-class>cwp.ShowMessage</servlet-class>
    <init-param>
      <param-name>message</param-name>
      <param-value>Shibboleth</param-value>
    </init-param>
    <init-param>
```

```
      <param-name>repeats</param-name>
      <param-value>5</param-value>
    </init-param>
  </servlet>
</web-app>
```

Listing 19.8 `servlets.properties` (for the JSWDK 1.0.1)

```
# servlets.properties used with the JSWDK

# Register servlet via servletName.code=servletClassFile
# You access it via http://host/examples/servlet/servletName
ShowMsg.code=cwp.ShowMessage

# Set init params via
#   servletName.initparams=param1=val1,param2=val2,...
ShowMsg.initparams=message=Shibboleth,repeats=5

# Standard setting
jsp.code=com.sun.jsp.runtime.JspServlet

# Set this to keep servlet source code built from JSP
jsp.initparams=keepgenerated=true
```

19.6 The Client Request: Form Data

One of the main motivations for building Web pages dynamically is to base the result upon query data submitted by the user. This section shows you how to access that data.

If you've ever used a search engine, visited an on-line bookstore, tracked stocks on the Web, or asked a Web-based site for quotes on plane tickets, you've probably seen funny-looking URLs like `http://host/path?user=Marty+Hall&origin=bwi&dest=lax`. The part after the question mark (i.e., `user=Marty+Hall& origin=bwi&dest=lax`) is known as *form data* (or *query data*) and is the most common way to get information from a Web page to a server-side program. Form data can be attached to the end of the URL after a question mark (as above) for `GET` requests, or sent to the server on a separate line for `POST` requests. If you're not familiar with HTML forms, see Chapter 18 (HTML Forms) for details on how to build forms that collect and transmit data of this sort.

Reading Form Data from CGI Programs

Extracting the needed information from form data is traditionally one of the most tedious parts of CGI programming. First of all, you have to read the data one way for `GET` requests (in traditional CGI, this is usually through the `QUERY_STRING` environment variable) and a different way for `POST` requests (by reading the standard input in traditional CGI). Second, you have to chop the pairs at the ampersands, then separate the parameter names (left of the equal signs) from the parameter values (right of the equal signs). Third, you have to URL-decode the values. Alphanumeric characters are sent unchanged, but spaces are converted to plus signs and other characters are converted to %*XX* where *XX* is the ASCII (or ISO Latin-1) value of the character, in hex.

Reading Form Data from Servlets

One of the nice features of servlets is that all the form parsing is handled automatically. You simply call the `getParameter` method of the `HttpServletRequest`, supplying the case-sensitive parameter name as an argument. You use `getParameter` exactly the same way when the data is sent by `GET` as you do when it is sent by `POST`. The servlet knows which request method was used and automatically does the right thing behind the scenes. The return value is a `String` corresponding to the URL-decoded value of the first occurrence of that parameter name. An empty `String` is returned if the parameter exists but has no value, and `null` is returned if there was no such parameter. If the parameter could potentially have more than one value, you should call `getParameterValues` (which returns an array of strings) instead of `getParameter` (which returns a single string). The return value of `getParameterValues` is `null` for nonexistent parameter names and is a one-element array when the parameter has only a single value.

Parameter names are case sensitive, so, for example, `request.getParameter("Param1")` and `request.getParameter("param1")` are *not* interchangeable.

Core Warning

The values supplied to `getParameter` and `getParameterValues` are case sensitive.

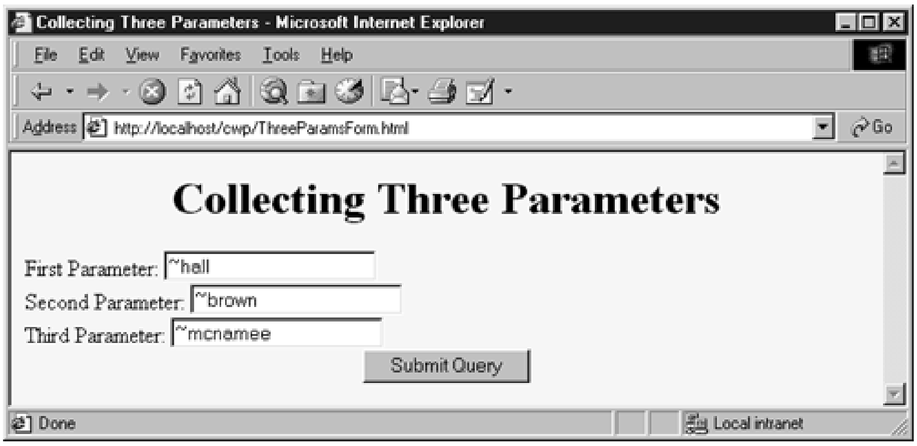
Finally, although most real servlets look for a specific set of parameter names, for debugging purposes it is sometimes useful to get a full list. Use `getParameterNames` to get this list in the form of an `Enumeration`, each entry of which can be cast to a `String` and used in a `getParameter` or `getParameterValues` call. Just note that the `HttpServletRequest` API does not specify the order in which the names appear within that `Enumeration`.

Example: Reading Three Explicit Parameters

Listing 19.9 presents a simple servlet called `ThreeParams` that reads form data parameters named `param1`, `param2`, and `param3` and places their values in a bulleted list. Listing 19.10 shows an HTML form that collects user input and sends it to this servlet. By use of an `ACTION` URL that begins with a slash (e.g., `/servlet/cwp.ThreeParams`), the form can be installed anywhere on the system running the servlet; there need not be any particular association between the directory containing the form and the servlet installation directory. On engines compatible with servlets 2.2, HTML files (and images and JSP pages) go in the directory above the one containing the `WEB-INF` directory. For example, the default Tomcat location is *`install_dir`*`/webapps/ROOT` and the default JRun location is *`install_dir`*`/servers/default/default-app`. Older servers have no standard location (e.g., the JSWDK uses *`install_dir`*`/webpages`). Also note that the `ThreeParams` servlet reads the query data after it starts generating the page. Although you are required to specify *response* settings before beginning to generate the content, there is no requirement that you read the *request* parameters at any particular time.

Figures 19-4 and 19-5 show the result of the HTML front end and the servlet, respectively.

Figure 19-4. HTML front end resulting from `ThreeParamsForm.html`.



Collecting Three Parameters - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address
Go
Submit Query
Done
Local intranet

http://localhost/cwp/ThreeParamsForm.html

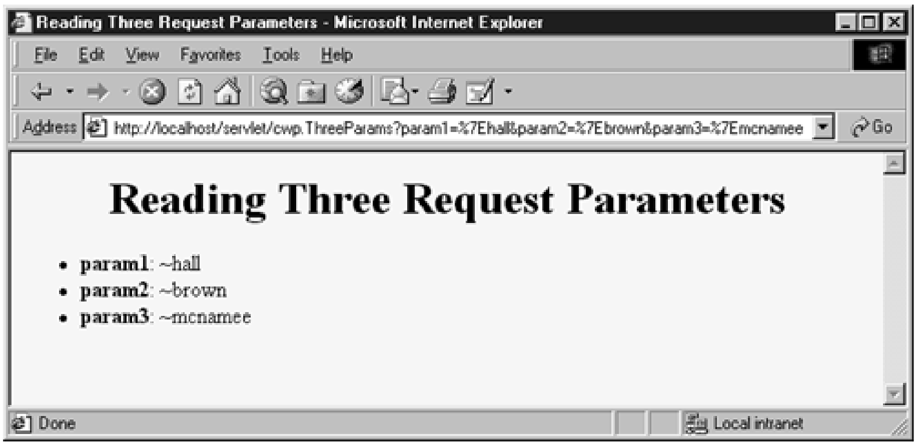
Collecting Three Parameters

First Parameter: ~hall

Second Parameter: ~brown

Third Parameter: ~mcnamee

Figure 19-5. Output of `ThreeParams` servlet.



Reading Three Request Parameters - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address
Go
Done
Local intranet

http://localhost/servlet/cwp.ThreeParams?param1=%7Ehall&param2=%7Ebrown&param3=%7Emcnamee

Reading Three Request Parameters

- **param1**: ~hall
- **param2**: ~brown
- **param3**: ~mcnamee

Listing 19.9 `ThreeParams.java`

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

public class ThreeParams extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String title = "Reading Three Request Parameters";
    out.println(ServletUtilities.headWithTitle(title) +
                "<BODY BGCOLOR=\"#FDF5E6\">\n" +
                "<H1 ALIGN=\"CENTER\">" + title + "</H1>\n" +
                "<UL>\n" +
                "  <LI><B>param1</B>: "
                + request.getParameter("param1") + "\n" +
                "  <LI><B>param2</B>: "
                + request.getParameter("param2") + "\n" +
                "  <LI><B>param3</B>: "
                + request.getParameter("param3") + "\n" +
                "</UL>\n" +
                "</BODY></HTML>");
  }
}
```

Listing 19.10 **ThreeParamsForm.html**

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
  <TITLE>Collecting Three Parameters</TITLE>
</HEAD>
<BODY BGCOLOR="#FDF5E6">
<H1 ALIGN="CENTER">Collecting Three Parameters</H1>

<FORM ACTION="/servlet/cwp.ThreeParams">
  First Parameter:  <INPUT TYPE="TEXT" id="param1"><BR>
  Second Parameter: <INPUT TYPE="TEXT" id="param2"><BR>
  Third Parameter:  <INPUT TYPE="TEXT" id="param3"><BR>
  <CENTER><INPUT TYPE="SUBMIT"></CENTER>
</FORM>

</BODY>
</HTML>
```

If you're accustomed to the traditional CGI approach where you read POST data through the standard input, you should note that you can do the same thing with servlets by calling getReader or getInputStream on the HttpServletRequest and then using that stream to obtain the raw input. This is a bad idea for regular parameters; getParameter is simpler and yields results that are parsed and URL-decoded. However, reading the raw input might be of use for uploaded files or POST data being sent by custom clients. Note, however, that if you read the POST data in this manner, it might no longer be found by getParameter.

Filtering Query Data

In the previous example, we read the param1, param2, and param3 request parameters and inserted them verbatim into the page being generated. This is not necessarily safe, since the request parameters might contain HTML characters such as "<" that could disrupt the rest of the page processing, causing some of the subsequent tags to be interpreted incorrectly. A safer approach is to filter out the HTML-specific characters before inserting the values into the page. Listing 19.11 shows a static filter method that accomplishes this task.

Listing 19.11 **ServletUtilities.java**

```
package cwp;

import javax.servlet.*;
import javax.servlet.http.*;

public class ServletUtilities {
// Other parts of ServletUtilities shown elsewhere.
/** Given a string, this method replaces all occurrences of
   *  '<' with '&lt;', all occurrences of '>' with
   *  '&gt;', and (to handle cases that occur inside attribute
   *  values), all occurrences of double quotes with
   *  '&quot;' and all occurrences of '&' with '&amp;'.
   *  Without such filtering, an arbitrary string
   *  could not safely be inserted in a Web page.
   */
  public static String filter(String input) {
    StringBuffer filtered = new StringBuffer(input.length());
    char c;
    for(int i=0; i<input.length(); i++) {
      c = input.charAt(i);
      if (c == '<') {
        filtered.append("&lt;");
      } else if (c == '>') {
        filtered.append("&gt;");
      } else if (c == '"') {
        filtered.append("&quot;");
      } else if (c == '&') {
        filtered.append("&amp;");
      } else {
        filtered.append(c);
      }
    }
    return(filtered.toString());
  }
}
```

19.7 The Client Request: HTTP Request Headers

One of the keys to creating effective servlets is understanding how to manipulate the HyperText Transfer Protocol (HTTP). Getting a thorough grasp of this protocol is not an esoteric, theoretical concept, but rather a practical issue that can have an immediate impact on the performance and usability of your servlets. This section discusses the HTTP information that is sent from the browser to the server in the form of request headers. It explains the most important HTTP 1.1 request headers, summarizing how and why they would be used in a servlet. The section also includes two detailed examples: listing all request headers sent by the browser and reducing download time by encoding the Web page with gzip when appropriate.

Note that HTTP request headers are distinct from the form (query) data discussed in the previous section. Form data results directly from user input and is sent as part of the URL for GET requests and on a separate line for POST requests. Request headers, on the other hand, are indirectly set by the browser and are sent immediately following the initial GET or POST request line. For instance, the following example shows an HTTP request that might result from a user submitting a book-search request to a servlet at http://www.somebookstore.com/servlet/Search. The request includes the headers Accept, Accept-Encoding, Connection, Cookie, Host, Referer, and User-Agent, all of which might be important to the operation of the servlet, but none of which can be derived from the form data or deduced automatically: the servlet needs to explicitly read the request headers to make use of this information.

```
GET /servlet/Search?keywords=servlets+jsp HTTP/1.1
Accept: image/gif, image/jpg, */*
```

```
Accept-Encoding: gzip
Connection: Keep-Alive
Cookie: userid=id456578
Host: www.somebookstore.com
Referer: http://www.somebookstore.com/findbooks.html
User-Agent: Mozilla/4.7 [en] (Win98; U)
```

Reading Request Headers from Servlets

Reading headers is straightforward; just call the `getHeader` method of `HttpServletRequest`, which returns a `String` if the specified header was supplied on this request, `null` otherwise. Header names are not case sensitive. So, for example, `request.getHeader("Connection")` and `request.getHeader ("connection")` are interchangeable.

Although `getHeader` is the general-purpose way to read incoming headers, a few headers are so commonly used that they have special access methods in `HttpServletRequest`. Following is a summary.

- **`getCookies`** The `getCookies` method returns the contents of the `Cookie` header, parsed and stored in an array of `Cookie` objects. This method is discussed in more detail in Section 19.11 (Cookies).
- **`getAuthType and getRemoteUser`** The `getAuthType` and `getRemoteUser` methods break the `Authorization` header into its component pieces.
- **`getContentLength`** The `getContentLength` method returns the value of the `Content-Length` header (as an `int`).
- **`getContentType`** The `getContentType` method returns the value of the `Content-Type` header (as a `String`).
- **`getDateHeader` and `getIntHeader`** The `getDateHeader` and `getIntHeader` methods read the specified headers and then convert them to `Date` and `int` values, respectively.
- **`getHeaderNames`** Rather than looking up one particular header, you can use the `getHeaderNames` method to get an `Enumeration` of all header names received on this particular request. This capability is illustrated in Listing 19.12.
- **`getHeaders`** In most cases, each header name appears only once in the request. Occasionally, however, a header can appear multiple times, with each occurrence listing a separate value. `Accept-Language` is one such example. With servlets version 2.2, you can use `getHeaders` to obtain an `Enumeration` of the values of all occurrences of the header.

Finally, in addition to looking up the request headers, you can get information on the main request line itself, also by means of methods in `HttpServletRequest`. Here is a summary of the three main methods:

- **`getMethod`** The `getMethod` method returns the main request method (normally `GET` or `POST`, but things like `HEAD`, `PUT`, and `DELETE` are possible).
- **`getRequestURI`** The `getRequestURI` method returns the part of the URL that comes

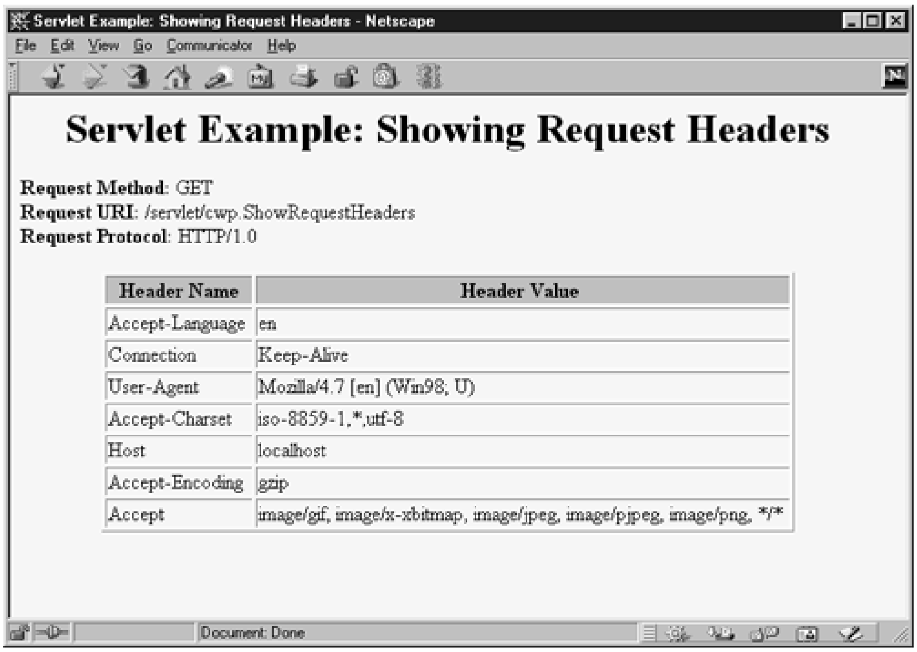
after the host and port but before the form data. For example, for a URL of http://randomhost.com/servlet/search.BookSearch, `getRequestURI` would return `/servlet/search.BookSearch`.

- **`getProtocol`** The `getProtocol` method returns the third part of the request line, which is generally `HTTP/1.0` or `HTTP/1.1`. Servlets should usually check `getProtocol` before specifying *response* headers (Section 19.10) that are specific to HTTP 1.1.

Example: Making a Table of All Request Headers

Listing 19.12 shows a servlet that simply creates a table of all the headers it receives, along with their associated values. It also prints out the three components of the main request line (method, URI, and protocol). Figures 19-6 and 19-7 show typical results with Netscape and Internet Explorer.

Figure 19-6. Request headers sent by Netscape 4.7 on Windows 98.

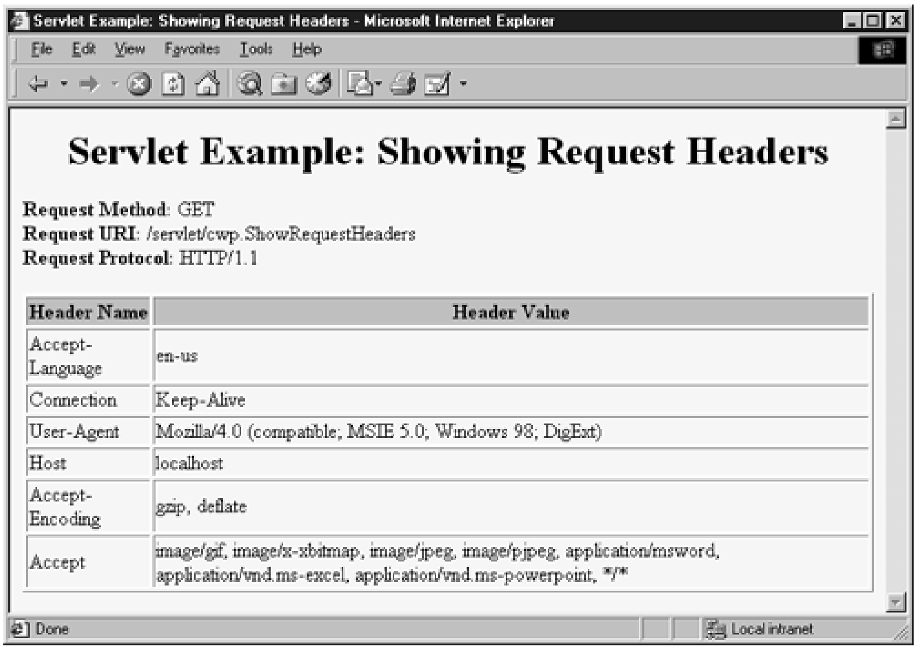

Servlet Example: Showing Request Headers - Netscape
File Edit View Go Communicator Help
Document: Done

Servlet Example: Showing Request Headers

Request Method: GET
Request URI: /servlet/cwp.ShowRequestHeaders
Request Protocol: HTTP/1.0

Header Name	Header Value
Accept-Language	en
Connection	Keep-Alive
User-Agent	Mozilla/4.7 [en] (Win98; U)
Accept-Charset	iso-8859-1,*,utf-8
Host	localhost
Accept-Encoding	gzip
Accept	image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, image/png, */*

Figure 19-7. Request headers sent by Internet Explorer 5.0 on Windows 98.


Servlet Example: Showing Request Headers - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Done
Local intranet

Servlet Example: Showing Request Headers

Request Method: GET
Request URI: /servlet/cwp.ShowRequestHeaders
Request Protocol: HTTP/1.1

Header Name	Header Value
Accept-Language	en-us
Connection	Keep-Alive
User-Agent	Mozilla/4.0 (compatible; MSIE 5.0; Windows 98; DigExt)
Host	localhost
Accept-Encoding	gzip, deflate
Accept	image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, application/msword, application/vnd.ms-excel, application/vnd.ms-powerpoint, */*

Listing 19.12 `ShowRequestHeaders.java`

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
import java.util.*;

/** Shows all the request headers sent on this request. */

public class ShowRequestHeaders extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String title = "Servlet Example: Showing Request Headers";
    out.println(ServletUtilities.headWithTitle(title) +
                "<BODY BGCOLOR=\"#FDF5E6\">\n" +
                "<H1 ALIGN=\"CENTER\">" + title + "</H1>\n" +
                "<B>Request Method: </B>" +
                request.getMethod() + "<BR>\n" +
                "<B>Request URI: </B>" +
                request.getRequestURI() + "<BR>\n" +
                "<B>Request Protocol: </B>" +
                request.getProtocol() + "<BR><BR>\n" +
                "<TABLE BORDER=1 ALIGN=\"CENTER\">\n" +
                "<TR BGCOLOR=\"#FFAD00\">\n" +
                "<TH>Header Name<TH>Header Value");
    Enumeration headerNames = request.getHeaderNames();
    while(headerNames.hasMoreElements()) {
      String headerName = (String)headerNames.nextElement();
      out.println("<TR><TD>" + headerName);
      out.println("    <TD>" + request.getHeader(headerName));
    }
    out.println("</TABLE>\n</BODY></HTML>");
  }

  /** Let the same servlet handle both GET and POST. */

  public void doPost(HttpServletRequest request,
                     HttpServletResponse response)
      throws ServletException, IOException {
    doGet(request, response);
  }
}
```

HTTP 1.1 Request Headers

Access to the request headers permits servlets to perform a number of optimizations and to provide a number of features not otherwise possible. This subsection summarizes the headers most often used by servlets. Note that HTTP 1.1 supports a superset of the headers permitted in HTTP 1.0. For additional details on these and other headers, see the HTTP 1.1 specification, given in RFC 2616. The official RFCs are archived in a number of places; your best bet is to start at http://www.rfc-editor.org/ to get a current list of the archive sites.

Accept This header specifies the MIME types that the browser or other clients can handle. A servlet that can return a resource in more than one format can examine the `Accept` header to decide which format to use. For example, images in PNG format have some compression advantages over those in GIF, but only a few browsers support PNG. If you had images in both formats, a servlet could call `request.getHeader("Accept")`, check for `image/png`, and if it finds a match, use *xxx*`.png` filenames in all the `IMG` elements it generates. Otherwise, it would just use *xxx*`.gif`.

See Table 19.1 in Section 19.10 (The Server Response: HTTP Response Headers) for the names and meanings of the common MIME types.

Accept-Charset This header indicates the character sets (e.g., ISO-8859-1) the browser can use.

Accept-Encoding This header designates the types of encodings that the client knows how to handle. If the server receives this header, it is free to encode the page by using the format specified (usually to reduce transmission time), sending the `Content-Encoding` response header to indicate that it has done so. This encoding type is completely distinct from the MIME type of the actual document (as specified in the `Content-Type` response header), since this encoding is reversed *before* the browser decides what to do with the content. On the other hand, using an encoding the browser doesn't understand results in totally incomprehensible pages. Consequently, it is critical that you explicitly check the `Accept-Encoding` header before using any type of content encoding. Values of `gzip` or `compress` are the two standard possibilities.

Compressing pages before returning them is a valuable service because the decoding time is likely to be small compared to the savings in transmission time. See the following subsection for an example where compression reduces download times by a factor of 10.

Accept-Language This header specifies the client's preferred languages in case the servlet can produce results in more than one language. The value of the header should be one of the standard language codes such as `en`, `en-us`, `da`, etc. See RFC 1766 for details.

Authorization This header is used by clients to identify themselves when accessing password-protected Web pages.

Connection This header tells whether or not the client can handle persistent HTTP connections. These let the client or other browser retrieve multiple files (e.g., an HTML file and several associated images) with a single socket connection, saving the overhead of negotiating several independent connections. With an HTTP 1.1 request, persistent connections are the default, and the client must specify a value of `close` for this header to use old-style connections. In HTTP 1.0, a value of `Keep-Alive` means that persistent connections should be used.

Each HTTP request results in a new invocation of a servlet, regardless of whether the request is a separate connection. That is, the server invokes the servlet only after the server has already read the HTTP request. This means that servlets need help from the server to handle persistent connections. Consequently, the servlet's job is just to make it *possible* for the server to use persistent connections, which the server does by sending a `Content-Length` response header.

Content-Length This header is only applicable to `POST` requests and gives the size of the `POST` data in bytes. Rather than calling `request.getIntHeader ("Content-Length")`, you can simply use `request.getContentLength()`. However, since servlets take care of reading the form data for you (see Section 19.6, "The Client Request: Form Data"), you rarely use this header explicitly.

Cookie This header is used to return cookies to servers that previously sent them to the browser. For details, see Section 19.11 (Cookies). Technically, `Cookie` is not part of HTTP 1.1. It was originally a Netscape extension but is now widely supported, including support by both Netscape and Internet Explorer.

Host Browsers and other clients are *required* to specify this header, which indicates the host and port as given in the original URL. Due to request forwarding and machines that have multiple hostnames, it is quite possible that the server could not otherwise determine this information. This header is not new in HTTP 1.1, but in HTTP 1.0 it was optional, not required.

If-Modified-Since This header indicates that the client wants the page only if it has been changed after the specified date. The server sends a 302 (Not Modified) header if no newer result is available. This option is useful because it lets browsers cache documents and reload them over the network only when they've changed. However, servlets don't need to deal directly with this header. Instead, they should just implement the `getLastModified` method to have the system handle modification dates automatically.

If-Unmodified-Since This header is the reverse of `If-Modified-Since`; it indicates that the operation should succeed only if the document is older than the specified date. Typically, `If-Modified-Since` is used for `GET` requests ("give me the document only if it is newer than my cached version"), whereas `If-Unmodified-Since` is used for `PUT` requests ("update this document only if nobody else has changed it since I generated it").

Referer This header indicates the URL of the referring Web page. For example, if you are at Web page 1 and click on a link to Web page 2, the URL of Web page 1 is included in the `Referer` header when the browser requests Web page 2. All major browsers set this header, so it is a useful way of tracking where requests came from. This capability is helpful for tracking advertisers who refer people to your site, for slightly changing content depending on the referring site, or simply for keeping track of where your traffic comes from. In the last case, most people simply rely on Web server log files, since the `Referer` is typically recorded there. Although the `Referer` header is useful, don't rely too heavily on it since it can easily be spoofed by a custom client. Finally, note that this header is `Referer`, not the expected `Referrer`, due to a spelling mistake by one of the original HTTP authors.

User-Agent This header identifies the browser or other client making the request and can be used to return different content to different types of browsers. Be wary of this usage, however; relying on a hard-coded list of browser versions and associated features can make for unreliable and hard-to-modify servlet code.

Whenever possible, use something specific in the HTTP headers instead. For example, instead of trying to remember which browsers support gzip on which platforms, simply check the `Accept-Encoding` header.

Most Internet Explorer versions list a "Mozilla" (Netscape) version first in their `User-Agent` line, with the real browser version listed parenthetically. This is done for compatibility with JavaScript, where the `User-Agent` header is sometimes used to determine which JavaScript features are supported. Also note that this header can be easily spoofed, a fact that calls into question the reliability of sites that use this header to "show" market penetration of various browser versions. Hmm, millions of dollars in marketing money riding on statistics that could be skewed by a custom client written in less than an hour, and we should take those numbers as accurate ones?

Sending Compressed Web Pages

Several recent browsers know how to handle gzipped content, automatically uncompressing documents that are marked with the `Content-Encoding` header and then treating the result as though it were the original document. Sending such compressed content can be a real time saver, since the time required to compress the document on the server and then uncompress it on the client is typically dwarfed by the savings in download time, especially when dialup connections are used.

Browsers that support content encoding include most versions of Netscape for Unix, Netscape 4.7 and later for Windows, and most versions of Internet Explorer for Windows. Earlier Netscape versions on Windows and Internet Explorer on nonWindows platforms generally do not support gzip compression. Fortunately, browsers that support this feature indicate that they do so by setting the `Accept-Encoding` request header. Listing 19.13 and Figure 19-8 show a servlet that checks this header, sending a compressed Web page to clients that support gzip encoding and sending a regular Web page to those that don't. The result showed a *tenfold* speedup for the compressed page when a dialup connection was used. In repeated tests with Netscape 4.7 and Internet Explorer 5.0 on a 28.8K modem connection, the compressed page averaged less than 5 seconds to completely download, whereas the uncompressed page consistently took more than 50 seconds.

Figure 19-8. Since the Windows version of Netscape 4.7 supports gzip (see Figure 19-6), this page was sent gzipped over the network and reconstituted by the browser, resulting in a large saving in download time.

graphics/19fig08.gif

Core Tip

Gzip compression can dramatically reduce the download time of long text pages.

Implementing compression is straightforward since the gzip format is built in to the Java programming languages through classes in `java.util.zip`. The servlet first checks the `Accept-Encoding` header to see if it contains an entry for gzip. If so, it uses a `GZIPOutputStream` to generate the page, specifying `gzip` as the value of the `Content-Encoding` header. You must explicitly call `close` when using a `GZIPOutputStream`. If gzip is not supported, the servlet uses the normal `PrintWriter` to send the page. To make it easy to compare compressed and uncompressed times with the same browser, we also added a feature whereby compression could be suppressed by including `?encoding=none` at the end of the URL.

Listing 19.13 `EncodedPage.java`

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
import java.util.zip.*;

/** Example showing benefits of gzipping pages to browsers
 *  that can handle gzip.
 */

public class EncodedPage extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    String encodings = request.getHeader("Accept-Encoding");
    String encodeFlag = request.getParameter("encoding");
    PrintWriter out;
    String title;
    if ((encodings != null) &&
        (encodings.indexOf("gzip") != -1) &&
        !"none".equals(encodeFlag)) {
      title = "Page Encoded with GZip";
      OutputStream out1 = response.getOutputStream();
      out = new PrintWriter(new GZIPOutputStream(out1), false);
      response.setHeader("Content-Encoding", "gzip");
    } else {
      title = "Unencoded Page";
      out = response.getWriter();
    }
    out.println(ServletUtilities.headWithTitle(title) +
                "<BODY BGCOLOR=\"#FDF5E6\">\n" +
                "<H1 ALIGN=\"CENTER\">" + title + "</H1>\n");
    String line = "Blah, blah, blah, blah, blah. " +
                  "Yadda, yadda, yadda, yadda.";
    for(int i=0; i<10000; i++) {
      out.println(line);
    }
    out.println("</BODY></HTML>");
    out.close();
    }
}
```

19.8 The Servlet Equivalent of the Standard CGI Variables

If you come to servlets with a background in traditional Common Gateway Interface (CGI) programming, you are probably used to the idea of "CGI variables." These are a somewhat eclectic collection of information about the current request. Some are based on the HTTP request line and headers (e.g., form data), others are derived from the socket itself (e.g., the name and IP address of the requesting host), and still others are taken from server installation parameters (e.g., the mapping of URLs to actual paths).

Although it probably makes more sense to think of different sources of data (request data, server information, etc.) as distinct, experienced CGI programmers may find it useful to see the servlet equivalent of each of the CGI variables. If you don't have a background in traditional CGI, first, count your blessings; servlets are easier to use, more flexible and more efficient than standard CGI. Second, just skim this section, noting the parts not directly related to the incoming HTTP request. In particular, observe that you can use `getServletContext().getRealPath` to map a URI (here, URI refers to the part of the URL that comes after the host and port) to an actual path and that you can use `request.getRemoteHost()` and `request.getRemoteAddress()` to get the name and IP address of the client.

AUTH_TYPE If an `Authorization` header was supplied, this variable gives the scheme specified (`basic` or `digest`). Access it with `request.getAuthType()`.

CONTENT_LENGTH For `POST` requests only, this variable stores the number of bytes of data sent, as given by the `Content-Length` request header. Technically, since the `CONTENT_LENGTH` CGI variable is a string, the servlet equivalent is `String.valueOf(request.getContentLength())` or `request.getHeader("Content-Length")`. You'll probably want to just call `request.getContentLength()`, which returns an `int`.

CONTENT_TYPE `CONTENT_TYPE` designates the MIME type of attached data, if specified See Table 19.1 in Section 19.10 (The Server Response: HTTP Response Headers) for the names and meanings of the common MIME types. Access `CONTENT_TYPE` with `request.getContentType()`.

DOCUMENT_ROOT The `DOCUMENT_ROOT` variable specifies the real directory corresponding to the URL `http://host/">http://host/`. Access it with `getServletContext().getRealPath("/")`. In older servlet specifications, you accessed this variable with `request.getRealPath("/")`; however, the older access method is no longer supported. Also, you can use `getServletContext ().getRealPath` to map an arbitrary URI (i.e., URL suffix that comes after the hostname and port) to an actual path on the local machine.

HTTP_XXX_YYY Variables of the form `HTTP_HEADER_NAME` were how CGI programs obtained access to arbitrary HTTP request headers. The `Cookie` header became `HTTP_COOKIE`, `User-Agent` became `HTTP_USER_AGENT`, `Referer` became `HTTP_REFERER`, and so forth. Servlets should just use `request.getHeader` or one of the shortcut methods described in Section 19.7 (The Client Request: HTTP Request Headers).

PATH_INFO This variable supplies any path information attached to the URL after the address of the servlet but before the query data. For example, with http://host/servlet/cwp.SomeServlet/foo/bar?baz=quux, the path information is /foo/bar. Since servlets, unlike standard CGI programs, can talk directly to the server, they don't need to treat path information specially. Path information could be sent as part of the regular form data and then translated by getServletContext().getRealPath. Access the value of PATH_INFO by using request.getPathInfo().

PATH_TRANSLATED PATH_TRANSLATED gives the path information mapped to a real path on the server. Again, with servlets there is no need to have a special case for path information, since a servlet can call getServletContext().getRealPath() to translate partial URLs into real paths. This translation is not possible with standard CGI because the CGI program runs entirely separately from the server. Access this variable by means of request.getPathTranslated().

QUERY_STRING For GET requests, this variable gives the attached data as a single string with values still URL-encoded. You rarely want the raw data in servlets; instead, use request.getParameter to access individual parameters, as described in Section 19.7 (The Client Request: HTTP Request Headers). However, if you do want the raw data, you can get it with request.getQueryString().

REMOTE_ADDR This variable designates the IP address of the client that made the request, as a String (e.g., "198.137.241.30"). Access it by calling request.getRemoteAddr().

REMOTE_HOST REMOTE_HOST indicates the fully qualified domain name (e.g., whitehouse.gov) of the client that made the request. The IP address is returned if the domain name cannot be determined. You can access this variable with request.getRemoteHost().

REMOTE_USER If an Authorization header was supplied and decoded by the server itself, the REMOTE_USER variable gives the user part, which is useful for session tracking in protected sites. Access it with request.getRemoteUser().

REQUEST_METHOD This variable stipulates the HTTP request type, which is usually GET or POST but is occasionally HEAD, PUT, DELETE, OPTIONS, or TRACE. Servlets rarely need to look up REQUEST_METHOD explicitly, since each of the request types is typically handled by a different servlet method (doGet, doPost, etc.). An exception is HEAD, which is handled automatically by the service method returning whatever headers and status codes the doGet method would use. Access this variable by means of request.getMethod().

SCRIPT_NAME This variable specifies the path to the servlet, relative to the server's root directory. It can be accessed through request.getServletPath().

SERVER_NAME SERVER_NAME gives the host name of the server machine. It can be accessed by means of request.getServerName().

SERVER_PORT This variable stores the port the server is listening on. Technically, the servlet equivalent is String.valueOf(request.getServerPort()), which returns a String. You'll usually just want request.getServerPort(), which returns an int.

SERVER_PROTOCOL The SERVER_PROTOCOL variable indicates the protocol name and version used in the request line (e.g., HTTP/1.0 or HTTP/1.1). Access it by calling request.getProtocol().

SERVER_SOFTWARE This variable gives identifying information about the Web server. Access it with `getServletContext().getServerInfo()`.

19.9 The Server Response: HTTP Status Codes

When a Web server responds to a request from a browser or other Web client, the response typically consists of a status line, some response headers, a blank line, and the document. Here is a minimal example:

```
HTTP/1.1 200 OK
Content-Type: text/plain

Hello World
```

The status line consists of the HTTP version (`HTTP/1.1` in the example above), a status code (an integer; 200 in the example), and a very short message corresponding to the status code (`OK` in the example). In most cases, all of the headers are optional except for `Content-Type`, which specifies the MIME type of the document that follows. Although most responses contain a document, some don't. For example, responses to `HEAD` requests should never include a document, and a variety of status codes essentially indicate failure and either don't include a document or include only a short error message document.

Servlets can perform a variety of important tasks by manipulating the status line and the response headers. For example, they can forward the user to other sites; indicate that the attached document is an image, Adobe Acrobat file, or HTML file; tell the user that a password is required to access the document; and so forth. This section discusses the most important status codes and what can be accomplished with them; the following section discusses the response headers.

Specifying Status Codes

As just described, the HTTP response status line consists of an HTTP version, a status code, and an associated message. Since the message is directly associated with the status code and the HTTP version is determined by the server, all a servlet needs to do is to set the status code. The way to do this is by the `setStatus` method of `HttpServletResponse`. If your response includes a special status code *and* a document, be sure to call `setStatus` *before* actually returning any of the content with the `PrintWriter`. That's because an HTTP response consists of the status line, one or more headers, a blank line, and the actual document, *in that order.* As discussed in Section 19.3 (Basic Servlet Structure), servlets do not necessarily buffer the document (version 2.1 servlets never do so), so you have to either set the status code before first using the `PrintWriter` or carefully check that the buffer hasn't been flushed and content actually sent to the browser.

Core Approach

*Set status codes **before** sending any document content to the client.*

The `setStatus` method takes an `int` (the status code) as an argument, but instead of using explicit numbers, for clarity and reliability use the constants defined in `HttpServletResponse`. The name of each constant is derived from the standard HTTP 1.1 message for each constant, all upper case with a prefix of `SC` (for *Status Code*) and spaces changed to underscores. Thus, since the message for 404 is "Not Found," the equivalent constant in `HttpServletResponse` is `SC_NOT_FOUND`. In version 2.1 of the servlet specification, there are three exceptions. The constant for code 302 is derived from the HTTP 1.0 message (Moved Temporarily), not the HTTP 1.1 message (Found), and the constants for codes 307 (Temporary Redirect) and 416 (Requested

Range Not Satisfiable) are missing altogether. Version 2.2 added the constant for 416, but the inconsistencies for 307 and 302 remain.

Although the general method of setting status codes is simply to call `response.setStatus (int)`, there are two common cases where a shortcut method in `HttpServletResponse` is provided. Just be aware that both of these methods throw `IOException`, whereas `setStatus` doesn't.

- **`public void sendError(int code, String message)`**

  The `sendError` method sends a status code (usually 404) along with a short message that is automatically formatted inside an HTML document and sent to the client.

- **`public void sendRedirect(String url)`**

  The `sendRedirect` method generates a 302 response along with a `Location` header giving the URL of the new document. With servlets version 2.1, this must be an absolute URL. In version 2.2, either an absolute or a relative URL is permitted; the system automatically translates relative URLs into absolute ones before putting them in the `Location` header.

Setting a status code does not necessarily mean that you don't need to return a document. For example, although most servers automatically generate a small "File Not Found" message for 404 responses, a servlet might want to customize this response. Again, remember that if you do send output, you have to call `setStatus` or `sendError` *first.*

HTTP 1.1 Status Codes

In this subsection we describe the most important status codes available for use in servlets talking to HTTP 1.1 clients, along with the standard message associated with each code. A good understanding of these codes can dramatically increase the capabilities of your servlets, so you should at least skim the descriptions to see what options are at your disposal. You can come back for details when you are ready to make use of some of the capabilities.

The complete HTTP 1.1 specification is given in RFC 2616, which you can access on-line by going to http://www.rfc-editor.org/ and following the links to the latest RFC archive sites. Codes that are new in HTTP 1.1 are noted, since some browsers support only HTTP 1.0. You should only send the new codes to clients that support HTTP 1.1, as verified by checking `request.getRequestProtocol`.

The rest of this section describes the specific status codes available in HTTP 1.1. These codes fall into five general categories:

- **100–199** Codes in the 100s are informational, indicating that the client should respond with some other action.
- **200–299** Values in the 200s signify that the request was successful.
- **300–399** Values in the 300s are used for files that have moved and usually include a `Location` header indicating the new address.
- **400–499** Values in the 400s indicate an error by the client.
- **500–599** Codes in the 500s signify an error by the server.

The constants in `HttpServletResponse` that represent the various codes are derived from the standard messages associated with the codes. In servlets, you usually refer to status codes only by means of these constants. For example, you would use `response.setStatus` (response.SC_NO_CONTENT) rather than response.setStatus(204), since the latter is unclear to readers and is prone to typographical errors. However, you should note that servers are allowed to vary the messages slightly, and clients pay attention only to the numeric value. So, for example, you might see a server return a status line of HTTP/1.1 200 Document Follows instead of HTTP/1.1 200 OK.

100 (Continue) If the server receives an Expect request header with a value of 100-continue, it means that the client is asking if it can send an attached document in a follow-up request. In such a case, the server should either respond with status 100 (SC_CONTINUE) to tell the client to go ahead or use 417 (Expectation Failed) to tell the browser it won't accept the document. This status code is new in HTTP 1.1.

200 (OK) A value of 200 (SC_OK) means that everything is fine. The document follows for GET and POST requests. This status is the default for servlets; if you don't use setStatus, you'll get 200.

201 (Created) A status code of 201 (SC_CREATED) signifies that the server created a new document in response to the request; the Location header should give its URL.

202 (Accepted) A value of 202 (SC_ACCEPTED) tells the client that the request is being acted upon, but processing is not yet complete.

204 (No Content) A status code of 204 (SC_NO_CONTENT) stipulates that the browser should continue to display the previous document because no new document is available. This behavior is useful if the user periodically reloads a page by pressing the Reload button, and you can determine that the previous page is already up-to-date.

205 (Reset Content) A value of 205 (SC_RESET_CONTENT) means that there is no new document, but the browser should reset the document view. This status code is used to force browsers to clear form fields. It is new in HTTP 1.1.

301 (Moved Permanently) The 301 (SC_MOVED_PERMANENTLY) status indicates that the requested document is elsewhere; the new URL for the document is given in the Location response header. Browsers should automatically follow the link to the new URL.

302 (Found) This value is similar to 301, except that in principle the URL given by the Location header should be interpreted as a temporary replacement, not a permanent one. In practice, most browsers treat 301 and 302 identically. Note: in HTTP 1.0, the message was Moved Temporarily instead of Found, and the constant in HttpServletResponse is SC_MOVED_TEMPORARILY, not the expected SC_FOUND.

Status code 302 is useful because browsers automatically follow the reference to the new URL given in the Location response header. It is so useful, in fact, that there is a special method for it, sendRedirect. Using response.sendRedirect(url) has a couple of advantages over using response.setStatus (response.SC_MOVED_TEMPORARILY) and response.setHeader ("Location", url). First, it is shorter and easier.

Second, with sendRedirect, the servlet automatically builds a page containing the link to show to older browsers that don't automatically follow redirects. Finally, with version 2.2 of servlets (the version in J2EE), sendRedirect can handle relative URLs, automatically translating them into absolute ones.

Technically, browsers are only supposed to automatically follow the redirection if the original request was `GET`. For details, see the discussion of the 307 status code.

Core Note

The constant representing 302 is `SC_MOVED_TEMPORARILY`, not `SC_FOUND`.

303 (See Other) The 303 (`SC_SEE_OTHER`) status is similar to 301 and 302, except that if the original request was `POST`, the new document (given in the `Location` header) should be retrieved with `GET`. This code is new in HTTP 1.1.

304 (Not Modified) When a client has a cached document, it can perform a conditional request by supplying an `If-Modified-Since` header to indicate that it only wants the document if it has been changed since the specified date. A value of 304 (`SC_NOT_MODIFIED`) means that the cached version is up-to-date and the client should use it. Otherwise, the server should return the requested document with the normal (200) status code. Servlets normally should not set this status code directly. Instead, they should implement the `getLastModified` method and let the default `service` method handle conditional requests based upon this modification date.

307 (Temporary Redirect) The rules for how a browser should handle a 307 status are identical to those for 302. The 307 value was added to HTTP 1.1 since many browsers erroneously follow the redirection on a 302 response even if the original message is a `POST`. Browsers are supposed to follow the redirection of a `POST` request only when they receive a 303 response status. This new status is intended to be unambiguously clear: follow redirected `GET` *and* `POST` requests in the case of 303 responses; follow redirected `GET` but *not* `POST` requests in the case of 307 responses. Note: For some reason there is no constant in `HttpServletResponse` corresponding to this status code, so you have to use 307 explicitly. This status code is new in HTTP 1.1.

400 (Bad Request) A 400 (`SC_BAD_REQUEST`) status indicates bad syntax in the client request.

401 (Unauthorized) A value of 401 (`SC_UNAUTHORIZED`) signifies that the client tried to access a password-protected page without proper identifying information in the `Authorization` header. The response must include a `WWW-Authenticate` header.

403 (Forbidden) A status code of 403 (`SC_FORBIDDEN`) means that the server refuses to supply the resource, regardless of authorization. This status is often the result of bad file or directory permissions on the server.

404 (Not Found) The infamous 404 (`SC_NOT_FOUND`) status tells the client that no resource could be found at that address. This value is the standard "no such page" response. It is such a common and useful response that there is a special method for it in the `HttpServletResponse` class: `sendError("message")`. The advantage of `sendError` over `setStatus` is that, with `sendError`, the server automatically generates an error page showing the error message. Unfortunately, however, the default behavior of Internet Explorer 5 is to ignore the error page you send back and to display its own, even though doing so contradicts the HTTP specification. To turn off this setting, you can go to the Tools menu, select Internet Options, choose the Advanced tab, and make sure "Show friendly HTTP error messages" box is not checked. Unfortunately, however, few users are aware of this setting, so this "feature" prevents most users of Internet Explorer version 5 from seeing any informative messages you return. Other major browsers and version 4 of Internet Explorer properly display server-generated error pages.

Core Warning

By default, Internet Explorer version 5 ignores server-generated error pages.

405 (Method Not Allowed) A 405 (SC_METHOD_NOT_ALLOWED) value indicates that the request method (GET, POST, HEAD, PUT, DELETE, etc.) was not allowed for this particular resource. This status code is new in HTTP 1.1.

410 (Gone) A value of 410 (SC_GONE) tells the client that the requested document is gone and no forwarding address is known. Status 410 differs from 404 in that the document is known to be permanently gone, not just unavailable for unknown reasons, as with 404. This status code is new in HTTP 1.1.

411 (Length Required) A status of 411 (SC_LENGTH_REQUIRED) signifies that the server cannot process the request (presumably a POST request with an attached document) unless the client sends a Content-Length header indicating the amount of data being sent to the server. This value is new in HTTP 1.1.

413 (Request Entity Too Large) A status code of 413 (SC_REQUEST_ENTITY_TOO_LARGE) tells the client that the requested document is bigger than the server wants to handle. If the server thinks it can handle the request later, it should include a Retry-After response header. This value is new in HTTP 1.1.

414 (Request URI Too Long) The 414 (SC_REQUEST_URI_TOO_LONG) status is used when the URI is too long. In this context, "URI" means the part of the URL that came after the host and port in the URL. For example, in http://www.y2k-disaster.com:8080/we/look/silly/now/, the URI is /we/look/silly/now/. This status code is new in HTTP 1.1.

415 (Unsupported Media Type) A value of 415 (SC_UNSUPPORTED_MEDIA_TYPE) means that the request had an attached document of a type the server doesn't know how to handle. This status code is new in HTTP 1.1.

417 (Expectation Failed) If the server receives an Expect request header with a value of 100-continue, it means that the client is asking if it can send an attached document in a follow-up request. In such a case, the server should either respond with this status (417) to tell the browser it won't accept the document or use 100 (SC_CONTINUE) to tell the client to go ahead. This status code is new in HTTP 1.1.

500 (Internal Server Error) 500 (SC_INTERNAL_SERVER_ERROR) is the generic "server is confused" status code. It often results from CGI programs or (heaven forbid!) servlets that crash or return improperly formatted headers.

501 (Not Implemented) The 501 (SC_NOT_IMPLEMENTED) status notifies the client that the server doesn't support the functionality to fulfill the request. It is used, for example, when the client issues a command like PUT that the server doesn't support.

503 (Service Unavailable) A status code of 503 (SC_SERVICE_UNAVAILABLE) signifies that the server cannot respond because of maintenance or overloading. For example, a servlet might return this header if some thread or database connection pool is currently full. The server can supply a Retry-After header to tell the client when to try again.

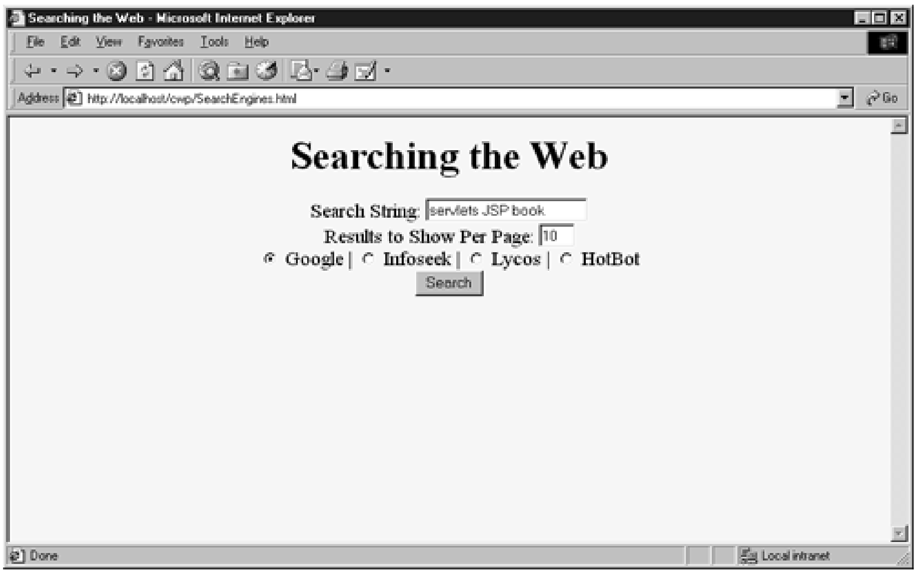
505 (HTTP Version Not Supported) The 505 (`SC_HTTP_VERSION_NOT_SUPPORTED`) code means that the server doesn't support the version of HTTP named in the request line. This status code is new in HTTP 1.1.

A Front End to Various Search Engines

Listing 19.14 presents an example that makes use of the two most common status codes other than 200 (OK): 302 (Found) and 404 (Not Found). The 302 code is set by the shorthand `sendRedirect` method of `HttpServletResponse`, and 404 is specified by `sendError`.

In this application, an HTML form (see Figure 19-9 and the source code in Listing 19.16) first displays a page that lets the user choose a search string, the number of results to show per page, and the search engine to use. When the form is submitted, the servlet extracts those three parameters, constructs a URL with the parameters embedded in a way appropriate to the search engine selected (see the `SearchSpec` class of Listing 19.15), and redirects the user to that URL (see Figure 19-10). If the user fails to choose a search engine or specify search terms, an error page informs the client of this fact (but see warning under the 404 status code in the previous subsection).

Figure 19-9. Front end to the `SearchEngines` servlet. See Listing 19.16 for the HTML source code.



Address: http://localhost/cwp/SearchEngines.html

Searching the Web

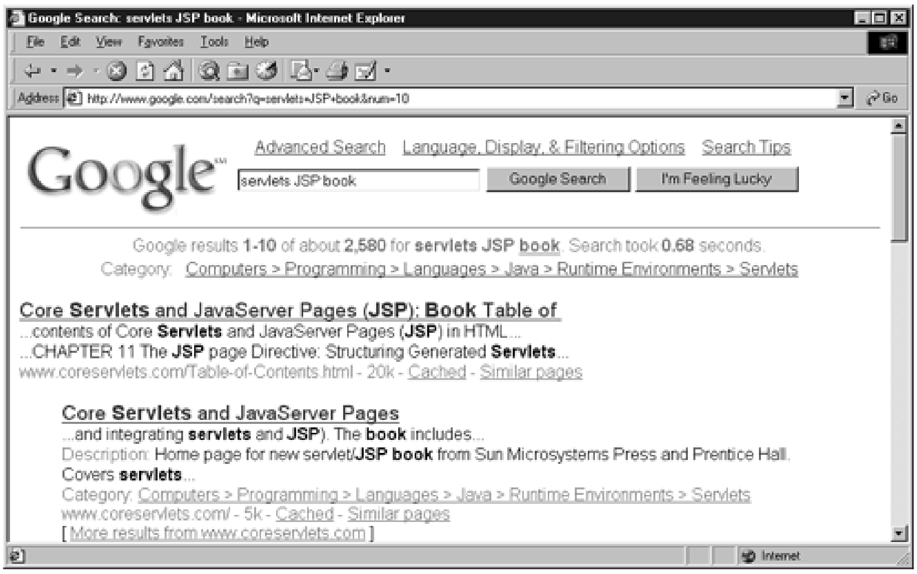
Search String: servlets JSP book

Results to Show Per Page: 10

● Google | ○ Infoseek | ○ Lycos | ○ HotBot

Search

Figure 19-10. Result of the `SearchEngines` servlet when the form of Figure 19-9 is submitted.


Google Search: servlets JSP book - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://www.google.com/search?q=servlets+JSP+book&num=10
Go
Google
Advanced Search Language, Display, & Filtering Options Search Tips
servlets JSP book
Google Search
I'm Feeling Lucky
Internet

Google results **1-10** of about **2,580** for **servlets JSP book**. Search took **0.68** seconds.
Category: Computers > Programming > Languages > Java > Runtime Environments > Servlets

Core **Servlets** and JavaServer Pages (**JSP**): **Book** Table of
...contents of Core **Servlets** and JavaServer Pages (**JSP**) in HTML...
...CHAPTER 11 The **JSP** page Directive: Structuring Generated **Servlets**...
www.coreservlets.com/Table-of-Contents.html - 20k - Cached - Similar pages

Core **Servlets** and JavaServer Pages
...and integrating **servlets** and **JSP**). The **book** includes...
Description: Home page for new servlet/**JSP book** from Sun Microsystems Press and Prentice Hall. Covers **servlets**...
Category: Computers > Programming > Languages > Java > Runtime Environments > Servlets
www.coreservlets.com/ - 5k - Cached - Similar pages
[More results from www.coreservlets.com]

Listing 19.14 **SearchEngines.java**

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
import java.net.*;
/** Servlet that takes a search string, number of results per
 *  page, and a search engine name, sending the query to
 *  that search engine. Illustrates manipulating
 *  the response status line. It sends a 302 response
 *  (via sendRedirect) if it gets a known search engine,
 *  and sends a 404 response (via sendError) otherwise.
 */

public class SearchEngines extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    String searchString = request.getParameter("searchString");
    if ((searchString == null) ||
        (searchString.length() == 0)) {
      reportProblem(response, "Missing search string.");
      return;
    }
    // The URLEncoder changes spaces to "+" signs and other
    // non-alphanumeric characters to "%XY", where XY is the
    // hex value of the ASCII (or ISO Latin-1) character.
    // Browsers always URL-encode form values, so the
    // getParameter method decodes automatically. But since
    // we're just passing this on to another server, we need to
    // re-encode it.
    searchString = URLEncoder.encode(searchString);
    String numResults = request.getParameter("numResults");
    if ((numResults == null) ||
        (numResults.equals("0")) ||
        (numResults.length() == 0)) {
      numResults = "10";
    }
    String searchEngine =
      request.getParameter("searchEngine");
    if (searchEngine == null) {
      reportProblem(response, "Missing search engine name.");
      return;
    }
    SearchSpec[] commonSpecs = SearchSpec.getCommonSpecs();
    for(int i=0; i<commonSpecs.length; i++) {
      SearchSpec searchSpec = commonSpecs[i];
      if (searchSpec.getName().equals(searchEngine)) {
        String url =
          searchSpec.makeURL(searchString, numResults);
        response.sendRedirect(url);
        return;
      }
    }
    reportProblem(response, "Unrecognized search engine.");
  }

  private void reportProblem(HttpServletResponse response,
                             String message)
      throws IOException {
    response.sendError(response.SC_NOT_FOUND,
                       "<H2>" + message + "</H2>");
  }

  public void doPost(HttpServletRequest request,
                     HttpServletResponse response)
      throws ServletException, IOException {
    doGet(request, response);
  }
}
```

Listing 19.15 **SearchSpec.java**

```
package cwp;

/** Small class that encapsulates how to construct a
 *  search string for a particular search engine.
 */

public class SearchSpec {
  private String name, baseURL, numResultsSuffix;

  private static SearchSpec[] commonSpecs =
    { new SearchSpec("google",
                     "http://www.google.com/search?q=",
                     "&num="),
      new SearchSpec("infoseek",
                     "http://infoseek.go.com/Titles?qt=",
                     "&nh="),
      new SearchSpec("lycos",
                     "http://lycospro.lycos.com/cgi-bin/" +
                        "pursuit?query=",
                     "&maxhits="),
      new SearchSpec("hotbot",
                     "http://www.hotbot.com/?MT=",
                     "&DC=")
    };

  public SearchSpec(String name,
                    String baseURL,
                    String numResultsSuffix) {
    this.name = name;
    this.baseURL = baseURL;
    this.numResultsSuffix = numResultsSuffix;
  }

  public String makeURL(String searchString,
                        String numResults) {
    return(baseURL + searchString +
           numResultsSuffix + numResults);
  }

  public String getName() {
    return(name);
  }

  public static SearchSpec[] getCommonSpecs() {
    return(commonSpecs);
  }
}
```

Listing 19.16 **SearchEngines.html**

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
  <TITLE>Searching the Web</TITLE>
</HEAD>

<BODY BGCOLOR="#FDF5E6">
<H1 ALIGN="CENTER">Searching the Web</H1>

<FORM ACTION="/servlet/cwp.SearchEngines">
  <CENTER>
    Search String:
    <INPUT TYPE="TEXT" id="searchString"><BR>
    Results to Show Per Page:
```

```
    <INPUT TYPE="TEXT" id="numResults"
                       VALUE=10 SIZE=3><BR>
    <INPUT TYPE="RADIO" id="searchEngine"
                        VALUE="google">
    Google |
    <INPUT TYPE="RADIO" id="searchEngine"
                        VALUE="infoseek">
    Infoseek |
    <INPUT TYPE="RADIO" id="searchEngine"
                        VALUE="lycos">
    Lycos |
    <INPUT TYPE="RADIO" id="searchEngine"
                        VALUE="hotbot">
    HotBot
    <BR>
    <INPUT TYPE="SUBMIT" VALUE="Search">
  </CENTER>
</FORM>

</BODY>
</HTML>
```

19.10 The Server Response: HTTP Response Headers

As discussed in the previous section, a response from a Web server normally consists of a status line, one or more response headers, a blank line, and the document. To get the most out of your servlets, you need to know how to use the status line and response headers effectively, not just how to generate the document.

Setting the HTTP response headers often goes hand in hand with setting the status codes in the status line, as discussed in the previous section. For example, all the "document moved" status codes (300 through 307) have an accompanying `Location` header, and a 401 (`Unauthorized`) code always includes an accompanying `WWW-Authenticate` header. However, specifying headers can also play a useful role even when no unusual status code is set. Response headers can be used to specify cookies, to supply the page modification date (for client-side caching), to instruct the browser to reload the page after a designated interval, to give the file size so that persistent HTTP connections can be used, to designate the type of document being generated, and to perform many other tasks.

Setting Response Headers from Servlets

The most general way to specify headers is to use the `setHeader` method of `HttpServletResponse`. This method takes two strings: the header name and the header value. As with setting status codes, you must specify headers *before* returning the actual document.

In addition to the general-purpose `setHeader` method, `HttpServletResponse` also has two specialized methods to set headers that contain dates and integers:

- **`setDateHeader(String header, long milliseconds)`** This method saves you the trouble of translating a Java date in milliseconds since 1970 (as returned by `System.currentTimeMillis`, `Date.getTime`, or `Calendar.getTimeInMillis`) into a GMT time string.

- **`setIntHeader(String header, int headerValue)`** This method spares you the minor inconvenience of converting an `int` to a `String` before inserting it into a header.

HTTP allows multiple occurrences of the same header name, and you sometimes want to add a new header rather than replace any existing header with the same name. For example, it is quite common to have multiple `Accept` and `Set-Cookie` headers that specify different supported MIME types and different cookies, respectively. With servlets version 2.1, `setHeader`, `setDateHeader` and `setIntHeader`, always *add* new headers, so there is no way to "unset" headers that were set earlier (e.g., by an inherited method). With servlets version 2.2, `setHeader`, `setDateHeader`, and `setIntHeader` *replace* any existing headers of the same name, whereas `addHeader`, `addDateHeader`, and `addIntHeader` add a header regardless of whether a header of that name already exists. If it matters to you whether a specific header has already been set, use `containsHeader` to check.

Finally, `HttpServletResponse` also supplies a number of convenience methods for specifying common headers. These methods are summarized as follows.

- **`setContentType`** This method sets the `Content-Type` header and is used by the majority of servlets.

- **`setContentLength This method sets the Content-Length`** header, which is useful if the browser supports persistent (keep-alive) HTTP connections.

- **`addCookie`** This method inserts a cookie into the `Set-Cookie` header. There is no corresponding `setCookie` method, since it is normal to have multiple `Set-Cookie` lines. See Section 19.11 (Cookies) for a discussion of cookies.

- **`sendRedirect`** As discussed in the previous section, the `sendRedirect` method sets the `Location` header as well as setting the status code to 302. See Listing 19.14 for an example.

HTTP 1.1 Response Headers

Following is a summary of the most useful HTTP 1.1 response headers. A good understanding of these headers can increase the effectiveness of your servlets, so you should at least skim the descriptions to see what options are at your disposal. You can come back for details when you are ready to use the capabilities.

These headers are a superset of those permitted in HTTP 1.0. For additional details on these headers, see the HTTP 1.1 specification, given in RFC 2616. The official RFCs are on-line in various places; your best bet is to start at http://www.rfc-editor.org/ to get a current list of the archive sites. Header names are not case sensitive but are traditionally written with the first letter of each word capitalized.

Be cautious in writing servlets whose behavior depends on response headers that are only available in HTTP 1.1, especially if your servlet needs to run on the WWW "at large," rather than on an intranet—many older browsers support only HTTP 1.0. It is best to explicitly check the HTTP version with `request.getRequestProtocol` before using new headers.

Allow The `Allow` header specifies the request methods (`GET`, `POST`, etc.) that the server supports. It is required for 405 (`Method Not Allowed`) responses. The default `service` method of servlets automatically generates this header for `OPTIONS` requests.

Cache-Control This useful header tells the browser or other client the circumstances in which the response document can safely be cached. It has the following possible values:

- **`public`:** Document is cacheable, even if normal rules (e.g., for password-protected pages) indicate that it shouldn't be.

- **`private`:** Document is for a single user and can only be stored in private (nonshared) caches.

- **`no-cache`:** Document should never be cached (i.e., used to satisfy a later request). The server can also specify "`no-cache="header1,header2,...,headerN"`" to indicate the headers that should be omitted if a cached response is later used. Browsers normally do not cache documents that were retrieved by requests that include form data. However, if a servlet generates different content for different requests even when the requests contain no form data, it is critical to tell the browser not to cache the response. Since older browsers use the `Pragma` header for this purpose, the typical servlet approach is to set *both* headers, as in the following example.

  ```
  response.setHeader("Cache-Control", "no-cache");
  response.setHeader("Pragma", "no-cache");
  ```

- **`no-store`:** Document should never be cached and should not even be stored in a temporary location on disk. This header is intended to prevent inadvertent copies of sensitive information.

- **`must-revalidate`:** Client must revalidate document with original server (not just intermediate proxies) each time it is used.

- **`proxy-revalidate`:** This is the same as `must-revalidate`, except that it applies only to shared caches.

- **`max-age=`***xxx:* Document should be considered stale after *xxx* seconds. This is a convenient alternative to the `Expires` header but only works with HTTP 1.1 clients. If both `max-age` and `Expires` are present in the response, the `max-age` value takes precedence.

- **`s-max-age=`***xxx:* Shared caches should consider the document stale after *xxx* seconds.

Connection A value of `close` for this response header instructs the browser not to use persistent HTTP connections. Technically, persistent connections are the default when the client supports HTTP 1.1 and does *not* specify a "`Connection: close`" request header (or when an HTTP 1.0 client specifies "`Connection: keep-alive`"). However, since persistent connections require a `Content-Length` response header, there is no reason for a servlet to explicitly use the `Connection` header. Just omit the `Content-Length` header if you aren't using persistent connections.

The `Cache-Control` header is new in HTTP 1.1.

Content-Encoding This header indicates the way in which the page was encoded during transmission. The browser should reverse the encoding before deciding what to do with the document. Compressing the document with gzip can result in huge savings in transmission time; for an example, see Section 19.7 (The Client Request: HTTP Request Headers).

Content-Language The `Content-Language` header signifies the language in which the document is written. The value of the header should be one of the standard language codes such as `en`, `en-us`, `da`, etc. See RFC 1766 for details (you can access RFCs on-line at one of the archive sites listed at http://www.rfc-editor.org/).

Content-Length This header indicates the number of bytes in the response. This information is needed only if the browser is using a persistent (keep-alive) HTTP connection. See the `Connection` header for determining when the browser supports persistent connections. If you want your servlet to take advantage of persistent connections when the browser supports it, your servlet should write the document into a `ByteArrayOutputStream`, look up its size when done, put that into the `Content-Length` field with `response.setContentLength`, then send the content by `byteArrayStream.writeTo(response.getOutputStream())`.

Content-Type The `Content-Type` header gives the MIME (Multipurpose Internet Mail Extension) type of the response document. Setting this header is so common that there is a special method in `HttpServletResponse` for it: `setContentType`. MIME types are of the form `maintype/subtype` for officially registered types, and of the form `maintype/x-subtype` for unregistered types. The default MIME type for servlets is `text/plain`, but servlets usually explicitly specify `text/html`. They can, however, specify other types instead.

Table 19.1 lists some the most common MIME types used by servlets.

For more detail, many of the common MIME types are listed in RFC 1521 and RFC 1522 (again, see http://www.rfc-editor.org/ for a list of RFC archive sites). However, new MIME types are registered all the time, so a dynamic list is a better place to look. The officially registered types are listed at http://www.isi.edu/in-notes/iana/assignments/media-types/media-types. For common unregistered types, http://www.ltsw.se/knbase/internet/mime.htp is a good source.

Table 19.1. Common MIME Types

Type	***Meaning***
application/msword	Microsoft Word document
application/octet--stream	Unrecognized or binary data
application/pdf	Acrobat (.pdf) file
application/postscript	PostScript file
application/vnd.lotus--notes	Lotus Notes file
application/vnd.ms--excel	Excel spreadsheet
application/vnd.ms--powerpoint	PowerPoint presentation
application/x--gzip	Gzip archive
application/x--java--archive	JAR file
application/x--java--serialized--object	Serialized Java object
application/x--java--vm	Java bytecode (.class) file
application/zip	Zip archive
audio/basic	Sound file in .au or .snd format
audio/x--aiff	AIFF sound file
audio/x--wav	Microsoft Windows sound file
audio/midi	MIDI sound file
text/css	HTML cascading style sheet
text/html	HTML document
text/plain	Plain text
image/gif	GIF image
image/jpeg	JPEG image
image/png	PNG image

image/tiff	TIFF image
image/x--xbitmap	X Windows bitmap image
video/mpeg	MPEG video clip
video/quicktime	QuickTime video clip

Expires This header stipulates the time at which the content should be considered out-of-date and thus no longer be cached. A servlet might use this for a document that changes relatively frequently, to prevent the browser from displaying a stale cached value. For example, the following would instruct the browser not to cache the document for longer than 10 minutes.

```
long currentTime = System.currentTimeMillis();
long tenMinutes = 10*60*1000; // In milliseconds
response.setDateHeader("Expires",
                       currentTime + tenMinutes);
```

Also see the `max-age` value of the `Cache-Control` header.

Last-Modified This very useful header indicates when the document was last changed. The client can then cache the document and supply a date by an `If-Modified-Since` request header in later requests. This request is treated as a conditional `GET`, with the document being returned only if the `Last-Modified` date is later than the one specified for `If-Modified-Since`. Otherwise, a 304 (`Not Modified`) status line is returned, and the client uses the cached document. If you set this header explicitly, use the `setDateHeader` method to save yourself the bother of formatting GMT date strings. However, in most cases you simply implement the `getLastModified` method and let the standard `service` method handle `If-Modified-Since` requests.

Location This header, which should be included with all responses that have a status code in the 300s, notifies the browser of the document address. The browser automatically reconnects to this location and retrieves the new document. This header is usually set indirectly, along with a 302 status code, by the `sendRedirect` method of `HttpServletResponse`. An example is given in the previous section.

Pragma Supplying this header with a value of `no-cache` instructs HTTP 1.0 clients not to cache the document. However, support for this header was inconsistent with HTTP 1.0 browsers. In HTTP 1.1, "`Cache-Control: no-cache`" is a more reliable replacement.

Refresh This header indicates how soon (in seconds) the browser should ask for an updated page. For example, to tell the browser to ask for a new copy in 30 seconds, you would specify a value of 30 with

```
response.setIntHeader("Refresh", 30)
```

Note that `Refresh` does not stipulate continual updates; it just specifies when the *next* update should be. So, you have to continue to supply `Refresh` in all subsequent responses, and sending a 204 (`No Content`) status code stops the browser from reloading further. For an example, see the following subsection.

Instead of having the browser just reload the current page, you can specify the page to load. You do this by supplying a semicolon and a URL after the refresh time. For example, to tell the browser to go to `http://host/path` after 5 seconds, you would do the following.

```
response.setHeader("Refresh", "5; URL=http://host/path/")
```

This setting is useful for "splash screens," where an introductory image or message is displayed briefly before the real page is loaded.

Note that this header is commonly set indirectly by putting

```
<META HTTP-EQUIV="Refresh"
      CONTENT="5; URL=http://host/path/">
```

in the HEAD section of the HTML page, rather than as an explicit header from the server. That usage came about because automatic reloading or forwarding is something often desired by authors of static HTML pages. For servlets, however, setting the header directly is easier and clearer.

This header is not officially part of HTTP 1.1 but is an extension supported by both Netscape and Internet Explorer.

Retry-After This header can be used in conjunction with a 503 (Service Unavailable) response to tell the client how soon it can repeat its request.

Set-Cookie The Set-Cookie header specifies a cookie associated with the page. Each cookie requires a separate Set-Cookie header. Servlets should not use response.setHeader("Set-Cookie", ...) but instead should use the special-purpose addCookie method of HttpServletResponse. For details, see Section 19.11 (Cookies). Technically, Set-Cookie is not part of HTTP 1.1. It was originally a Netscape extension but is now widely supported, including support in both Netscape and Internet Explorer.

WWW-Authenticate This header is always included with a 401 (Unauthorized) status code. It tells the browser what authorization type and realm the client should supply in its Authorization header. Frequently, servlets let password-protected Web pages be handled by the Web server's specialized mechanisms (e.g., .htaccess or declarative security in J2EE servers) rather than handling them directly.

Persistent Servlet State and Auto-Reloading Pages

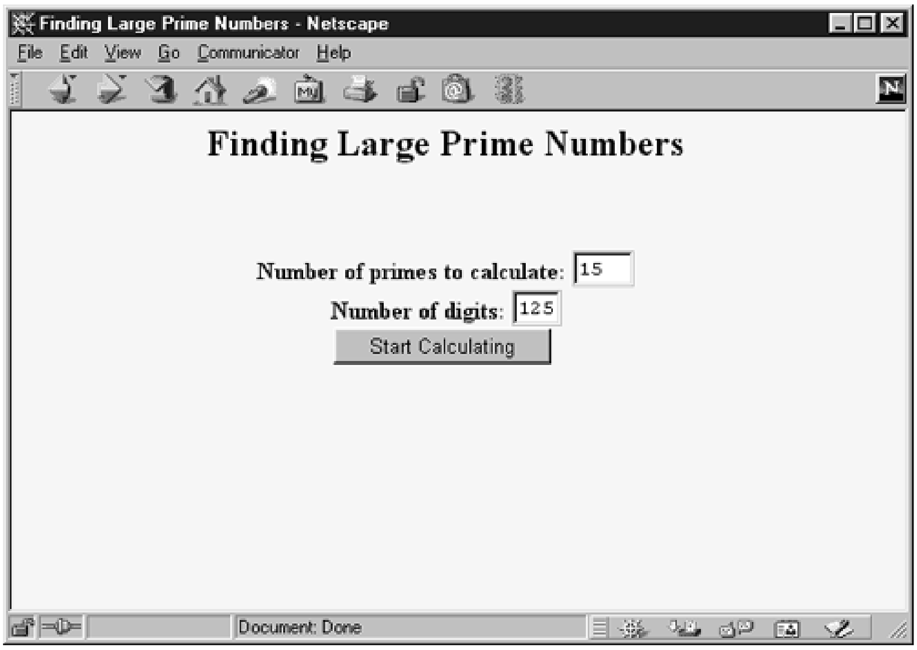
Here is an example that lets you ask for a list of some large, randomly chosen prime numbers. This computation may take some time for very large numbers (e.g., 150 digits), so the servlet immediately returns initial results but then keeps calculating, using a low-priority thread so that it won't degrade Web server performance. If the calculations are not complete, the servlet uses the Refresh header to instruct the browser to ask for a new page in a few seconds.

In addition to illustrating the value of HTTP response headers, this example shows two other valuable servlet capabilities. First, it shows that the same servlet can handle multiple simultaneous connections, each with its own thread. So, while one thread is finishing a calculation for one client, another client can connect and still see partial results.

Second, this example shows how easy it is for servlets to maintain state between requests, something that is cumbersome to implement in traditional CGI and many CGI alternatives. Only a single instance of the servlet is created, and each request simply results in a new thread calling the servlet's service method (which calls doGet or doPost). So, shared data simply has to be placed in a regular instance variable (field) of the servlet. Thus, the servlet can access the appropriate ongoing calculation when the browser reloads the page and can keep a list of the *N* most recently requested results, returning them immediately if a new request specifies the same parameters as a recent one. Of course, the normal rules that require authors to synchronize multithreaded access to shared data still apply to servlets. Servlets can also store persistent data in the `ServletContext` object that is available through the `getServletContext` method. `ServletContext` has `setAttribute` and `getAttribute` methods that let you store arbitrary data associated with specified keys. The difference between storing data in instance variables and storing it in the `ServletContext` is that the `ServletContext` is shared by all servlets in the servlet engine (or in the Web application, if your server supports such a capability).

Listing 19.17 shows the main servlet class. First, it receives a request that specifies two parameters: `numPrimes` and `numDigits`. These values are normally collected from the user and sent to the servlet by means of a simple HTML form. Listing 19.18 shows the source code and Figure 19-11 shows the result. Next, these parameters are converted to integers by means of a simple utility that uses `Integer.parseInt` (see Listing 19.21). These values are then matched by the `findPrimeList` method to a `Vector` of recent or ongoing calculations to see if there is a previous computation corresponding to the same two values. If so, that previous value (of type `PrimeList`) is used; otherwise, a new `PrimeList` is created and stored in the ongoing-calculations `Vector`, potentially displacing the oldest previous list. Next, that `PrimeList` is checked to determine if it has finished finding all of its primes. If not, the client is sent a `Refresh` header to tell it to come back in five seconds for updated results. Either way, a list of the current values is returned to the client. Figure 19-12 shows intermediate results; Figure 19-13 shows the final result.

Figure 19-11. Result of `PrimeNumbers.html`, used as a front end to the `PrimeNumbers` servlet.

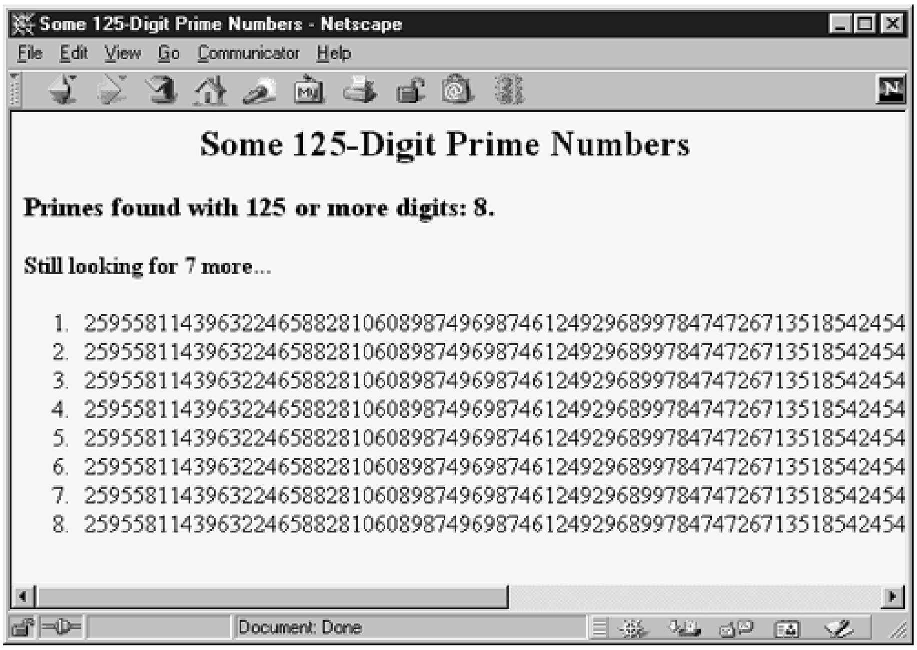


Finding Large Prime Numbers

Number of primes to calculate: 15

Number of digits: 125

Figure 19-12. Intermediate result of a request to the `PrimeNumbers` servlet. This result can be obtained when the browser reloads automatically or when a different client independently enters the same parameters as those from an ongoing or recent request. Either way, the browser will automatically reload the page to get updated results.


Some 125-Digit Prime Numbers - Netscape
File Edit View Go Communicator Help
Document: Done

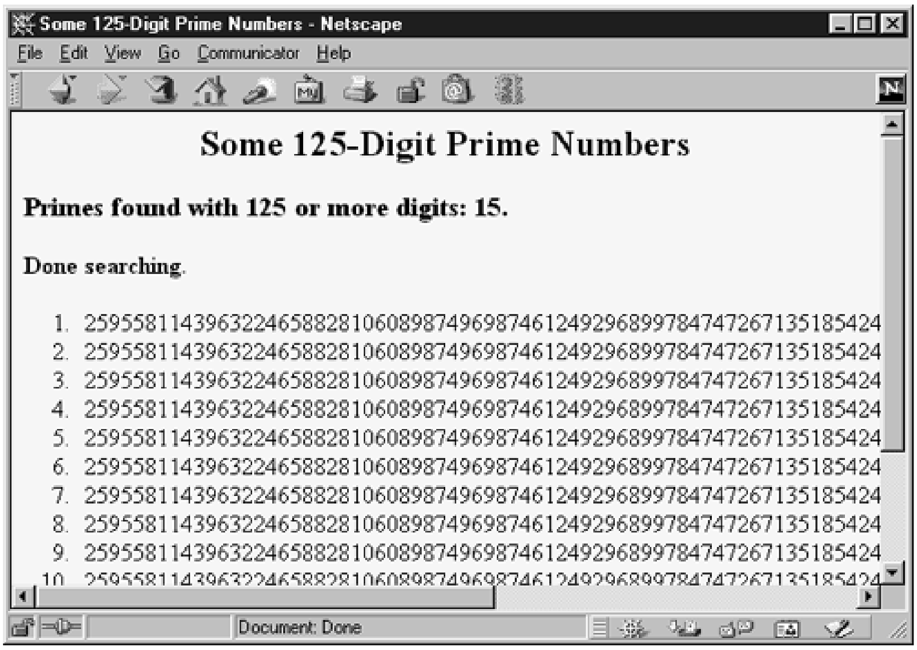
Some 125-Digit Prime Numbers

Primes found with 125 or more digits: 8.

Still looking for 7 more...

1. 25955811439632246588281060898749698746124929689978474726713518542454
2. 25955811439632246588281060898749698746124929689978474726713518542454
3. 25955811439632246588281060898749698746124929689978474726713518542454
4. 25955811439632246588281060898749698746124929689978474726713518542454
5. 25955811439632246588281060898749698746124929689978474726713518542454
6. 25955811439632246588281060898749698746124929689978474726713518542454
7. 25955811439632246588281060898749698746124929689978474726713518542454
8. 25955811439632246588281060898749698746124929689978474726713518542454

Figure 19-13. Final result of a request to the `PrimeNumbers` servlet. This result can be obtained when the browser reloads automatically or when a different client independently enters the same parameters as those from an ongoing or recent request. The browser will stop updating the page at this point.


Some 125-Digit Prime Numbers - Netscape
File Edit View Go Communicator Help
Document: Done

Some 125-Digit Prime Numbers

Primes found with 125 or more digits: 15.

Done searching.

1. 259558114396322465882810608987496987461249296899784747267135185424
2. 259558114396322465882810608987496987461249296899784747267135185424
3. 259558114396322465882810608987496987461249296899784747267135185424
4. 259558114396322465882810608987496987461249296899784747267135185424
5. 259558114396322465882810608987496987461249296899784747267135185424
6. 259558114396322465882810608987496987461249296899784747267135185424
7. 259558114396322465882810608987496987461249296899784747267135185424
8. 259558114396322465882810608987496987461249296899784747267135185424
9. 259558114396322465882810608987496987461249296899784747267135185424
10. 259558114396322465882810608987496987461249296899784747267135185424

Listings 19.19 (PrimeList.java) and 19.20 (Primes.java) present auxiliary code used by the servlet. `PrimeList.java` handles the background thread for the creation of a list of primes for a specific set of values. `Primes.java` contains the low-level algorithms for choosing a random number of a specified length and then finding a prime at or above that value. It uses built-in methods in the `BigInteger` class for determining if the number is prime.

Listing 19.17 `PrimeNumbers.java`

```
package cwp;
```

```
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
import java.util.*;

/** Servlet that processes a request to generate n
 *  prime numbers, each with at least m digits.
 *  It performs the calculations in a low--priority background
 *  thread, returning only the results it has found so far.
 *  If these results are not complete, it sends a Refresh
 *  header instructing the browser to ask for new results a
 *  little while later. It also maintains a list of a
 *  small number of previously calculated prime lists
 *  to return immediately to anyone who supplies the
 *  same n and m as a recent completed computation.
 */

public class PrimeNumbers extends HttpServlet {
  private Vector primeListVector = new Vector();
  private int maxPrimeLists = 30;

  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    int numPrimes =
      ServletUtilities.getIntParameter(request,
                                       "numPrimes", 50);
    int numDigits =
      ServletUtilities.getIntParameter(request,
                                       "numDigits", 120);
    PrimeList primeList =
      findPrimeList(primeListVector, numPrimes, numDigits);
    if (primeList == null) {
      primeList = new PrimeList(numPrimes, numDigits, true);
      // Multiple servlet request threads share the instance
      // variables (fields) of PrimeNumbers. So
      // synchronize all access to servlet fields.
      synchronized(primeListVector) {
        if (primeListVector.size() >= maxPrimeLists)
          primeListVector.removeElementAt(0);
        primeListVector.addElement(primeList);
      }
    }
    Vector currentPrimes = primeList.getPrimes();
    int numCurrentPrimes = currentPrimes.size();
    int numPrimesRemaining = (numPrimes -- numCurrentPrimes);
    boolean isLastResult = (numPrimesRemaining == 0);
    if (!isLastResult) {
      response.setHeader("Refresh", "5");
    }
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String title = "Some " + numDigits + "--Digit Prime Numbers";
    out.println(ServletUtilities.headWithTitle(title) +
                "<BODY BGCOLOR=\"#FDF5E6\">\n" +
                "<H2 ALIGN=CENTER>" + title + "</H2>\n" +
                "<H3>Primes found with " + numDigits +
                " or more digits: " + numCurrentPrimes +
                ".</H3>");
    if (isLastResult)
      out.println("<B>Done searching.</B>");
    else
      out.println("<B>Still looking for " + numPrimesRemaining +
                  " more<BLINK>...</BLINK></B>");
    out.println("<OL>");
    for(int i=0; i<numCurrentPrimes; i++) {
      out.println("  <LI>" + currentPrimes.elementAt(i));
    }
    out.println("</OL>");
    out.println("</BODY></HTML>");
  }

  public void doPost(HttpServletRequest request,
                     HttpServletResponse response)
      throws ServletException, IOException {
    doGet(request, response);
  }
  // See if there is an existing ongoing or completed
  // calculation with the same number of primes and number
  // of digits per prime. If so, return those results instead
  // of starting a new background thread. Keep this list
  // small so that the Web server doesn't use too much memory.
  // Synchronize access to the list since there may be
  // multiple simultaneous requests.

  private PrimeList findPrimeList(Vector primeListVector,
                                  int numPrimes,
                                  int numDigits) {
    synchronized(primeListVector) {
      for(int i=0; i<primeListVector.size(); i++) {
        PrimeList primes =
          (PrimeList)primeListVector.elementAt(i);
        if ((numPrimes == primes.numPrimes()) &&
            (numDigits == primes.numDigits()))
          return(primes);
      }
      return(null);
    }
  }
}
```

Listing 19.18 `PrimeNumbers.html`

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
```

```
<HTML>
<HEAD>
  <TITLE>Finding Large Prime Numbers</TITLE>
</HEAD>

<BODY BGCOLOR="#FDF5E6">
<H2 ALIGN="CENTER">Finding Large Prime Numbers</H2>
<BR><BR>
<CENTER>
<FORM ACTION="/servlet/cwp.PrimeNumbers">
  <B>Number of primes to calculate:</B>
  <INPUT TYPE="TEXT" id="numPrimes" VALUE=25 SIZE=4><BR>
  <B>Number of digits:</B>
  <INPUT TYPE="TEXT" id="numDigits" VALUE=150 SIZE=3><BR>
  <INPUT TYPE="SUBMIT" VALUE="Start Calculating">
</FORM>
</CENTER>
</BODY>
</HTML>
```

Listing 19.19 `PrimeList.java`

```
package cwp;

import java.util.*;
import java.math.BigInteger;

/** Creates a Vector of large prime numbers, usually in
 *  a low--priority background thread. Provides a few small
 *  thread--safe access methods.
 */

public class PrimeList implements Runnable {
  private Vector primesFound;
  private int numPrimes, numDigits;

  /** Finds numPrimes prime numbers, each of which is
   *  numDigits long or longer. You can set it to only
   *  return when done, or have it return immediately,
   *  and you can later poll it to see how far it
   *  has gotten.
   */
  public PrimeList(int numPrimes, int numDigits,
                   boolean runInBackground) {
    // Using Vector instead of ArrayList
    // to support JDK 1.1 servlet engines
    primesFound = new Vector(numPrimes);
    this.numPrimes = numPrimes;
    this.numDigits = numDigits;
    if (runInBackground) {
      Thread t = new Thread(this);
      // Use low priority so you don't slow down server.
      t.setPriority(Thread.MIN_PRIORITY);
      t.start();
    } else {
      run();
    }
  }

  public void run() {
    BigInteger start = Primes.random(numDigits);
    for(int i=0; i<numPrimes; i++) {
      start = Primes.nextPrime(start);
      synchronized(this) {
        primesFound.addElement(start);
      }
    }
  }

  public synchronized boolean isDone() {
    return(primesFound.size() == numPrimes);
  }

  public synchronized Vector getPrimes() {
    if (isDone())
      return(primesFound);
    else
      return((Vector)primesFound.clone());
  }

  public int numDigits() {
    return(numDigits);
  }

  public int numPrimes() {
    return(numPrimes);
  }

  public synchronized int numCalculatedPrimes() {
    return(primesFound.size());
  }
}
```

Listing 19.20 Primes.java

```
package cwp;

import java.math.BigInteger;

/** A few utilities to generate a large random BigInteger,
 *  and find the next prime number above a given BigInteger.
 */

public class Primes {
```

```
// Note that BigInteger.ZERO was new in JDK 1.2, and 1.1
// code is being used to support the most servlet engines.
private static final BigInteger ZERO = new BigInteger("0");
private static final BigInteger ONE = new BigInteger("1");
private static final BigInteger TWO = new BigInteger("2");

// Likelihood of false prime is less than 1/2^ERR_VAL
// Assumedly BigInteger uses the Miller--Rabin test or
// equivalent, and thus is NOT fooled by Carmichael numbers.
// See section 33.8 of Cormen et al. Introduction to
// Algorithms for details.
private static final int ERR_VAL = 100;

public static BigInteger nextPrime(BigInteger start) {
  if (isEven(start))
    start = start.add(ONE);
  else
    start = start.add(TWO);
  if (start.isProbablePrime(ERR_VAL))
    return(start);
  else
    return(nextPrime(start));
}

private static boolean isEven(BigInteger n) {
  return(n.mod(TWO).equals(ZERO));
}

private static StringBuffer[] digits =
  { new StringBuffer("0"), new StringBuffer("1"),
    new StringBuffer("2"), new StringBuffer("3"),
    new StringBuffer("4"), new StringBuffer("5"),
    new StringBuffer("6"), new StringBuffer("7"),
    new StringBuffer("8"), new StringBuffer("9") };
private static StringBuffer randomDigit() {
  int index = (int)Math.floor(Math.random() * 10);
  return(digits[index]);
}

public static BigInteger random(int numDigits) {
  StringBuffer s = new StringBuffer("");
  for(int i=0; i<numDigits; i++) {
    s.append(randomDigit());
  }
  return(new BigInteger(s.toString()));
}

/** Simple command--line program to test. Enter number
 *  of digits, and it picks a random number of that
 *  length and then prints the first 50 prime numbers
 *  above that.
 */
```

```
  public static void main(String[] args) {
    int numDigits;
    if (args.length > 0)
      numDigits = Integer.parseInt(args[0]);
    else
      numDigits = 150;
    BigInteger start = random(numDigits);
    for(int i=0; i<50; i++) {
      start = nextPrime(start);
      System.out.println("Prime " + i + " = " + start);
    }
  }
}
```

Listing 19.21 **ServletUtilities.java**

```
package cwp;

import javax.servlet.*;
import javax.servlet.http.*;

public class ServletUtilities {
  // Other methods shown earlier

  /** Read a parameter with the specified name, convert it
   *  to an int, and return it. Return the designated default
   *  value if the parameter doesn't exist or if it is an
   *  illegal integer format.
  */

  public static int getIntParameter(HttpServletRequest request,
                                    String paramName,
                                    int defaultValue) {
    String paramString = request.getParameter(paramName);
    int paramValue;
    try {
      paramValue = Integer.parseInt(paramString);
    } catch(NumberFormatException nfe) { // null or bad format
      paramValue = defaultValue;
    }
    return(paramValue);
  }
}
```

19.11 Cookies

Cookies are small bits of textual information that a Web server sends to a browser and that the browser returns unchanged when later visiting the same Web site or domain. By letting the server read information it sent the client previously, the site can provide visitors with a number of conveniences such as presenting the site the way the visitor previously customized it or letting identifiable visitors in without their having to enter a password. Most browsers avoid caching documents associated with cookies, so the site can return different content each time.

This section discusses how to explicitly set and read cookies from within servlets, and the next section shows how to use the servlet session tracking API (which can use cookies behind the scenes) to keep track of users as they move around to different pages within your site.

Benefits of Cookies

There are four typical ways in which cookies can add value to your site.

Identifying a User During an E-commerce Session

Many on-line stores use a "shopping cart" metaphor in which the user selects an item, adds it to his shopping cart, then continues shopping. Since the HTTP connection is usually closed after each page is sent, when the user selects a new item to add to the cart, how does the store know that it is the same user who put the previous item in the cart? Persistent (keep-alive) HTTP connections do not solve this problem, since persistent connections generally apply only to requests made very close together in time, as when a browser asks for the images associated with a Web page. Besides, many servers and browsers lack support for persistent connections. Cookies, however, *can* solve this problem. In fact, this capability is so useful that servlets have an API specifically for session tracking, and servlet authors don't need to manipulate cookies directly to take advantage of it. Session tracking is discussed in Section 19.12.

Avoiding Username and Password

Many large sites require you to register to use their services, but it is inconvenient to remember and enter the username and password each time you visit. Cookies are a good alternative for low-security sites. When a user registers, a cookie containing a unique user ID is sent to him. When the client reconnects at a later date, the user ID is returned, the server looks it up, determines it belongs to a registered user, and permits access without an explicit username and password. The site may also remember the user's address, credit card number, and so forth, thus simplifying later transactions.

Customizing a Site

Many "portal" sites let you customize the look of the main page. They might let you pick which weather report you want to see, what stock and sports results you care about, how search results should be displayed, and so forth. Since it would be inconvenient for you to have to set up your page each time you visit their site, they use cookies to remember what you wanted. For simple settings, this customization could be accomplished by storing the page settings directly in the cookies. For more complex customization, however, the site just sends the client a unique identifier and keeps a server-side database that associates identifiers with page settings.

Focusing Advertising

Most advertiser-funded Web sites charge their advertisers much more for displaying "directed" ads than "random" ads. Advertisers are generally willing to pay much more to have their ads shown to people that are known to have some interest in the general product category. For example, if you go to a search engine and do a search on "Java Servlets," the search site can charge an advertiser much more for showing you an ad for a servlet development environment than for an ad for an on-line travel agent specializing in Indonesia. On the other hand, if the search had been for "Java Hotels," the situation would be reversed. Without cookies, the sites have to show a random ad when you first arrive and haven't yet performed a search, as well as when you search on something that doesn't match any ad categories.

Some Problems with Cookies

Providing convenience to the user and added value to the site owner is the purpose behind cookies. And despite much misinformation, cookies are not a serious security threat. Cookies are never interpreted or executed in any way and thus cannot be used to insert viruses or attack your system. Furthermore, since browsers generally only accept 20 cookies per site and 300 cookies total and since each cookie can be limited to 4 kilobytes, cookies cannot be used to fill up someone's disk or launch other denial-of-service attacks.

However, even though cookies don't present a serious *security* threat, they can present a significant threat to *privacy.* First, some people don't like the fact that search engines can remember that they're the user who usually does searches on certain topics. For example, they might search for job openings or sensitive health data and don't want some banner ad tipping off their coworkers next time they do a search. Even worse, two sites can share data on a user by each loading small images off the same third-party site, where that third party uses cookies and shares the data with both original sites. (Netscape, however, provides a nice feature that lets you refuse cookies from sites other than that to which you connected, but without disabling cookies altogether.) This trick of associating cookies with images can even be exploited via e-mail if you use an HTML-enabled e-mail reader that "supports" cookies and is associated with a browser. Thus, people could send you e-mail that loads images, attach cookies to those images, then identify you (e-mail address and all) if you subsequently visit their Web site. Boo.

A second privacy problem occurs when sites rely on cookies for overly sensitive data. For example, some of the big on-line bookstores use cookies to remember users and let you order without reentering much of your personal information. This is not a particular problem since they don't actually display the full credit card number and only let you send books to an address that was specified when you *did* enter the credit card in full or use the username and password. As a result, someone using your computer (or stealing your cookie file) could do no more harm than sending a big book order to your address, where the order could be refused. However, other companies might not be so careful, and an attacker who gained access to someone's computer or cookie file could get on-line access to valuable personal information. Even worse, incompetent sites might embed credit card or other sensitive information directly in the cookies themselves, rather than using innocuous identifiers that are only linked to real users on the server. This is dangerous, since most users don't view leaving their computer unattended in their office as being tantamount to leaving their credit card sitting on their desk.

The point of this discussion is twofold. First, due to real and perceived privacy problems, some users turn off cookies. So, even when you use cookies to give added value to a site, your site shouldn't *depend* on them. Second, as the author of servlets that use cookies, you should be careful not to use cookies for particularly sensitive information, since this would open users up to risks if somebody accessed their computer or cookie files.

The Servlet Cookie API

To send cookies to the client, a servlet should create one or more cookies with designated names and values with `new Cookie(name, value)`, set any optional attributes with `cookie.set`*Xxx* (readable later by `cookie.get`*Xxx*), and insert the cookies into the response headers with `response.addCookie(cookie)`. To read incoming cookies, a servlet should call `request.getCookies`, which returns an array of `Cookie` objects corresponding to the cookies the browser has associated with your site (this is a zero-length but non-null array if there are no cookies in the request). In most cases, the servlet loops down this array until it finds the one whose name (`getName`) matches the name it had in mind, then calls `getValue` on that `Cookie` to see the value associated with that name. Each of these topics is discussed in more detail in the following sections.

Creating Cookies

You create a cookie by calling the `Cookie` constructor, which takes two strings: the cookie name and the cookie value. Neither the name nor the value should contain white space or any of the following characters:

```
 [ ] ( ) = , " / ? @ : ;
```

Placing Cookies in the Response Headers

The cookie is inserted into a `Set-Cookie` HTTP response header by means of the `addCookie` method of `HttpServletResponse`. The method is called `addCookie`, not `setCookie`, because any previously specified `Set-Cookie` headers are left alone and a new header is set. Here's an example:

```
Cookie userCookie = new Cookie("user", "uid1234");
userCookie.setMaxAge(60*60*24*365); // 1 year
response.addCookie(userCookie);
```

Reading Cookies from the Client

To send cookies *to* the client, you create a `Cookie`, then use `addCookie` to send a `Set-Cookie` HTTP response header. To read the cookies that come back *from* the client, you call `getCookies` on the `HttpServletRequest`. This call returns an array of `Cookie` objects corresponding to the values that came in on the `Cookie` HTTP request header. If the request contains no cookies, `getCookies` returns `null`. Once you have this array, you typically loop down it, calling `getName` on each `Cookie` until you find one matching the name you have in mind. You then call `getValue` on the matching `Cookie` and finish with some processing specific to the resultant value. This is such a common process that, at the end of this section, we present two utilities that simplify retrieving a cookie or cookie value that matches a designated cookie name.

Cookie Attributes

Before adding the cookie to the outgoing headers, you can set various characteristics of the cookie by using one of the following `set`*Xxx* methods, where *Xxx* is the name of the attribute you want to specify. Each `set`*Xxx* method has a corresponding `get`*Xxx* method to retrieve the attribute value. Except for name and value, the cookie attributes apply only to *outgoing* cookies from the server to the client; they aren't set on cookies that come *from* the browser to the server.

public String getComment()

public void setComment(String comment)

These methods look up or specify a comment associated with the cookie. With version 0 cookies (see the upcoming entry on `getVersion` and `setVersion`), the comment is used purely for informational purposes on the server; it is not sent to the client.

public String getDomain()

public void setDomain(String domainPattern)

These methods get or set the domain to which the cookie applies. Normally, the browser only returns cookies to the same hostname that sent them. You can use `setDomain` method to instruct the browser to return them to other hosts within the same domain. To prevent servers from setting cookies that apply to hosts outside their domain, the domain specified is required to start with a dot (e.g., `.prenhall.com`), and must contain two dots for noncountry domains like `.com`, `.edu`, and `.gov`; and three dots for country domains like `.co.uk` and `.edu.es`. For instance, cookies sent from a servlet at `bali.vacations.com` would not normally get sent by the browser to pages at `mexico.vacations.com`. If the site wanted this to happen, the servlets could specify `cookie.setDomain(".vacations.com")`.

public int getMaxAge()

public void setMaxAge(int lifetime)

These methods tell how much time (in seconds) should elapse before the cookie expires. A negative value, which is the default, indicates that the cookie will last only for the current session (i.e., until the user quits the browser) and will not be stored on disk. See the `LongLivedCookie` class (Listing 19.25), which defines a subclass of `Cookie` with a maximum age automatically set one year in the future. Specifying a value of 0 instructs the browser to delete the cookie.

public String getName()

public void setName(String cookieName)

This pair of methods gets or sets the name of the cookie. The name and the value are the two pieces you virtually *always* care about. However, since the name is supplied to the `Cookie` constructor, you rarely need to call `setName`. On the other hand, `getName` is used on almost every cookie received on the server. Since the `getCookies` method of `HttpServletRequest` returns an array of `Cookie` objects, it is common to loop down this array, calling `getName` until you have a particular name, then to check the value with `getValue`. For an encapsulation of this process, see the `getCookieValue` method shown in Listing 19.24.

public String getPath()

public void setPath(String path)

These methods get or set the path to which the cookie applies. If you don't specify a path, the browser returns the cookie only to URLs in or below the directory containing the page that sent the cookie. For example, if the server sent the cookie from http://ecommerce.site.com/toys/specials.html, the browser would send the cookie back when connecting to http://ecommerce.site.com/toys/bikes/beginners.html, but not to http://ecommerce.site.com/cds/classical.html. The `setPath` method can specify something more general. For example, `someCookie.setPath("/")` specifies that *all* pages on the server should receive the cookie. The path specified must include the current page; that is, you may specify a more general path than the default, but not a more specific one. So, for example, a servlet at `http://host/store/cust-service/request` could specify a path of `/store/` (since `/store/` includes `/store/cust-service/`) but not a path of `/store/cust-service/returns/` (since this directory does not include `/store/cust-service/`).

public boolean getSecure()

public void setSecure(boolean secureFlag)

This pair of methods gets or sets the boolean value indicating whether the cookie should only be sent over encrypted (i.e., SSL) connections. The default is `false`; the cookie should apply to all connections.

public String getValue()

public void setValue(String cookieValue)

The `getValue` method looks up the value associated with the cookie; the `setValue` method specifies it. Again, the name and the value are the two parts of a cookie that you almost *always* care about, although in a few cases, a name is used as a boolean flag and its value is ignored (i.e., the existence of a cookie with the designated name is all that matters).

public int getVersion()

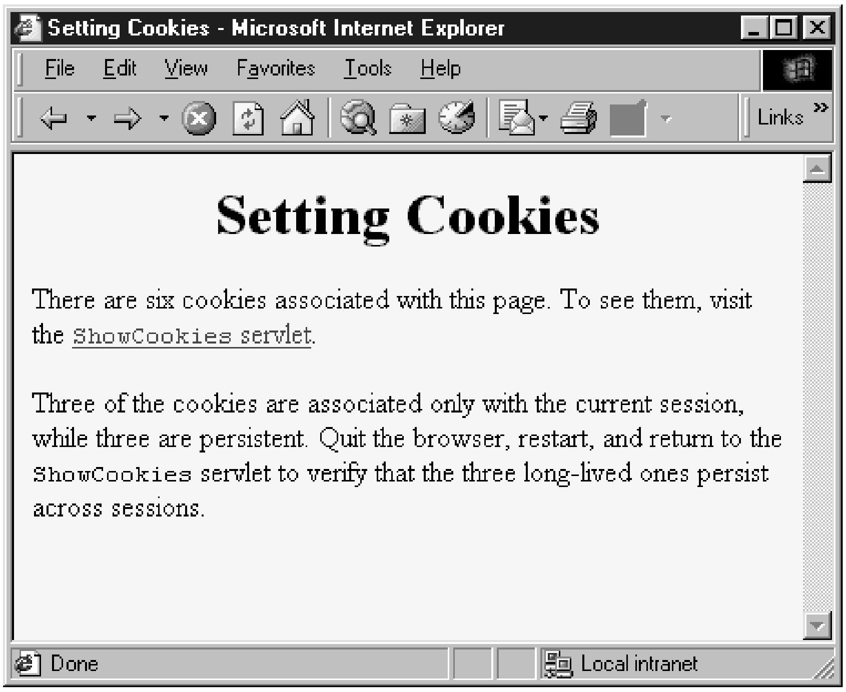
public void setVersion(int version)

These methods get and set the cookie protocol version the cookie complies with. Version 0, the default, follows the original Netscape specification (http://www.netscape.com/newsref/std/cookie_spec.html). Version 1, not yet widely supported, adheres to RFC 2109 (retrieve RFCs from the archive sites listed at http://www.rfc-editor.org/).

Examples of Setting and Reading Cookies

Listing 19.22 and Figure 19-14 show the `SetCookies` servlet, a servlet that sets six cookies. Three have the default expiration date, meaning that they should apply only until the user next restarts the browser. The other three use `setMaxAge` to stipulate that they should apply for the next hour, regardless of whether the user restarts the browser or reboots the computer to initiate a new browsing session.

Figure 19-14. Result of `SetCookies` servlet.



Setting Cookies - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Links
Done
Local intranet

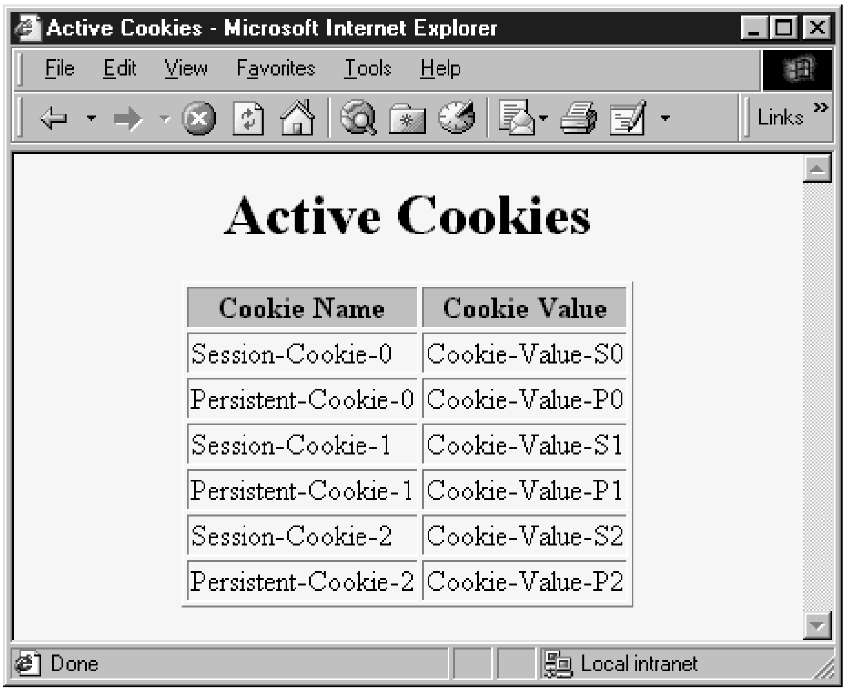
Setting Cookies

There are six cookies associated with this page. To see them, visit the `ShowCookies` servlet.

Three of the cookies are associated only with the current session, while three are persistent. Quit the browser, restart, and return to the `ShowCookies` servlet to verify that the three long-lived ones persist across sessions.

Listing 19.23 shows a servlet that creates a table of all the cookies sent to it in the request. Figure 19-15 shows this servlet immediately after the `SetCookies` servlet is visited. Figure 19-16 shows it after `SetCookies` is visited and the browser is then closed and restarted.

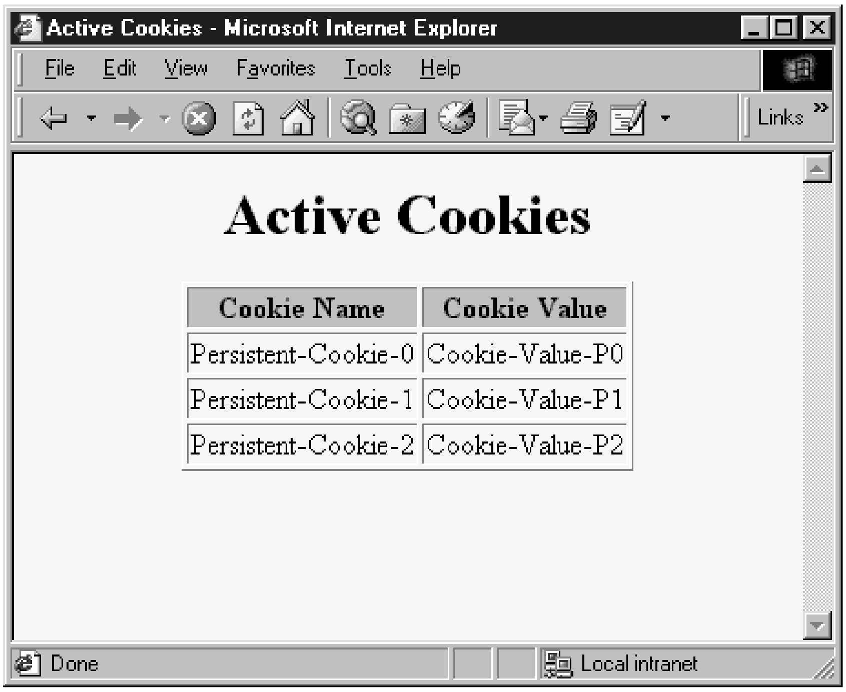
Figure 19-15. Result of visiting the `ShowCookies` servlet within an hour of visiting `SetCookies` in the same browser session.


Active Cookies - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Links
Done
Local intranet

Active Cookies

Cookie Name	Cookie Value
Session-Cookie-0	Cookie-Value-S0
Persistent-Cookie-0	Cookie-Value-P0
Session-Cookie-1	Cookie-Value-S1
Persistent-Cookie-1	Cookie-Value-P1
Session-Cookie-2	Cookie-Value-S2
Persistent-Cookie-2	Cookie-Value-P2

Figure 19-16. Result of visiting the `ShowCookies` servlet within an hour of visiting `SetCookies` in a different browser session.


Active Cookies - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Links
Done
Local intranet

Active Cookies

Cookie Name	Cookie Value
Persistent-Cookie-0	Cookie-Value-P0
Persistent-Cookie-1	Cookie-Value-P1
Persistent-Cookie-2	Cookie-Value-P2

Listing 19.22 `SetCookies.java`

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

/** Sets six cookies: three that apply only to the current
```

```
 *  session (regardless of how long that session lasts)
 *  and three that persist for an hour (regardless of
 *  whether the browser is restarted).
 */

public class SetCookies extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    for(int i=0; i<3; i++) {
      // Default maxAge is --1, indicating cookie
      // applies only to current browsing session.
      Cookie cookie = new Cookie("Session--Cookie--" + i,
                                 "Cookie--Value--S" + i);
      response.addCookie(cookie);
      cookie = new Cookie("Persistent--Cookie--" + i,
                          "Cookie--Value--P" + i);
      // Cookie is valid for an hour, regardless of whether
      // user quits browser, reboots computer, or whatever.
      cookie.setMaxAge(3600);
      response.addCookie(cookie);
    }
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String title = "Setting Cookies";
    out.println
      (ServletUtilities.headWithTitle(title) +
       "<BODY BGCOLOR=\"#FDF5E6\">\n" +
       "<H1 ALIGN=\"CENTER\">" + title + "</H1>\n" +
       "There are six cookies associated with this page.\n" +
       "To see them, visit the\n" +
       "<A HREF=\"/servlet/cwp.ShowCookies\">\n" +
       "<CODE>ShowCookies</CODE> servlet</A>.\n" +
       "<P>\n" +
       "Three of the cookies are associated only with the\n" +
       "current session, while three are persistent.\n" +
       "Quit the browser, restart, and return to the\n" +
       "<CODE>ShowCookies</CODE> servlet to verify that\n" +
       "the three long--lived ones persist across sessions.\n" +
       "</BODY></HTML>");
  }
}
```

Listing 19.23 ShowCookies.java

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;

/** Creates a table of the cookies associated with
```

```
 *  the current page.
 */

public class ShowCookies extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String title = "Active Cookies";
    out.println(ServletUtilities.headWithTitle(title) +
                "<BODY BGCOLOR=\"#FDF5E6\">\n" +
                "<H1 ALIGN=\"CENTER\">" + title + "</H1>\n" +
                "<TABLE BORDER=1 ALIGN=\"CENTER\">\n" +
                "<TR BGCOLOR=\"#FFAD00\">\n" +
                "  <TH>Cookie Name\n" +
                "  <TH>Cookie Value");
    Cookie[] cookies = request.getCookies();
    if (cookies != null) {
      Cookie cookie;
      for(int i=0; i<cookies.length; i++) {
        cookie = cookies[i];
        out.println("<TR>\n" +
                    "  <TD>" + cookie.getName() + "\n" +
                    "  <TD>" + cookie.getValue());
      }
    }
    out.println("</TABLE></BODY></HTML>");
  }
}
```

Basic Cookie Utilities

This section presents some simple but useful utilities for dealing with cookies.

Finding Cookies with Specified Names

Listing 19.24 shows a section of `ServletUtilities.java` that simplifies the retrieval of a cookie or cookie value, given a cookie name. The `getCookieValue` method loops through the array of available `Cookie` objects, returning the value of any `Cookie` whose name matches the input. If there is no match, the designated default value is returned. So, for example, our typical approach for dealing with cookies is as follows:

```
Cookie[] cookies = request.getCookies();

String color =
  ServletUtilities.getCookieValue(cookies, "color", "black");

String font =

  ServletUtilities.getCookieValue(cookies, "font", "Arial");
```

The `getCookie` method also loops through the array comparing names but returns the actual

Cookie object instead of just the value. That method is for cases when you want to do something with the Cookie other than just read its value.

Listing 19.24 **ServletUtilities.java**

```
package cwp;

import javax.servlet.*;
import javax.servlet.http.*;

public class ServletUtilities {
  // Other methods in this class shown earlier.

/** Given an array of Cookies, a name, and a default value,
   *  this method tries to find the value of the cookie with
   *  the given name. If there is no cookie matching the name
   *  in the array, then the default value is returned instead.
   */

  public static String getCookieValue(Cookie[] cookies,
                                      String cookieName,
                                      String defaultValue) {
    if (cookies != null) {
      for(int i=0; i<cookies.length; i++) {
        Cookie cookie = cookies[i];
        if (cookieName.equals(cookie.getName()))
          return(cookie.getValue());
      }
    }
    return(defaultValue);
  }

  /** Given an array of cookies and a name, this method tries
   *  to find and return the cookie from the array that has
   *  the given name. If there is no cookie matching the name
   *  in the array, null is returned.
   */

  public static Cookie getCookie(Cookie[] cookies,
                                 String cookieName) {
    if (cookies != null) {
      for(int i=0; i<cookies.length; i++) {
        Cookie cookie = cookies[i];
        if (cookieName.equals(cookie.getName()))
          return(cookie);
      }
    }
    return(null);
  }
}
```

Creating Long-Lived Cookies

Listing 19.25 shows a small class that you can use instead of `Cookie` if you want your cookie to automatically persist for a year when the client quits the browser.

Listing 19.25 `LongLivedCookie.java`

```
package cwp;

import javax.servlet.http.*;

/** Cookie that persists 1 year. Default Cookie doesn't
 *  persist past current session.
 */

public class LongLivedCookie extends Cookie {
  public static final int SECONDS_PER_YEAR = 60*60*24*365;

  public LongLivedCookie(String name, String value) {
    super(name, value);
    setMaxAge(SECONDS_PER_YEAR);
  }
}
```

19.12 Session Tracking

This section shows you how to use the servlet session tracking API to keep track of visitors as they move around at your site.

The Need for Session Tracking

HTTP is a "stateless" protocol: each time a client retrieves a Web page, it opens a separate connection to the Web server, and the server does not automatically maintain contextual information about a client. Even with servers that support persistent (keep-alive) HTTP connections and keep a socket open for multiple client requests that occur close together in time, there is no built-in support for maintaining contextual information. This lack of context causes a number of difficulties. For example, when clients at an on-line store add an item to their shopping carts, how does the server know what's already in the carts? Similarly, when clients decide to proceed to checkout, how can the server determine which previously created shopping carts are theirs?

There are three typical solutions to this problem: cookies, URL-rewriting, and hidden form fields. The following subsections quickly summarize what would be required if you had to implement session tracking yourself (without using the built-in session tracking API) by each of the three ways.

Cookies

You can use HTTP cookies to store information about a shopping session, and each subsequent connection can look up the current session and then extract information about that session from some location on the server machine. For example, a servlet could do something like the following:

```
String sessionID = makeUniqueString();
Hashtable sessionInfo = new Hashtable();
Hashtable globalTable = findTableStoringSessions();
globalTable.put(sessionID, sessionInfo);
Cookie sessionCookie = new Cookie("JSESSIONID", sessionID);
sessionCookie.setPath("/");
response.addCookie(sessionCookie);
```

Then, in later requests the server could use the `globalTable` hash table to associate a session ID from the `JSESSIONID` cookie with the `sessionInfo` hash table of data associated with that particular session. This is an excellent solution and is the most widely used approach for session handling. Still, it is nice that servlets have a higher-level API that handles all this plus the following tedious tasks:

- Extracting the cookie that stores the session identifier from the other cookies (there may be many cookies, after all)
- Setting an appropriate expiration time for the cookie
- Associating the hash tables with each request
- Generating the unique session identifiers

URL-Rewriting

With this approach, the client appends some extra data on the end of each URL that identifies the session, and the server associates that identifier with data it has stored about that session. For example, with `http://host/path/ file.html;jsessionid=1234`, the session information is attached as `jsessionid=1234`. This is also an excellent solution and even has the advantage that it works when browsers don't support cookies or when the user has disabled them. However, it has most of the same problems as cookies, namely, that the server-side program has a lot of straightforward but tedious processing to do. In addition, you have to be very careful that every URL that references your site and is returned to the user (even by indirect means like `Location` fields in server redirects) has the extra information appended. And, if the user leaves the session and comes back via a bookmark or link, the session information can be lost.

Hidden Form Fields

HTML forms can have an entry that looks like the following:

```
<INPUT TYPE="HIDDEN" id="session" VALUE="...">
```

This entry means that, when the form is submitted, the specified name and value are included in the `GET` or `POST` data. This hidden field can be used to store information about the session but has the major disadvantage that it only works if every page is dynamically generated.

Session Tracking in Servlets

Servlets provide an outstanding technical solution: the `HttpSession` API. This high-level interface is built on top of cookies or URL-rewriting. In fact, some servers use cookies if the browser supports them but automatically revert to URL-rewriting when cookies are unsupported or explicitly disabled. But, the servlet author doesn't need to bother with many of the details, doesn't have to explicitly manipulate cookies or information appended to the URL, and is automatically given a convenient place to store arbitrary objects that are associated with each session.

The Session Tracking API

Using sessions in servlets is straightforward and involves looking up the session object associated with the current request, creating a new session object when necessary, looking up information associated with a session, storing information in a session, and discarding completed or abandoned sessions. Finally, if you return any URLs to the clients that reference your site and URL-rewriting is being used, you need to attach the session information to the URLs.

Looking Up the HttpSession Object Associated with the Current Request

You look up the HttpSession object by calling the getSession method of HttpServletRequest. Behind the scenes, the system extracts a user ID from a cookie or attached URL data, then uses that as a key into a table of previously created HttpSession objects. But this is all done transparently to the programmer: you just call getSession. If getSession returns null, this means that the user is not already participating in a session, so you can create a new session. Creating a new session in this case is so commonly done that there is an option to automatically create a new session if one doesn't already exist. Just pass true to getSession. Thus, your first step usually looks like this:

```
HttpSession session = request.getSession(true);
```

If you care whether the session existed previously or is newly created, you can use isNew to check.

Looking Up Information Associated with a Session

HttpSession objects live on the server; they're just automatically associated with the client by a behind-the-scenes mechanism like cookies or URL-rewriting. These session objects have a built-in data structure that lets you store any number of keys and associated values. In version 2.1 and earlier of the servlet API, you use session.getValue("attribute") to look up a previously stored value. The return type is Object, so you have to do a typecast to whatever more specific type of data was associated with that attribute name in the session. The return value is null if there is no such attribute, so you need to check for null before calling methods on objects associated with sessions.

In version 2.2 of the servlet API, getValue is deprecated in favor of getAttribute because of the better naming match with setAttribute (in version 2.1, the match for getValue is putValue, not setValue).

Here's a representative example, assuming ShoppingCart is some class you've defined to store information on items being purchased.

```
HttpSession session = request.getSession(true);
ShoppingCart cart =
  (ShoppingCart)session.getAttribute("shoppingCart");
if (cart == null) { // No cart already in session
  cart = new ShoppingCart();
  session.setAttribute("shoppingCart", cart);
}
doSomethingWith(cart);
```

In most cases, you have a specific attribute name in mind and want to find the value (if any) already associated with that name. However, you can also discover all the attribute names in a given session by calling getValueNames, which returns an array of strings. This method is your only option for finding attribute names in version 2.1, but in servlet engines supporting version 2.2 of the servlet specification, you can use getAttributeNames. That method is more consistent in that it returns an Enumeration, just like the getHeaderNames and getParameterNames methods of HttpServletRequest.

Although the data that was explicitly associated with a session is the part you care most about, some other pieces of information are sometimes useful as well. Here is a summary of the methods available in the HttpSession class.

public Object getValue(String name)

public Object getAttribute(String name)

These methods extract a previously stored value from a session object. They return `null` if no value is associated with the given name. Use `getValue` in version 2.1 of the servlet API. Version 2.2 supports both methods, but `getAttribute` is preferred and `getValue` is deprecated.

public void putValue(String name, Object value)

public void setAttribute(String name, Object value)

These methods associate a value with a name. Use `putValue` with version 2.1 servlets and either `setAttribute` (preferred) or `putValue` (deprecated) with version 2.2 servlets. If the object supplied to `putValue` or `setAttribute` implements the `HttpSessionBindingListener` interface, the object's `valueBound` method is called after it is stored in the session. Similarly, if the previous value implements `HttpSessionBindingListener`, its `valueUnbound` method is called.

public void removeValue(String name)

public void removeAttribute(String name)

These methods remove any values associated with the designated name. If the value being removed implements `HttpSessionBindingListener`, its `valueUnbound` method is called. With version 2.1 servlets, use `removeValue`. In version 2.2, `removeAttribute` is preferred, but `removeValue` is still supported (albeit deprecated) for backward compatibility.

public String[] getValueNames()

public Enumeration getAttributeNames()

These methods return the names of all attributes in the session. Use `getValueNames` in version 2.1 of the servlet specification. In version 2.2, `getValueNames` is supported but deprecated; use `getAttributeNames` instead.

public String getId()

This method returns the unique identifier generated for each session. It is useful for debugging or logging.

public boolean isNew()

This method returns `true` if the client (browser) has never seen the session, usually because it was just created rather than being referenced by an incoming client request. It returns `false` for preexisting sessions.

public long getCreationTime()

This method returns the time in milliseconds since midnight, January 1, 1970 (GMT) at which the session was first built. To get a value useful for printing, pass the value to the `Date` constructor or the `setTimeInMillis` method of `GregorianCalendar`.

public long getLastAccessedTime()

This method returns the time in milliseconds since midnight, January 1, 1970 (GMT) at which the session was last sent from the client.

public int getMaxInactiveInterval()

public void setMaxInactiveInterval(int seconds)

These methods get or set the amount of time, in seconds, that a session should go without access before being automatically invalidated. A negative value indicates that the session should never time out. Note that the timeout is maintained on the server and is *not* the same as the cookie expiration date, which is sent to the client.

public void invalidate()

This method invalidates the session and unbinds all objects associated with it.

Associating Information with a Session

As discussed in the previous section, you *read* information associated with a session by using `getValue` (in version 2.1 of the servlet specification) or `getAttribute` (in version 2.2). To *specify* information in version 2.1 servlets, you use `putValue`, supplying a key and a value. Use `setAttribute` in version 2.2. This is a more consistent name because it uses the `get`/`set` notation of the JavaBeans API. To let your values perform side effects when they are stored in a session, simply have the object you are associating with the session implement the `HttpSessionBindingListener` interface. Now, every time `putValue` or `setAttribute` is called on one of those objects, its `valueBound` method is called immediately afterward.

Be aware that `putValue` and `setAttribute` replace any previous values; if you want to remove a value without supplying a replacement, use `removeValue` in version 2.1 and `removeAttribute` in version 2.2. These methods trigger the `valueUnbound` method of any values that implement `HttpSessionBindingListener`. Sometimes, you just want to replace previous values; see the `referringPage` entry in the example below for an example. Other times, you want to retrieve a previous value and augment it; for an example, see the `previousItems` entry below. This example assumes a `ShoppingCart` class with an `addItem` method to store items being ordered, and a `Catalog` class with a static `getItem` method that returns an item, given an item identifier.

```
HttpSession session = request.getSession(true);
session.setAttribute("referringPage",
                     request.getHeader("Referer"));
ShoppingCart cart =
  (ShoppingCart)session.getAttribute("previousItems");
if (cart == null) { // No cart already in session
  cart = new ShoppingCart();
  session.setAttribute("previousItems", cart);
}
String itemID = request.getParameter("itemID");
if (itemID != null) {
  cart.addItem(Catalog.getItem(itemID));
}
```

Terminating Sessions

Sessions automatically become inactive when the amount of time between client accesses exceeds the interval specified by `getMaxInactiveInterval`. When this happens, any objects bound to the `HttpSession` object automatically get unbound. Then, your attached objects are automatically notified if they implement the `HttpSessionBindingListener` interface.

Rather than waiting for sessions to time out, you can explicitly deactivate a session with the session's `invalidate` method.

Encoding URLs Sent to the Client

If you are using URL-rewriting for session tracking and you send a URL that references your site to the client, you need to explicitly add on the session data. Since some servlet and JSP engines automatically switch to URL-rewriting when cookies aren't supported by the client, you should routinely encode *all* URLs that reference your site. There are two possible places where you might use URLs that refer to your own site. The first is where the URLs are embedded in the Web page that the servlet generates. These URLs should be passed through the `encodeURL` method of `HttpServletResponse`. The method determines if URL-rewriting is currently in use and appends the session information only if necessary. The URL is returned unchanged otherwise.

Here's an example:

```
String originalURL = someRelativeOrAbsoluteURL;
String encodedURL = response.encodeURL(originalURL);
out.println("<A HREF=\"" + encodedURL + "\">...</A>");
```

The second place you might use a URL that refers to your own site is in a `sendRedirect` call (i.e., placed into the `Location` response header). In this second situation, different rules determine whether session information needs to be attached, so you cannot use `encodeURL`. Fortunately, `HttpServletResponse` supplies an `encodeRedirectURL` method to handle that case. Here's an example:

```
String originalURL = someURL; // Relative URL OK in version 2.2
String encodedURL = response.encodeRedirectURL(originalURL);
response.sendRedirect(encodedURL);
```

Since you often don't know if your servlet will later become part of a series of pages that use session tracking, it is good practice with servlets to plan ahead and encode URLs that reference their site.

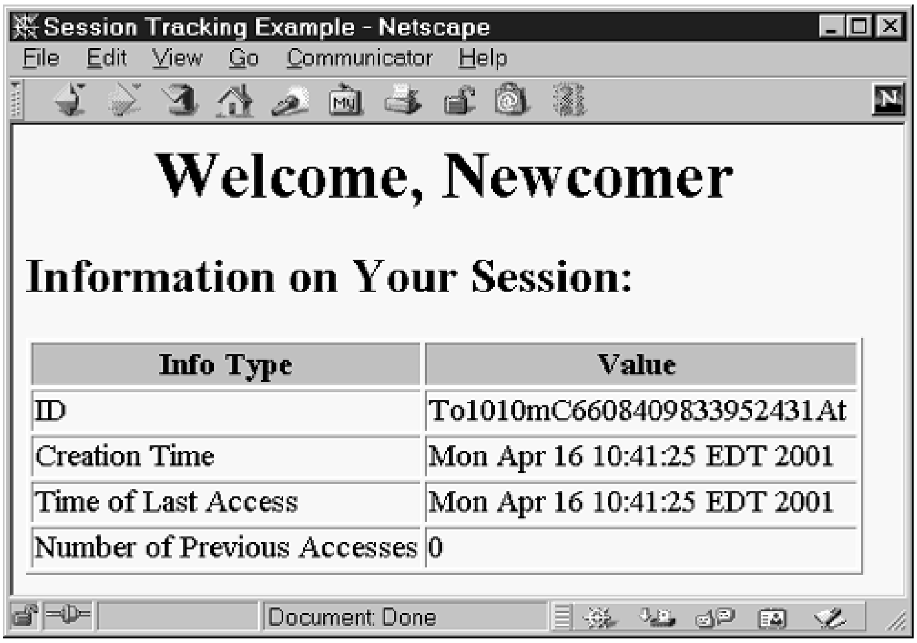
Core Approach

Plan ahead: pass URLs that refer to your own site through `response.encodeURL` *or* `response.encodeRedirectURL`*, regardless of whether your servlet is using session tracking.*

A Servlet Showing Per-Client Access Counts

Listing 19.26 presents a simple servlet that shows basic information about the client's session. When the client connects, the servlet uses `request.getSession(true)` to either retrieve the existing session or, if there was no session, to create a new one. The servlet then looks for an attribute of type `Integer` called `accessCount`. If it cannot find such an attribute, it uses 0 as the number of previous accesses. This value is then incremented and associated with the session by `putValue`. Finally, the servlet prints a small HTML table showing information about the session. Figures 19-17 and 19-18 show the servlet on the initial visit and after the page was reloaded several times.

Figure 19-17. First visit by client to `ShowSession` servlet.



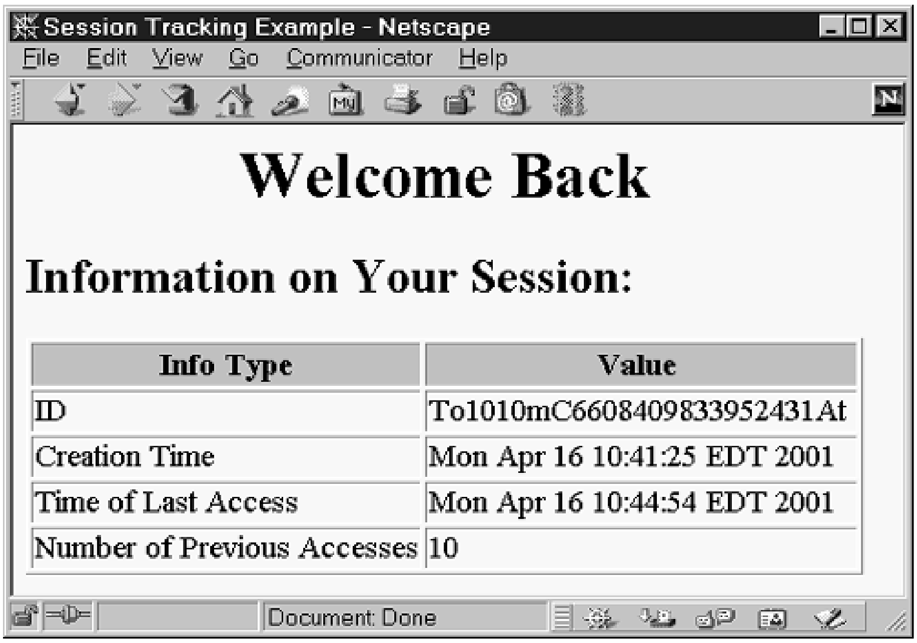
Session Tracking Example - Netscape
File Edit View Go Communicator Help
Document: Done

Welcome, Newcomer

Information on Your Session:

Info Type	Value
ID	To1010mC6608409833952431At
Creation Time	Mon Apr 16 10:41:25 EDT 2001
Time of Last Access	Mon Apr 16 10:41:25 EDT 2001
Number of Previous Accesses	0

Figure 19-18. Eleventh visit to ShowSession servlet. Access count is independent of number of visits by other clients.



Session Tracking Example - Netscape
File Edit View Go Communicator Help
Document: Done

Welcome Back

Information on Your Session:

Info Type	Value
ID	To1010mC6608409833952431At
Creation Time	Mon Apr 16 10:41:25 EDT 2001
Time of Last Access	Mon Apr 16 10:44:54 EDT 2001
Number of Previous Accesses	10

Listing 19.26 ShowSession.java

```
package cwp;

import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
import java.net.*;
import java.util.*;

/** Simple example of session tracking. */
```

```
public class ShowSession extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String title = "Session Tracking Example";
    HttpSession session = request.getSession(true);
    String heading;
    Integer accessCount =
      (Integer)session.getAttribute("accessCount");
    if (accessCount == null) {
      accessCount = new Integer(0);
      heading = "Welcome, Newcomer";
    } else {
      heading = "Welcome Back";
      accessCount = new Integer(accessCount.intValue() + 1);
    }
    // Use setAttribute instead of putValue in version 2.2.
    session.setAttribute("accessCount", accessCount);

    out.println(ServletUtilities.headWithTitle(title) +
                "<BODY BGCOLOR=\"#FDF5E6\">\n" +
                "<H1 ALIGN=\"CENTER\">" + heading + "</H1>\n" +
                "<H2>Information on Your Session:</H2>\n" +
                "<TABLE BORDER=1 ALIGN=\"CENTER\">\n" +
                "<TR BGCOLOR=\"#FFAD00\">\n" +
                "  <TH>Info Type<TH>Value\n" +
                "<TR>\n" +
                "  <TD>ID\n" +
                "  <TD>" + session.getId() + "\n" +
                "<TR>\n" +
                "  <TD>Creation Time\n" +
                "  <TD>" +
                new Date(session.getCreationTime()) + "\n" +
                "<TR>\n" +
                "  <TD>Time of Last Access\n" +
                "  <TD>" +
                new Date(session.getLastAccessedTime()) + "\n" +
                "<TR>\n" +
                "  <TD>Number of Previous Accesses\n" +
                "  <TD>" + accessCount + "\n" +
                "</TABLE>\n" +
                "</BODY></HTML>");
  }

  /** Handle GET and POST requests identically. */

  public void doPost(HttpServletRequest request,
                     HttpServletResponse response)
      throws ServletException, IOException {
    doGet(request, response);
  }
}
```

19.13 Summary

Servlets are efficient, convenient, powerful, portable, secure, and inexpensive alternatives to CGI and other server-side programming technologies. Despite their many benefits, they have one major drawback: generating HTML. Using `println` statements to build large sections of mostly static HTML is tedious, awkward, and hard to maintain. Besides, it mixes the code that generates the data with the code that presents it, making it hard to put different team members on different parts of the same project. That's where JavaServer Pages (JSP) comes in. Read on!

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