CS209

Computer system design and application

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The package java.util.concurrent contains some useful classes for multithreading.

java.util.concurrent

Thread-aware collections (interfaces + classes)

Three "executor" interfaces

FutureTask<V> Let's have q quick look.

Threadpools

1 Executor – Simplifies writing

```
(new Thread(r)).start();
```

Runnable

Executor

```
e.execute(r);
```

Executors a simple convenient classes for running threads.

2 ExecutorService

When you call execute() you only return when the thread has started.

Runnable .execute()

Callable<V> .submit()

.invokeAll()

You can return earlier.

returns a Future<V>

.isDone()

.get()

.cancel()

returns a list of Future<V>

You can also check the status of tasks you'submit'.

3

`ScheduledExecutorService`

Specify a delay

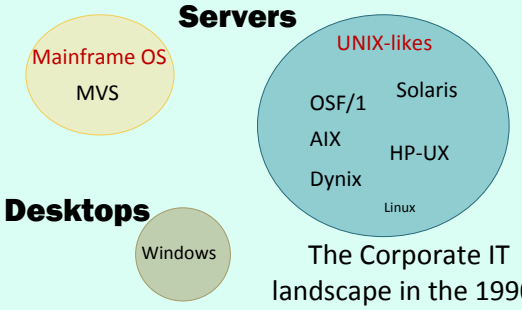
Execute once or periodically

You can also schedule repetitive tasks. This is often used. For instance you might want to check a folder for files to upload that are regularly stored there, or get say the last equity prices or currency exchange rates on a regular basis from some external source.

Java and the web

The last big topic of this course will be Java and the web. Complicated history, and an alphabet-soup of products. Let's start with history.

When Java appeared (and it hasn't changed that much since then, if you omit that Linux has taken a far bigger place and that many other Unixes have disappeared) this is what you found in most big companies.

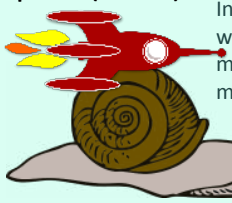


The Corporate IT landscape in the 1990s

1996 Write once, run everywhere

Gosling's promise of a language allowing to run the same .class on a lot of different computers running different systems was most attractive.

Just-in-Time Compiler (1997)
Hot-Spots (1999)

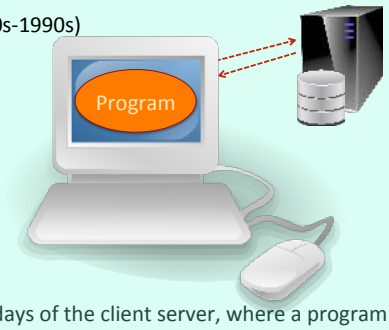


In the beginnings Java was extremely slow, but many enhancements made it a language that you could consider for business programs without looking like a clown.

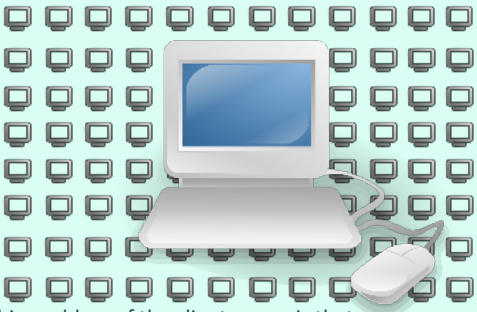
Reasonably slower than C

Client-server

(popular 1980s-1990s)



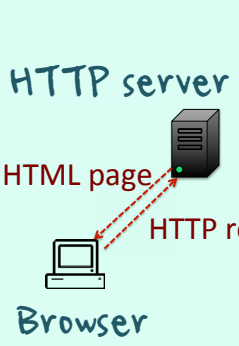
These were the days of the client server, where a program running on a desktop was talking to a (database) server.



One big problem of the client server is that every new release of a program had to be installed on perhaps thousands of computers.

Then the Web and the HTTP protocol came

In 1990 Tim Berners-Lee invented the HTTP protocol, and the rest is history. Initially getting a static page from a web server wasn't much of an improvement (except that graphically is was nicer) over the dumb terminal that had preceded the desktop client.
But people thought that you could not only download pages, but perhaps also programs that could be run by the browser.



Put a some bits of programs between the tags, when you just need to update pages on the server and everybody will instantly get the new version.

Text between tags

Small programs between tags

Brendan Eich

You may never have heard about Netscape but their 'Navigator' was the first "modern" browser, and in this company Brendan Eich coded, the legend says in 10 days, a crap^H^H^H^Hlight programming language that, after some name changes, became known as Javascript.

Javascript was kind of inspired by Java, but that's all. Not even a cheap imitation.

Meanwhile, James Gosling was seeing his language as the perfect candidate for being downloaded. There was just one problem: Java is too powerful, and there was a security risk.

The Java security model

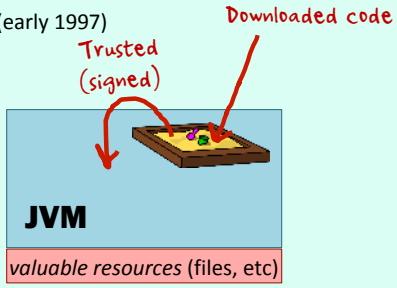
Verifier in the class loader

But a program could do nasty things on your computer!

People thought of running a Java "applet" (small application) in an isolated environment (sandbox)

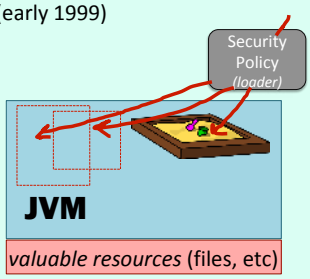
In a sandbox, you cannot, for instance, access files.

JDK 1.1 (early 1997)



But then, there was little benefit using Java compared to the easier Javascript. So people began to think about exceptions.

JDK 2.0 (early 1999)



And it became increasingly complicated. Rule of thumb: when things become too complicated, people begin to dump it for something perhaps not as good but easier to understand.

```
<script src="https://www.java.com/js/deployJava.js"></script>

    <applet code = "AppletName"
        archive = "AppletIsInside.jar"
        width = 300
        height = 300>
       <param name="permissions"
              value="sandbox" />
    </applet>
```

Additionally, permissions were set in the page. If I'm a really bad guy, I can set-up a server, and give all the permissions I want to my nasty code.

Meanwhile

hardware acceleration in browsers
(*around 2010/2011*)

Lots of excellent Javascript graphics libraries

HTML 5

Meanwhile, browser and Javascript improvements killed the one good reason (graphics) that people had of using a Java applet instead of Javascript. To make a long story short, Java applets are dead today, and no longer supported by major browsers.

What runs in the browser

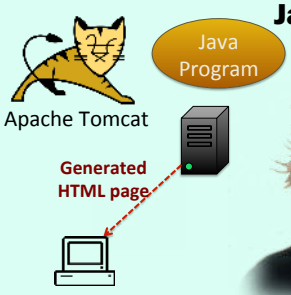
Front-end

Javascript frameworks (AngularJS, ReactJS, ...)

On the front-end, you'll mostly find JavaScript, mostly used in frameworks (Jquery used to be very popular, but there are new flavors-of-the-day).

But the front-end is only half the story ...

Java Server Pages
Servlet



Java is very much used for **generating** pages on a server (pages that may include references to Javascript). There have been several generations and technologies, and even a server (Tomcat) dedicated to Java applications.

Installation directory of Tomcat

TOMCAT_DIR
- bin
- conf
- lib
- logs
- temp
- webapps
- work

server.xml

A Tomcat installation looks like this. The port (8080 by default) is specified in server.xml.

TOMCAT_DIR
- bin
- conf
- lib
- logs
- temp
- webapps
  - ROOT
  - docs
  - examples
  - host-manager
  - manager
  - sample
  - MyServlet
    - WEB-INF
- work

Applications (.class programs generating HTML, mostly) are stored under the webapps directory.

Java Servlet API

`javax.servlet`

Web Container (also called *Servlet Container*)

URL

What Tomcat does is matching an URL that it receives with a .class program that will build the page.

Servlet

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

@WebServlet(name="MyServlet", urlPatterns={"/test"})
public class MyServlet extends HttpServlet {
```

NOT in default Java libraries!

This program must extend HttpServlet. You'll notice the heavy use of annotations, including one that says for which pattern this program should be called.

```
  public void doGet(HttpServletRequest  request,
                    HttpServletResponse response)
              throws IOException, ServletException {
    response.setContentType("text/html");
    PrintWriter pw = response.getWriter();
    try {
      pw.print("<html>");
      pw.print("<head>");
      pw.print("<title>My First Servlet</title>");
      pw.print("</head>");
      pw.print("<body>");
      pw.print("<h1>Yeepee it works!</h1>");
      pw.print("</body>");
      pw.print("</html>");
    } finally {
      pw.close();
    }
  }
}
```

Inside it, you just write HTML pages to a "PrintWriter" which is basically a text stream that will be sent back to the browser.

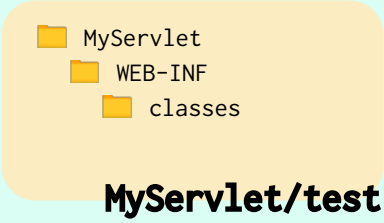
When you compile (same problem as with Jsoup) you must provide the location of the .jar that contains the HTTP stuff.

Replace with real location

```
javac -cp .:TOMCAT_DIR/lib/servlet-api.jar MyServlet.java
```

javax.servlet.* is HERE

Annotations provide everything Tomcat needs. If you are allergic to annotations, you can also write an .xml file.




```
@WebServlet(name="MyServlet", urlPatterns={"/test"})
```

"Application name" "Page name"

Re-doing the film database query with a servlet

Some changes

- Protocol formats results to a HTML table
- Writes directly to PrintWriter

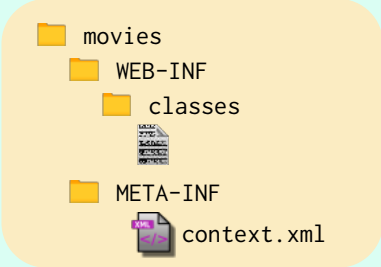
If you remember the "film server" created when talking about networking, I have redone it with a servlet.

```
...
ResultSetMetaData info = rs.getMetaData();
int               cols = info.getColumnCount();
out.print("<table class=\"films\"><tr class=\"headers\">");
for (int i = 1; i <= cols; i++) {
  out.print("<th>"+info.getColumnLabel(i)+"</th>");
}
out.print("</tr>\n");
while (rs.next()) {
  out.print("<tr>");
  for (int i = 1; i <= cols; i++) {
    if (rs.getString(i) != null) {
      out.print("<td class=\"film_col" + Integer.toString(i)
                          +"\">"+rs.getString(i)+"</td>");
    } else {
      out.print("<td></td>");
    }
  }
  out.println("</tr>");
}
...
```

I just output HTML with tags suitable for CSS formatting.

One nice feature is that Tomcat manages the database connection thanks to a component called JNDI.

Java Naming and Directory Interface



context.xml

I have briefly mentioned DataSources already, here they are again.

```xml
<?xml version="1.0" encoding="UTF-8"?>

<Context>
  <Resource name="filmdb" type="javax.sql.DataSource"
            maxTotal="10" maxIdle="5"
            maxWaitMillis="3000"
            url="jdbc:sqlite:path_to_sqlite_file"
            driverClassName="org.sqlite.JDBC"
  />
</Context>
```

TOMCAT_DIR

lib

JDBC driver (.jar file)

```java
import java.io.IOException;
import java.io.PrintWriter;
import java.util.ResourceBundle;

import javax.servlet.ServletException;
import javax.servlet.http.*;
import javax.servlet.annotation.*;
import javax.naming.InitialContext;
import javax.naming.NamingException;
import java.sql.Connection;
import java.sql.SQLException;
import javax.sql.DataSource;


@WebServlet(name="movies", urlPatterns={"/query"})
public class FilmServlet extends HttpServlet {
```

Let's create the Servlet. Lots of imports as usual, JDBC (of course) and also extended JDBC (javax.sql) for the DataSource.

```java
  private DataSource dataSource;
  private Connection con;

  public Connection getConnection(String jndiname)
         throws SQLException {
    try {
      dataSource = (DataSource)new
                   InitialContext().lookup("java:comp/env/"
                                           + jndiname);
    } catch (NamingException e) {
      // Handle error that it's not configured in JNDI.
      throw new IllegalStateException(jndiname
                                + " is missing in JNDI!", e);
    }
    return dataSource.getConnection();
  }
```

Connection is just "looking for a service" (in context.xml) that supplies all the right parameters.

```java
  @Override
  public void doGet(HttpServletRequest request,
                    HttpServletResponse response)
      throws IOException, ServletException {

    response.setContentType("text/html");
    response.setCharacterEncoding("UTF-8");
    PrintWriter out = response.getWriter();

    try {
      con = getConnection("filmdb");
      con.setAutoCommit(false);
    } catch (Exception e) {
      out.println(e.getMessage());
    }
```

My service is called "filmdb" (you may want to check context.xml a few slides back)

```
FilmProtocolHTML filmP = new FilmProtocolHTML(con, out);
out.println("<!DOCTYPE html><html>");
out.println("<head>");
out.println("<meta charset=\"UTF-8\" />");
out.println("<title>Film Database Query</title>");
out.println("</head>");
out.println("<body>");

out.println("<h3>Film Database</h3>");
out.println("<p>");
out.println("<form action=\"query\" method=POST>");
```

I pass my output stream to the (new) FilmProtocolHTML because it will write the rows to it as it retrieves them (much more efficient than loading a collection and passing it back). A "POST" query can be used when you send data (you normally use it whenever you want to CHANGE a database)

```
out.println("<form action=\"query\" method=POST>");
out.println("Title");
out.println("<input type=text size=80 name=\"title\">");
out.println("<br/>");
out.println("Director");
out.println("<input type=text size=40"
            + "        name=\"director\">");
out.println("<br/>");
out.println("Actor/Actress");
out.println("<input type=text size=40 name=\"actor\">");
out.println("<br/>");
out.println("Country");
out.println("<input type=text size=15"
            + "        name=\"country\">");
out.println("<br/>");
out.println("Year");
out.println("<input type=text size=4 name=\"year\">");
out.println("<br/>");
out.println("<input type=submit>");
out.println("</form>");
```

Input form

I'm passing here a command that follows the protocol defined in the client/server example

```
// If parameters were provided, execute the query
String title = request.getParameter("title");
String director = request.getParameter("director");
String actor = request.getParameter("actor");
String country = request.getParameter("country");
String year = request.getParameter("year");
StringBuffer theCommand = new StringBuffer();
if ((title != null) && (title.trim().length() > 0)) {
   theCommand.append("TITLE " + title);
}
if ((director != null)
    && (director.trim().length() > 0)) {
  if (theCommand.length() > 0) {
    theCommand.append(',');
  }
  theCommand.append("DIRECTOR " + director);
}
```

```
if ((actor != null) && (actor.trim().length() > 0)) {
  if (theCommand.length() > 0) {
    theCommand.append(',');
  }
  theCommand.append("ACTOR " + actor);
}
if ((country != null) && (country.trim().length() > 0)) {
  if (theCommand.length() > 0) {
    theCommand.append(',');
  }
  theCommand.append("COUNTRY " + country);
}
```

The form isn't as flexible as what my "language" allows (remember I could say "or" as well as "and") but it's easier for an end-user.

```
    if ((year != null) && (year.trim().length() > 0)) {
      if (theCommand.length() > 0) {
        theCommand.append(',');
      }
      theCommand.append("YEAR " + year);
    }
    if (theCommand.length() > 0) {
      filmP.processInput(theCommand.toString());
    }
    out.println("</body>");
    out.println("</html>");
  }
```

When I'm done I call the protocol that retieves rows (if it finds something) or displays an error message or whatever, and I just terminate the page. I have reused what had previously been done with minimal transformation because I'm lazy.

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

  @Override
  public void doPost(HttpServletRequest request,
                     HttpServletResponse response)
      throws IOException, ServletException {
      doGet(request, response);
  }

}
```

I'm defining "Post" to be the same as "Get"

```
  public void doGet(HttpServletRequest  request,
                    HttpServletResponse response)
              throws IOException, ServletException {
    response.setContentType("text/html");
    PrintWriter pw = response.getWriter();
    try {
      pw.print("<html>");
      pw.print("<head>");
      pw.print("<title>My First Servlet</title>");
      pw.print("</head>");
      pw.print("<body>");
      pw.print("<h1>Yeepee it works!</h1>");
      pw.print("</body>");
      pw.print("</html>");
    } finally {
      pw.close();
    }
  }
}
```

My Servlet is mostly a Java program that writes HTML.

HTML inside Java

OK if the web site is done by a single guy

Problem of division of labor otherwise

If I have one guy working on say data retrieval and another guy working on nice web pages, it may be inconvenient.

The design guy might want to add classes to the HTML tags.

Designer

TEMPLATES

The solution for this problem (which has been adopted in several languages) is to use templates (patterns, models). A template defines the global looks of a page, and is what the designer works on. Instead of writing the page from Java, we take an opposite approach and call bits of Java from inside a HTML page. Welcome to Java Server Pages (JSP).

You have similar technologies with other languages. A Servlet is more like what you can do with CGI, which includes a lot of things, including some Python frameworks.

Servlet = HTML in Java

Similar to CGI/Fast-CGI (Common Gateway Interface)

JSP = Java embedded in HTML

Similar to PHP

JSP looks more like PHP, or a product called ColdFusion – Special tags in a HTML page are processed by a module that reads the template.

```
<html>
   <head>
      ....
   </head>
 <body>

  <% Java code %>
      <div>
         ....
      </div>
  <% Java code %>

  </body>
</html>
```

Scriptlet

You can put bits of Java between <% and %> tags.

```
<html>
   <head>
      ....
   </head>
 <body>

  <%  if (var == 0) { %>
      <div>
         ....
      </div>
  <%  } %>

  </body>
</html>
```

It can even behave a bit like the C preprocessor (for those familiar with the C preprocessor ...). Java code may decide of what will remain of the HTML in what will be sent back to users.

```
<html>
  <head>
    <title>Very, very basic JSP</title>
  </head>
  <body>
      <h1>The time is <%= new java.util.Date() %></h1>
  </body>
</html>
```

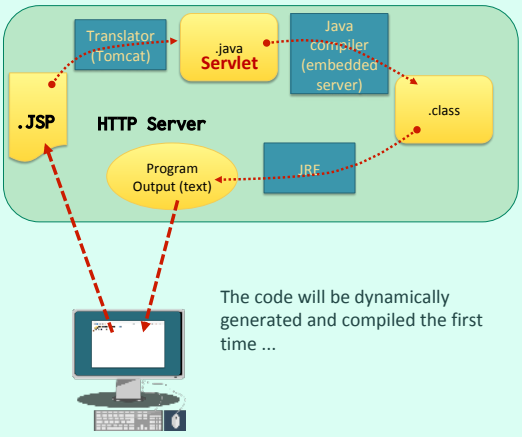
TOMCAT_DIR
- webapps
  - jspdemo
    - WEB-INF
    - date.jsp

Kind of useless demo application. Not completely useless: if you get the time in Javascript, it's the time where you are. Here it's the time on the server, which may be in a different time zone.

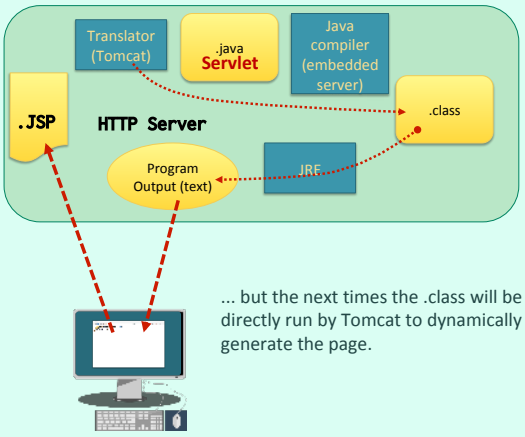
http://localhost:8888/jspdemo/date.jsp

What is really happening?

How is this done? By a number of software components that work together to build your page.



The code will be dynamically generated and compiled the first time ...



... but the next times the .class will be directly run by Tomcat to dynamically generate the page.

DEPLOYMENT

The Art of .war

(Web application Archive)

Extended .jar

For installing applications you use some .war files, which are kind of .jar files specialized for web applications.

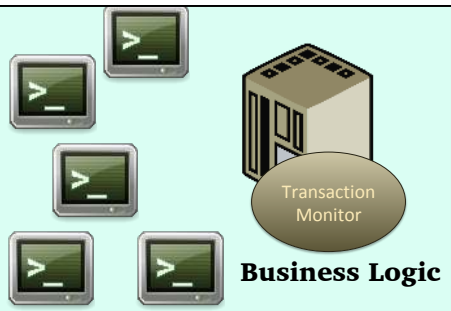
```
.class
.jsp
.xml
.html
```

and so forth

But Java-powered web applications evolved into something ...

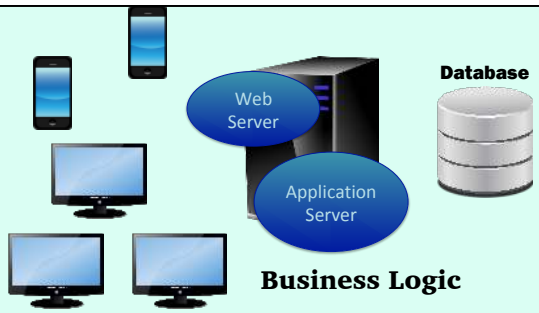
... based on an old idea.

What you have seen so far is enough for running a moderaely complex website, but for big popular websites (as well as for applications used by many employees in big companies – think about all the branches of a large retail bank) something more complex was devised.



... based on an old idea.

In the very old days of the dumb terminal, accesses to shared resources was managed by a "transaction monitor" that hosted all the "business logic" (functions performing business operations)

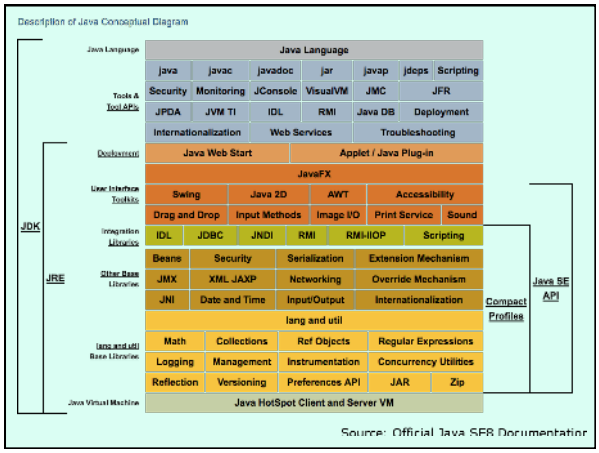


... based on an old idea.

The idea was dusted off to say "we'll have an application server distinct from the HTTP server and the database server that will contain the business logic".

Java Standard Edition

What you have been working with so far is known as "JSE", or Java Standard Edition. The following diagram comes from the Java documentation and describes JSE as a whole. I hope that you'll recognize more than a few components.



Not complicated enough ...

Far too simple for big companies. What big companies wanted (and what software vendors wanted to sell them) were ready-made components that could be reused and plugged into each other (think of Lego bricks). Application servers would mostly be the glue allowing all these components to work together. There are a few application servers that are popular on the market, Websphere (IBM), WebLogic (formerly BEA systems, bought over by Oracle that also bought Sun, owner of Java) and WildFly, formerly known as Jboss and bought by RedHat, better known for Linux distributions.

Need to inter-operate

Component-based architecture

Lego bricks are designed for interlocking. If we want software components to integrate without effort, they must be cleanly designed.

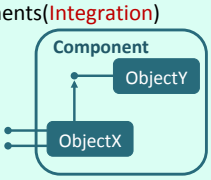
Component = Logical Processing Unit

Goal : modularity and reuse

Properties

Named, listed in a directory (Identification)
Usable alone (Independence)
Usable in different contexts (Reuse)
Can be combined with other components(Integration)

This basically lists the desirable qualities of a good software component.



Java Component : Java Bean

class

Specific Properties

Serializable

Default Constructor

Private Properties

Getters/Setters

In Java, components are called Beans. We have already encountered them in JavaFx, with TableViews and ListViews. Methods must have well-defined names so that they can be called automatically.

```
public <returntype> get<PropertyName>()
public void set<PropertyName> (parameter)
```

Java Component : Java Bean

class

Specific Properties

Methods for catching events

Use of listeners and event generation
For instance PropertyChangeListener

Beans must react to events (remember that ListViews, for instance, are backed by a collection and must refresh if the collection is modified)

```
public class InvoiceBean implements Serializable {
   private String  customer;
   private double  amount;
   private boolean paid;

   public InvoiceBean() { }

   public String getCustomer() {
     return this.customer;
   }

   public void setCustomer(String customer) {
     this.customer = customer;
   }

   public boolean isPaid() {
     return this.paid;
   }

   public void setPaid(boolean paid) {
     this.paid = paid;
   }
   ...
}
```

This is a boring example of Bean to implement accounting operations. Serializable, private properties, default constructor, getters and setters.

Java Enterprise Edition

Java EE JEE J2EE

A set of specifications

Defined by Sun microsystems now owned by ORACLE

JEE is basically a set of standards.

Agreed to by multiple international (mostly US) companies www.jcp.org

Java Enterprise Edition

A set of specifications

Based on Java SE

+ Application Server specs

Libraries for the development of business applications (APIs)

These standards defines how components should work together.

Reference Implementation: the GlassFish application server (Open Source)

Based on Java Beans.

But you have better than the humble Java Bean: the Enterprise Java Bean!

Deal with:

Enterprise JavaBeans

Transactions

Concurrency

Messaging

Scheduling

and so forth.

EJB

It includes the support of many functions that are important in business applications.

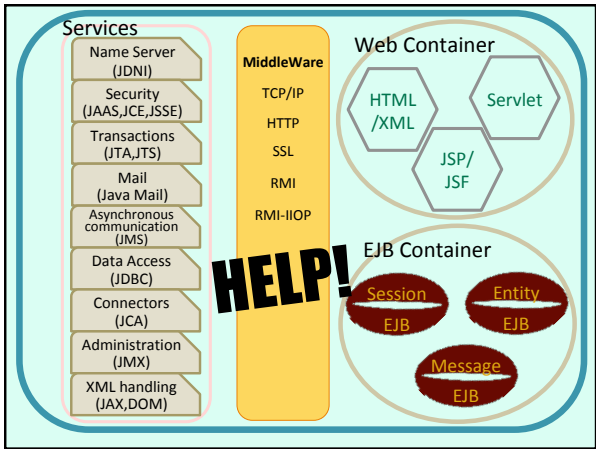
Different areas of responsibility for beans

Presentation	User interface	View
Processing	Logic	Controller
Resources	Data management	Model

Where things become ugly is that basically you don't always know where the code is running.

V V C M

But in practice almost everything can be anywhere!



What is the purpose of containers?

They simplify set-up

"managed beans"

@ManagedBean

@SessionScoped

What containers do is that they use reflection to read annotations and generate or call the necessary code. The alternative is writing configuration information into xml files – you have seen en excellent example with the Tomcat servlet example.

Java Server Faces (JSF)

Framework relying on managed beans

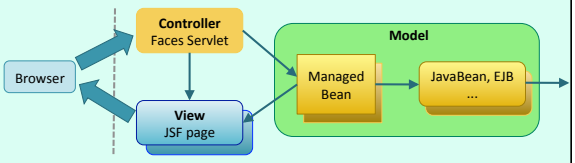
"Faces Servlet" used as controller

XHTML templates (used to be JSP)

Then the Java folks invented JSF, to try to better organize applications.

JSF separates the view from logic and data, both parts of the "model"

model = logic + data



JSF Allows to build easily data-entry forms (not the most interesting thing you can code)

Input Form ⟷ Managed Bean

properties (getters/setters)
One pair per input element

Action controller
one per form button

Called automatically

Place-holders for result data
(only getters)

NOT called automatically

As everything was getting a bit out of hand, some other folks created other development frameworks that have become quite successful.

There are other frameworks

spring by Pivotal — Integrates

Struts — Web side only
Navigates between .jsp

As you can see, it can become

VERY complicated.

After Flickr:rocksee

Architectures are very often monsters. You have a lot of products, some of them are very trendy one year, the next year the hot product is something else ...

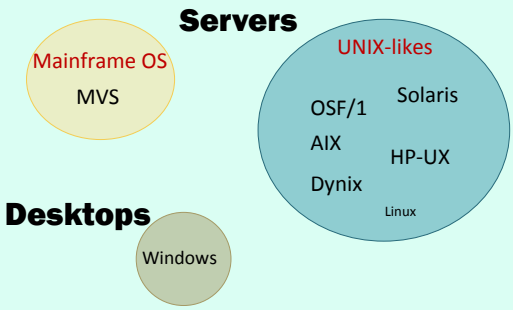
Many fashions in Information Technology

Because investments are huge in software development, a lot of technologies survive many years after having dropped out of fashion.

Art by Nancy Duong

Java and the web

The Corporate IT landscape in the 1990s



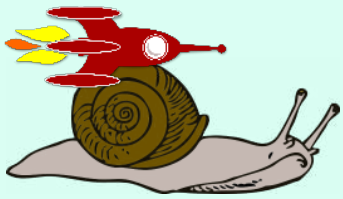
1996

Write once, run everywhere

In the early days

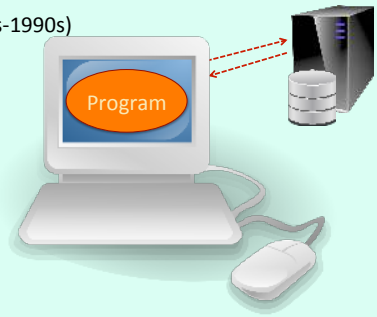
10 to 20 times slower than C

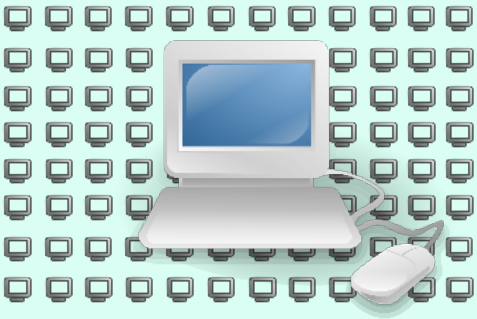
Just-in-Time Compiler (1997)
Hot-Spots (1999)

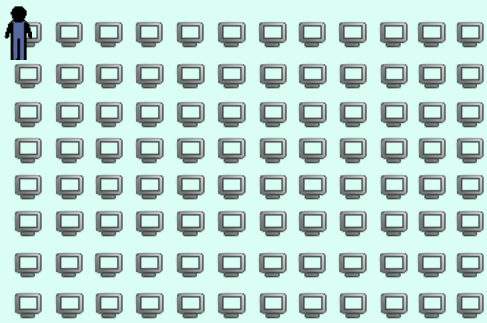


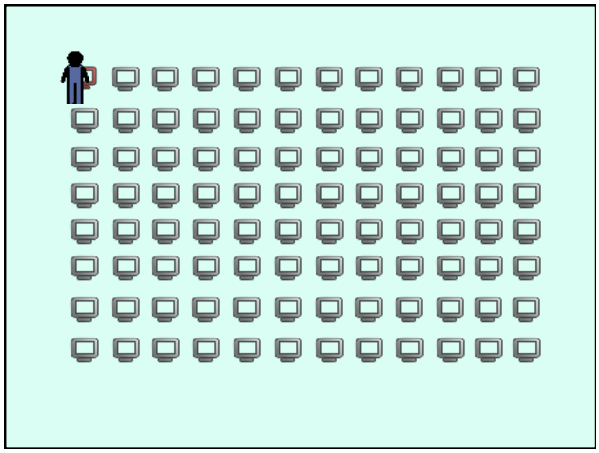
Reasonably slower than C

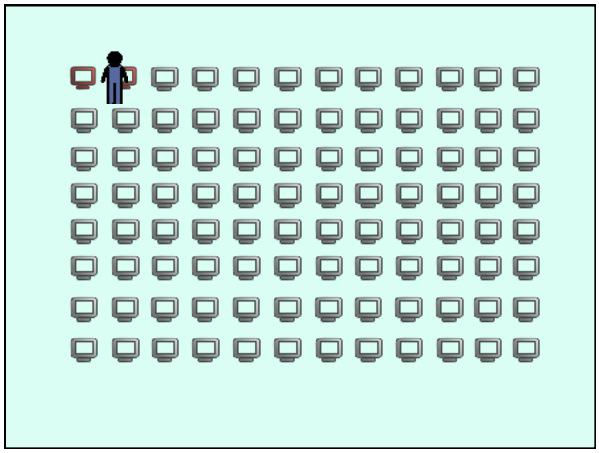
Client-server
(popular 1980s-1990s)

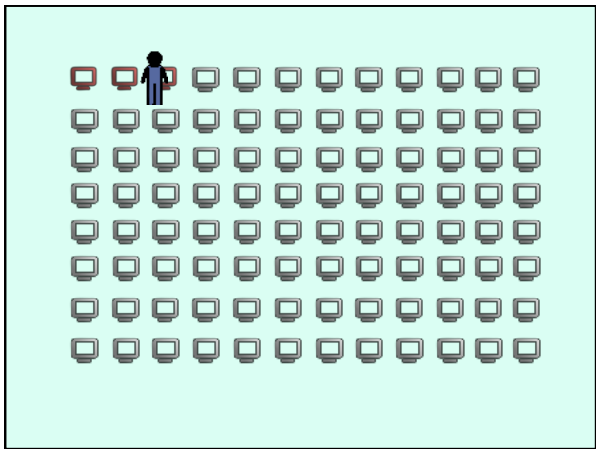








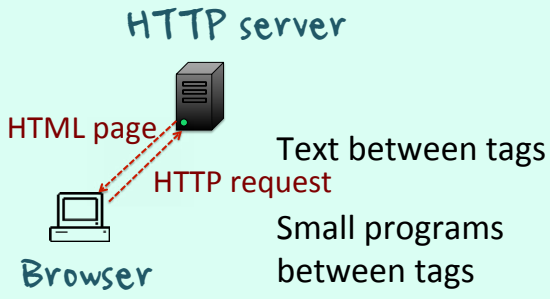




Time Consuming

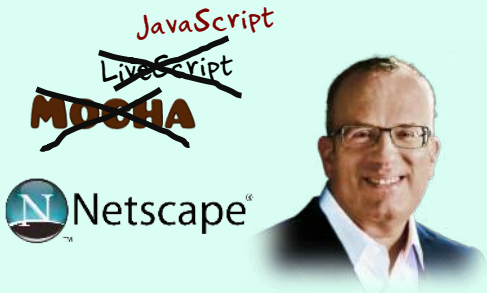
Costly

Then the Web and the HTTP protocol came



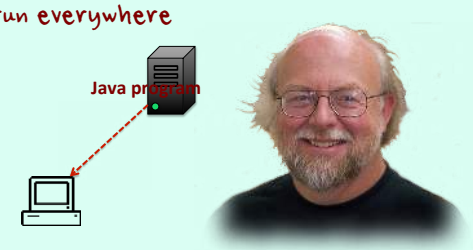
Run automatically

Updated on the server only



Brendan Eich

Write once,
run everywhere



Write once,
run everywhere

SECURITY?

small application

Runs in another process than the browser → Access to 3D Hardware acceleration

The Java security model

Verifier in the class loader

But a program could do nasty things on your computer!

An applet has no `main()`

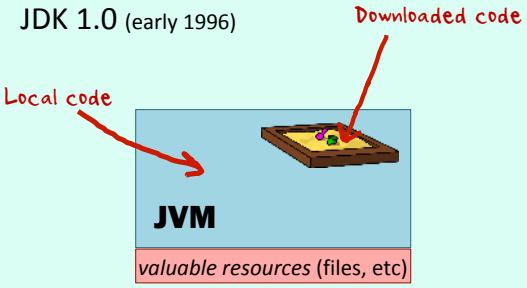
equivalent of constructor

Applet Container

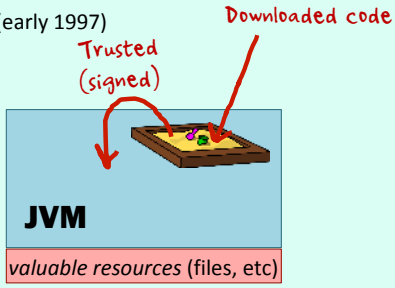
```
public void init()
public void start()
public void stop()
public void destroy()
```

```
java.awt.Panel
java.applet.Applet
javax.swing.JApplet
```

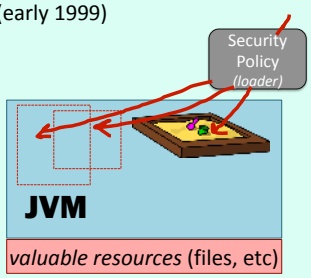
JDK 1.0 (early 1996)



JDK 1.1 (early 1997)



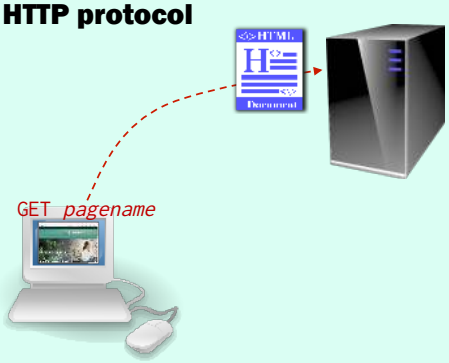
JDK 2.0 (early 1999)



Applet on the server

in a .jar file

The HTTP protocol




```
<html>
  <head>
    <title>Page Title</title>
</head>
<body>
  <h1>Title</h1>
 <p>Blah blah blah</p>
</body>
</html>
```

```
<script src="https://www.java.com/js/deployJava.js"></script>
```

```
<applet code = "AppletName"
    archive = "AppletIsInside.jar"
    width = 300
    height = 300>
    <param name="permissions"
           value="sandbox" />
</applet>
```

OR

Java Network Launch Protocol (JNPL)

```
<applet code = "AppletName"
        jnlp_href = "AppletName.jnlp"
        width = 300
        height = 300 />
```

Text file that provides permission details

All these files are downloaded from the website

Permissions are set on the server ...

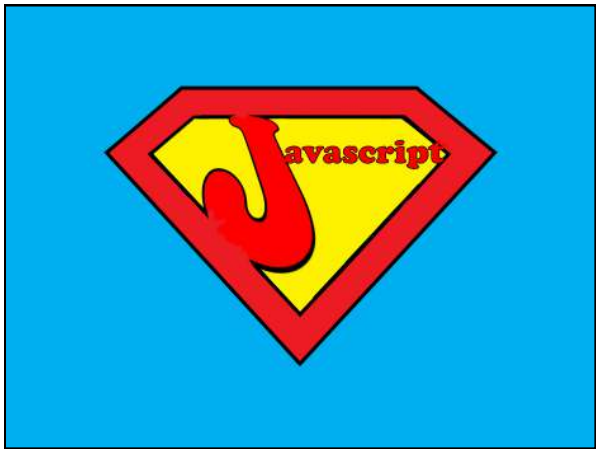
You can sign anything ...

Meanwhile

hardware acceleration in browsers
(*around 2010/2011*)

Lots of excellent Javascript graphics libraries

HTML 5



Applets are now history

Chrome stopped supporting them in 2015

Firefox stopped supporting them in March 2017

What runs in the browser

Front-end

Javascript frameworks (AngularJS, ReactJS, ...)

What about the back-end?

Java much in use there!

https://en.wikipedia.org/wiki/Programming_languages_used_in_most_popular_websites

Websites	Popularity (unique visitors per month)[1]	Front-end (Client-side)	Back-end (Server-side)	Database	Notes
Google.com[2]	1,600,000,000	JavaScript	C, C++, Go,[3] Java, Python, PHP (HHVM)	Bigtable,[4] MariaDB[5]	The most used search engine in the world
Facebook.com	1,100,000,000	JavaScript	Hack, PHP (HHVM), Python, C++, Java, Erlang, D,[6] XHP,[7] Haskell[8]	MariaDB, MySQL,[9] HBase, Cassandra[10]	The most visited social networking site
YouTube.com	1,100,000,000	JavaScript	C, C++, Python, Java, ActionScript, Go[12]	Vitess, Bigtable, MariaDB[13]	The most visited video sharing site
Yahoo	750,000,000	JavaScript	PHP	MySQL, PostgreSQL[14]	Yahoo is presently[15][16] transitioning to Node.js[17]
Amazon.com	500,000,000	JavaScript	Java, C++, Perl[18]	Oracle Database[19]	Popular internet shopping site
Wikipedia.org	475,000,000	JavaScript	PHP, Hack	MariaDB[20]	"MediaWiki" is programmed in PHP, runs on HHVM; free online encyclopedia
Twitter.com	250,000,000	JavaScript	C++, Java, Scala, Ruby[21]	MySQL[22]	Popular social network.
Bing	315,000,000	JavaScript	C++	Microsoft SQL Server	
eBay.com	285,000,000	JavaScript	Java,[23] JavaScript,[24] Scala[25]	Oracle Database	Online auction house
MSN.com	280,000,000	JavaScript	C++	Microsoft SQL Server	An email client, for simple use. Mostly known as "messenger".
Microsoft	270,000,000	JavaScript	C++	Microsoft SQL Server	One of the worlds largest software companies.
LinkedIn.com	260,000,000	JavaScript	Java, JavaScript,[26] Scala	Voldemort[27]	Worlds largest professional network
Pinterest	250,000,000	JavaScript	Django,[28] Erlang	MySQL, Redis[29]	
WordPress.com	240,000,000	JavaScript	PHP, JavaScript[30] (Node.js)	MariaDB, MySQL	

HTML page

```
<a href="http://www.other_site.com/page.html">link</a>
```

link

Javascript program

```
<script type="text/javascript" >
   program_name="http://www.other_site.com/their_program.js">
</script>
```

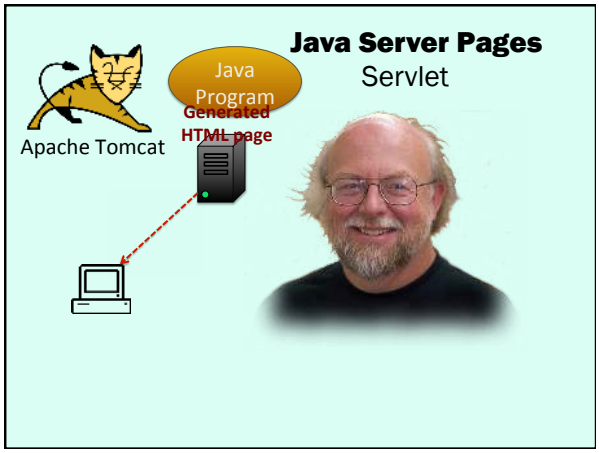
Style sheet

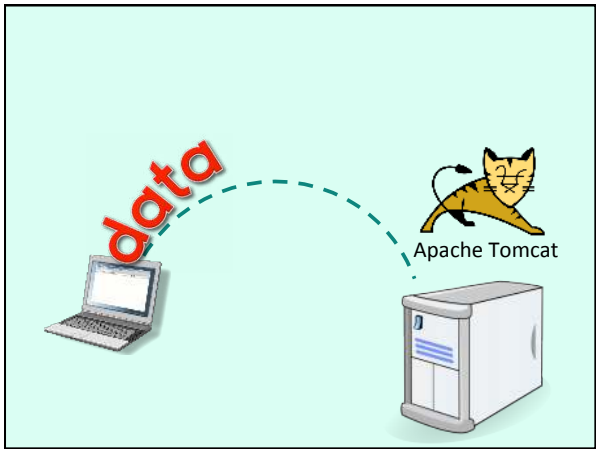
```
<style type="text/css" ... >
</style>
```

Multimedia content

```
<img src="..." />
```

Interactive HTML pages generated





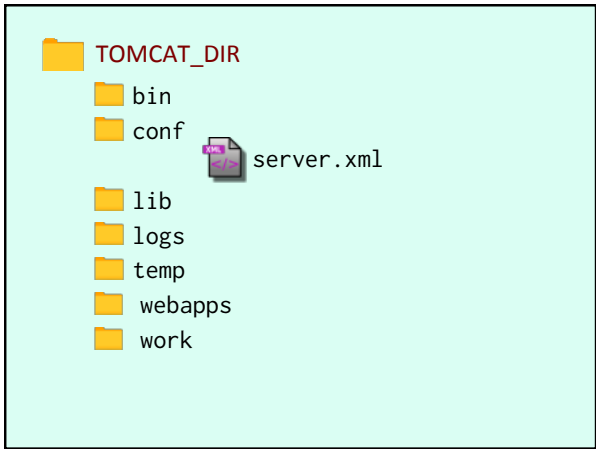
TOMCAT_DIR *Installation directory of Tomcat*

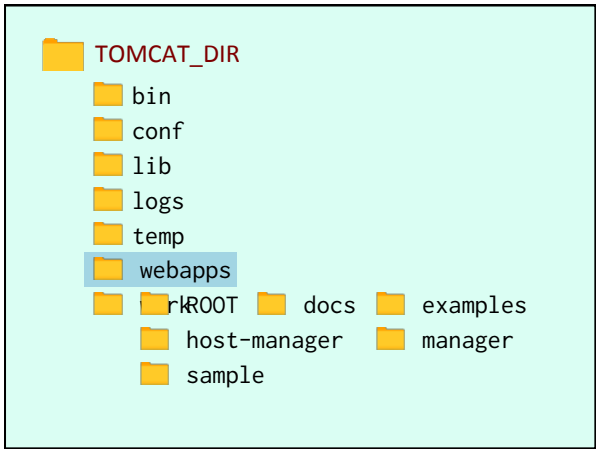
- bin
- conf
- lib
- logs
- temp
- webapps
- work

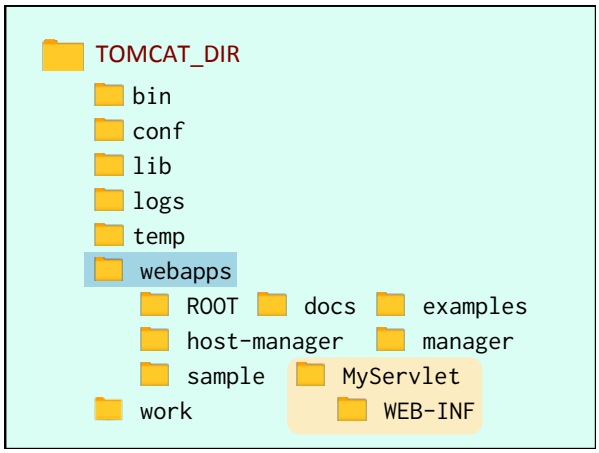
TOMCAT_DIR

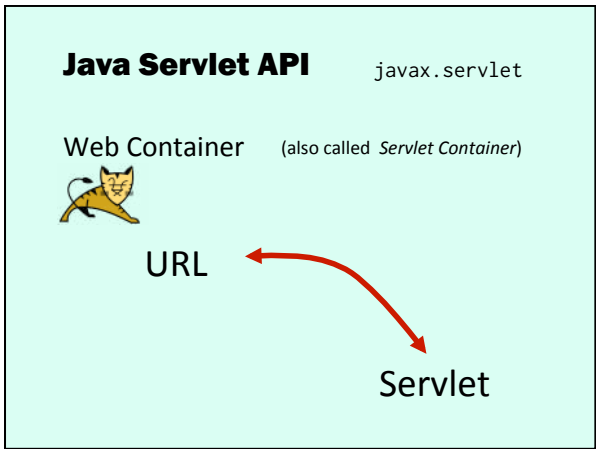
- bin
- conf
- lib
- logs
- temp
- webapps
- work

server.xml


TOMCAT_DIR
bin
conf
server.xml
lib
logs
temp
webapps
work


TOMCAT_DIR
bin
conf
lib
logs
temp
webapps
ROOT
docs
examples
host-manager
manager
sample


TOMCAT_DIR
bin
conf
lib
logs
temp
webapps
ROOT
docs
examples
host-manager
manager
sample
MyServlet
WEB-INF
work


Java Servlet API
javax.servlet
Web Container
(also called Servlet Container)
URL
Servlet

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

@WebServlet(name="MyServlet", urlPatterns={"/test"})
public class MyServlet extends HttpServlet {
  @Override
  public void doGet(HttpServletRequest  request,
                    HttpServletResponse response)
              throws IOException, ServletException {
    response.setContentType("text/html");
    PrintWriter pw = response.getWriter();
```

NOT in default Java libraries!

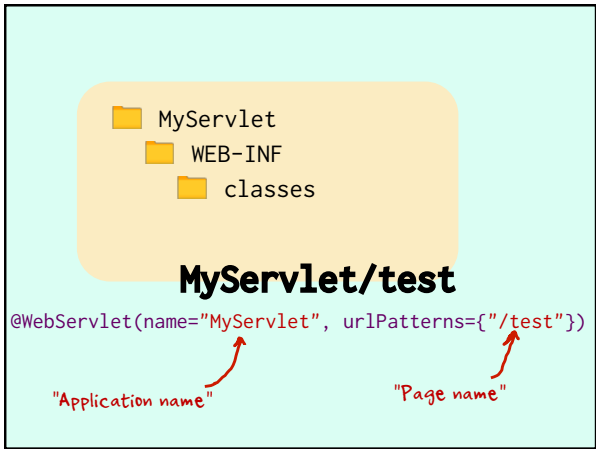
```java
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
import javax.servlet.annotation.*;

@WebServlet(name="MyServlet", urlPatterns={"/test"})
public class MyServlet extends HttpServlet {
  @Override
  public void doGet(HttpServletRequest  request,
                    HttpServletResponse response)
              throws IOException, ServletException {
    response.setContentType("text/html");
    PrintWriter pw = response.getWriter();
```

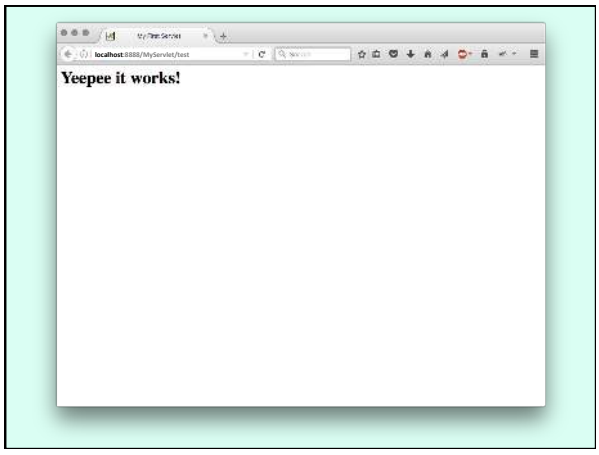
```java
  public void doGet(HttpServletRequest  request,
                    HttpServletResponse response)
              throws IOException, ServletException {
    response.setContentType("text/html");
    PrintWriter pw = response.getWriter();
    try {
      pw.print("<html>");
      pw.print("<head>");
      pw.print("<title>My First Servlet</title>");
      pw.print("</head>");
      pw.print("<body>");
      pw.print("<h1>Yeepee it works!</h1>");
      pw.print("</body>");
      pw.print("</html>");
    } finally {
      pw.close();
    }
  }
}
```

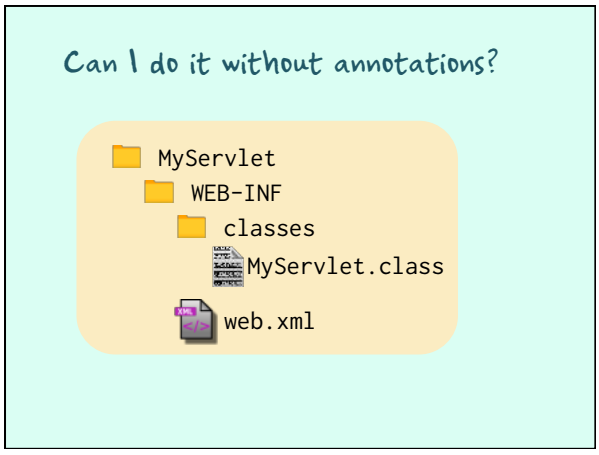
Replace with real location

```
javac -cp .:TOMCAT_DIR/lib/servlet-api.jar MyServlet.java
```

javax.servlet.* is HERE


MyServlet
WEB-INF
classes
MyServlet/test
@WebServlet(name="MyServlet", urlPatterns={"/test"})
"Application name"
"Page name"


Yeepee it works!


Can I do it without annotations?
MyServlet
WEB-INF
classes
MyServlet.class
web.xml

```xml
<?xml version="1.0" encoding="ISO-8859-1"?>
<web-app version="3.0"
   xmlns="http://java.sun.com/xml/ns/javaee"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd">

   <servlet>
     <servlet-name>MyServlet</servlet-name>
     <servlet-class>MyServlet</servlet-class>
   </servlet>

   <servlet-mapping>
      <servlet-name>MyServlet</servlet-name>
      <url-pattern>/test</url-pattern>
   </servlet-mapping>
</web-app>
```

I ♥ @nnotations

Re-doing the film database query with a servlet

Some changes

- Protocol formats results to a HTML table
- Writes directly to PrintWriter

```
...
ResultSetMetaData info = rs.getMetaData();
int               cols = info.getColumnCount();
out.print("<table class=\"films\"><tr class=\"headers\">");
for (int i = 1; i <= cols; i++) {
  out.print("<th>"+info.getColumnLabel(i)+"</th>");
}
out.print("</tr>\n");
while (rs.next()) {
  out.print("<tr>");
  for (int i = 1; i <= cols; i++) {
    if (rs.getString(i) != null) {
      out.print("<td class=\"film_col" + Integer.toString(i)
                          +"\">"+rs.getString(i)+"</td>");
    } else {
      out.print("<td></td>");
    }
  }
  out.println("</tr>");
}
...
```

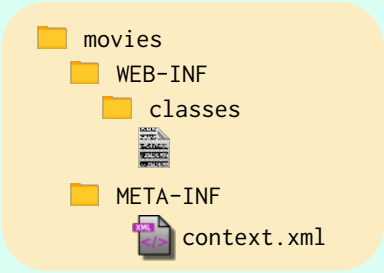
```
...
ResultSetMetaData info = rs.getMetaData();
int               cols = info.getColumnCount();
out.print("<table class=\"films\"><tr class=\"headers\">");
for (int i = 1; i <= cols; i++) {
  out.print("<th>"+info.getColumnLabel(i)+"</th>");
}
out.print("</tr>\n");
while (rs.next()) {
  out.print("<tr>");
  for (int i = 1; i <= cols; i++) {
    if (rs.getString(i) != null) {
      out.print("<td class=\"film_col" + Integer.toString(i)
                          +"\">"+rs.getString(i)+"</td>");
    } else {
      out.print("<td></td>");
    }
  }
  out.println("</tr>");
}
...
```

Re-doing the film database query with a servlet

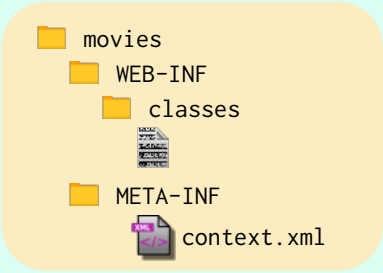
Some changes

- Protocol formats results to a HTML table
- Writes directly to PrintWriter
- Tomcat manages the database connection

Java Naming and Directory Interface



Java Naming and Directory Interface



context.xml

```
<?xml version="1.0" encoding="UTF-8"?>

<Context>
  <Resource name="filmdb" type="javax.sql.DataSource"
            maxTotal="10" maxIdle="5"
            maxWaitMillis="3000"
            url="jdbc:sqlite:path_to_sqlite_file"
            driverClassName="org.sqlite.JDBC"
  />
</Context>
```

TOMCAT_DIR

lib

JDBC driver (.jar file)

```
import java.io.IOException;
import java.io.PrintWriter;
import java.util.ResourceBundle;

import javax.servlet.ServletException;
import javax.servlet.http.*;
import javax.servlet.annotation.*;
import javax.naming.InitialContext;
import javax.naming.NamingException;
import java.sql.Connection;
import java.sql.SQLException;
import javax.sql.DataSource;


@WebServlet(name="movies", urlPatterns={"/query"})
public class FilmServlet extends HttpServlet {

    private DataSource dataSource;
    private Connection con;
```


```
import java.io.IOException;
import java.io.PrintWriter;
import java.util.ResourceBundle;

import javax.servlet.ServletException;
import javax.servlet.http.*;
import javax.servlet.annotation.*;
import javax.naming.InitialContext;
import javax.naming.NamingException;
import java.sql.Connection;
import java.sql.SQLException;
import javax.sql.DataSource;


@WebServlet(name="movies", urlPatterns={"/query"})
public class FilmServlet extends HttpServlet {

    private DataSource dataSource;
    private Connection con;
```


```
    private DataSource dataSource;
    private Connection con;

    public Connection getConnection(String jndiname)
           throws SQLException {
      try {
        dataSource = (DataSource)new
                     InitialContext().lookup("java:comp/env/"
                                             + jndiname);
      } catch (NamingException e) {
        // Handle error that it's not configured in JNDI.
        throw new IllegalStateException(jndiname
                                + " is missing in JNDI!", e);
      }
      return dataSource.getConnection();
    }
```

```java
private DataSource dataSource;
private Connection con;

public Connection getConnection(String jndiname)
       throws SQLException {
  try {
    dataSource = (DataSource)new
                 InitialContext().lookup("java:comp/env/"
                                         + jndiname);
  } catch (NamingException e) {
    // Handle error that it's not configured in JNDI.
    throw new IllegalStateException(jndiname
                         + " is missing in JNDI!", e);
  }
  return dataSource.getConnection();
}
```

```java
  return dataSource.getConnection();
}

@Override
public void doGet(HttpServletRequest request,
                  HttpServletResponse response)
    throws IOException, ServletException {

  response.setContentType("text/html");
  response.setCharacterEncoding("UTF-8");
  PrintWriter out = response.getWriter();

  try {
    con = getConnection("filmdb");
    con.setAutoCommit(false);
  } catch (Exception e) {
    out.println(e.getMessage());
  }
```

```java
  return dataSource.getConnection();
}

@Override
public void doGet(HttpServletRequest request,
                  HttpServletResponse response)
    throws IOException, ServletException {

  response.setContentType("text/html");
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  try {
    con = getConnection("filmdb");
    con.setAutoCommit(false);
  } catch (Exception e) {
    out.println(e.getMessage());
  }
```

```java
  try {
    con = getConnection("filmdb");
    con.setAutoCommit(false);
  } catch (Exception e) {
    out.println(e.getMessage());
  }
  FilmProtocolHTML filmP = new FilmProtocolHTML(con, out);
  out.println("<!DOCTYPE html><html>");
  out.println("<head>");
  out.println("<meta charset=\"UTF-8\" />");
  out.println("<title>Film Database Query</title>");
  out.println("</head>");
  out.println("<body>");

  out.println("<h3>Film Database</h3>");
  out.println("<p>");
  out.println("<form action=\"query\" method=POST>");
```

```
try {
  con = getConnection("filmdb");
  con.setAutoCommit(false);
} catch (Exception e) {
  out.println(e.getMessage());
}
FilmProtocolHTML filmP = new FilmProtocolHTML(con, out);
out.println("<!DOCTYPE html><html>");
out.println("<head>");
out.println("<meta charset=\"UTF-8\" />");
out.println("<title>Film Database Query</title>");
out.println("</head>");
out.println("<body>");

out.println("<h3>Film Database</h3>");
out.println("<p>");
out.println("<form action=\"query\" method=POST>");
```

```
out.println("<form action=\"query\" method=POST>");
out.println("Title");
out.println("<input type=text size=80 name=\"title\">");
out.println("<br/>");
out.println("Director");
out.println("<input type=text size=40"
            + "        name=\"director\">");
out.println("<br/>");
out.println("Actor/Actress");
out.println("<input type=text size=40 name=\"actor\">");
out.println("<br/>");
out.println("Country");
out.println("<input type=text size=15"
            + "        name=\"country\">");
out.println("<br/>");
out.println("Year");
out.println("<input type=text size=4 name=\"year\">");
out.println("<br/>");
out.println("<input type=submit>");
out.println("</form>");
```


```
out.println("<form action=\"query\" method=POST>");
out.println("Title");
out.println("<input type=text size=80 name=\"title\">");
out.println("<br/>");
out.println("Director");
out.println("<input type=text size=40"
            + "        name=\"director\">");
out.println("<br/>");
out.println("Actor/Actress");
out.println("<input type=text size=40 name=\"actor\">");
out.println("<br/>");
out.println("Country");
out.println("<input type=text size=15"
            + "        name=\"country\">");
out.println("<br/>");
out.println("Year");
out.println("<input type=text size=4 name=\"year\">");
out.println("<br/>");
out.println("<input type=submit>");
out.println("</form>");
```


```
out.println("<input type=submit>");
out.println("</form>");
// If parameters were provided, execute the query
String title = request.getParameter("title");
String director = request.getParameter("director");
String actor = request.getParameter("actor");
String country = request.getParameter("country");
String year = request.getParameter("year");
StringBuffer theCommand = new StringBuffer();
if ((title != null) && (title.trim().length() > 0)) {
   theCommand.append("TITLE " + title);
}
if ((director != null)
    && (director.trim().length() > 0)) {
  if (theCommand.length() > 0) {
    theCommand.append(',');
  }
  theCommand.append("DIRECTOR " + director);
}
```

```
        out.println("<input type=submit>");
        out.println("</form>");
        // If parameters were provided, execute the query
        String title = request.getParameter("title");
        String director = request.getParameter("director");
        String actor = request.getParameter("actor");
        String country = request.getParameter("country");
        String year = request.getParameter("year");
        StringBuffer theCommand = new StringBuffer();
        if ((title != null) && (title.trim().length() > 0)) {
           theCommand.append("TITLE " + title);
        }
        if ((director != null)
            && (director.trim().length() > 0)) {
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("DIRECTOR " + director);
        }
```

```
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("DIRECTOR " + director);
        }
        if ((actor != null) && (actor.trim().length() > 0)) {
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("ACTOR " + actor);
        }
        if ((country != null) && (country.trim().length() > 0)) {
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("COUNTRY " + country);
        }
```

```
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("DIRECTOR " + director);
        }
        if ((actor != null) && (actor.trim().length() > 0)) {
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("ACTOR " + actor);
        }
        if ((country != null) && (country.trim().length() > 0)) {
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("COUNTRY " + country);
        }
```

```
          }
          theCommand.append("COUNTRY " + country);
        }
        if ((year != null) && (year.trim().length() > 0)) {
          if (theCommand.length() > 0) {
            theCommand.append(',');
          }
          theCommand.append("YEAR " + year);
        }
        if (theCommand.length() > 0) {
          filmP.processInput(theCommand.toString());
        }
        out.println("</body>");
        out.println("</html>");
      }
```

```
        }
        theCommand.append("COUNTRY " + country);
      }
      if ((year != null) && (year.trim().length() > 0)) {
        if (theCommand.length() > 0) {
          theCommand.append(',');
        }
        theCommand.append("YEAR " + year);
      }
      if (theCommand.length() > 0) {
        filmP.processInput(theCommand.toString());
      }
      out.println("</body>");
      out.println("</html>");
    }
```

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

    @Override
    public void doPost(HttpServletRequest request,
                       HttpServletResponse response)
        throws IOException, ServletException {
        doGet(request, response);
    }

}
```

DEMO

What is the relationship between Java and HTML?

```
  public void doGet(HttpServletRequest  request,
                    HttpServletResponse response)
              throws IOException, ServletException {
    response.setContentType("text/html");
    PrintWriter pw = response.getWriter();
    try {
      pw.print("<html>");
      pw.print("<head>");
      pw.print("<title>My First Servlet</title>");
      pw.print("</head>");
      pw.print("<body>");
      pw.print("<h1>Yeepee it works!</h1>");
      pw.print("</body>");
      pw.print("</html>");
    } finally {
      pw.close();
    }
  }
}
```

HTML inside Java

Designer

TEMPLATES

Introducing

Java Server Pages

(JSP)

Servlet = HTML in Java

Similar to CGI/Fast-CGI (Common Gateway Interface)

JSP = Java embedded in HTML

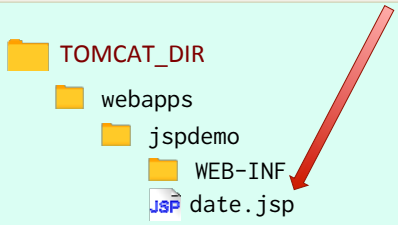
Similar to PHP

```
<html>
   <head>
     ....
   </head>
 <body>

  <% Java code %>
     <div>
        ....
     </div>
  <% Java code %>

  </body>
</html>
```

Scriptlet

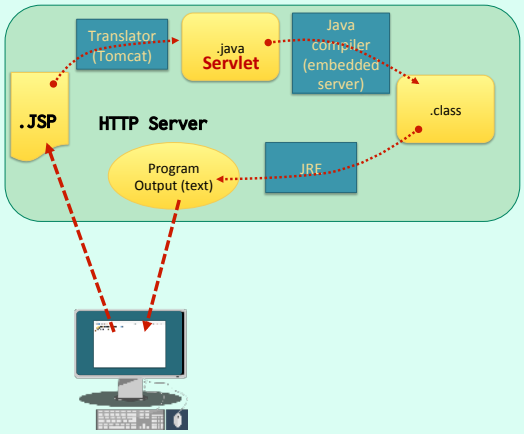
```
<html>
   <head>
     ....
   </head>
 <body>

  <%  if (var == 0) { %>
     <div>
        ....
     </div>
  <%  } %>

  </body>
</html>
```

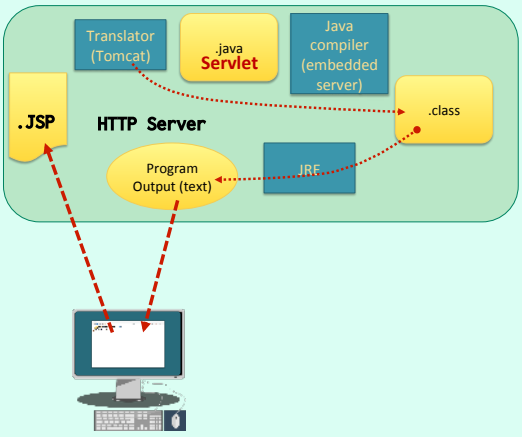
```
<html>
  <head>
    <title>Very, very basic JSP</title>
  </head>
  <body>
      <h1>The time is <%= new java.util.Date() %></h1>
  </body>
</html>
```



http://localhost:8888/jspdemo/date.jsp

What is really happening?





Predefined variables:

out	`out.println(...);`
request	`javax.servlet.http.HttpServletRequest`
session	

plus a few others

DEPLOYMENT

The Art of .war
(Web application Archive)

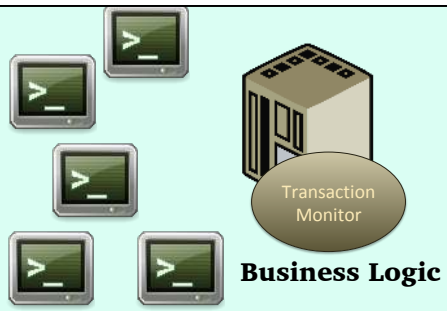
Extended .jar

```
.class
.jsp
.xml
.html
```

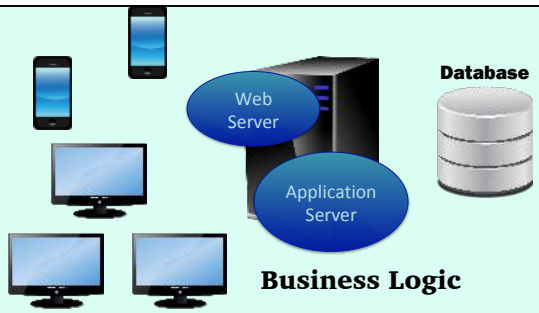
and so forth

But Java-powered web applications evolved into something ...

... based on an old idea.

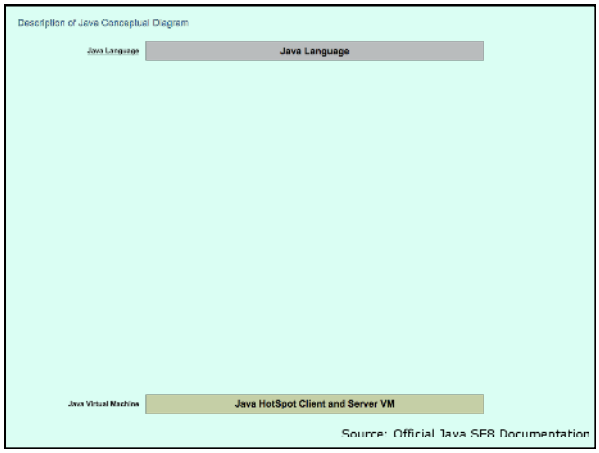


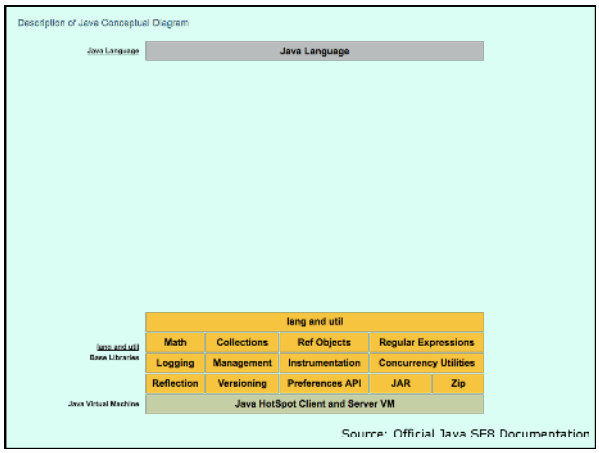
... based on an old idea.

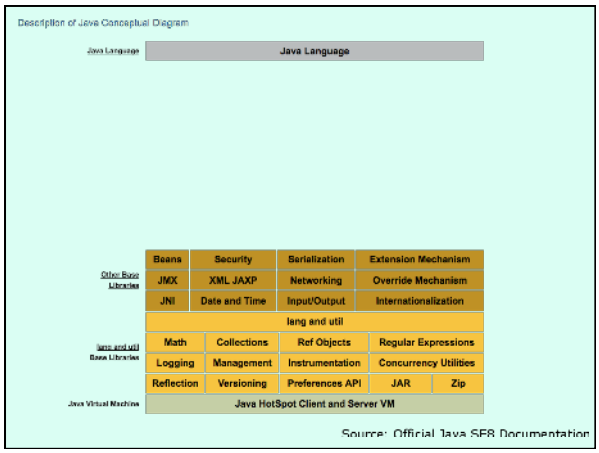


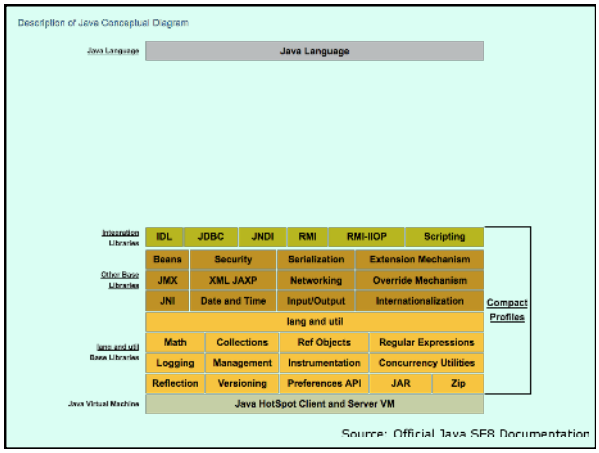
... based on an old idea.

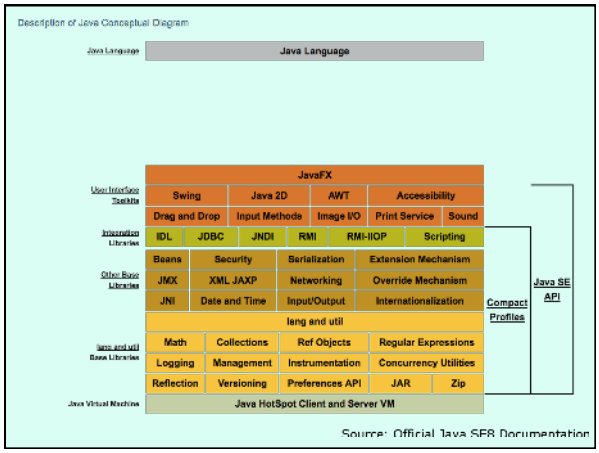
Java Standard Edition








Description of Java Conceptual Diagram
Java Language
Java Language
Integration Libraries
IDL
JDBC
JNDI
RMI
RMI-IIOP
Scripting
Other Base Libraries
Beans
Security
Serialization
Extension Mechanism
JMX
XML JAXP
Networking
Override Mechanism
JNI
Date and Time
Input/Output
Internationalization
lang and util
lang and util Base Libraries
Math
Collections
Ref Objects
Regular Expressions
Logging
Management
Instrumentation
Concurrency Utilities
Reflection
Versioning
Preferences API
JAR
Zip
Java Virtual Machine
Java HotSpot Client and Server VM
Compact Profiles
Source: Official Java SE8 Documentation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Java Language
Java Language
JavaFX
User Interface Toolkits
Swing
Java 2D
AWT
Accessibility
Drag and Drop
Input Methods
Image I/O
Print Service
Sound
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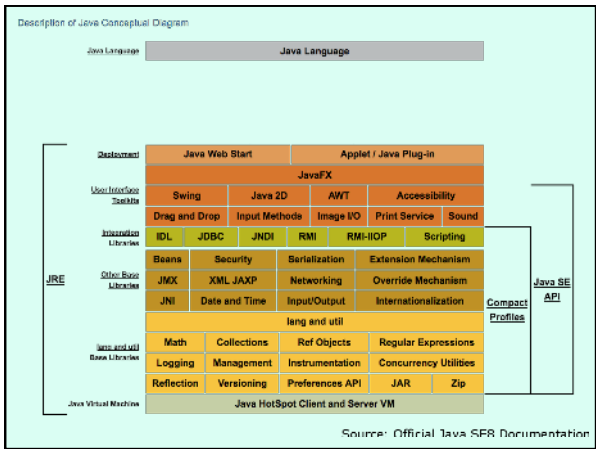
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Deployment
Java Web Start
Applet / Java Plug-in
JavaFX
User Interface Toolkits
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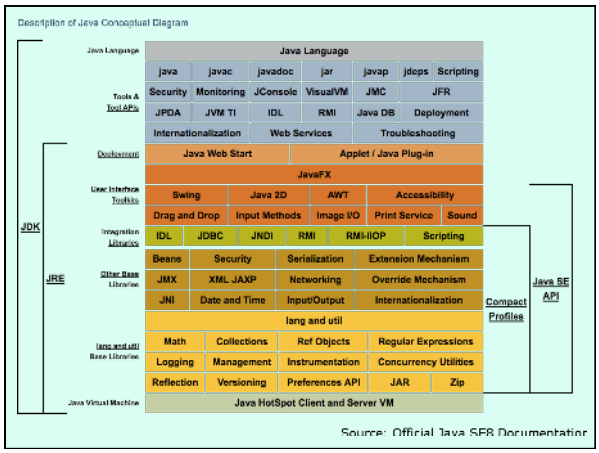
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JRE
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javac
javadoc
jar
javap
jdeps
Scripting
Tools & Tool APIs
Security
Monitoring
JConsole
VisualVM
JMC
JFR
JPDA
JVM TI
IDL
RMI
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Deployment
Internationalization
Web Services
Troubleshooting
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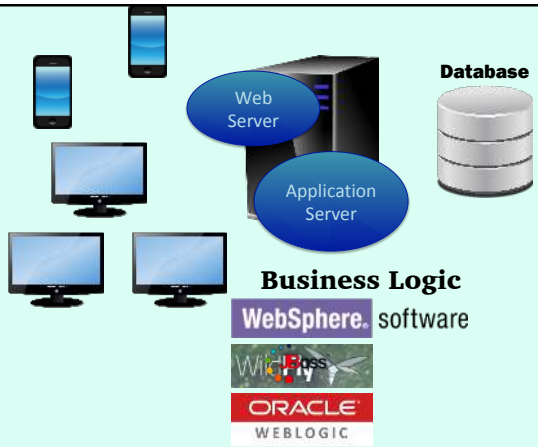
Source: Official Java SE8 Documentation

Not complicated enough ...



Need to inter-operate

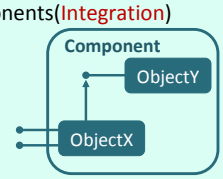
Component-based architecture

Component = Logical Processing Unit

Goal : modularity and reuse

Properties

Named, listed in a directory (Identification)
Usable alone (Independence)
Usable in different contexts (Reuse)
Can be combined with other components(Integration)



Java Component : Java Bean

class

Specific Properties

Serializable

Default Constructor

Private Properties

Getters/Setters

```
public <returntype> get<PropertyName>()
public void set<PropertyName> (parameter)
```

Java Component : Java Bean

class

Specific Properties

Methods for catching events

Use of listeners and event generation
For instance PropertyChangeListener

```
public class InvoiceBean implements Serializable {
   private String  customer;
   private double  amount;
   private boolean paid;

   public InvoiceBean() { }

   public String getCustomer() {
     return this.customer;
   }

   public void setCustomer(String customer) {
     this.customer = customer;
   }

   public boolean isPaid() {
     return this.paid;
   }

   public void setPaid(boolean paid) {
     this.paid = paid;
   }
   ...
}
```

Java Enterprise Edition

Java EE JEE J2EE

A set of specifications

Defined by ORACLE Sun microsystems

Agreed to by multiple international (mostly US) companies www.jcp.org

Java Enterprise Edition

A set of specifications

Dedicated to development, deployment and management of n-tier applications built from server-centered components.

Java Enterprise Edition

A set of specifications

Based on Java SE 

+ Application Server specs

Libraries for the development of business applications (APIs)

Reference Implementation: 
the GlassFish application server (Open Source)

Enterprise JavaBeans

Business Logic

Based on Java Beans.

Deal with:

Enterprise JavaBeans

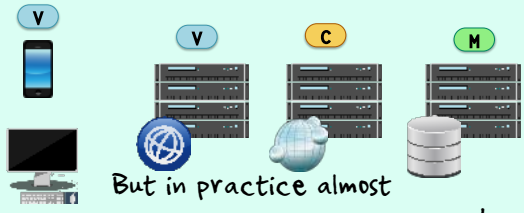
Transactions
Concurrency
Messaging
Scheduling

and so forth.

EJB

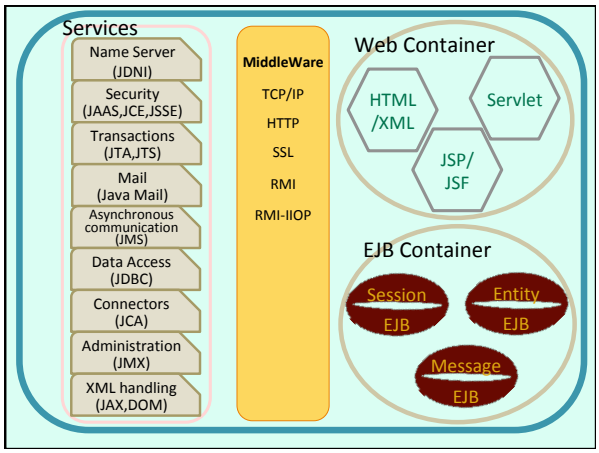
Different areas of responsibility for beans

Presentation	User interface	View
Processing	Logic	Controller
Resources	Data management	Model



But in practice almost everything can be anywhere!

What Java EE defines



What is the purpose of containers?

They simplify set-up

"managed beans"

```
@ManagedBean
@SessionScoped
```

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

@WebServlet(name="MyServlet", urlPatterns={"/test"})
public class MyServlet extends HttpServlet {
  @Override
  public void doGet(HttpServletRequest  request,
                    HttpServletResponse response)
              throws IOException, ServletException {
    response.setContentType("text/html");
    PrintWriter pw = response.getWriter();
```

Replaces .xml file

Web Container

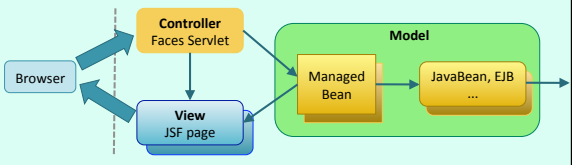
Java Server Faces
(JSF)

Framework relying on managed beans

"Faces Servlet" used as controller

XHTML templates (used to be JSP)

model = logic + data



Many fashions in Information Technology

Contrary to the street, many older fashions last and live along newer ones

Art by Nancy Duong

Many fashions in Information Technology

You always have to know several technologies