Lecture Overview

- Three-tier architectures
- Presentation tier
- Application tier

Components of Data-Intensive Systems

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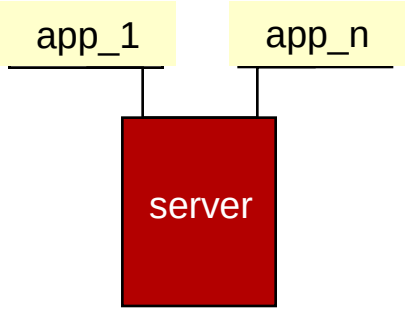
- Presentation
  - Primary interface to the user
  - Needs to adapt to different display devices (PC, PDA, cell phone, voice access, …)
- Application (“business”) logic
  - Implements business logic (implements complex actions, maintains state between different steps of a workflow)
  - Accesses different data management systems
- Data management
  - One or more standard database management systems
- system architecture determines whether these three components reside on a single system (“tier) or are distributed across several tiers

Single-Tier Architectures

- All functionality combined into a single tier
  - usually on a mainframe
  - User access through dumb terminals
- Advantage
  - Easy maintenance and administration
- Disadvantages
  - users expect graphical user interfaces
  - Heavy load on central system



Disadvantages of Thick Clients

- No central place to update the business logic
- Security issues: Server needs to trust clients
  - Access control and authentication needs to be managed at the server
  - Clients need to leave server database in consistent state
  - One possibility: Encapsulate all database access into stored procedures
- Does not scale to more than several 100s of clients
  - high data transfer volume between server and client
  - More than one server creates a problem:
    x clients, y servers => x*y connections

Example: Airline reservations

- Consider a system for making online airline reservations
- What is done in the different tiers?

- Client Program
  - Log in different users
  - display forms and human-readable output
- Application Server
  - Logic to make reservations, cancel reservations, add new airlines, etc.
- Database System
  - Airline info, available seats, customer info, etc.

Technologies

Client Program (Web Browser)

HTML
Javascript
XSLT

Ajax

Application Server

JSP
Servlets
Cookies
CGI

Database Management System

Tables, XML
Stored Procedures

Advantages of the Three-Tier Architecture

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- Heterogeneous systems
  - Tiers can be independently maintained, modified, and replaced
- Scalability
  - Replication at middle tier permits scalability of business logic
- Thin clients
  - Only presentation layer at clients (web browsers)
- Integrated data access
  - Several database systems can be handled transparently at the middle tier
  - Central management of connections
- Software development
  - Code for business logic is centralized
  - well-defined APIs between tiers allow use of standard components

Overview of Technologies: Client-side

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- Contents presented by browser (static)
  - Text, HTML/CSS, XML/DTD/XSL, images, movies, audio, ...
- Contents interpreted by the browser
  - Dynamic HTML; Browser scripting: JavaScript, VBScript, ...
- Programs executed in browser context
  - Java applets (byte code, virtual machine), ActiveX (native code)
- Dedicated programs in browser context
  - Plug-ins (flash, ...)
- External programs launched by browser
  - Helper applications
- *Security always an issue: keeping client machine safe from intruders*

Overview of Technologies: Server-side

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- Static contents (eg, HTML) with executable code
  - SSI (Server-Side Includes), XSSI
  - Server-side Scripting (Livewire, ASP, PHP, JSP, ...)
- Generated contents
  - Separate process per call: CGI
  - Within server context: Fast-CGI, Servlets, ...
- Server extensions
  - Google APIs, NSAPI, IISAPI, Apache modules, ...
  - Database gateways/frontends
- Application servers

Common requirements:
- flexibility
- good string (HTML!) handling
- rich functionality
- DB connectivity

- *Security always an issue: keeping the server safe from intruders*

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The Presentation Tier

- Recall: Functionality of the presentation tier
  - Primary interface to the user
  - Needs to adapt to different display devices (PC, PDA, cell phone, voice access?)
  - Simple functionality, such as field validity checking
- Mechanisms:
  - HTML Forms: How to pass data to the middle tier
  - Dynamic HTML / JavaScript: Simple functionality at the presentation tier
  - Style sheets: Separating data from formatting (see earlier)

HTML Forms (recall)

- Common way to communicate data from client to middle tier
- General format of a form:
  - <form action="page.jsp" method="GET" name="loginForm">
    <input type=… value=… name=…>
    </form>
- Components of an HTML form tag:
  - action: URI that handles the content
  - method: HTTP GET or POST method
  - name: Name of the form; can be used in client-side scripts to refer to the form

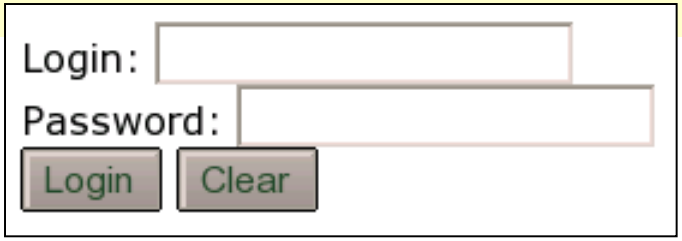
JavaScript

- Goal: Add functionality to the presentation tier
- Sample applications:
  - Detect browser type and load browser-specific page
  - Browser control: Open new windows, close existing windows (example: pop-up ads)
  - Client-side interaction (conditional forms elements, validation, …)
- embedded directly in HTML, or external reference
  - <script language="JavaScript" src="validate.js"/>

JavaScript: Example

- HTML Form:

```
<form method=”GET“ name=“LoginForm”
action="TableOfContents.jsp">
Login:
<input type="text" name="userid"/>
Password:
<input type="password“ name="password"/>
<input type="submit“ value="Login“
      name="submit” onClick=“testEmpty()”/>
<input type=“reset” value=“Clear”/>
</form>
```



- Associated JavaScript:

```
<script language="javascript">
function testEmpty()
{ loginForm = document.LoginForm
  if ( (loginForm.userid.value == "") ||
       (loginForm.password.value == "") )
  {  alert( ‘Error: Empty userid or password.‘ );
     return false;
  }
  else
    return true;
}
</script>
```

JavaScript: Browser Support

- Document Object Model (DOM)
  very different across browser types
  - Pertaining standard:
    see www.w3c.org/DOM/
  - In particular, non-standard
    in MS Internet Explorer
  - However, MS IE predominant (?)
- Example: access to forms
  - document.loginForm
  - document.all.loginForm
  - …
- Consequence:
  different code needed for different browsers
- Remedy: driver level
  with browser-specific differentiation
  - Bad: *browser sniffing*
    if (navigator.appName == 'MS IE 6.0') ...
  - Better: *capability sniffing*
    if (document.all && document.all.loginForm)
    document.all.loginForm = ...
  - Best: *build driver layer*
    hiding specifics through capability sniffing
    function changeElem(id, newValue)

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The Middle (Application) Tier

- Recall: Functionality of the middle tier
  - Encodes business logic
  - Connects to database system(s)
  - Accepts form input from the presentation tier
  - Generates output for the presentation tier
- Mechanisms:
  - CGI: Protocol for passing arguments to programs running at the middle tier
  - Application servers: Runtime environment at the middle tier
  - Servlets: Java programs at the middle tier
  - PHP: Program parts in schematic documents (see earlier)
  - How to maintain state at the middle tier

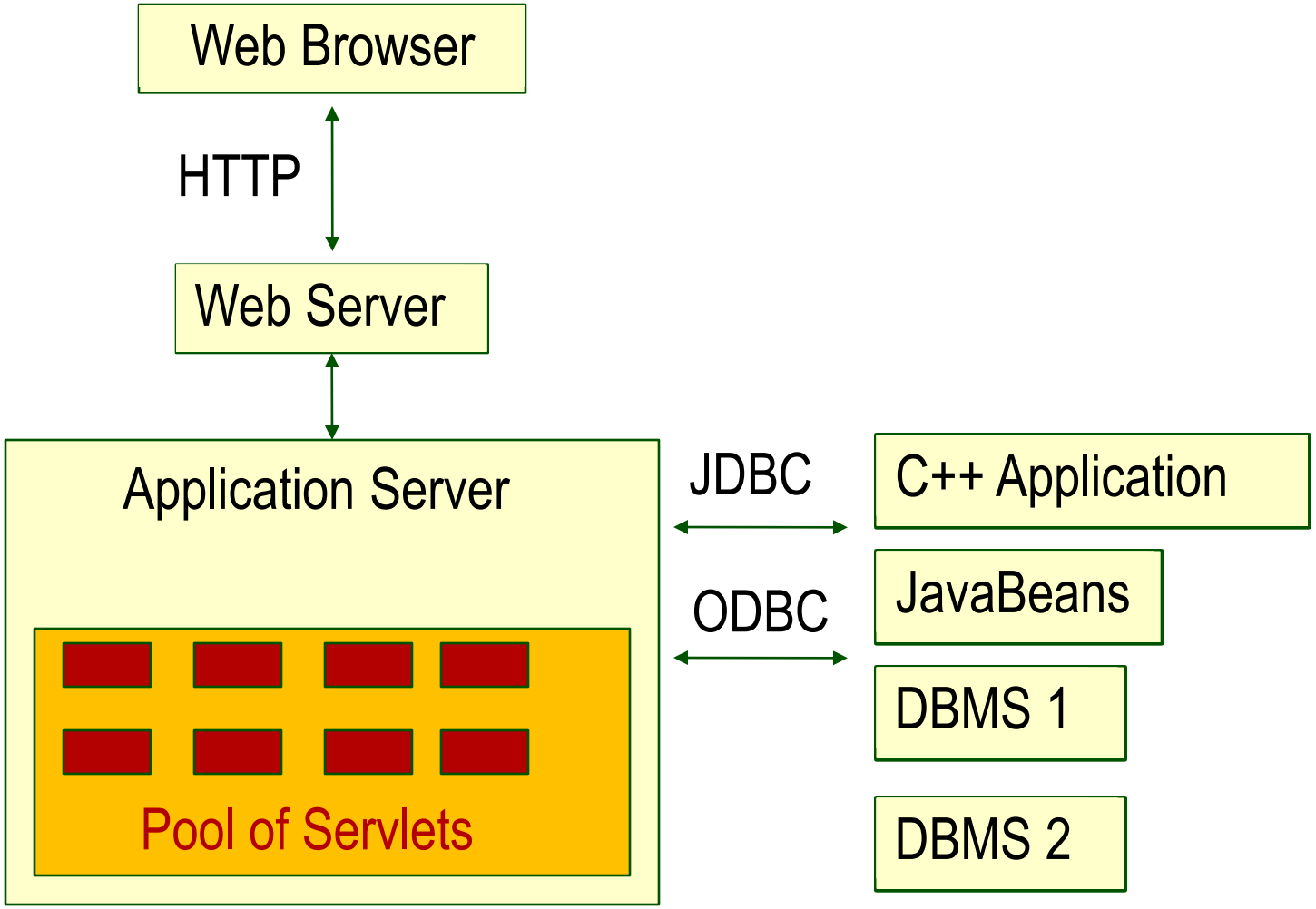
CGI: Common Gateway Interface

- Goal: Transmit arguments from HTML forms to application programs running at the middle tier
- Details of the actual CGI protocol unimportant
  - libraries implement high-level interfaces
- Disadvantages:
  - application program invoked in new process at every invocation (remedy: FastCGI)
  - No resource sharing (database connections!) between application programs (remedy: application servers)

Application Servers

- Idea: Avoid overhead of CGI
  - Main pool of threads of processes
  - Manage connections
  - Enable access to heterogeneous data sources
  - Other functionality such as APIs for session management

Application Server: Process Structure



Servlets

- Java Servlets: Java code that runs on the middle tier
  - Platform independent
  - Complete Java API, including JDBC
- Requires servlet engine (aka application server) such as Tomcat
  - Provides infrastructure to servlet: URL decoding, thread dispatching, std interfaces, …
- Life of a servlet?
  - Webserver forwards request to servlet container
  - Container creates servlet instance
  - Container calls service() method

Ex: Java With HTML Inside

```
/**
 * return a full HTML page, as opposed to fragments
 */
private String composeFullPage() throws ConnectionFailedException, ConfigurationExcep
{
    Debug.enterVerbose( "composeFullPage()" );

    String result =
            "<!doctype html public \"-//w3c/
          + "<html>"
          + "<head>"
          +   "<meta http-equiv='expires' co
          +   "<title>" + Globals.HTML_TITLE
          +   "<link rel='stylesheet' type='
          +   "<script type='text/javascript
          +   "<script type='text/javascript
          // start external: (open source, b
          +   "<script type='text/javascript
          +   "<script type='text/javascript
          +   "<script type='text/javascript
          // end external
          +   "<script type='text/javascript
          + "</head>"
          + "<body class='commander'>"
          + "<script type='text/javascript'
          + "<table class='commander' width=
          + "<tr>"
          +   "<td>"
          +     "<form method='POST' action=
          +     "<script type=text/javascrip
          +     "</script>";      // close s

    // provide area for global status report
    result += "<p>"
          + "<table class=globalMsg border=0
          + "<tr>"
```

```
    // initialize tree node id generator
    resetNodeId();                          // start new id namespace

    // START tree area (for JS manipulation)
    result += "<div id=" + Globals.JS_SERVICE_TREE_ROOT + " class=" + Global
            + "<script type=text/javascript>";

    // generate tree
    result += Globals.NODE_VARNAME  + " = new dTree('" + Globals.NODE_VARNAM
    int auxNode = newNodeId();              // fake root node, as dtree does
    result += mkInnerNode( auxNode, Globals.JS_SERVICE_TREE_ROOT_ID, "WMS se
            "[ <a href=\"javascript:" + Globals.NODE_VARNAME + ".openAll()
            + "/ <a href=\"javascript:" + Globals.NODE_VARNAME + ".closeAll(
            "", Globals.NO_KEY );
    int servicesNode = newNodeId();         // root node id for service

    // template: nodeId, parentId, nodeName, statusBulb, actions, msg, tuple
    result += mkInnerNode( servicesNode, auxNode, Globals.HTML_SERVICES+Glob
            "",
            "[ <a href=\"javascript:addService(" + Globals.NODE_VARNAME + ",
            "",
            Globals.NO_KEY );

    // recursively generate tree of services
    result += composeServices( servicesNode );

    // write out tree generated
    result += "document.write(" + Globals.NODE_VARNAME + ");";

    // END tree area (for JS manipulation)
    result += "</script>"
            + "</div>";

    // write tree and close document
    result += "    </form>"
            + "  </td>"
            + "</tr>"
            + "</table>"
            + "</body>"
            + "</html>";

    Debug.leaveVerbose( "composeFullPage()" );
    return result;
```

Vice versa, ie: HTML with PHP inside?
See earlier example & your project!

Speed Comparison

- Where is the overhead with CGI?
  - Fork process
  - Load Perl interpreter
  - Initialize Perl runtime system
  - Load payload script
  - Interpret / precompile&execute script
- Sample benchmarks [LAMP book]
  - CGI vs. mod_perl 36 : 6 = 6
  - /cgi-bin vs. /perl 200 : 8 = 25

Maintaining Client State

- http is stateless – but there is information that needs to persist
  - Old customer orders
  - “Click trails” of a user’s movement through a site
  - Permanent choices a user makes
- Advantages
  - Easy to use: don’t need anything
  - Great for static-information applications
  - Requires no extra memory space
- Disadvantage: No record of previous requests means:
  - No shopping baskets, no user logins
  - No custom or dynamic content
  - Security is more difficult to implement

Server-Side State

- Various types of server-side state, such as:
- 1. Store information in a database
  - Data will be safe in the database
  - BUT: requires a database access to query or update the information
- 2. Use application layer's local memory
  - Can map the user's IP address to some state
  - BUT: this information is volatile and takes up lots of server main memory

Client-side State: Cookies

- Cookie = (Name, Value) pair
- Text stored on client, passed to the application with every HTTP request
  - Lifetime can be preset (eg, 1 hour)
  - Can be disabled by client
  - wrongfully perceived as "dangerous", therefore will scare away potential site visitors if asked to enable cookies
- Advantages
  - Easy to use in Java Servlets / PHP
  - simple way to persist non-essential data on client even when browser has closed
- Disadvantages
  - Limit of 4 kilobytes
  - Users can (and often will) disable them
- Usage: store interactive state
  - current user's login information
  - current shopping basket
  - Any non-permanent choices user has made

Hidden State: Hidden Fields

- Declare hidden fields within a form:
  - <input type='hidden' name='user' value='username'/>
- Advantages
  - Users will not see information unless they view HTML source
- Disadvantages
  - If used prolifically, it's a performance killer
    – EVERY page must be contained within a form
  - Works only in presence of forms

Hidden State: KVP Information

- Information stored in URL GET request:
  - http://server.com/index.htm?user=jeffd
  - http://server.com/index.htm?user=jeffd&preference=pepsi
- Parsing field in Java:
  - javax.servlet.http.HttpUtils.parserQueryString()
- Advantages
  - Independent from forms
- Disadvantages
  - Limited to URL size (some kB)

Multiple state methods

- Typically all methods of state maintenance are used:
  - User logs in and this information is stored in a cookie
  - User issues a query which is stored in the URL information
  - User places an item in a shopping basket cookie
  - User purchases items and credit-card information is stored/retrieved from a database
  - User leaves a click-stream which is kept in a log on the web server (which can later be analyzed)

Some Web Service Security Hints

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- Never use anything blindly that comes from client side
  - don't assume that JavaScript code has been executed
  - double check cookies on server
  - don't trust hidden fields contents
- never assume anything!
  - set defaults (define in a central place!)
- Clear state after request response
- as with any API: clean, defensive programming
  - perform standard plausi checks:
    admissible number ranges, empty strings, max string lengths!
- *Be paranoid !!!*

Summary: 3-Tier Architectures

- Web services commonly architected as having 3 components
  - Presentation / application / data management tier
- Application tier needs most implementation flexibility
  - Rich choice of platforms (Java servlets, PHP, ...), each with tool support
- To maintain state, use:
  - Hidden form fields, hidden paths, cookies, server store, …
- *For every aspect & component, security is an issue!*