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

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 JSP and Servlet Books from Sun Press: <http://www.coreservlets.com>

## 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

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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.

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## 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.

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## 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);
}
```

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## 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`.

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## 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

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## 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" />
```

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## 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" />
```

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## 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

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## 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" />
```

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## 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

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## 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

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## 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);
    }
}
```

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## Bank Account Balances: JSP Code (Negative Balance)

```

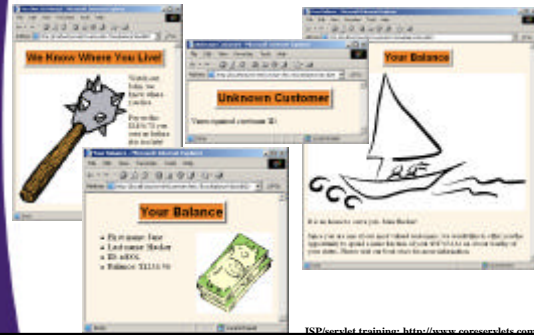
...
<BODY>
<TABLE BORDER=5 ALIGN="CENTER">
  <TR><TH CLASS="TITLE">
    We Know Where You Live!</TABLE>
<P>
<IMG SRC="/bank-support/Club.gif" ALIGN="LEFT">
<jsp:useBean id="badCustomer"
  type="coreservlets.BankCustomer"
  scope="request" />
Watch out,
<jsp:getProperty name="badCustomer"
  property="firstName" />,
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>

```

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## Bank Account Balances: Results



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## 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.

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## 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;
  }
}

```

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## 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);
  }
}

```

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## Request-Based Sharing: JSP

```

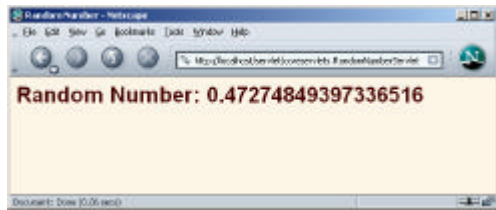
...
<BODY>
<jsp:useBean id="randomNum"
  type="coreservlets.NumberBean"
  scope="request" />
<H2>Random Number:
<jsp:getProperty name="randomNum"
  property="number" />
</H2>
</BODY></HTML>

```

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## Request-Based Sharing: Results



## 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



## 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);
    }
    ...
}
```

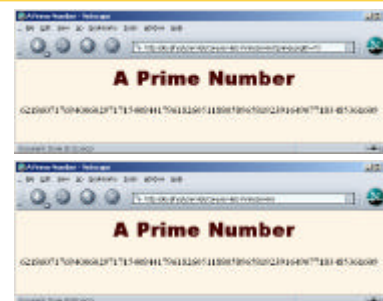
## ServletContext-Based Sharing: Servlet

```
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



## 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

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## 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

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## 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);
```

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## 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)

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## Questions?

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