Core Servlets and JavaServer Pages / 2e
Volume 1: Core Technologies
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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

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. Works well when:**
  - Output is a binary type. E.g.: an image
  - There is *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. Works well when:**
  - Output is mostly character data. E.g.: HTML
  - Format/layout mostly fixed.
- **Combination (MVC architecture). Needed when:**
  - A single request will result in multiple substantially different-looking results.
  - You have a large development team with different team members doing the Web development and the business logic.
  - You perform complicated data processing, but have a relatively fixed layout.

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

Review: Beans

- **Java classes that follow certain conventions**
  - Must have a zero-argument (empty) constructor
    - You can satisfy this requirement either by explicitly defining such a constructor or by omitting all constructors
  - Should have no public instance variables (fields)
    - I hope you already follow this practice and use accessor methods instead of allowing direct access to fields
  - Persistent values should be accessed through methods called get*Xxx* and set*Xxx*
    - If class has method **`getTitle`** that returns a String, class is said to have a String *property* named **`title`**
    - Boolean properties can use is*Xxx* instead of get*Xxx*

Example: StringBean

```
package coreservlets;

public class StringBean {
  private String message = "No message specified";

  public String getMessage() {
    return(message);
  }

  public void setMessage(String message) {
    this.message = message;
  }
}
```

- **Beans installed in normal Java directory**
  - …/WEB-INF/classes/*directoryMatchingPackageName*
- **Beans (and utility classes) must *always* be in packages!**

Implementing MVC with RequestDispatcher

1. **Define beans to represent the data**
2. **Use a servlet to handle requests**
   – Servlet reads request parameters, checks for missing and malformed data, etc.
3. **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.
4. **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)

5. **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.
6. **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 1.2

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

- JSP 2.0

```
${key.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 1.2

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

- JSP 2.0

```
${key.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 1.2

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

- JSP 2.0

```
${key.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 on 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);
```

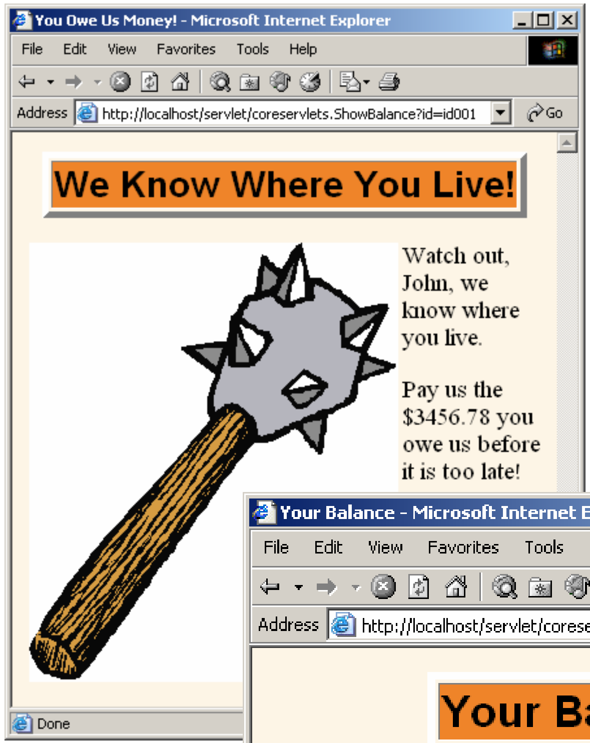
Bank Account Balances: JSP 1.2 Code (Negative Balance)

```
…
<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: JSP 2.0 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">
Watch out,
${badCustomer.firstName},
we know where you live.
<P>
Pay us the $${badCustomer.balanceNoSign}
you owe us before it is too late!
</BODY></HTML>
```

Bank Account Balances: Results

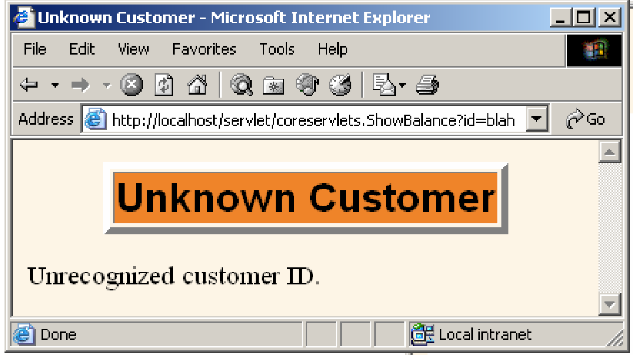

You Owe Us Money! - Microsoft Internet Explorer

http://localhost/servlet/coreservlets.ShowBalance?id=id001

We Know Where You Live!

Watch out, John, we know where you live.

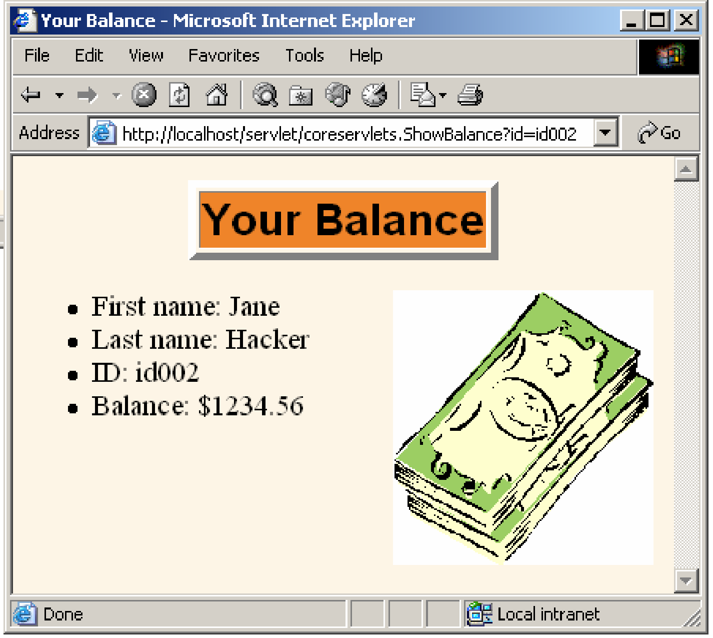
Pay us the $3456.78 you owe us before it is too late!


Unknown Customer - Microsoft Internet Explorer

http://localhost/servlet/coreservlets.ShowBalance?id=blah

Unknown Customer

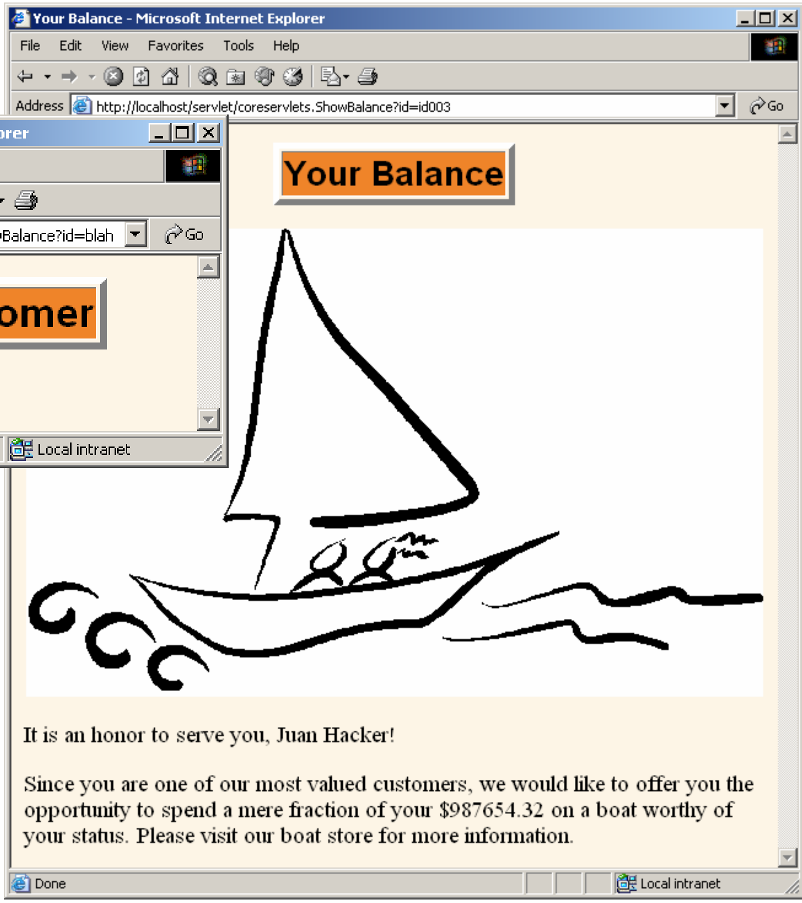
Unrecognized customer ID.


Your Balance - Microsoft Internet Explorer

http://localhost/servlet/coreservlets.ShowBalance?id=id002

Your Balance

- First name: Jane
- Last name: Hacker
- ID: id002
- Balance: $1234.56


Your Balance - Microsoft Internet Explorer

http://localhost/servlet/coreservlets.ShowBalance?id=id003

Your Balance

It is an honor to serve you, Juan Hacker!

Since you are one of our most valued customers, we would like to offer you the opportunity to spend a mere fraction of your $987654.32 on a boat worthy of your status. Please visit our boat store for more information.

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);
  }
}
```

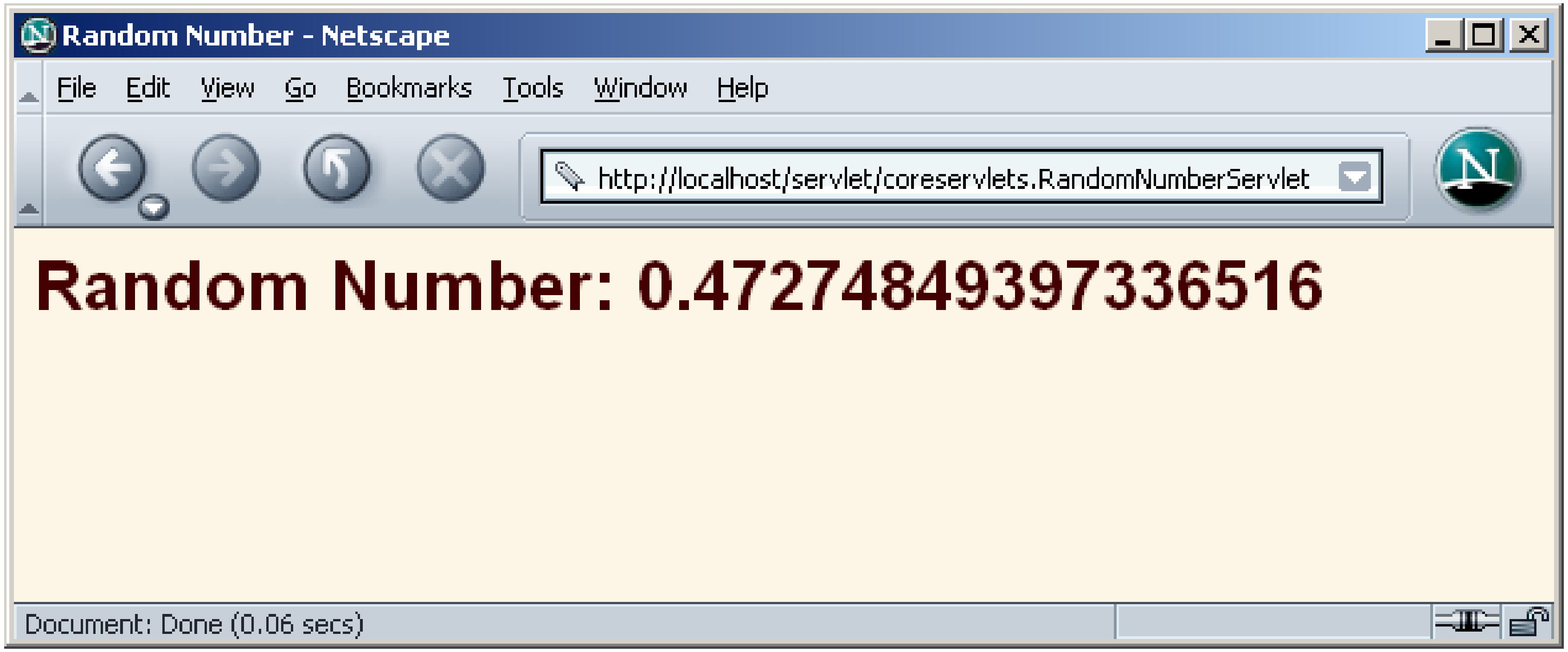
Request-Based Sharing: JSP 1.2

```
…
<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: JSP 2.0

```
…
<BODY>
<H2>Random Number:
${randomNum.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);
  }
}
```

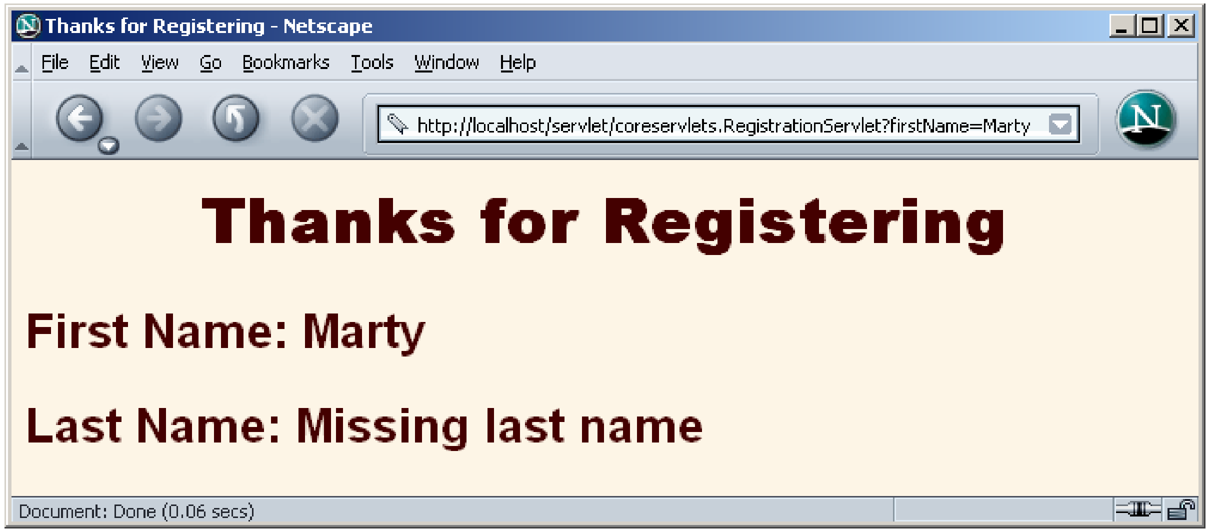
Session-Based Sharing: JSP 1.2

```
…
<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: JSP 2.0

```
…
<BODY>
<H1>Thanks for Registering</H1>
<H2>First Name:
${nameBean.firstName}</H2>
<H2>Last Name:
${nameBean.lastName}</H2>
</BODY></HTML>
```

Session-Based Sharing: Results


Thanks for Registering - Netscape
File Edit View Go Bookmarks Tools Window Help

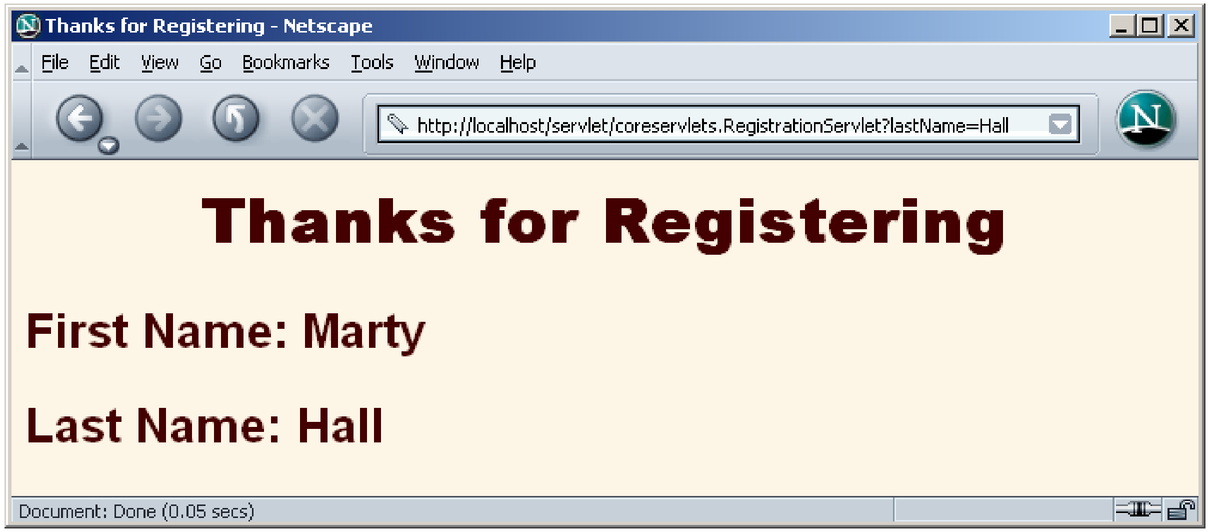
http://localhost/servlet/coreservlets.RegistrationServlet?firstName=Marty

Thanks for Registering

First Name: Marty

Last Name: Missing last name

Document: Done (0.06 secs)


Thanks for Registering - Netscape
File Edit View Go Bookmarks Tools Window Help

http://localhost/servlet/coreservlets.RegistrationServlet?lastName=Hall

Thanks for Registering

First Name: Marty

Last Name: Hall

Document: Done (0.05 secs)

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);
    }
  }
}
```

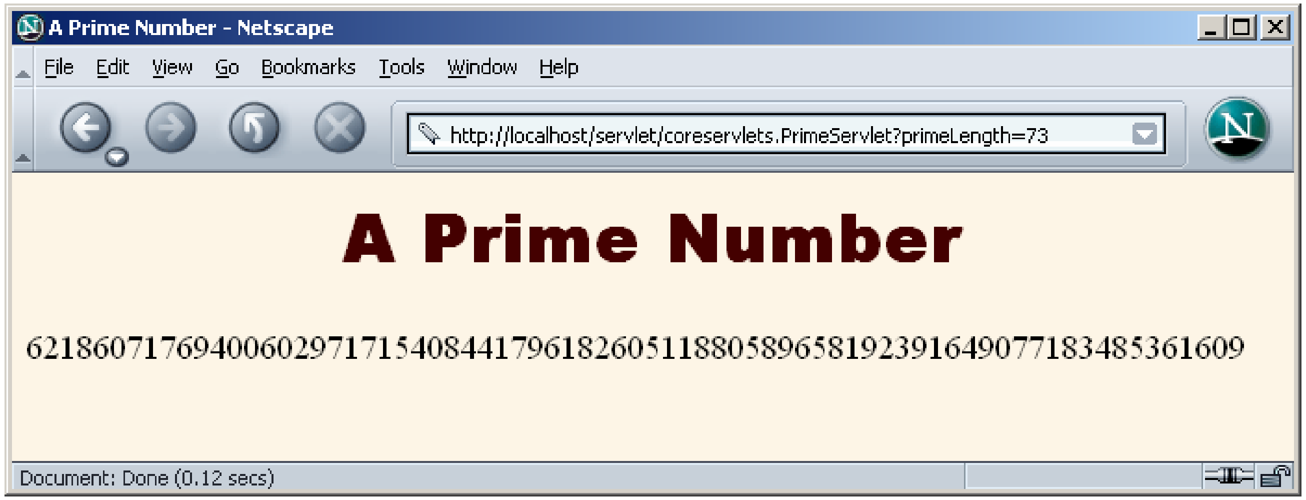
ServletContext-Based Sharing: JSP 1.2

```
…
<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: JSP 2.0

```
…
<BODY>
<H1>A Prime Number</H1>
${primeBean.prime}
</BODY></HTML>
```

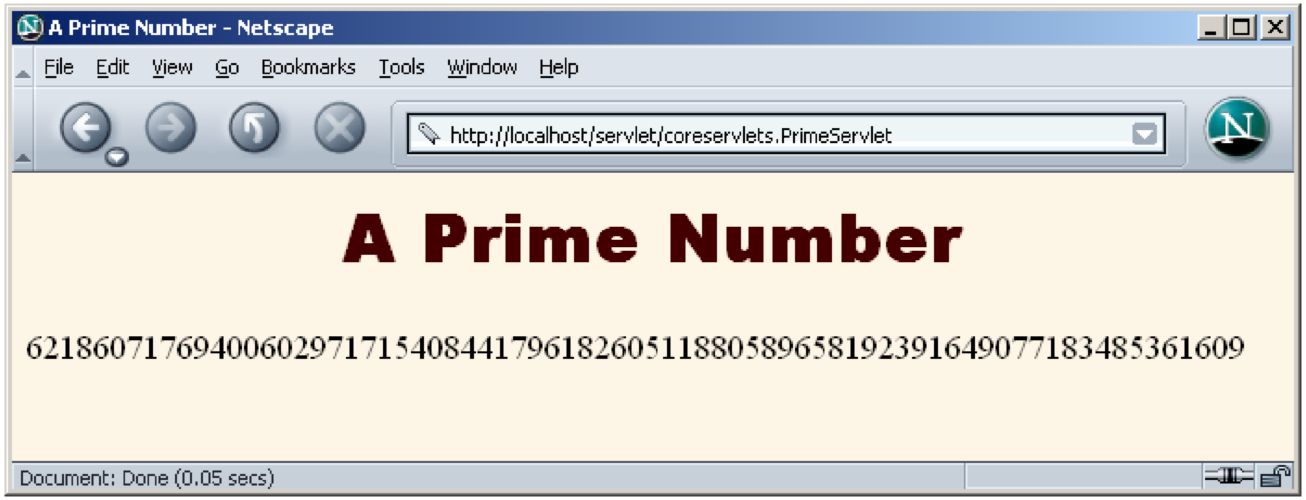
ServletContext-Based Sharing: Results


A Prime Number - Netscape
File Edit View Go Bookmarks Tools Window Help
http://localhost/servlet/coreservlets.PrimeServlet?primeLength=73

A Prime Number

621860717694006029717154084417961826051188058965819239164907718348536 1609

Document: Done (0.12 secs)


A Prime Number - Netscape
File Edit View Go Bookmarks Tools Window Help
http://localhost/servlet/coreservlets.PrimeServlet

A Prime Number

621860717694006029717154084417961826051188058965819239164907718348536 1609

Document: Done (0.05 secs)

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)