Integrating Servlets and JSP: The Model View Controller (MVC) Architecture

Agenda

- Understanding the benefits of MVC
- Using RequestDispatcher to implement MVC
- Forwarding requests from servlets to JSP pages
- Handling relative URLs
- Choosing among different display options
- Comparing data-sharing strategies
- Forwarding requests from JSP pages
- Including pages instead of forwarding to them

Uses of JSP Constructs

Simple Application ↓ Complex Application

- Scripting elements calling servlet code directly
- Scripting elements calling servlet code indirectly (by means of utility classes)
- Beans
- Servlet/JSP combo (MVC)
- MVC with JSP expression language
- Custom tags

Why Combine Servlets & JSP?

- **Typical picture: use JSP to make it easier to develop and maintain the HTML content**
  - For simple dynamic code, call servlet code from scripting elements
  - For slightly more complex applications, use custom classes called from scripting elements
  - For moderately complex applications, use beans and custom tags
- **But, that's not enough**
  - For complex processing, starting with JSP is awkward
  - Despite the ease of separating the real code into separate classes, beans, and custom tags, the assumption behind JSP is that a *single* page gives a *single* basic look

Possibilities for Handling a Single Request

- **Servlet only**
  - Output is a binary type. E.g.: an image
  - No output. E.g.: you are doing forwarding or redirection as in Search Engine example.
  - Format/layout of page is highly variable. E.g.: portal.
- **JSP only**
  - Output is mostly character data. E.g.: HTML
  - Format/layout mostly fixed.
- **Combination**
  - A single request will result in multiple substantially different-looking results.
  - Complicated data processing, but relatively fixed layout.
- **These apply to a *single* request**
  - You still use both servlets and JSP within your *overall* application.

MVC Misconceptions

- **An elaborate framework is necessary**
  - Frameworks are sometimes useful
    - Struts
    - JavaServer Faces (JSF)
  - They are *not* required!
    - Implementing MVC with the builtin RequestDispatcher works very well for most simple and moderately complex applications
- **MVC totally changes your overall system design**
  - You can use MVC for individual requests
  - Think of it as the MVC *approach*, not the MVC *architecture*
    - Also called the *Model 2* approach

Implementing MVC with RequestDispatcher

- **Define beans to represent the data**
- **Use a servlet to handle requests**
  - Servlet reads request parameters, checks for missing and malformed data, etc.
- **Populate the beans**
  - The servlet invokes business logic (application-specific code) or data-access code to obtain the results. Results are placed in the beans that were defined in step 1.
- **Store the bean in the request, session, or servlet context**
  - The servlet calls setAttribute on the request, session, or servlet context objects to store a reference to the beans that represent the results of the request.

Implementing MVC with RequestDispatcher (Continued)

- **Forward the request to a JSP page.**
  - The servlet determines which JSP page is appropriate to the situation and uses the forward method of RequestDispatcher to transfer control to that page.
- **Extract the data from the beans.**
  - The JSP page accesses beans with jsp:useBean and a scope matching the location of step 4. The page then uses jsp:getProperty to output the bean properties.
  - The JSP page does not create or modify the bean; it merely extracts and displays data that the servlet created.

Request Forwarding Example

```
public void doGet(HttpServletRequest request,
                  HttpServletResponse response)
  throws ServletException, IOException {
  String operation = request.getParameter("operation");
  if (operation == null) {
    operation = "unknown";
  }
  String address;
  if (operation.equals("order")) {
    address = "/WEB-INF/Order.jsp";
  } else if (operation.equals("cancel")) {
    address = "/WEB-INF/Cancel.jsp";
  } else {
    address = "/WEB-INF/UnknownOperation.jsp";
  }
  RequestDispatcher dispatcher =
    request.getRequestDispatcher(address);
  dispatcher.forward(request, response);
}
```

jsp:useBean in MVC vs. in Standalone JSP Pages

- **The JSP page should not create the objects**
  - The servlet, not the JSP page, should create all the data objects. So, to guarantee that the JSP page will not create objects, you should use
    <jsp:useBean ... type="package.Class" />

    instead of

    <jsp:useBean ... class="package.Class" />
- **The JSP page should not modify the objects**
  - So, you should use jsp:getProperty but not jsp:setProperty.

Reminder: jsp:useBean Scope Alternatives

- **request**
  - <jsp:useBean id="..." type="..." scope="request" />
- **session**
  - <jsp:useBean id="..." type="..." scope="session" />
- **application**
  - <jsp:useBean id="..." type="..." scope="application" />
- **page**
  - <jsp:useBean id="..." type="..." scope="page" />
    or just
    <jsp:useBean id="..." type="..." />
  - This scope is not used in MVC (Model 2) architecture

Request-Based Data Sharing

- **Servlet**

```
ValueObject value = new ValueObject(...);
request.setAttribute("key", value);
RequestDispatcher dispatcher =
  request.getRequestDispatcher
                         ("/WEB-INF/SomePage.jsp");
dispatcher.forward(request, response);
```

- **JSP**

```
<jsp:useBean id="key" type="somePackage.ValueObject"
             scope="request" />
<jsp:getProperty name="key" property="someProperty" />
```

Session-Based Data Sharing

- Servlet

```
ValueObject value = new ValueObject(...);
HttpSession session = request.getSession();
session.setAttribute("key", value);
RequestDispatcher dispatcher =
  request.getRequestDispatcher
                   ("/WEB-INF/SomePage.jsp");
dispatcher.forward(request, response);
```

- JSP

```
<jsp:useBean id="key" type="somePackage.ValueObject"
             scope="session" />
<jsp:getProperty name="key" property="someProperty" />
```

Session-Based Data Sharing: Variation

- Use response.sendRedirect instead of RequestDispatcher.forward
- Distinctions: with sendRedirect:
  - User sees JSP URL (user sees only servlet URL with RequestDispatcher.forward)
  - Two round trips to client (only one with forward)
- Advantage of sendRedirect
  - User can visit JSP page separately
    - User can bookmark JSP page
- Disadvantage of sendRedirect
  - Since user can visit JSP page without going through servlet first, JSP data might not be available
    - So, JSP page needs code to detect this situation

ServletContext-Based Data Sharing

- Servlet

```
synchronized(this) {
  ValueObject value = new ValueObject(...);
  getServletContext().setAttribute("key", value);
  RequestDispatcher dispatcher =
    request.getRequestDispatcher
                     ("/WEB-INF/SomePage.jsp");
  dispatcher.forward(request, response);
}
```

- JSP

```
<jsp:useBean id="key" type="somePackage.ValueObject"
             scope="application" />
<jsp:getProperty name="key" property="someProperty" />
```

Relative URLs in JSP Pages

- Issue:
  - Forwarding with a request dispatcher is transparent to the client. *Original* URL is only URL browser knows about.
- Why does this matter?
  - What will browser do with tags like the following:

    ```
    <IMG SRC="foo.gif" …>
    <LINK REL=STYLESHEET
          HREF="JSP-Styles.css"
          TYPE="text/css">
    <A HREF="bar.jsp">…</A>
    ```
  - Answer: browser treats them as relative to *servlet URL*
- Simplest solution:
  - Use URLs that begin with a slash

Applying MVC: Bank Account Balances

- Bean
  - BankCustomer
- Servlet that populates bean and forwards to appropriate JSP page
  - Reads customer ID, calls data-access code to populate BankCustomer
  - Uses current balance to decide appropriate result page
- JSP pages to display results
  - Negative balance: warning page
  - Regular balance: standard page
  - High balance: page with advertisements added
  - Unknown customer ID: error page

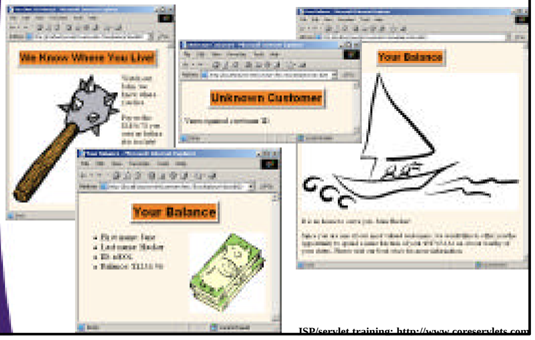
Bank Account Balances: Servlet Code

```
public class ShowBalance extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    BankCustomer customer =
      BankCustomer.getCustomer
                     (request.getParameter("id"));
    String address;
    if (customer == null) {
      address =
        "/WEB-INF/bank-account/UnknownCustomer.jsp";
    } else if (customer.getBalance() < 0) {
      address =
        "/WEB-INF/bank-account/NegativeBalance.jsp";
      request.setAttribute("badCustomer", customer);
    }
    …
    RequestDispatcher dispatcher =
      request.getRequestDispatcher(address);
    dispatcher.forward(request, response);
```

Bank Account Balances: JSP Code (Negative Balance)

```
…
<BODY>
<TABLE BORDER=5 ALIGN="CENTER">
  <TR><TH CLASS="TITLE">
      We Know Where You Live!</TABLE>
<P>
<IMG SRC="/bank-support/Club.gif" ALIGN="LEFT">
<jsp:useBean id="badCustomer"
             type="coreservlets.BankCustomer"
             scope="request" />
Watch out,
<jsp:getProperty name="badCustomer"
                 property="firstName" />,
we know where you live.
<P>
Pay us the $<jsp:getProperty name="badCustomer"
                          property="balanceNoSign" />
you owe us before it is too late!
</BODY></HTML>
```

Bank Account Balances: Results



Comparing Data-Sharing Approaches: Request

- **Goal**
  - Display a random number to the user
- **Type of sharing**
  - Each request should result in a new number, so request-based sharing is appropriate.

Request-Based Sharing: Bean

```
package coreservlets;

public class NumberBean {
  private double num = 0;

  public NumberBean(double number) {
    setNumber(number);
  }

  public double getNumber() {
    return(num);
  }

  public void setNumber(double number) {
    num = number;
  }
}
```

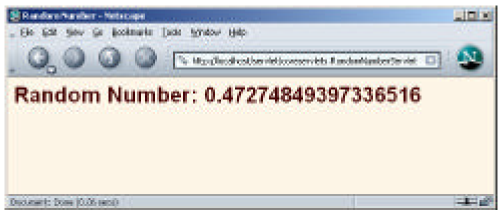
Request-Based Sharing: Servlet

```
public class RandomNumberServlet extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    NumberBean bean =
      new NumberBean(Math.random());
    request.setAttribute("randomNum", bean);
    String address =
      "/WEB-INF/mvc-sharing/RandomNum.jsp";
    RequestDispatcher dispatcher =
      request.getRequestDispatcher(address);
    dispatcher.forward(request, response);
  }
}
```

Request-Based Sharing: JSP

```
…
<BODY>
<jsp:useBean id="randomNum"
             type="coreservlets.NumberBean"
             scope="request" />
<H2>Random Number:
<jsp:getProperty name="randomNum"
                 property="number" />
</H2>
</BODY></HTML>
```

Request-Based Sharing: Results


Random Number - Netscape
File Edit View Go Bookmarks Tools Window Help
http://localhost/servlet/coreservlets.RandomNumberServlet
Document: Done (0.06 secs)

Random Number: 0.47274849397336516

Comparing Data-Sharing Approaches: Session

- **Goal**
  - Display users' first and last names.
  - If the users fail to tell us their name, we want to use whatever name they gave us previously.
  - If the users do not explicitly specify a name and no previous name is found, a warning should be displayed.
- **Type of sharing**
  - Data is stored for each client, so session-based sharing is appropriate.

Session-Based Sharing: Bean

```
package coreservlets;

public class NameBean {
  private String firstName = "Missing first name";
  private String lastName = "Missing last name";

  public NameBean() {}

  public NameBean(String firstName, String lastName) {
    setFirstName(firstName);
    setLastName(lastName);
  }

  public String getFirstName() {
    return(firstName);
  }

  …
}
```

Session-Based Sharing: Servlet

```
public class RegistrationServlet extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    HttpSession session = request.getSession();
    NameBean nameBean =
      (NameBean)session.getAttribute("nameBean");
    if (nameBean == null) {
      nameBean = new NameBean();
      session.setAttribute("nameBean", nameBean);
    }
```

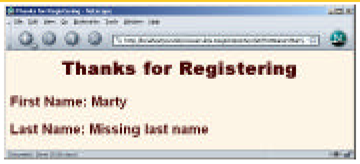
Session-Based Sharing: Servlet (Continued)

```
    String firstName =
      request.getParameter("firstName");
    if ((firstName != null) &&
        (!firstName.trim().equals(""))) {
      nameBean.setFirstName(firstName);
    }
    String lastName =
      request.getParameter("lastName");
    if ((lastName != null) &&
        (!lastName.trim().equals(""))) {
      nameBean.setLastName(lastName);
    }
    String address =
      "/WEB-INF/mvc-sharing/ShowName.jsp";
    RequestDispatcher dispatcher =
      request.getRequestDispatcher(address);
    dispatcher.forward(request, response);
  }
}
```

Session-Based Sharing: JSP

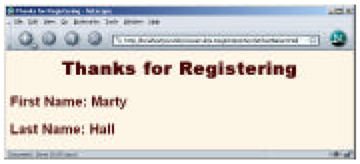
```
…
<BODY>
<H1>Thanks for Registering</H1>
<jsp:useBean id="nameBean"
             type="coreservlets.NameBean"
             scope="session" />
<H2>First Name:
<jsp:getProperty name="nameBean"
                 property="firstName" /></H2>
<H2>Last Name:
<jsp:getProperty name="nameBean"
                 property="lastName" /></H2>
</BODY></HTML>
```

Session-Based Sharing: Results


Thanks for Registering

First Name: Marty

Last Name: Missing last name


Thanks for Registering

First Name: Marty

Last Name: Hall

Comparing Data-Sharing Approaches: ServletContext

- **Goal**
  - Display a prime number of a specified length.
  - If the user fails to tell us the desired length, we want to use whatever prime number we most recently computed for *any* user.
- **Type of sharing**
  - Data is shared among multiple clients, so application-based sharing is appropriate.

ServletContext-Based Sharing: Bean

```
package coreservlets;
import java.math.BigInteger;

public class PrimeBean {
  private BigInteger prime;

  public PrimeBean(String lengthString) {
    int length = 150;
    try {
      length = Integer.parseInt(lengthString);
    } catch(NumberFormatException nfe) {}
    setPrime(Primes.nextPrime(Primes.random(length)));
  }

  public BigInteger getPrime() {
    return(prime);
  }
  …
}
```

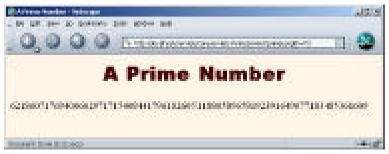
ServletContext-Based Sharing: Servlet

```
public class PrimeServlet extends HttpServlet {
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws ServletException, IOException {
    String length = request.getParameter("primeLength");
    ServletContext context = getServletContext();
    synchronized(this) {
      if ((context.getAttribute("primeBean") == null) ||
          (length != null)) {
        PrimeBean primeBean = new PrimeBean(length);
        context.setAttribute("primeBean", primeBean);
      }
      String address =
        "/WEB-INF/mvc-sharing/ShowPrime.jsp";
      RequestDispatcher dispatcher =
        request.getRequestDispatcher(address);
      dispatcher.forward(request, response);
    }
  }
}
```

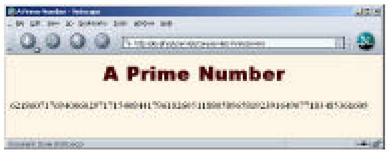
ServletContext-Based Sharing: JSP

```
…
<BODY>
<H1>A Prime Number</H1>
<jsp:useBean id="primeBean"
             type="coreservlets.PrimeBean"
             scope="application" />
<jsp:getProperty name="primeBean"
                 property="prime" />
</BODY></HTML>
```

ServletContext-Based Sharing: Results


A Prime Number

[illegible]


A Prime Number

[illegible]

Forwarding from JSP Pages

```
<% String destination;
   if (Math.random() > 0.5) {
     destination = "/examples/page1.jsp";
   } else {
     destination = "/examples/page2.jsp";
   }
%>
<jsp:forward page="<%= destination %>" />
```

- **Legal, but bad idea**
  - Business and control logic belongs in servlets
  - Keep JSP focused on presentation

Including Pages Instead of Forwarding to Them

- **With the `forward` method of RequestDispatcher:**
  - Control is *permanently* transferred to new page
  - Original page *cannot* generate any output
- **With the `include` method of RequestDispatcher:**
  - Control is *temporarily* transferred to new page
  - Original page *can* generate output before and after the included page
  - Original servlet does not see the output of the included page (for this, see later topic on servlet/JSP filters)
  - Useful for portals: JSP presents pieces, but pieces arranged in different orders for different users

Including Pages Instead of Forwarding to Them

```
response.setContentType("text/html");
String firstTable, secondTable, thirdTable;
if (someCondition) {
  firstTable = "/WEB-INF/Sports-Scores.jsp";
  secondTable = "/WEB-INF/Stock-Prices.jsp";
  thirdTable = "/WEB-INF/Weather.jsp";
} else if (...) { ... }
RequestDispatcher dispatcher =
  request.getRequestDispatcher("/WEB-INF/Header.jsp");
dispatcher.include(request, response);
dispatcher =
  request.getRequestDispatcher(firstTable);
dispatcher.include(request, response);
dispatcher =
  request.getRequestDispatcher(secondTable);
dispatcher.include(request, response);
dispatcher =
  request.getRequestDispatcher(thirdTable);
dispatcher.include(request, response);
dispatcher =
  request.getRequestDispatcher("/WEB-INF/Footer.jsp");
dispatcher.include(request, response);
```

Summary

- **Use MVC (Model 2) approach when:**
  - One submission will result in more than one basic look
  - Several pages have substantial common processing
- **Architecture**
  - A servlet answers the original request
  - Servlet does the real processing & stores results in beans
    - Beans stored in HttpServletRequest, HttpSession, or ServletContext
  - Servlet forwards to JSP page via forward method of RequestDispatcher
  - JSP page reads data from beans by means of jsp:useBean with appropriate scope (request, session, or application)

Questions?

JSP and Servlet Training Courses: http://courses.coreservlets.com
JSP and Servlet Books from Sun Press: http://www.coreservlets.com