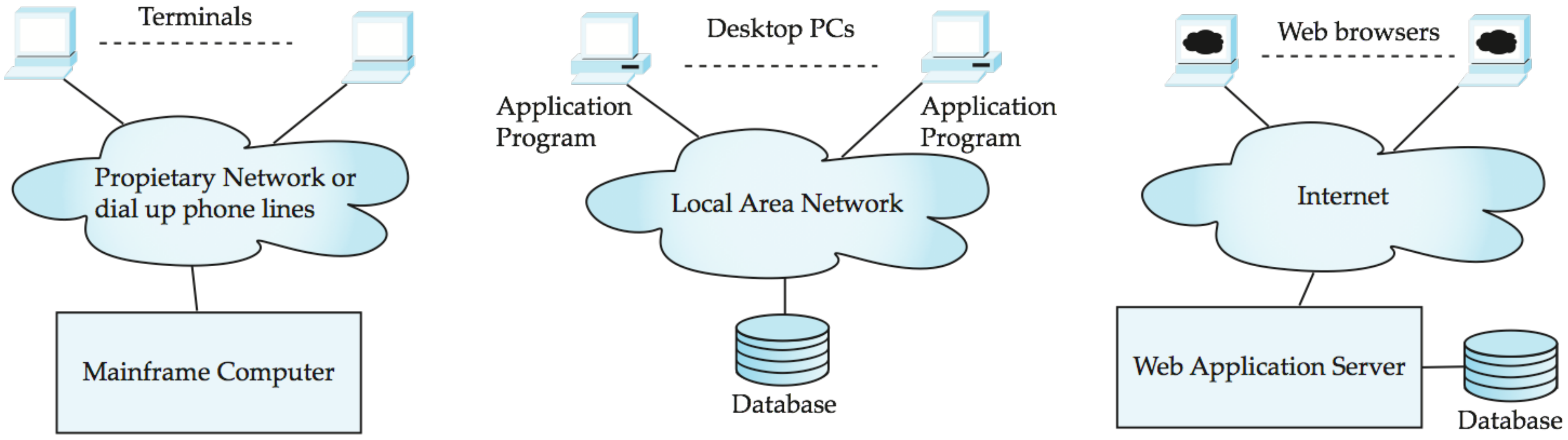
Introduction to networking

APPLICATION ARCHITECTURE

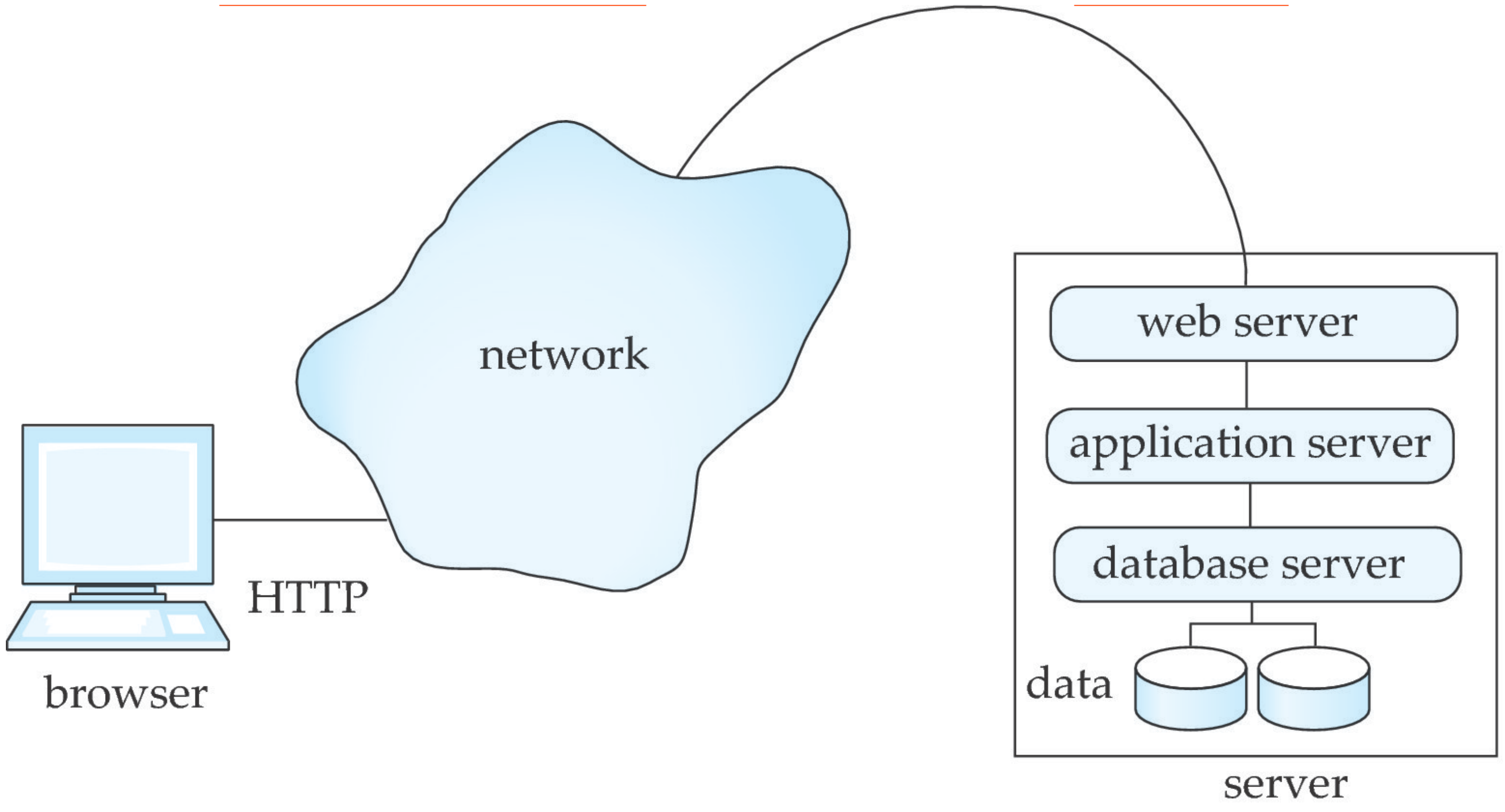
Application Architecture Evolution

- Three distinct era's of application architecture
  - mainframe (1960's and 70's)
  - personal computer era (1980's)
  - C/S era (1990's onwards)
  - Cluod (today …)



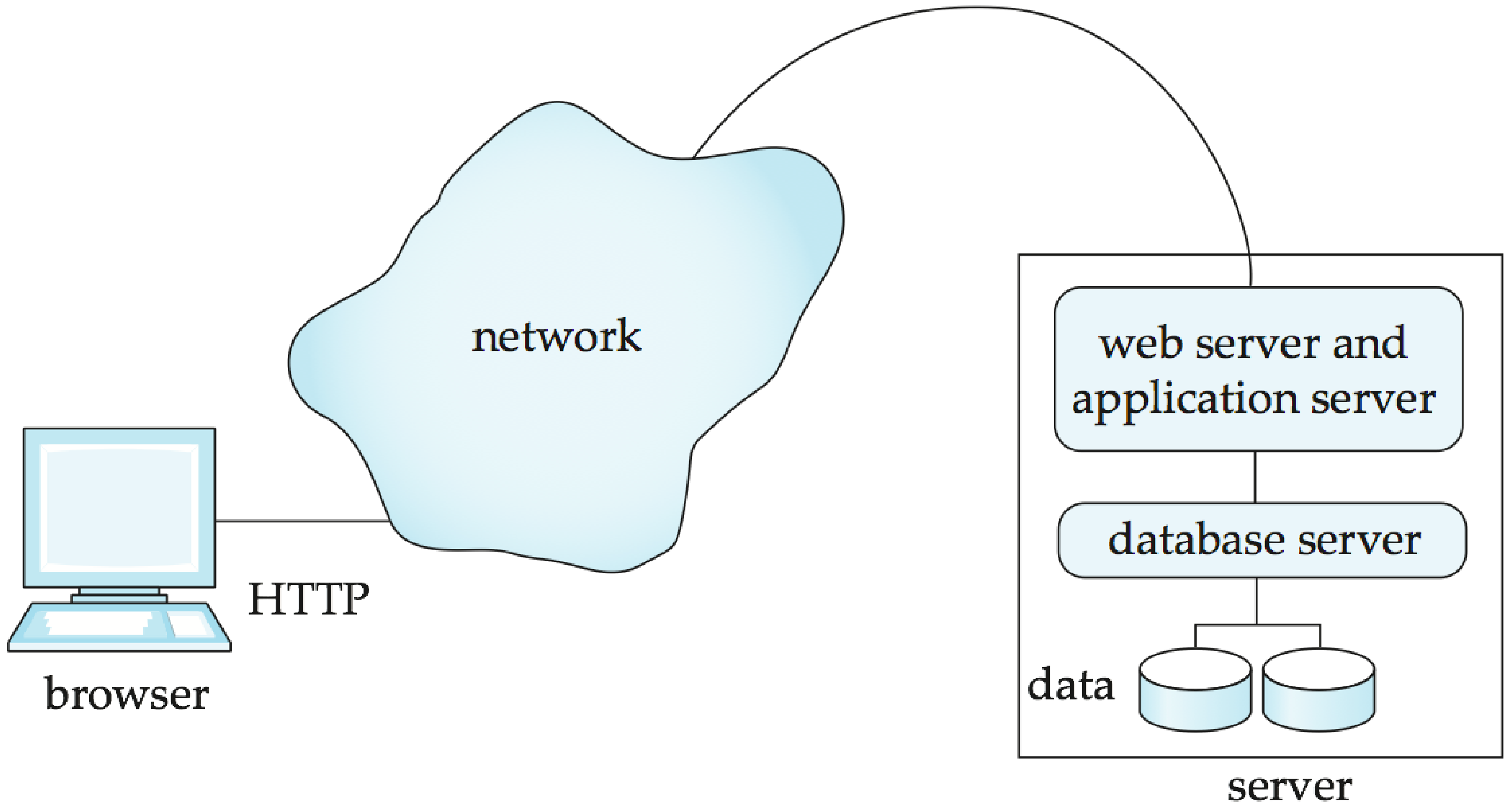
(a) Mainframe Era (b) Personal Computer Era (c) Web era

Three-Layer Web Architecture



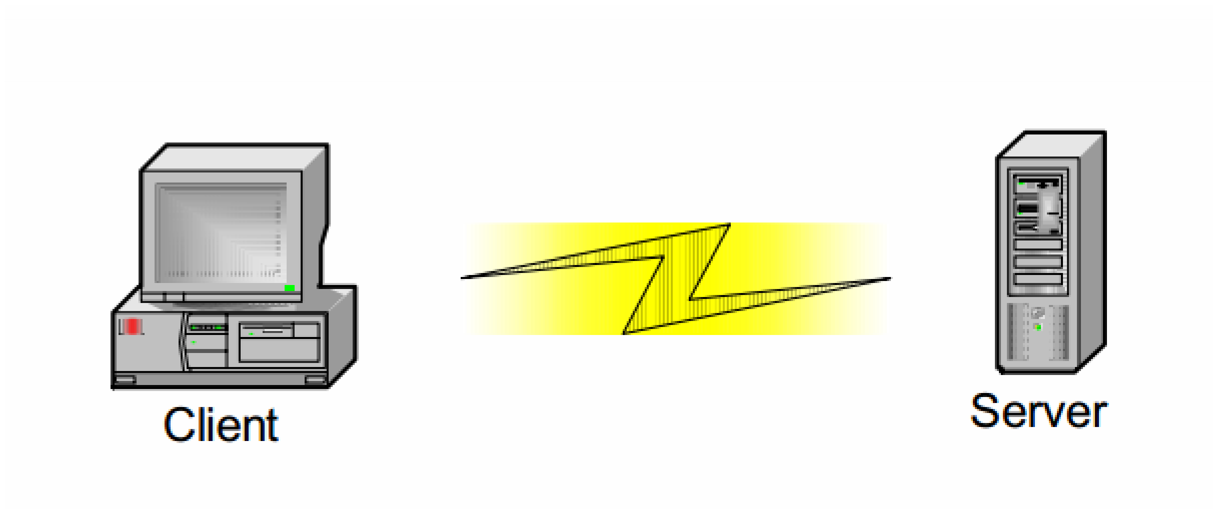
Two-Layer Web Architecture

- Multiple levels of indirection have overheads
  - Alternative: two-layer architecture



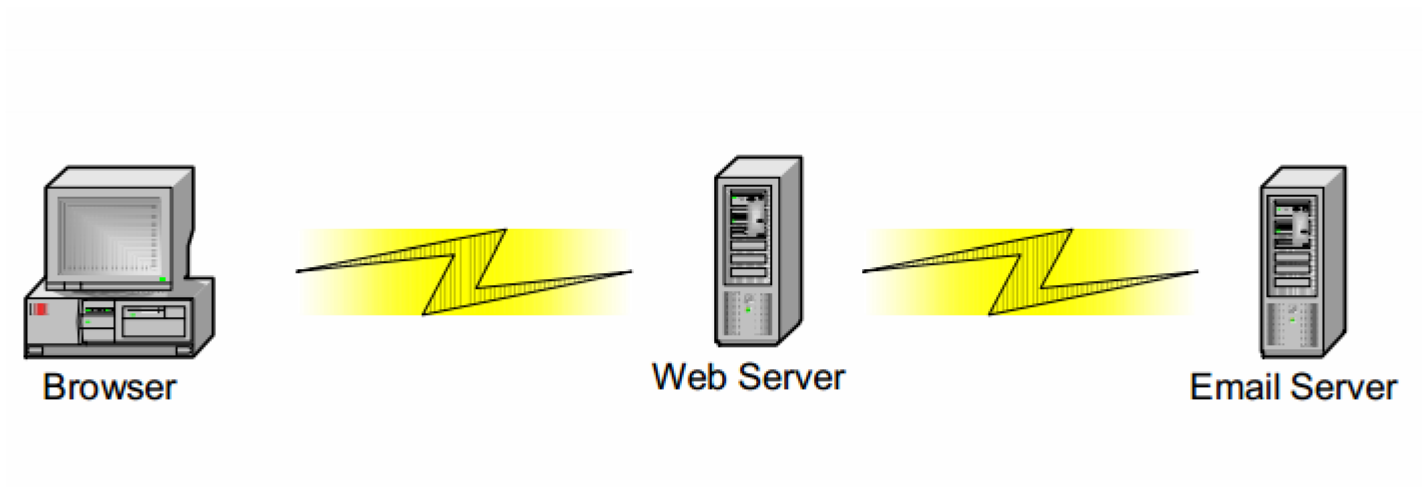
n-Tier Enterprise Applications

- N = 2
- client tier
  - presents data to user, gathers data from user
- server tier
  - hosts application logic, databases, and data services



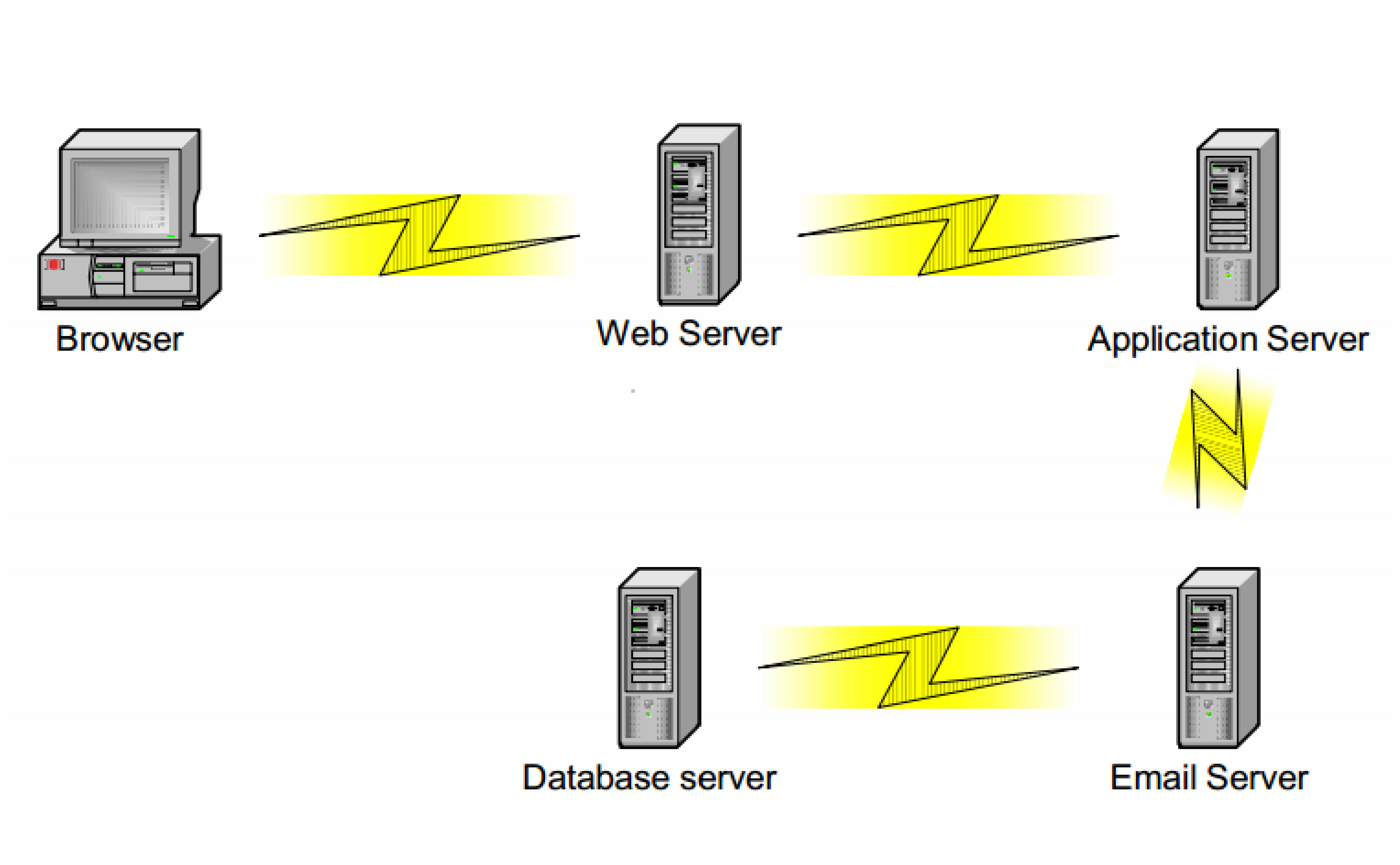
n-Tier Enterprise Applications

- N = 3
- client tier
  - presents data to user, gathers data from user
- Middle Tier
  - hosts application logic
- Back-End Tier
  - hosts databases and data services



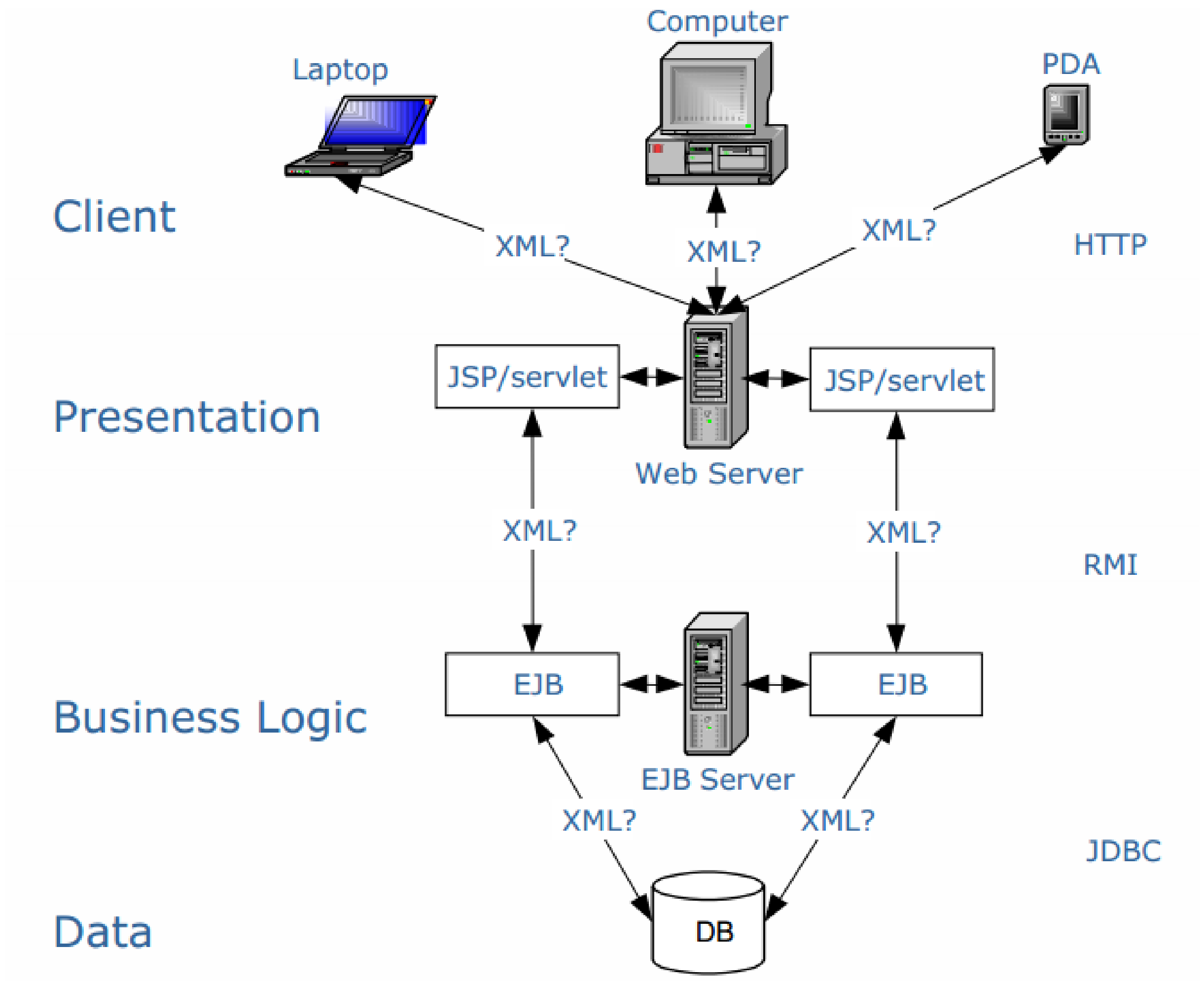
n-Tier Enterprise Applications

- N = 5



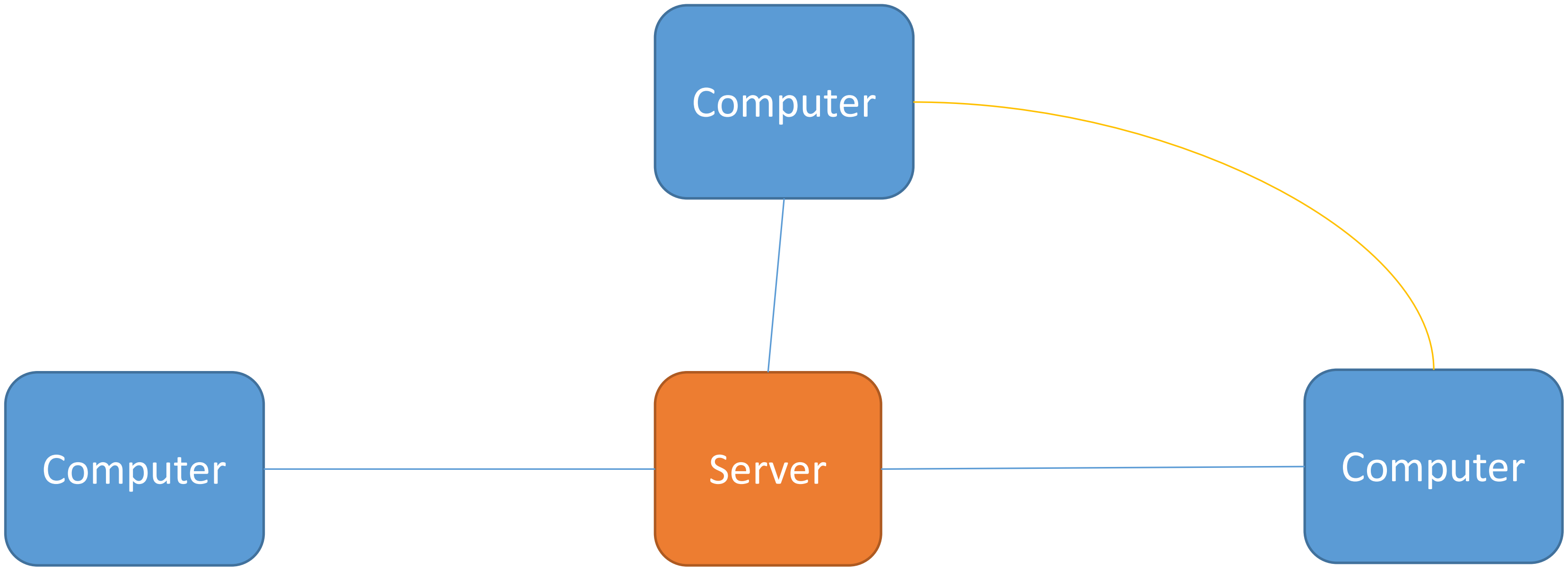
n-Tier Enterprise Applications

- Typical J2EE Architecture



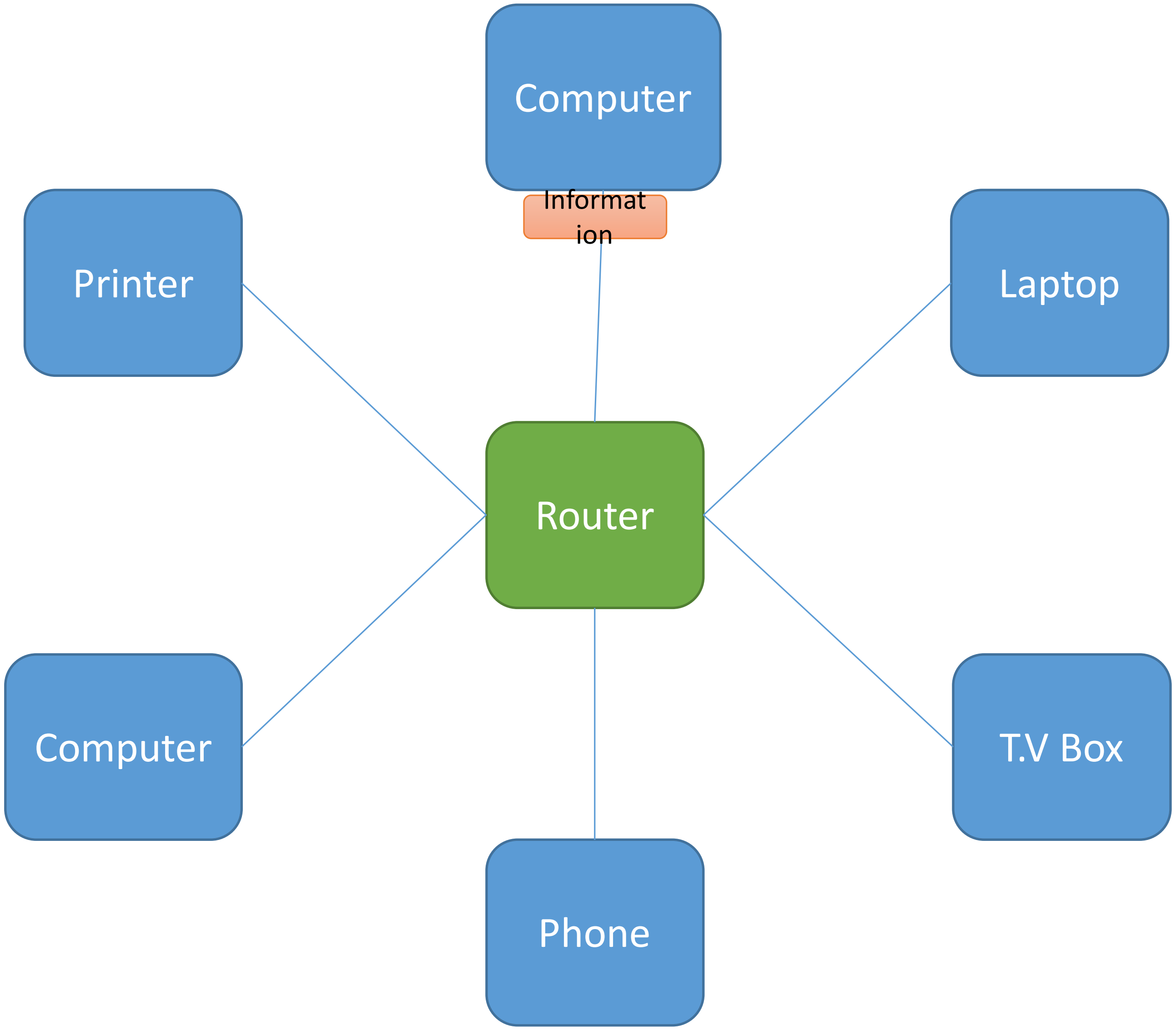
THE WHOLE PICTURE

The internet

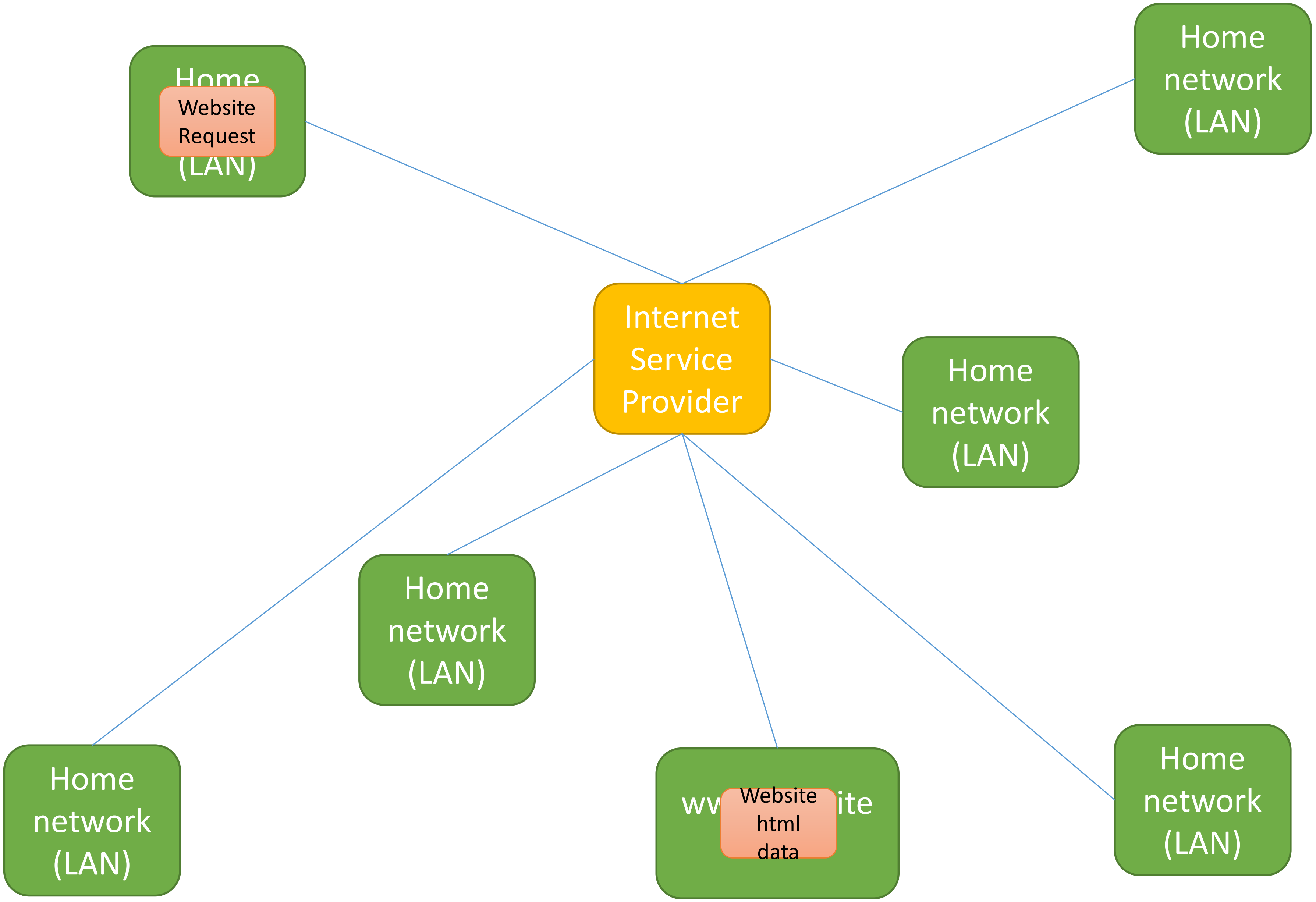


This is a computer
A network is a combination of computers and servers. They are all connected to allowing them to share information.
Most of the time, computers are connected to one another through a server.
But sometimes computers are directly connected to each other.

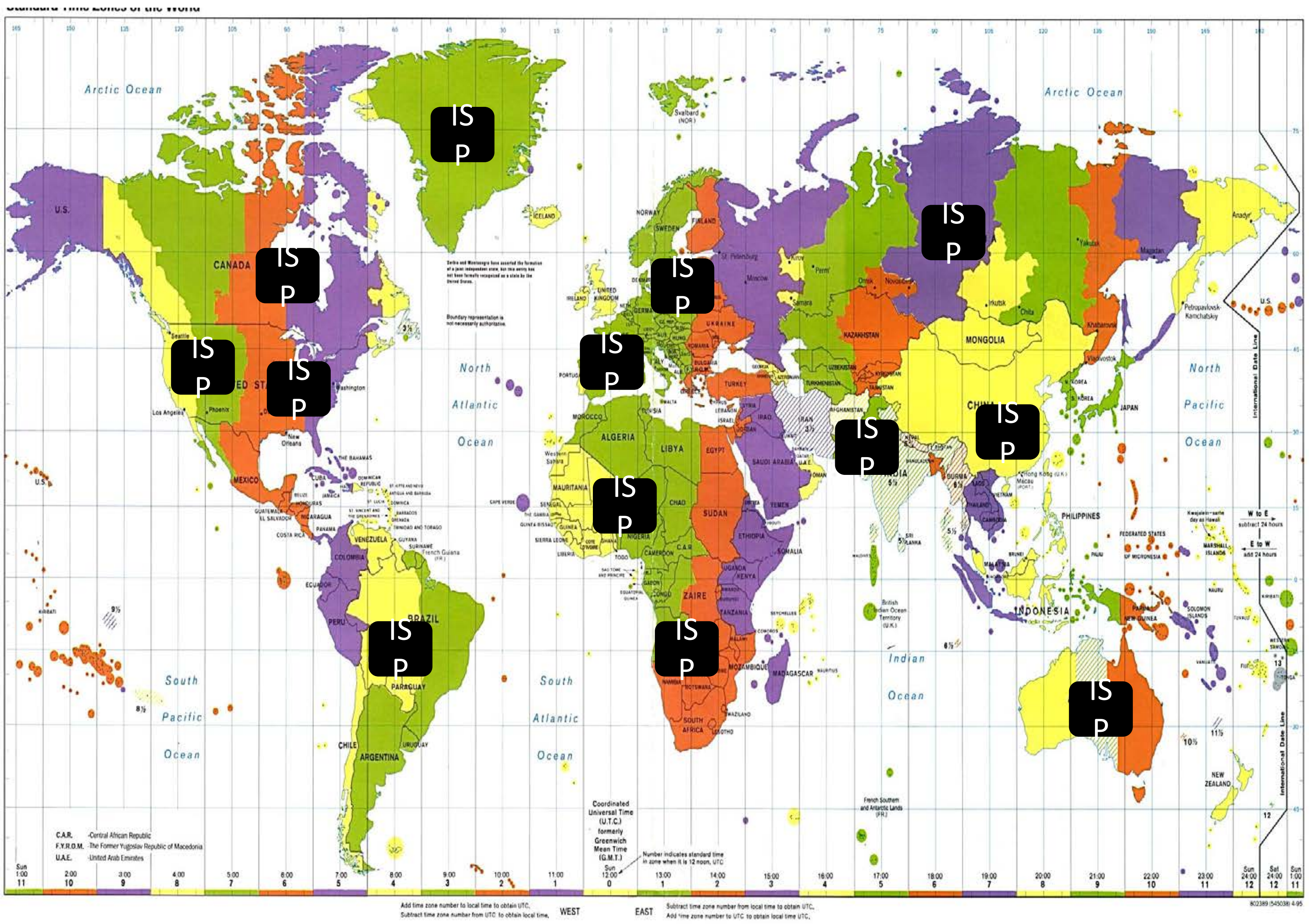
Your home


Computer
Information
Printer
Laptop
Router
Computer
T.V Box
Phone

Your ISP


Home
Website Request
(LAN)
Home network (LAN)
Internet Service Provider
Home network (LAN)
Home network (LAN)
Home network (LAN)
ww
Website html data
ite
Home network (LAN)

The Internet.



IP Address

Computer

Bad!

68.29.54.17
6

248.124.21
5.129

201.205.30.
60

112.139.11
8.21

89.99.186.7
6

66.69.175.7
2

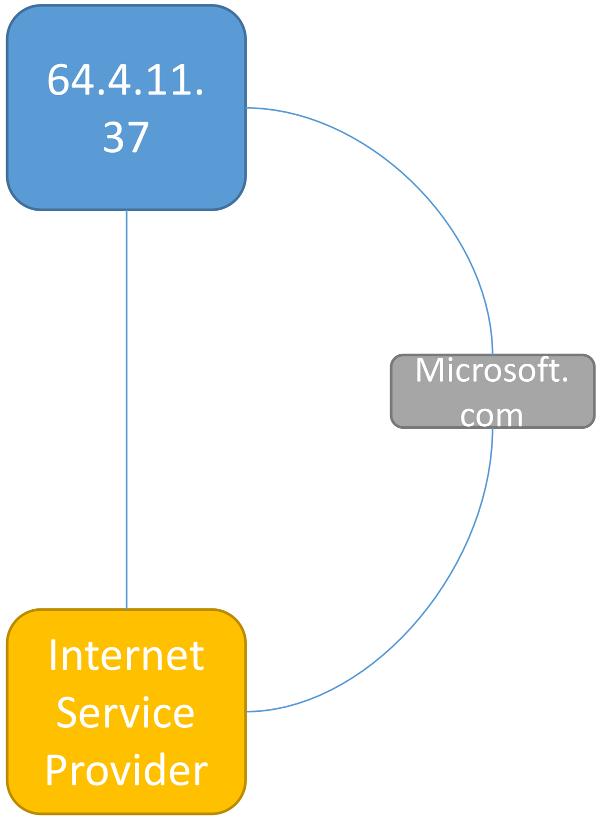
Very good!

All computers have names. Computers names aren’t as unique as Alex, Jason, Susan, Jamie, etc.
Computers like numbers.

IPv4 – X.X.X.X uses 32-bit address scheme

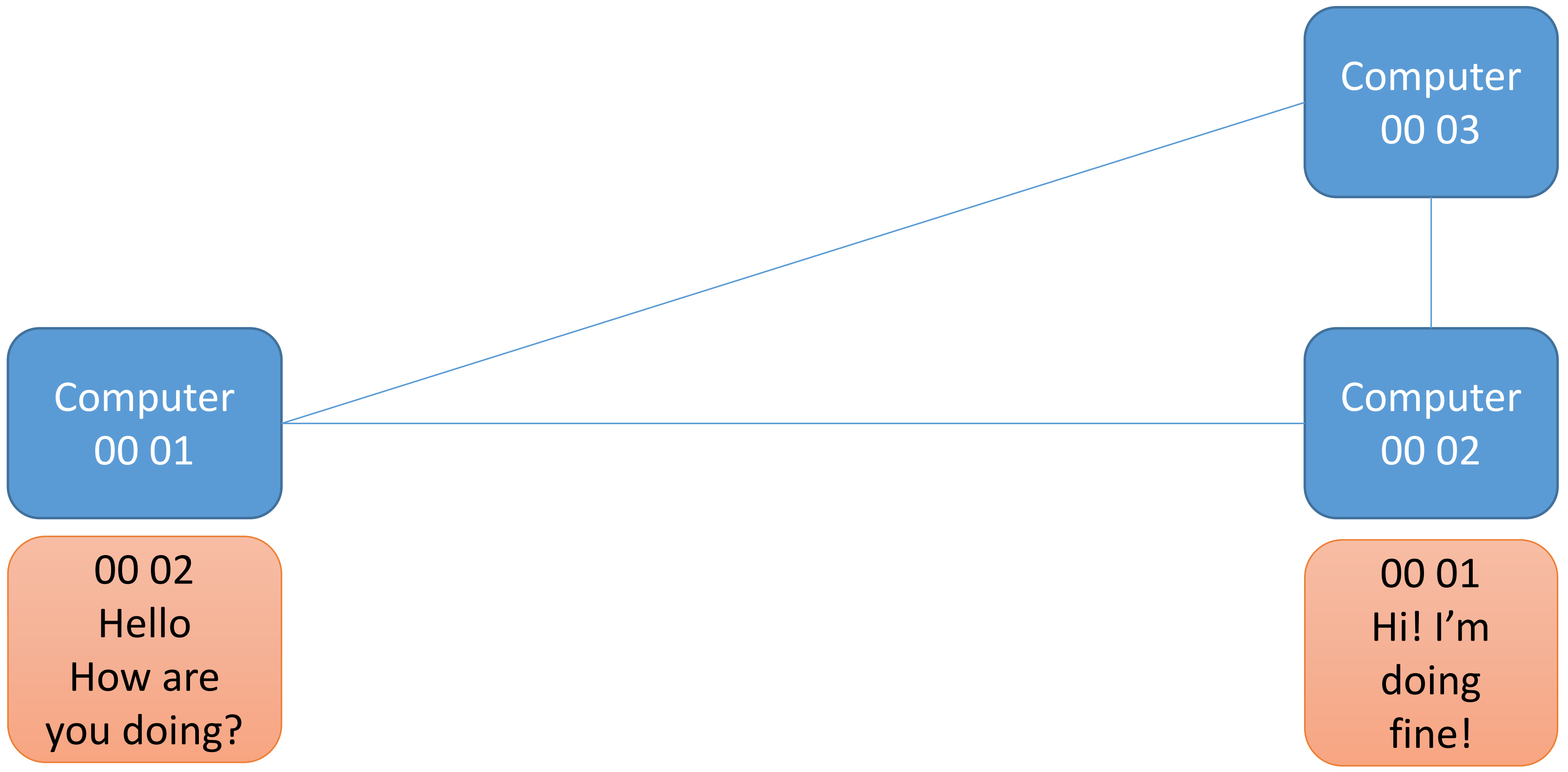
IPv6 – X:X:X:X:X:X uses 128-bit address scheme (uses Hex digits)

Websites?



http://64.4.11.37/

Information Sending – Packets – UDP – Sending Packets



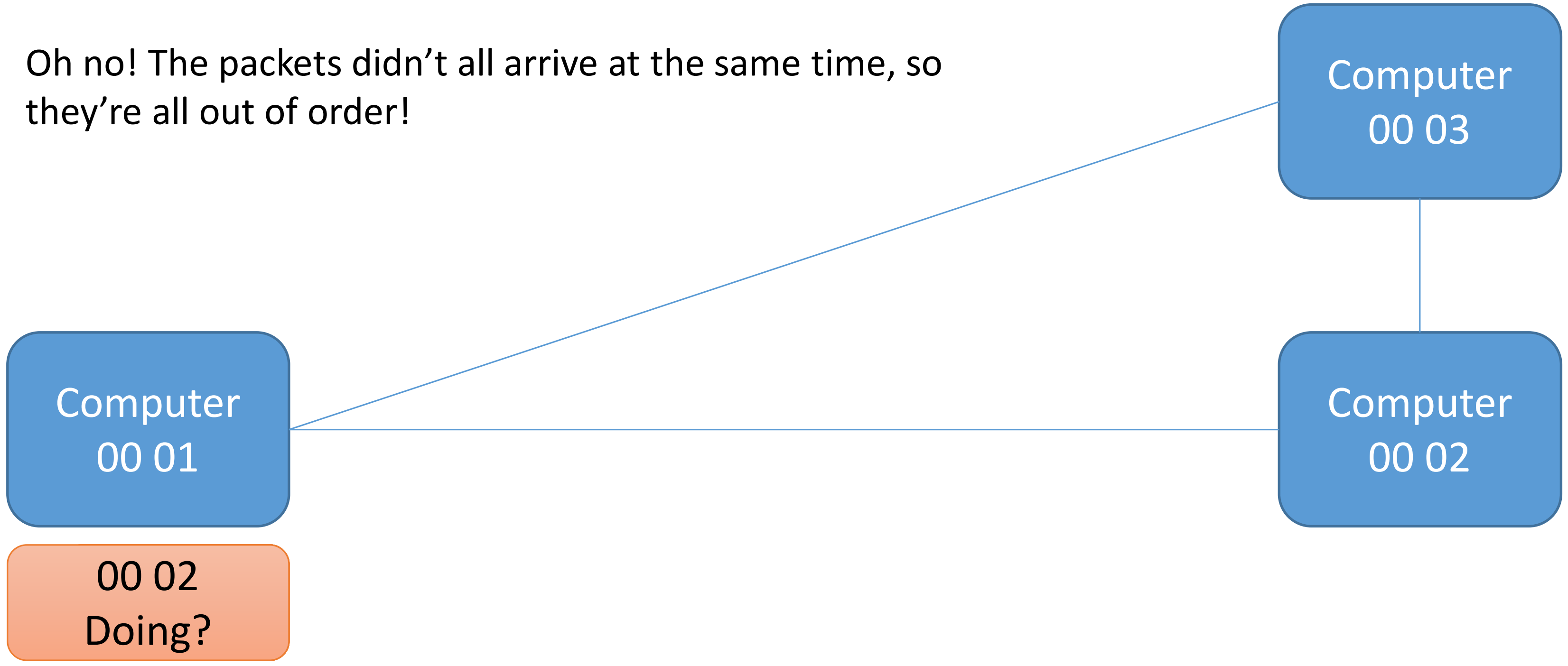
Basic Packet Protocol

Who are you sending the information to?

What is the information you want to send?

Information Sending – Packets – UDP – Out of Order!

Oh no! The packets didn't all arrive at the same time, so they're all out of order!

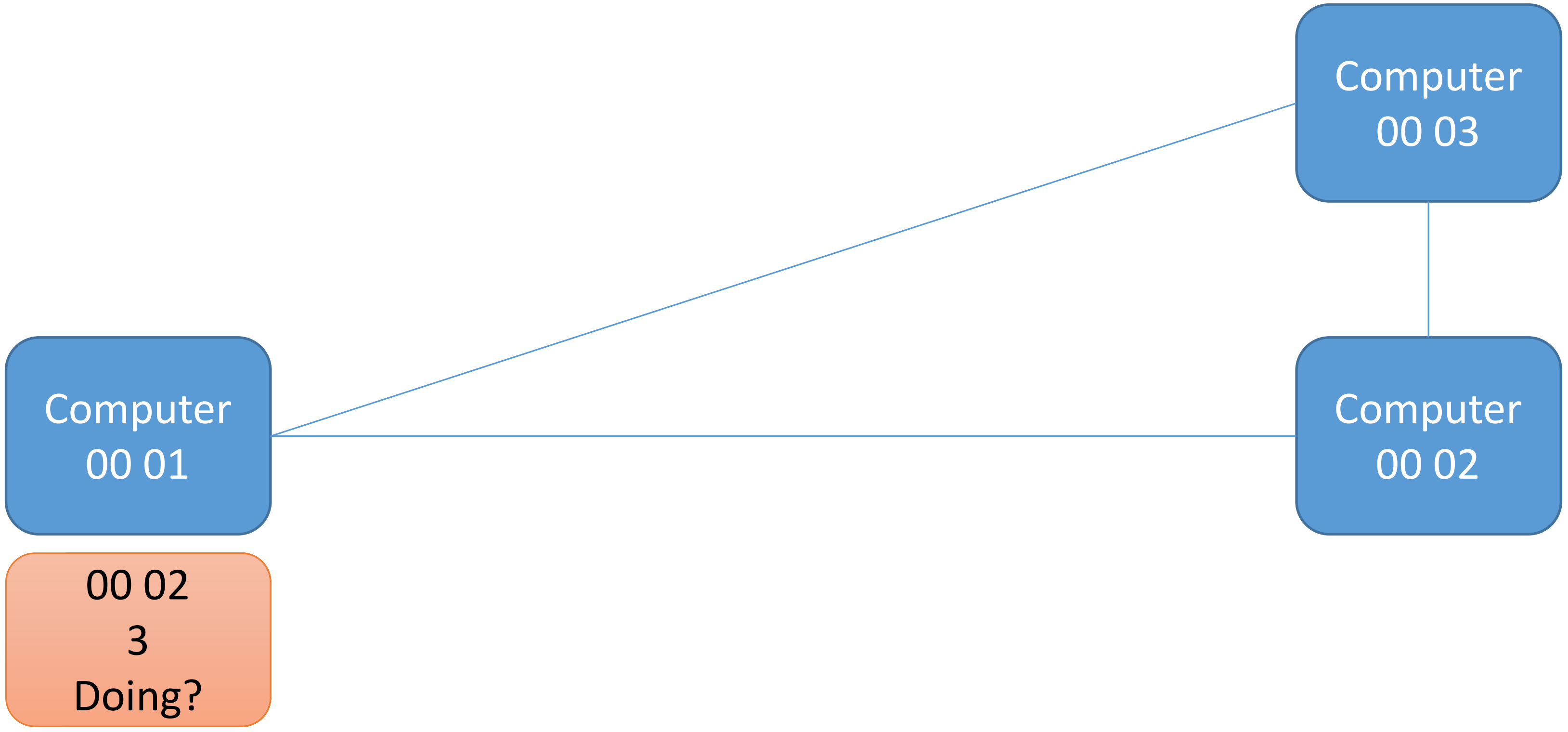


Basic Packet Protocol

Who are you sending the information to?

What is the information you want to send?

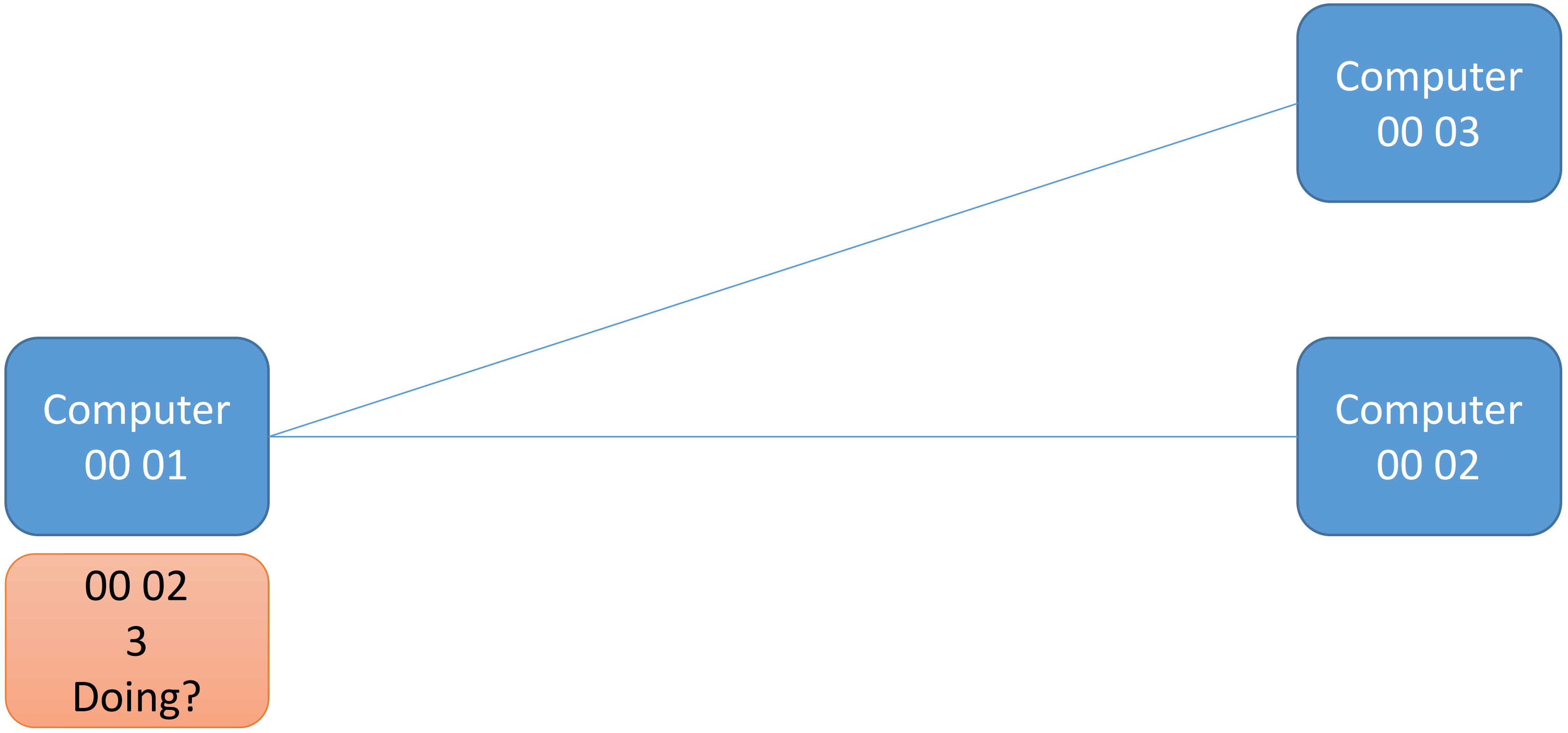
Information Sending – Packets – UDP – Reorder those packets.



Basic Packet Protocol

- Who are you sending the information to?
- What is the information you want to send?

Information Sending – Packets – UDP – Broken Connections

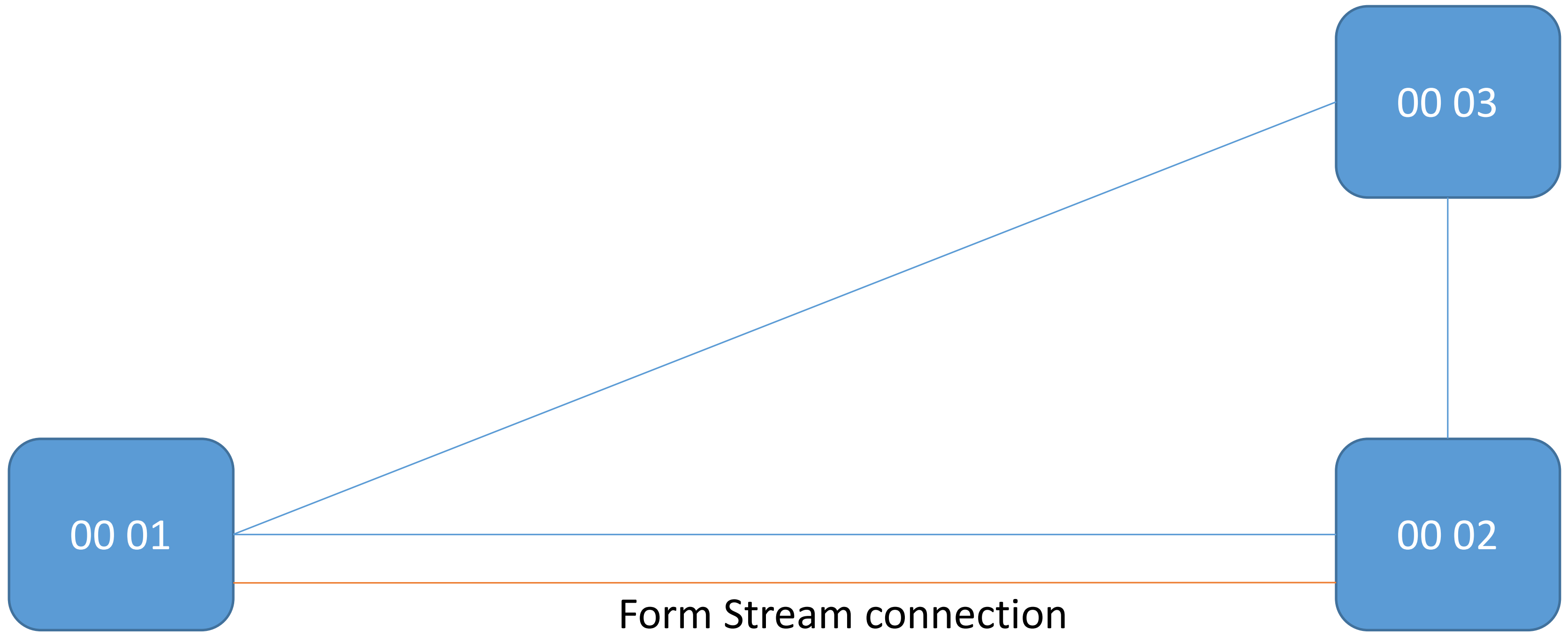


Basic Packet Protocol

Who are you sending the information to?

What is the information you want to send?

Information Sending – Streams – TCP – Sending Packets



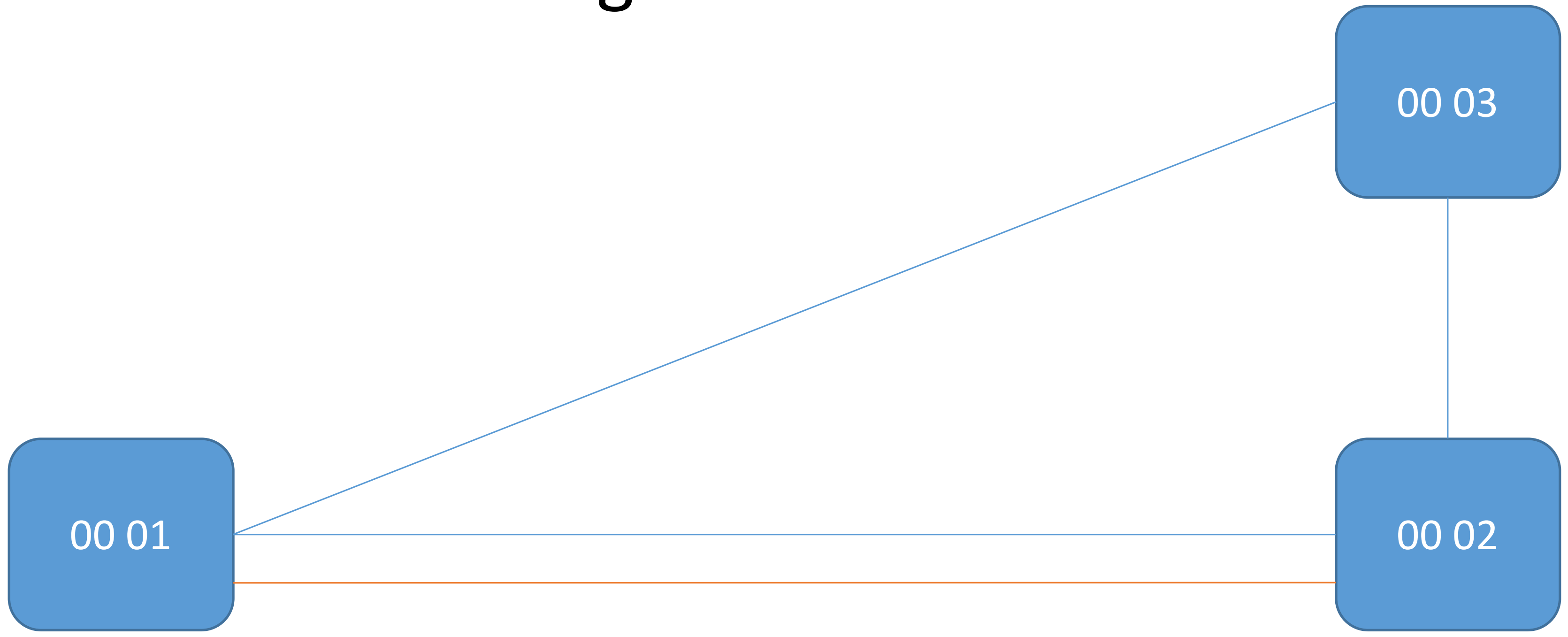
Hello how are you doing?

Stream protocol

Form connection with end computer

Send information.

Information Sending – Streams – TCP – Stream of Info



01100100011011110110100101101110011001110011111

Stream protocol

Form connection with end computer

Send information.

Two-way communication

- TCP/IP Transmission Control Protocol
  - Reliable connection that uses the internet client/server model

  1. Client opens connection to the server
  2. Client sends a request to the server
  3. Server sends a response to the client
  4. Client closes the connection to the server

  - (*steps 2 and 3 may be repeated*)

java.net package

- Low-level API
  - Networking concepts that uses **sockets** to establish connections (send and responses)
    - A socket is one end-point of the two-way connection *(client will have a socket and the server will have a socket)*
  - When you have multiple clients connecting to the same server, they'll use the same **port number**.
    - **Socket** class for the client socket
    - **ServerSocket** class for the ser's socket
- Establishing a connection between client and server is a process that's classed **handshaking**
- High-level API

JAVA SERVLET

Java Servlets

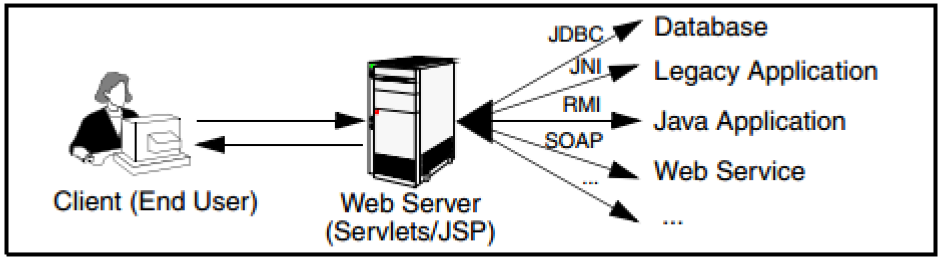
- “A servlet is a Java™ technology-based Web component, managed by a container, that generates dynamic content.

- Like other Java-based components, Servlets are platform-independent Java classes that are compiled to **platform-neutral byte code** that can be loaded dynamically into and run by a java-enabled web server.

- Java Servlet specification defines an API for communication between the Web/application server and application program running in the server
  - E.g., methods to get parameter values from Web forms, and to send HTML text back to client

Servlets

- **Servlets are Java programs that run on Web or application servers**, acting as middle layer between requests coming from Web browser (HTTP) and application (database) on the HTTP server

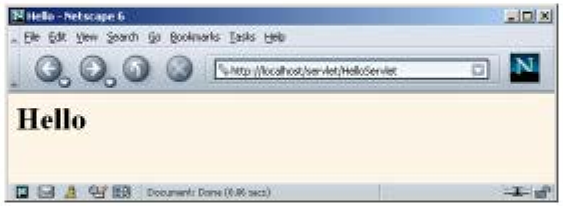


Java Servlets

- **What is a Servlet Container?**
  - "The servlet container is a part of a Web server or application server that provides the network services over which requests and responses are sent, decodes MIME-based requests, and formats MIME-based responses"
  - A servlet container also contains and manages servlets through their lifecycle."
  - Java Servlet Containers
    - Apache Tomcat
    - BEA WebLogic Server
    - IBM WebSphere Application Server
    - JBoss Application Server
    - Oracle Application Server
    - Glassfish

Java Servlet Example: HelloServlet.java

```
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
public class HelloServlet extends HttpServlet {
    public void doGet(HttpServletRequest request, HttpServletResponse response)
                                        throws ServletException, IOException {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    String docType =  "<!DOCTYPE HTML PUBLIC \"-//W3C//DTD HTML 4.0 " +
    "Transitional//EN\">\n";
    out.println(docType +
        "<HTML>\n" +
        "<HEAD><TITLE>Hello</TITLE></HEAD>\n" +
        "<BODY BGCOLOR=\"#FDF5E6\">\n" +
        "<H1>Hello</H1>\n" +
        "</BODY></HTML>");
    }
   }
```


Hello - Netscape 6
File Edit View Search Go Bookmarks Tasks Help
http://localhost/servlet/HelloServlet
Hello
Document: Done (0.46 secs)

Example Servlet Code: request and response OBJECTS

```
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
public class PersonQueryServlet extends HttpServlet {
  public void doGet (HttpServletRequest request, HttpServletResponse response)
                        throws ServletException, IOException
  {
    response.setContentType("text/html");
    PrintWriter out = response.getWriter();
    out.println("<HEAD><TITLE> Query Result</TITLE></HEAD>");
    out.println("<BODY>");
      ….. BODY OF SERVLET (next slide) …
    out.println("</BODY>");
    out.close();
  }
}
```

Example Servlet Code: request and response OBJECTS

```
String persontype = request.getParameter("persontype");
String number = request.getParameter("name");
if(persontype.equals("student")) {
    ... code to find students with the specified name ...
    ... using JDBC to communicate with the database ..
    out.println("<table BORDER COLS=3>");
    out.println(" <tr> <td>ID</td> <td>Name: </td>" + " <td>Department</td> </tr>");
    for(... each result ...){
        ... retrieve ID, name and dept name
        ... into variables ID, name and deptname
        out.println("<tr> <td>" + ID + "</td>" + "<td>" + name + "</td>" + "<td>" + deptname
                + "</td></tr>");
    };
    out.println("</table>");
}
else {
    ... as above, but for instructors ...
}
```

Servlet: Typical Sequence of Events

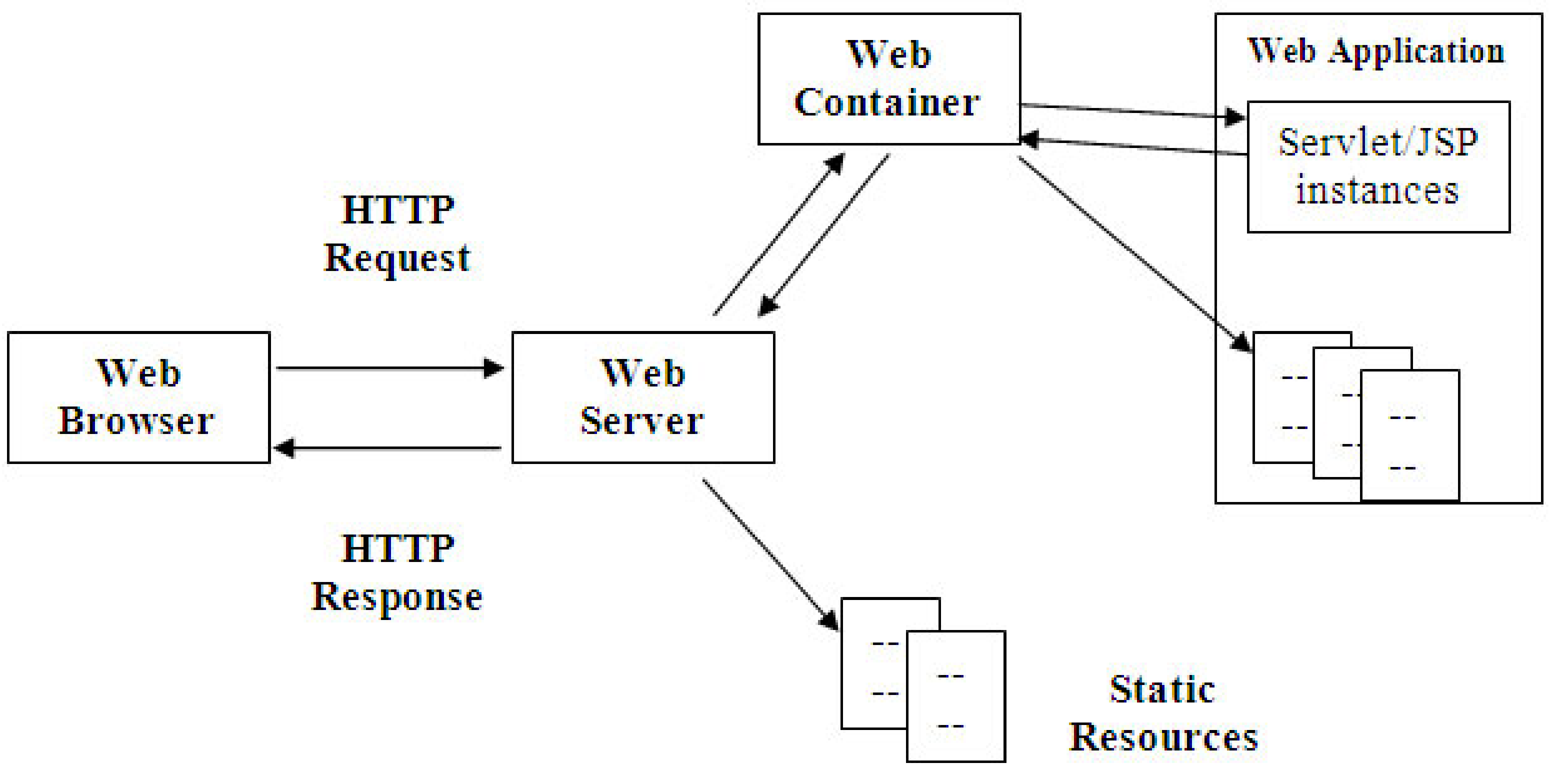
1. A **client** (e.g., a Web browser) accesses a Web server and makes an HTTP request.
2. The request is received by the Web server and handed off to the **servlet container.** The servlet container can be running :
   - in the same process as the host web server,
   - in a different process on the same host, or
   - on a different host from the web server for which it processes requests.
3. The servlet container determines **which servlet to invoke** based on the configuration of its servlets, and calls it with objects representing the request and response.
   - *Web.xml configuration file (URLs to Java Servlet code)*
4. The servlet uses the **request object** to find out who the remote user is, what HTTP POST parameters may have been sent as part of this request, and other relevant data.
   - The servlet performs whatever logic it was programmed with, and generates data to send back to the client. It sends this data back to the client via the **response object**.
5. Once the servlet has finished processing the request, the servlet container ensures that the response is properly flushed, and returns control back to the host Web server.

Servlet Sessions

- Servlet API supports handling of sessions
  - Sets a **cookie** on first interaction with browser, and uses it to identify session on further interactions
- To check if session is already active:
  - if (request.getSession(false) == true)
    - .. then existing session
    - else .. redirect to authentication page
  - authentication page
    - check login/password
    - request.getSession(true): creates new session
- Store/retrieve attribute value pairs for a particular session
  - session.setAttribute(“userid”, userid)
  - session.getAttribute(“userid”)

Web Servers

- Outputs and receives HTML



JSP

SERVER-SIDE SCRIPTING

Server-Side Scripting

- Server-side scripting simplifies the task of connecting a database to the Web
  - Define an HTML document with **embedded executable** code/SQL queries.
  - Input values from HTML forms can be used directly in the embedded code(SQL queries).
  - When the document is requested, the Web server executes the embedded code to generate the actual HTML document.

- Numerous server-side scripting languages
  - JSP, PHP
  - General purpose scripting languages: VBScript, Perl, Python

JSP

- JSP is HTML pages with Java code embedded inside of them
  - a JSP document is just another way of writing a servlet.
  - JSP pages get translated into servlets, the servlets get compiled, and it is the servlets that run at request time.

- **JSP And Servlets are essentially the same thing**
  - JSP is focused on simplifying the creation and maintenance of the HTML.
  - Servlets are best at invoking the business logic and performing complicated operations.
  - A quick rule of thumb is that servlets are best for tasks oriented toward **processing**, whereas JSP is best for tasks oriented toward **presentation**

- “You can think of **servlets** as Java code with HTML inside”
- “you can think of **JSP** as HTML with Java code inside”

JSP Programming

- To make JSP page more interactive we can read and process the data entered in a an HTML form.
  - **request.getParameter method**
    - Takes the name of the HTML field name as parameter
    - Returns the value entered by the user
    - String authorName = request.getParameter ("AuthorName");

Java Server Pages (JSP)

- A JSP page with embedded Java code

```
<html>
<head> <title> Hello </title> </head>
<body>
<% if (request.getParameter(“name”) == null)
        { out.println(“Hello World”); }
else
        { out.println(“Hello, ” + request.getParameter(“name”)); }
%>
</body>
</html>
```

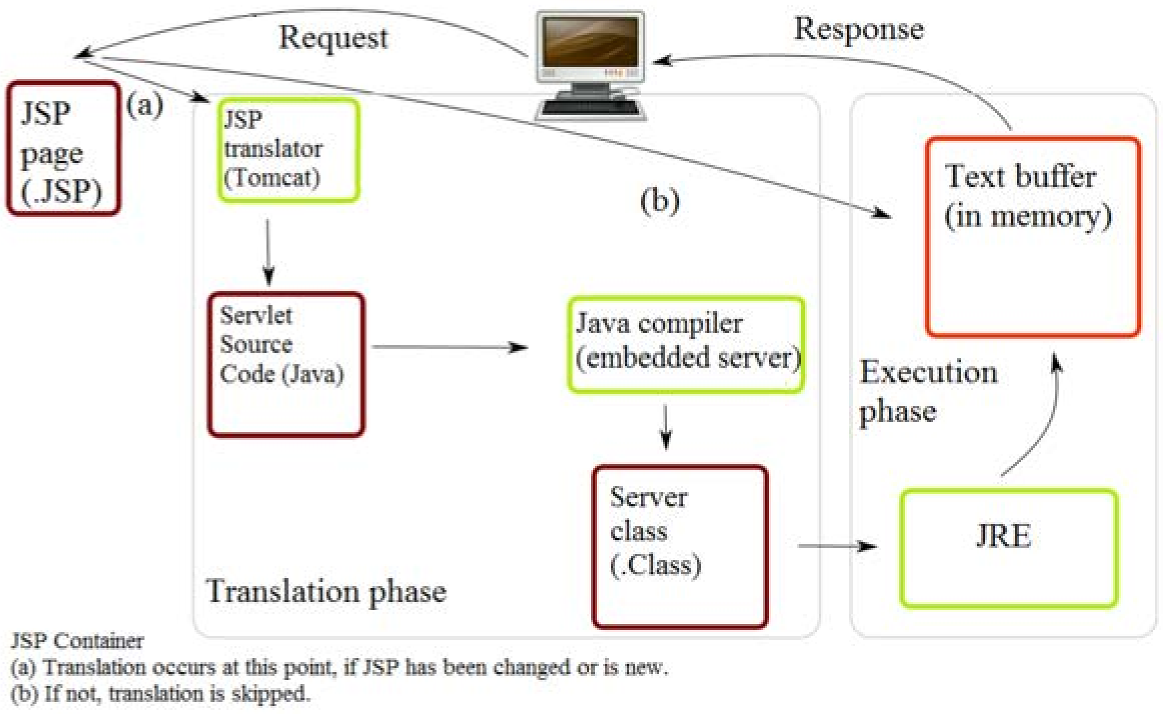
- JSP is compiled into Java + Servlets

JSP Programming

- JSP Elements
  - All of these elements are identified by their own tags
  - **Declarations**
    - These tags allows you to define variables and methods
    - **<%!**
      - private int count = 0;
      - private void increments () { count ++;}
    - %>
  - **Expressions**
    - We can access variables and methods
    - <p> The value of Count is : **<%=** count %> </p>
  - **Scriptlets**
    - Blocks of Java code
    - <% out.println (“Hello Students”); %> //out is already defined in javax.servlet.jsp.JspWriter
    - <%
      - out.println(“The counter =“ + count + <br />);
      - incrementCount();
    - %>
  - **Directives**
    - Instructions on how to process a JSP program (Importing packages)
    - <%@ page import=“java.util.*,java.sql.*” %>

Running JSP Program

- JSP Servlets Engine
  - JSP/Servlet engine dynamically compiles the JSP source code into Servlet if a current compiled Servlet does not exist


Request
Response
JSP page (.JSP)
(a)
JSP translator (Tomcat)
(b)
Text buffer (in memory)
Servlet Source Code (Java)
Java compiler (embedded server)
Execution phase
Server class (.Class)
JRE
Translation phase
JSP Container
(a) Translation occurs at this point, if JSP has been changed or is new.
(b) If not, translation is skipped.

STATIC JSP DEMO

Sample web.xml File

```
<?xml version="1.0" encoding="ISO-8859-1" ?>

<web-app xmlns="http://java.sun.com/xml/ns/j2ee"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/j2ee http://java.sun.com/xml/ns/j2ee/web-app_2_4.xsd"
    version="2.4">

    <display-name>HelloWorld Application</display-name>
    <description>
        This is a simple web application with a source code organization
        based on the recommendations of the Application Developer's Guide.
    </description>

    <servlet>
        <servlet-name>HelloServlet</servlet-name>
        <servlet-class>examples.Hello</servlet-class>
    </servlet>

    <servlet-mapping>
        <servlet-name>HelloServlet</servlet-name>
        <url-pattern>/hello</url-pattern>
    </servlet-mapping>

</web-app>
```

- In the preceding web.xml deployment descriptor file:
  - **<servlet>** XML element declares the HelloServlet,
    - the examples.Hello Java class implements the servlet,
  - **<servlet-mapping>** XML element specifies the /hello URL pattern that invokes the servlet in a browser.
    - This URL pattern is used in the index.html file.

Java Source of the Hello.java Servlet

```
package examples;

import java.io.IOException;                       import java.io.PrintWriter;
import javax.servlet.ServletException;        import javax.servlet.http.HttpServlet;
import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;

public final class Hello extends HttpServlet {

    public void doGet(HttpServletRequest request, HttpServletResponse response)
      throws IOException, ServletException {
        response.setContentType("text/html");
        PrintWriter writer = response.getWriter();
        writer.println("<html>");
        writer.println("<head>");
        writer.println("<title>Sample Application Servlet Page</title>");
        writer.println("</head>");
        writer.println("<body bgcolor=white>");

            writer.println("<h1>Sample Application Servlet</h1>");

        writer.println("This is the output of a servlet that is part of");
        writer.println("the Hello, World application.");

        writer.println("</body>");
        writer.println("</html>");
    }
}
```

JSP Source for the hello.jsp JSP

```
<html>
  <head>
    <title>Sample Application JSP Page</title>
  </head>
        <h1>Sample Application JSP Page</h1>
        <p>This is the output of a JSP page that is part of the HelloWorld application.</p>

  <%= new String("Hello!") %>
  </body>
</html>
```

The hello.jsp includes the following simple JSP directive:

`<%= new String("Hello!") %>`

This JSP directive simply prints out a message to the client (browser): Hello!

Sample Default index.html File

- <html>
- <head>
- <title>Sample "Hello, World" Application</title>
- </head>
- <body>
  - <h1>Sample "Hello, World" Application</h1>
  - <p>This is the home page for the HelloWorld Web application. </p>
  - <p>To prove that they work, you can execute either of the following links:
    - <ul>
    - <li>To a <a href="hello.jsp">JSP page</a>.
    - <li>To a <a href="hello">servlet</a>.
    - </ul>
- </body>
- </html>

PHP

PHP Scripting Environment

- PHP is widely used for Web server scripting
- Extensive libaries including for database access using ODBC

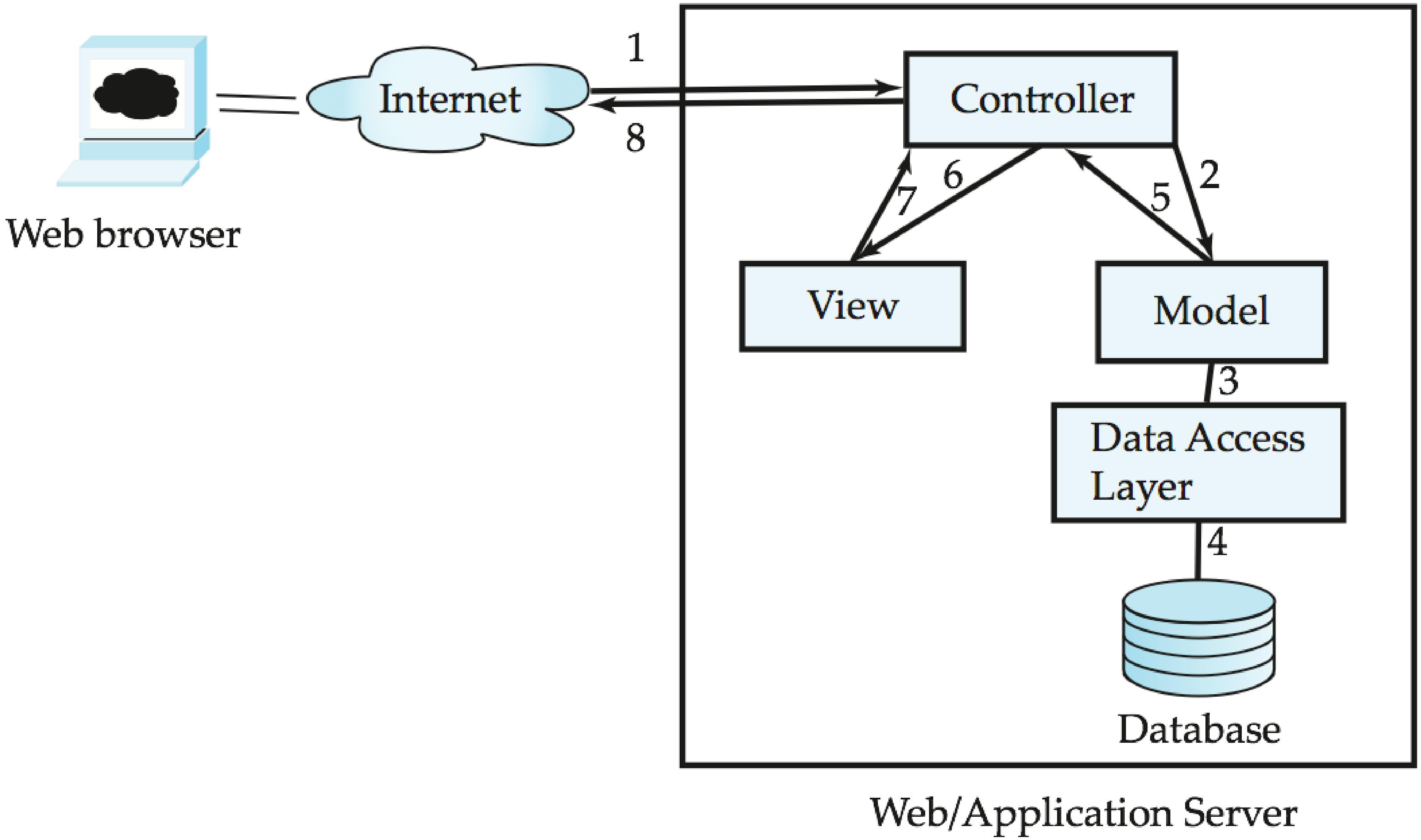
```
<html>
 <head> <title> Hello </title> </head>
 <body>
 <?php
 if (!isset($_REQUEST['name']))
        { echo "Hello World"; }
 else
        { echo "Hello, " + $_REQUEST['name']; }
 ?>
 </body>
 </html>
```

Application Architectures

Application Architectures

- Application layers
  - Presentation or user interface
    - **model-view-controller (MVC)** architecture
      - **model**: business logic
      - **view**: presentation of data, depends on display device
      - **controller**: receives events, executes actions, and returns a view to the user
  - **business-logic** layer
    - provides high level view of data and actions on data
      - often using an object data model
    - hides details of data storage schema
  - **data access** layer
    - interfaces between business logic layer and the underlying database
    - provides mapping from object model of business layer to relational model of database

Application Architecture



Business Logic Layer

- Provides abstractions of entities
  - e.g. students, instructors, courses, etc
- Enforces **business rules** for carrying out actions
  - E.g. student can enroll in a class only if she has completed prerequsites, and has paid her tuition fees
- Supports **workflows** which define how a task involving multiple participants is to be carried out
  - E.g. how to process application by a student applying to a university
  - Sequence of steps to carry out task
  - Error handling
    - e.g. what to do if recommendation letters not received on time
  - Workflows discussed in Section 26.2

Object-Relational Mapping

- Allows application code to be written on top of object-oriented data model, while storing data in a traditional relational database
  - alternative: implement object-oriented or object-relational database to store object model

- Schema designer has to provide a mapping between object data and relational schema
  - e.g. Java class *Student* mapped to relation *student,* with corresponding mapping of attributes
  - An object can map to multiple tuples in multiple relations
- Application opens a session, which connects to the database
- Objects can be created and saved to the database using
  session.save(object)
  - mapping used to create appropriate tuples in the database
- Query can be run to retrieve objects satisfying specified predicates

Object-Relational Mapping and Hibernate (Cont.)

- The **Hibernate** object-relational mapping system is widely used
  - public domain system, runs on a variety of database systems
  - supports a query language that can express complex queries involving joins
    - translates queries into SQL queries
  - allows relationships to be mapped to sets associated with objects
    - e.g. courses taken by a student can be a set in Student object

- The **Entity Data Model** developed by Microsoft
  - provides an entity-relationship model directly to application
  - maps data between entity data model and underlying storage, which can be relational
  - Entity SQL language operates directly on Entity Data Model

NEXT
JAVA NETWORK DEMO1

java.net.* package

Download source code from the code folder on blackboard