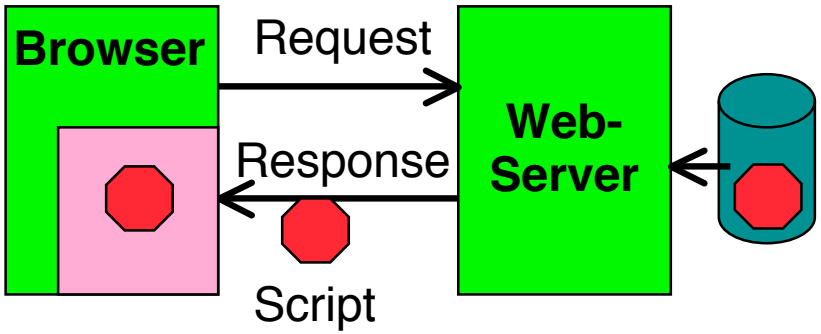
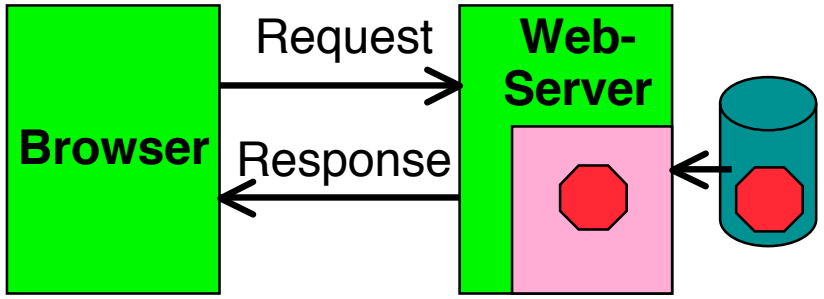
Chapter 3: Interactive Web Applications

Server-Side vs. Client-Side Realisation





- Client-side realisation:
  - Browser contains execution engine for scripts
  - Web server does not need to execute scripts
  - Script ist sent to client as part of server response
  - Examples: JavaScript, **Java Applets**

- Server-side realisation:
  - Web server contains execution engine for scripts
  - Browser does not need to execute scripts
  - Script is executed on server and computes response to client
  - Examples: PHP, **Java Servlets, Java Server Pages**

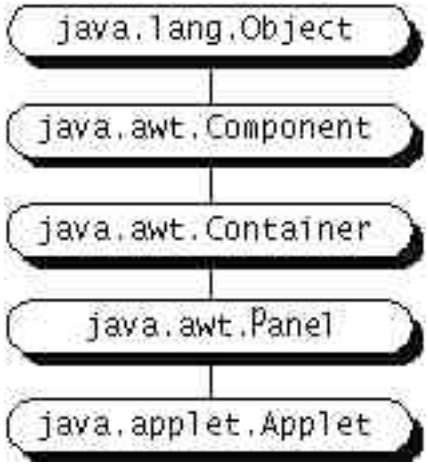
Applets

- *Applet:*
  - “application snippet”
  - Java program, embedded in HTML page
  - Executed by browser software
    - » directly or via *plugin*
  - Does not contain a "main()" method!
- *Application:*
  - *Stand-alone* Java program
  - Contains a static "main()" method

Example: Hello-World Applet (1)

```
import java.applet.Applet;
import java.awt.Graphics;

public class HelloWorldApplet extends Applet {
    public void paint(Graphics g) {
            g.setFont(new Font("SansSerif", Font.PLAIN, 48));
            g.drawString("Hello world!", 50, 50);
    }
}
```

- Class for applet derived from **`Applet`**
- **`Applet`** derived from **`Component`**
  - Calls **`paint`** Method
  - Redefining means it is executed at display time
- Cf. Java Swing, Java 2D



Example: Hello-World Applet (2 – Old Version)

```
<html>
  <head>
     <title> Hello World </title>
  </head>
  <body>

The Hello-World example applet is called: <br>

     <applet code="HelloWorldApplet.class" width=300>
     </applet>

  </body>
</html>
```

This is frequently used but deprecated HTML syntax!

Example: Hello-World Applet (2 – New Version)

```
<html>
  <head>
     <title> Hello World </title>
  </head>
  <body>

The Hello-World example applet is called: <br>

     <object   classid="java:HelloWorldApplet"
               codetype="application/x-java-applet"
               width=300>
     <object>

  </body>
</html>
```

Modern HTML syntax

Parameter Passing in HTML – Old Version

Applet:

```
public class HelloWorldAppletParam extends Applet {

    public void paint(Graphics g) {
     String it = getParameter("insertedtext");
     g.setFont(new Font("SansSerif", Font.PLAIN, 48));
        g.drawString("Hello "+it+" world!", 50, 50);
    }
}
```

HTML:

```
<html>
  ...
     <br>
     <applet code="HelloWorldAppletParam.class”
          width="800">
          <param name="insertedtext" value="wonderful">
     </applet>
  ...
</html>
```

Parameter Passing in HTML – New Version

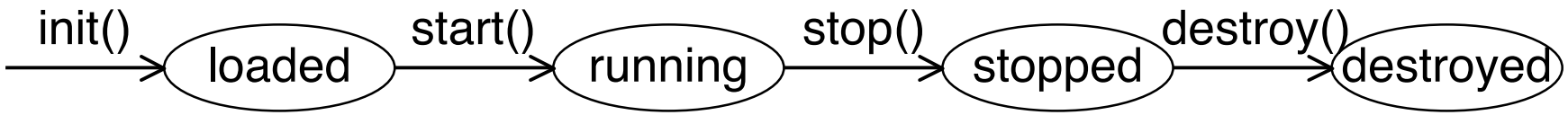
Applet:

```
public class HelloWorldAppletParam extends Applet {

    public void paint(Graphics g) {
     String it = getParameter("insertedtext");
     g.setFont(new Font("SansSerif", Font.PLAIN, 48));
        g.drawString("Hello "+it+" world!", 50, 50);
    }
}
```

HTML:

```
<html>
  ...
     <br>
     <object classid="java:HelloWorldAppletParam"
          codetype="application/x-java-applet"
          width="800">
          <param name="insertedtext" value="wonderful">
     </object>
  ...
</html>
```

Applet Life Cycle



Callback methods:

```
public class ... extends Applet {
    . . .
    public void init() { . . . }
    public void start() { . . . }
    public void stop() { . . . }
    public void destroy() { . . . }
    . . .
}
```

User Interaction in Applets

- Applets are able to react to user input
  - Define an event handler
  - Register during applet initialisation (init())
- Applets are executed locally, and therefore have full access to local input
  - Mouse movements, key press, …
  - This is not possible with server-side code!
- Applets can make use of graphics libraries
  - For instance Java 2D
  - This is not easily possible with server-side code!

Example: Mouse Interaction in an Applet

```
public class ClickMe extends Applet implements MouseListener {
    private Point spot;
    private static final int RADIUS = 7;

    public void init() {
      addMouseListener(this);
    }

    public void paint(Graphics g) {
      . . .
      g.setColor(Color.red);
      if (spot != null) {
            g.fillOval(spot.x - RADIUS, spot.y - RADIUS,'
            RADIUS * 2, RADIUS * 2);
        }
    }

    public void mousePressed(MouseEvent event) {
      if (spot == null)
            spot = new Point();
      spot.x = event.getX();
      spot.y = event.getY();
      repaint();
    }
    . . .
}
```

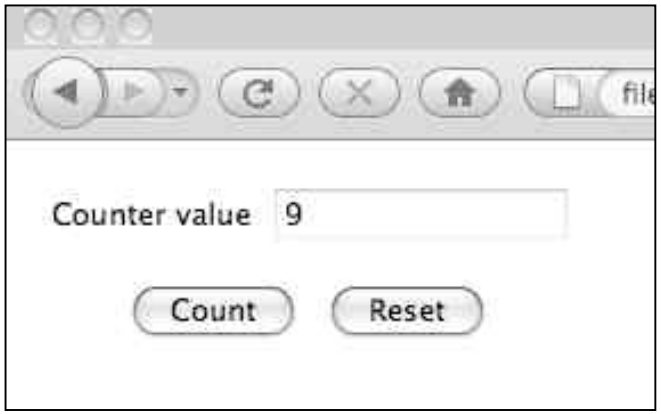
Swing Applets

- Class **`javax.swing.JApplet`**
  - Derived from **`Applet`**
  - Is a top level Swing Container
- All Swing GUI components can be used
- Particularities of Swing Applets:
  - Add panels, layout managers etc as with **`JFrame`**
  - Default layout manager ist **`BorderLayout`**
  - Direct drawing into a Swing applets is not recommended
  - Redefine method **`paintComponent()`**
  - Call parent method:

```
public void paintComponent(Graphics g){
   super.paintComponent(g);
   . . .
}
```

Example: Counter as Swing-Applet (1)

```
public class CounterSwingApplet extends JApplet {

    CounterPanel counterPanel;

    public void init() {
       counterPanel = new CounterPanel();
       add(counterPanel);
   }
}

// The View
class CounterPanel
       extends JPanel implements Observer {

   private Counter ctr;

   JPanel valuePanel = new JPanel();
   JTextField valueDisplay = new JTextField(10);

   JButton countButton = new JButton("Count");
   JButton resetButton = new JButton("Reset");
   JPanel buttonPanel = new JPanel();

   . . .
```



Example: Counter as Swing Applet (2)

```
   public CounterPanel () {          class CounterPanel (contd.)

        ctr = new Counter();
        valuePanel.add(new Label("Counter value"));
        . . .
        add(valuePanel,BorderLayout.NORTH);

        countButton.addActionListener(new ActionListener() {
            public void actionPerformed (ActionEvent event) {
                ctr.count();
            }
        });
        . . .
        ctr.addObserver(this);
    }

    public void update (Observable o, Object arg) {
        valueDisplay.setText(String.valueOf(ctr.getValue()));
    }

    public void paintComponent(Graphics g){
         super.paintComponent(g);
   }
}

class Counter extends Observable { . . . }
```

Organisation of Bytecode Files

- **<applet>** and **<applet>** tags allow
  - Declaration of a "codebase" directory (attribute **codebase**)
  - Declaration of a Java archive (JAR) file (attribute **archive**)
- Advantages of vodebase:
  - Java bytecode concentrated at one location
  - Fits with Java file conventions
- Advantages of archives:
  - Less files, less HTTP connections, better performance
  - Lower bandwidth requirements due to (LZW) compression

Applets and Security

- "Sandbox security": An applet is not allowed to
  - Open network connections (except of the host from which it was loaded)
  - Start a program on the client
  - Read or write files locally on the client
  - Load libraries
  - Call "native" methods (e.g. developed in C)
- "Trusted" Applets
  - Installed locally on the client, or
  - Digitally signed and verified
  - Such applets may get higher permissions, e.g. for reading/writing files

Advantages and Disadvantages of Java Applets

- Advantages:
  - Interaction
  - Graphics programming
  - No network load created during local interactions
  - Decentrally executed – good scalability
- Disadvantages:
  - Dependencies on browser type, browser version, Java version
  - Generally known as a not very reliable technlogy
  - Debugging is problematic

Chapter 3: Interactive Web Applications

3.1 Web Server Interfaces

...

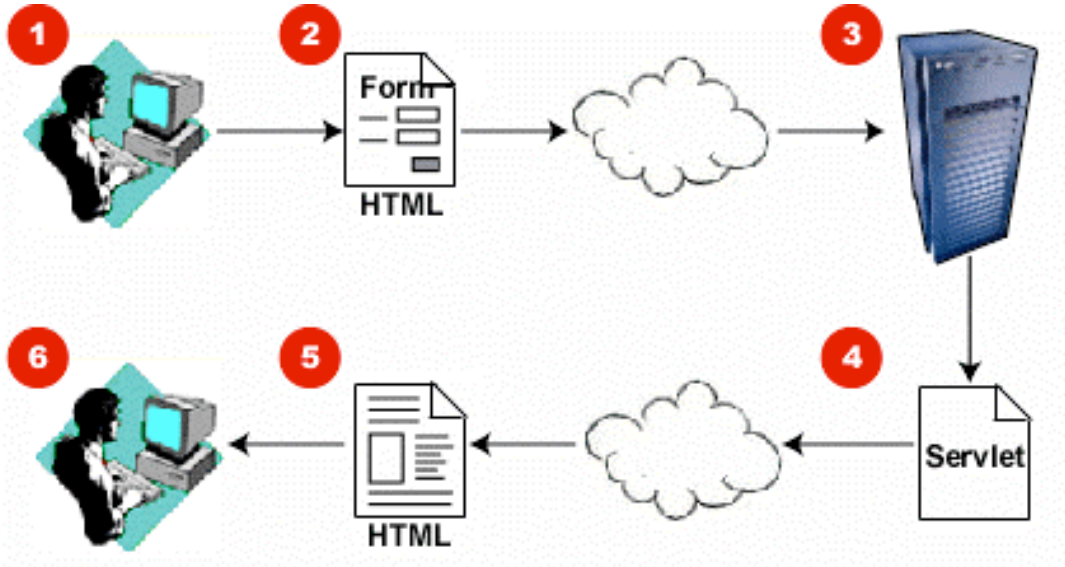
3.5 Web Programming with Java
(Applets, Servlets, Java Server Pages)

Applets
Servlets
Java Server Pages

Literature:

http://java.sun.com/products/servlet/docs.html
http://tomcat.apache.org/

Basic Principle: Server-Side Execution



1. User fills form
2. Form is sent as HTTP request to server
3. Server determines servlet program and executesit
4. Servlet computes response as HTML text
5. Response is sent to browser
6. Response, as generated by servlet, is displayed in browser

Java-Enabled Web Server

- Servlets are part of Java *Enterprise* Edition (Java EE)
- Prerquisite:
  - Web server must be enabled for Java *servlets*
    - » Recognize servlet requests
    - » Administer servlets
    - » Execute servlets *(servlet container)*
- Before doing any experments:
  - Install Servlet Container software
  - E.g. Apache Tomcat

Java Servlets

- Java Servlet Specification (JSS):
  - First version: 1996 (Java: 1995)
  - Current version: 2.5 (with Java EE 5)
- Java Server Pages: 1997-1999

- Important reference implementation:
  - "Jakarta" project of the "Apache" group
    - » Apache: OpenSource Web server
  - "Tomcat":
    - » Supports Servlets and JSP
    - » Separate server (used for the examples) or as module for Apache
    - » Some development environments include a servlet container

- Basic principle:
  - Web server calls servlet code on request from client (pattern Template Method)
  - Servlet determines response to client by manipulating data structures

Servlet-API: Basics

- **`abstract class javax.servlet.GenericServlet`**
  - Declares method **`service()`**
- **`abstract class javax.servlet.http.HttpServlet`**
  - Subclass of GenericServlet for HTTP servlets
  - Defines standard implementation for method **`service()`**, calls
    - » **`doPost(), doGet(), doPut()`**

```
protected void doGet(HttpServletRequest req,
    HttpServletResponse resp)
protected void doPost(HttpServletRequest req,
    HttpServletResponse resp)
```

- **`interface javax.servlet.http.HttpServletRequest`**
  - Provides information on request, method examples: **`getAttribute(), getParameter(), getReader()`**
- **`interface javax.servlet.http.HttpServletResponse`**
  - Access to response constrution, method examples: **`setContentType(), getWriter()`**

Example: Hello-World Servlet

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

public class HelloWorld extends HttpServlet {

    public void doGet(HttpServletRequest request,
            HttpServletResponse response)
      throws IOException, ServletException
    {
        response.setContentType("text/html");
        PrintWriter out = response.getWriter();
        out.println("<html>");
        out.println("<head>");
        out.println("<title>Hello World!</title>");
        out.println("</head>");
        out.println("<body>");
        out.println("<h1>Hello World!</h1>");
        out.println("</body>");
        out.println("</html>");
    }
}
```

Example: Very Simple Dynamic Servlet

HTML page showing current date and time

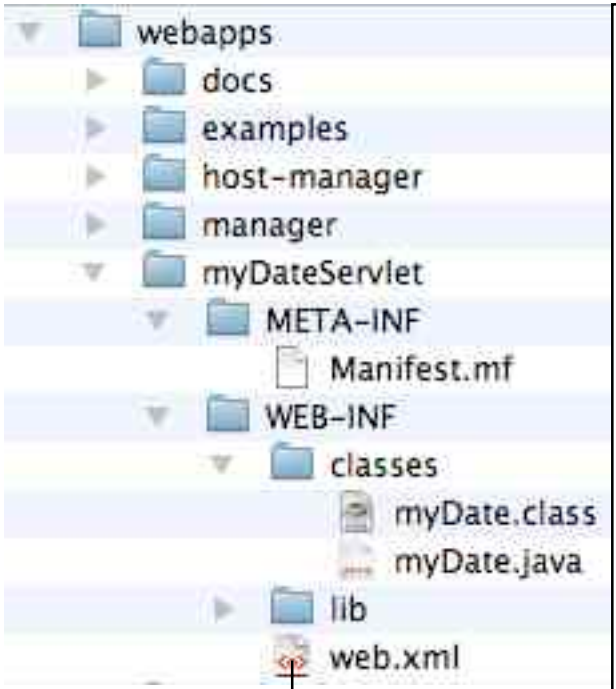
```
public class DateServlet extends HttpServlet {
  public void doGet (HttpServletRequest request,
                     HttpServletResponse response)
              throws ServletException, IOException {
    String title = "Date Servlet Page";
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    out.println("<html><head><title>");
    out.println(title);
    out.println("<title><head><body>");
    out.println("<h1>" + title + "</h1>");
    out.print("<p>Current time is: ");
    out.println(new java.util.GregorianCalendar().getTime());
    out.println("</body><html>");
    out.close();
  }
}
```

Java HTML

Deployment of Servlet Application

- Servlet is a Java code file (myDate.java)
  - Needs to be compiled
  - Needs to be made known to the Servlet Container
- *Deployment:*
  - Installation of new server-side java code in the server software
  - Provide a location (directory), called *context path*
  - Provide metadata on the new application
- Simplest way to deploy on Tomcat:
  - Create file structure according to conventions
  - Copy directory into Tomcat's "webapps" directory
  - Restart Tomcat server
- Other ways for deployment exist
  - E.g. adiministrative Web interface

File Structure for Deployment



Meta information

As a single archive:
Web application
archive (.war file)

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE web-app ... "http://java.sun.com/dtd/web-app_2_
<web-app>
    <display-name>My little Date Application</display-nam
    <description>
      Small demo example, by Heinrich Hussmann, LMU.
    </description>
    <context-param>
      <param-name>webmaster</param-name>
      <param-value>husmann@ifi.lmu.de</param-value>
      <description>...</description>
    </context-param>
   <servlet>
       <servlet-name>myDate</servlet-name>
       <description> ... </description>
       <servlet-class>myDate</servlet-class>
   </servlet>
   <servlet-mapping>
       <servlet-name>myDate</servlet-name>
       <url-pattern>/myDate</url-pattern>
   </servlet-mapping>
    <session-config>
      <session-timeout>30</session-timeout>    <!-- 30 mi
    </session-config>
</web-app>
```

Administration Interface for Server

Applications

Path	Display Name	Running	Sessions	Commands
/	Welcome to Tomcat	true	0	Start Stop Reload Undeploy Expire sessions with idle ≥ 30 minutes
/docs	Tomcat Documentation	true	0	Start Stop Reload Undeploy Expire sessions with idle ≥ 30 minutes
/examples	Servlet and JSP Examples	true	0	Start Stop Reload Undeploy Expire sessions with idle ≥ 30 minutes
/host-manager	Tomcat Manager Application	true	0	Start Stop Reload Undeploy Expire sessions with idle ≥ 30 minutes
/manager	Tomcat Manager Application	true	1	Start Stop Reload Undeploy Expire sessions with idle ≥ 30 minutes
/myDateServlet	My little Date Application	true	0	Start Stop Reload Undeploy Expire sessions with idle ≥ 30 minutes

Deploy

Deploy directory or WAR file located on server

Context Path (required):

XML Configuration file URL:

WAR or Directory URL:

Deploy

Chapter 3: Interactive Web Applications

3.1 Web Server Interfaces

...

3.5 Web Programming with Java
(Applets, Servlets, Java Server Pages)

Applets
Servlets
Java Server Pages

Literature:

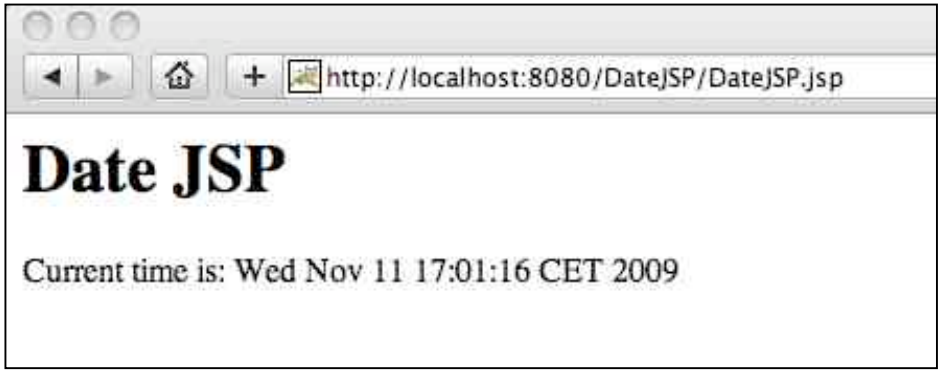
http://java.sun.com/products/jsp
http://www.apl.jhu.edu/~hall/java/Servlet-Tutorial/

Introductory Example: Java Server Page (JSP)

HTML page with current date/time

```
<html>
<%! String title = "Date JSP"; %>
<head><title> <%=title%> <title><head>
<body>
<h1> <%=title%> </h1>
<p>Current time is:
<% java.util.Date now = new GregorianCalendar().getTime(); %>
<%=now%></p>
</body></html>
```

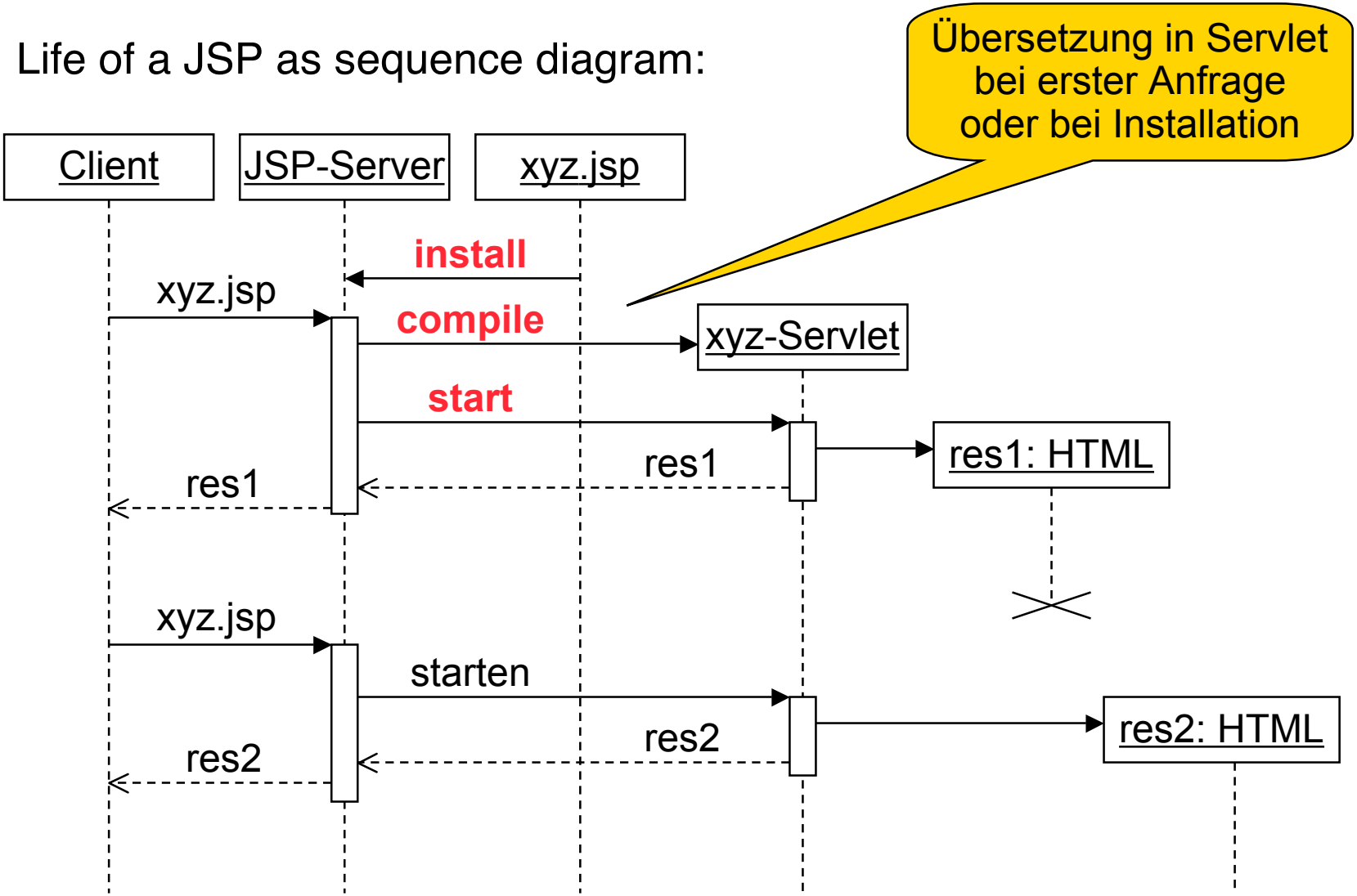
- Basic idea for Java Server Pages:
  - Scripts embedded in HTML ("*Scriptlets*")
  - Automatic translation into Java Servlet code



Java HTML

Java Server Pages und Servlets

Life of a JSP as sequence diagram:



JSP Language Elements

- Script elements
  - Embedding of Java code
- Implicit objects
  - Access to important parts of servlets
- Directives
  - Global instructions for compilation
- Actions
  - Standard elements for runtime behaviour

- JSP can be used to generate arbitrary texts, not only HTML
  - Interesting target language: XML

Embedding of Scriptlets in HTML

- Two options for embedding
- JSP-specific syntax: Tags with special symbols

  `<%, <%!, <%=, <%@, %>, <%--, --%>`

  – Not elegant, but very practical
- XML-Syntax with *name spaces*
  - » XML name space (xmlns) prefix, e.g. "jsp"
  - » Prefix definition is bound to a URL
  - » Tags take the form **`<jsp: xyz>`**
  - » Used for JSP actions in particular

JSP Script Elements

- Declarations
  - Syntax: `<%! declarations %>`
    `<jsp:declaration> declaration </jsp:declaration>`
  - Example: `<%! String title = "Date JSP"; %>`
  - Is translated into instance variable of generated class, i.e. visible in all methods of the class.
- Anweisungen (*Scriptlets*)
  - Syntax: `<% commands %>`
    `<jsp:scriptlet> commands </jsp:scriptlet>`
  - Example:
    ```
    <% java.util.Date now = new
       GregorianCalendar().getTime(); %>
    ```
  - Local variables are not visible in other methods.
- Expressions
  - Syntax: `<%= expression %>`
    `<jsp:expression> expression </jsp:expression>`
  - Example: `<%= now %>`
  - Equivalent to `<% out.print(now); %>`

Implicit Objects in JSP Scripts

The most important implicit objects:

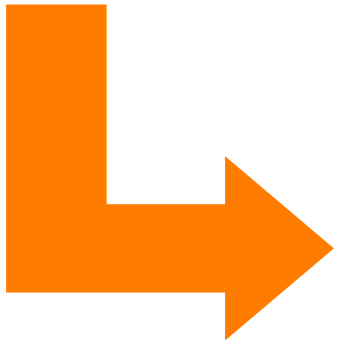
- **`request (javax.servlet.http.HttpServletRequest)`**
  - To read HTTP headers, parameters, cookies etc. from request
- **`response (javax.servlet.http.HttpServletResponse)`**
  - To write HTTP headern, cookies etc. into the response
- **`session (javax.servlet.http.HttpSession)`**
  - Tracking of associated interactions ("sessions")
- **`out (javax.servlet.jsp.JspWriter)`**
  - Output stream (result test)
  - Standard **`print()`** and **`println()`** commands

- Example:

```
<% if (request.getParameter("CountButton")!=null) {
     counter.count();
   }; %>
```

Generated Servlet Code (Excerpt)

```
<html>
  <%! String title = "Date JSP"; %>
  <head>
      <title> <%=title%> </title>
  </head>
  <body>
      <h1> <%=title%> </h1>
      <p>Current time is:
            <% java.util.Date now = new GregorianCalendar().getTime(); %>
            <%=now%>
  </body>
</html>
```



```
...
out.write("\r\n");
out.write("\t<body>\n");
out.write("\t\t<h1> ");
out.print(title);
out.write(" </h1>\n");
out.write("\t\t<p>Current time is:\n");
out.write("\t\t\t");
java.util.Date now = new GregorianCalendar().getTime();
out.write("\n");
out.write("\t\t\t");
out.print(now);
out.write("\n");
```

Cleaning Up the JSP Code

- Mixture between Java scriptlets and HTML markup
  - Is confusing
  - Is difficult to maintain
- Approaches to a better structure of the JSP:
  - Use JavaBeans
  - Use Tag Libraries
  - Use JSPX (since JSP 2.0)

What Is a JavaBean?

- JavaBeans is a *software component* model for Java
- Software components:
  - Units of software which can be stored, transmitted, deployed, configured, executed without knowing the internal implementation
  - Main usage: Tools for composing components
- Driver for JavaBeans technology: User Interfaces
  - AWT and Swing components are JavaBeans
  - GUI editing tools instantiate and configure JavaBeans
- Main properties of a JavaBean:
  - Has a simple constructor without parameters
  - Provides public getter and setter methods for its properties: **`get`*`Prop`*`, set`*`Prop`***
  - Is serializable
  - Supports listener mechanism for property changes

JavaBeans in JSP: Action useBean

- Syntax of useBean Aktion:

```
<jsp:useBean id=localName class=className
             scope=scopeDefn />
```

  scope: "page“ (current page), "request" (current request)
  "session" (current session), "application" (full application)

- Reading properties:

```
<jsp:getProperty   name=localName
                   property=propertyName/>
```

- Writing properties:

```
<jsp:setProperty   name=localName
                   property=propertyName/>
                   value=valueAsString/>
```

```
<jsp:getProperty   name="counter" property="current"/>
```

is equivalent to:

```
<%=counter.getCurrent();%>
```

Counter as JavaBean (1)

```
package counter;
import java.beans.*;


public class Counter extends Object implements java.io.Serializable {

    private static final String PROP_CURRENT = "current";
    private static final String PROP_START_VALUE = "start value";
    private static final String PROP_INCR_VALUE = "incr value";
    private static final String PROP_ENABLED = "enabled";
    private int count;
    private int startValue;
    private int incrValue;
    private boolean enabled;
    private PropertyChangeSupport propertySupport;

    public Counter() {
        propertySupport = new PropertyChangeSupport ( this );
        startValue = 0;
        incrValue = 1;
        reset();
        enabled = true;
    }
```

Counter as JavaBean (2)

Contd.

```
public int getCurrent () {
    return count;
}

public int getStartValue () {
    return startValue;
}

public void setStartValue (int value) {
    int oldStartValue = startValue;
    startValue = value;
    propertySupport.firePropertyChange
      (PROP_START_VALUE, oldStartValue, startValue);
}

public int getIncrValue () {
    return incrValue;
}

public void setIncrValue (int value) {
    int oldIncrValue = incrValue;
    incrValue = value;
    propertySupport.firePropertyChange
      (PROP_INCR_VALUE, oldIncrValue, incrValue);
}
```

Counter as JavaBean (3)

```
    public boolean getEnabled () {...}

    public void setEnabled (boolean value) {...}

    public void reset () {
        count = startValue;
    }

    public void count () {
        if (enabled) {
            int oldCountValue = count;
            count += incrValue;
            propertySupport.firePropertyChange
              (PROP_CURRENT, oldCountValue, count);
        }
    }

    public void addPropertyChangeListener
      (PropertyChangeListener listener) {
        propertySupport.addPropertyChangeListener (listener);
    }

    public void removePropertyChangeListener (...) {...}
}
```

Counter JSP with JavaBeans: HTML Source

```
<%@ page contentType="text/html" session="true"%>
<%@ page language="java"%>
<html>
   <head><title>Counter Demo Page</title></head>
   <body>
        <jsp:useBean id="counter" scope="session"
                class="counter.Counter"/>
        <%      if (request.getParameter("CountButton")!=null) {
                        counter.count();
                };
                if (request.getParameter("ResetButton")!=null) {
                        counter.reset();
                }
        %>

        <h2 align="center">Counter Demo</h2>
        Current counter value =
        <jsp:getProperty name="counter" property="current" />
        <br>
        <form method="POST" action="CounterJSP.jsp">
                <input name="CountButton" type="submit" value="Count">
                <input name="ResetButton" type="submit" value="Reset">
        </form>
   </body>
</html>
```

JSP Directives

- A JSP directive affects the overall structure of the generated servlet class.
- Syntax:

  <%@ *directiveType attribute=value*> or

  <jsp:directive.*directiveType attribute=value*>
- Frequently used directive: **page**
  - Import of packages
  - Content type for response
  - Session support
  - Language (java)
  - ...

JSP Tag Libraries

- A tag library is a collection of *custom tags*
  - –A custom tag invokes a *custom action*, described by *tag handler* code
- Typical examples of actions which may be invoked by custom tags:
  - –Form processing, accessing databases, email, flow control
- Custom tags can be customized on the JSP page by attributes
  - –Reduces actual scripting required on page
- Example: Custom *iteration* tag

```
<%@ taglib uri="/tlt" prefix="tlt" %>
<html>...<body>
   <jsp:useBean id="org" class="Organization"/>
   <table border=2 cellspacing=3 cellpadding=3>
   <tlt:iteration name="departmentName" type="String"
      group="<%= org.getDepartmentNames()%>">
    ...
    <tr>
      <td><a href="list.jsp?deptName=
             <%= departmentName %>">
            <%= departmentName %></a></td>
    </tr>
   </tlt:iteration>
   </table>
</body></html>
```

Example: Tag Handler for Iteration Custom Tag

```
private Iterator iterator;

public void setGroup(Collection members){
      if(members.size() > 0)
            iterator = members.iterator();
}
public int doStartTag() {
      if(iterator == null) {
            return SKIP_BODY;
      }
      if(iterator.hasNext()){
            pageContext.setAttribute(name, iterator.next());
            return EVAL_BODY_TAG;
      } else {
            return SKIP_BODY;
      }
}
...
```

Sun JSP Tutorial

Java Server Pages Standard Tag Library (JSTL)

- Standardized collection of custom tags
  - To simplify construction of JSP pages
  - To avoid use of scripting (=Java)
  - To achieve homogeneity in style
- Areas covered by JSTL:
  - General purpose actions (display expressions, set and read attributes, ...}
  - Control flow actions (conditionals, iterators)
  - Tag library validation (enforce coding styles and specific libraries)
  - Frequently uses functions:
    - » Accessing URL-based resources
    - » Internationalization, text formatting
    - » Relational database access (SQL)
    - » XML processing
    - » String manipulation

JSTL Examples

```
You have <c:out value="${sessionScope.user.itemCount}"/> items.
```

```
<table>
    <c:forEach var="customer" items="${customers}">
        <tr><td>${customer}</td></tr>
    </c:forEach>
</table>
```

```
<acme:fullMoon v
<c:choose>
  <c:when test="
    ...
  </c:when>
  <c:otherwise>
    ...
  </c:otherwise>
</c:choose>
```

```
<sql:query var="customers" dataSource="${dataSource}">
 SELECT * FROM customers
 WHERE country = 'China'
 ORDER BY lastname
</sql:query>

<table>
 <c:forEach var="row" items="${customers.rows}">
   <tr>
     <td><c:out value="${row.lastName}"/></td>
     <td><c:out value="${row.firstName)"/></td>
     <td><c:out value="${row.address}"/></td>
   </tr>
 </c:forEach>
</table>
```

JSP Expression Language (EL)

- With JSTL, a simpler way to access values was introduced
  - Syntax: Delimited by `${ ... }`
- Since JSP 2.0, Expression Language is part of general JSP specification
- EL features:
  - Access to implicit objects
  - Type system
  - Classical operators
    (with textual keyword equivalents to special characters)

Alternatives to JSP

- Microsoft Active Server Pages (ASP)
  - Uses a script language (VBScript, Jscript, Perl)
  - Comparable to PHP, no longer maintained!
- Microsoft Server Pages .NET
  - www.asp.net
  - Creation of Web applications with all languages supported by .NET framework
    - » E.g. C#, F#
  - Free technology
  - Comparable in functionality to JSP

    ```
    <%Response.Write(now())%>
    ```
  - Server controls (tags evaluated on server) (`"runat="server"`)
  - Event handlers
- Open source alternatives in development:
  - Python Server Pages, Perl Server Pages