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Materials from Learning Patterns

Overview of the Spring Framework

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The Challenge of Enterprise Applications

- **Enterprise applications** have many complex requirements which makes them difficult to write
  - Many object types, with complex dependencies between them
  - Persistent data to be retrieved from and stored to a data store
  - Transactional requirements
  - Remote (distributed) access requirements
  - Web access requirements
- Java/Java EE (Enterprise Edition) has many capabilities to build these enterprise applications
  - Java SE defines basic building blocks like Java primitives and core libraries like Collections
  - Java EE defines a large suite of technologies for building enterprise applications
  - However, there are shortcomings to the Java solution

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Shortcomings of Java/Java EE

- Though rich in functionality, Java/Java EE has significant shortcomings when writing applications, some of which are:
- Basic Java has little support for **managing the lifecycle of your objects and the dependencies** between them
  - Since Java programs are composed of many collaborating objects, managing them requires significant effort
- The Java EE platform is quite large and requires a fairly heavyweight application server
  - Even if you are not using most of the capabilities of Java EE, the application server generally supports all of them
- Java EE has been difficult to use, and intrusive in its design
  - For example, using Enterprise JavaBeans (EJB) required you to write business classes that implemented a specific API
  - This is changing, and newer releases, such as EJB 3, are less intrusive

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What is Spring?

- Spring is a **lightweight framework for building enterprise applications**
  - It is "lightweight" in the sense that it is non-intrusive in your programming, and allows you to use only those parts you need
- It provides the following capabilities
  - A **Dependency Injection** (**Inversion of Control**) / container to manage objects and their dependencies
  - A **DAO** package that abstracts JDCB and simplifies its use
  - An **ORM** package providing integration with technologies such as Hibernate and JPA (Java Persistence API)
  - An **AOP** package for doing aspect-oriented programming
  - A **Web** package to integrate with Web technologies
  - An **MVC** package that provides a full Model-View-Controller based Web framework for Web applications

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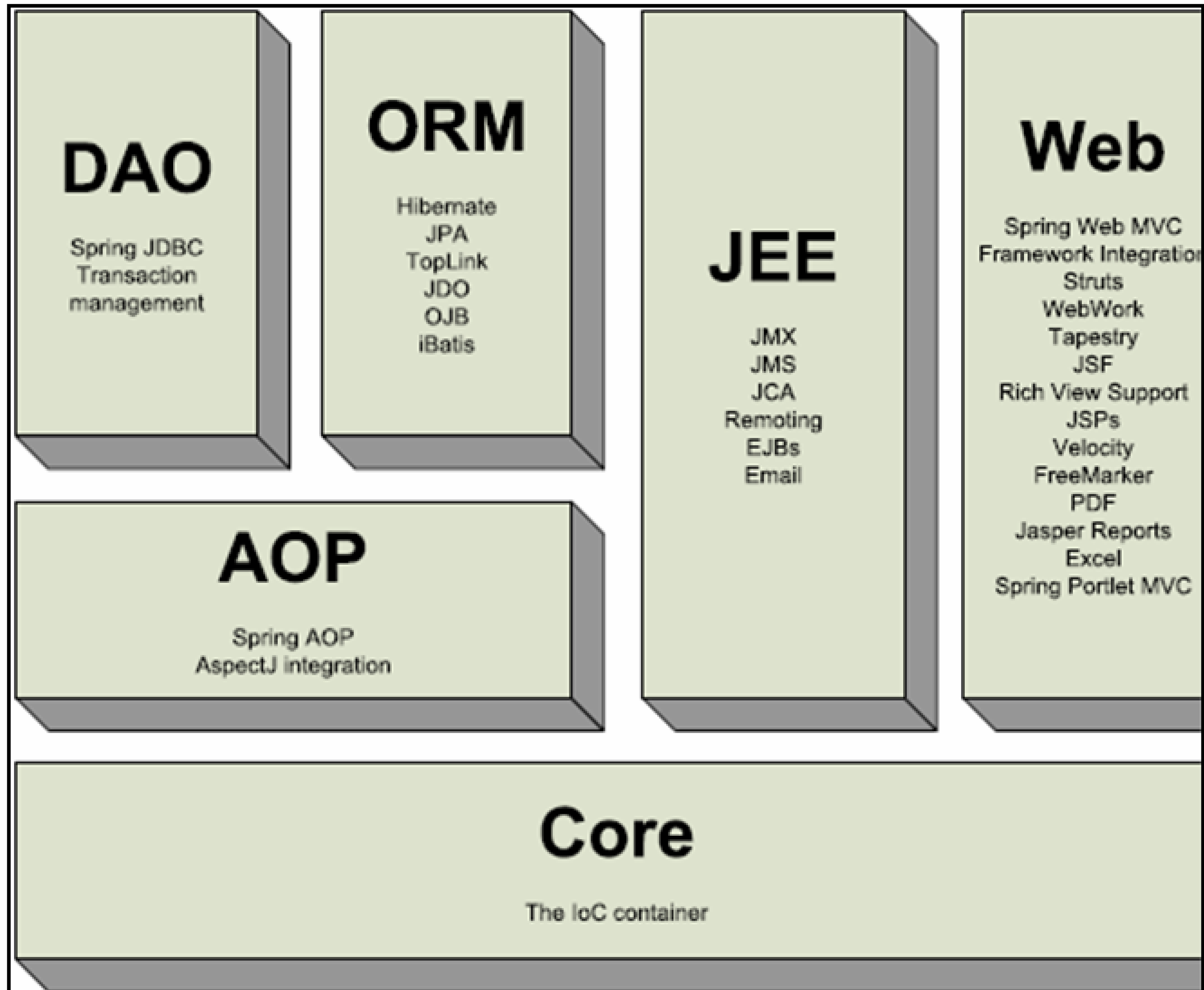
The Spring Components



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The Spring Distribution

- The Spring home page is **http://www.springframework.org**
  - Spring can be downloaded from this site
- The framework is distributed as a set of zip files
  - Generally speaking, each module is packaged in its own zip
- Spring also has a large number of dependencies on other technologies
  - For example, commons logging, log4j, and many others
- There is a **basic download** which has just the spring jars for all the modules, and a reference manual
  - There is a **download with dependencies** which has all the jars spring depends on, and additional documentation such as the javadocs for the API – it is much larger than the basic download

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Spring Introduction

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Dependency Injection

Managing Beans

- One of the core Spring capabilities is managing the objects in your application
- These managed objects are called **beans**
  - Spring borrowed this terminology from JavaBeans and EJB
  - A bean is just a **POJO** (Plain Old Java Object)
- Spring uses a **container**, the **Dependency Injection** (**DI**) or **Inversion of Control** (**IoC**) container, to manage objects
  - Configuration metadata is supplied to the container so it knows how to **instantiate, configure, and assemble** your beans
  - Generally, this configuration data is in a simple XML format
  - We will only cover the XML format in this course
- You use the configuration metadata to provide bean definitions and dependencies to the container
  - The container then does all the work of managing the beans

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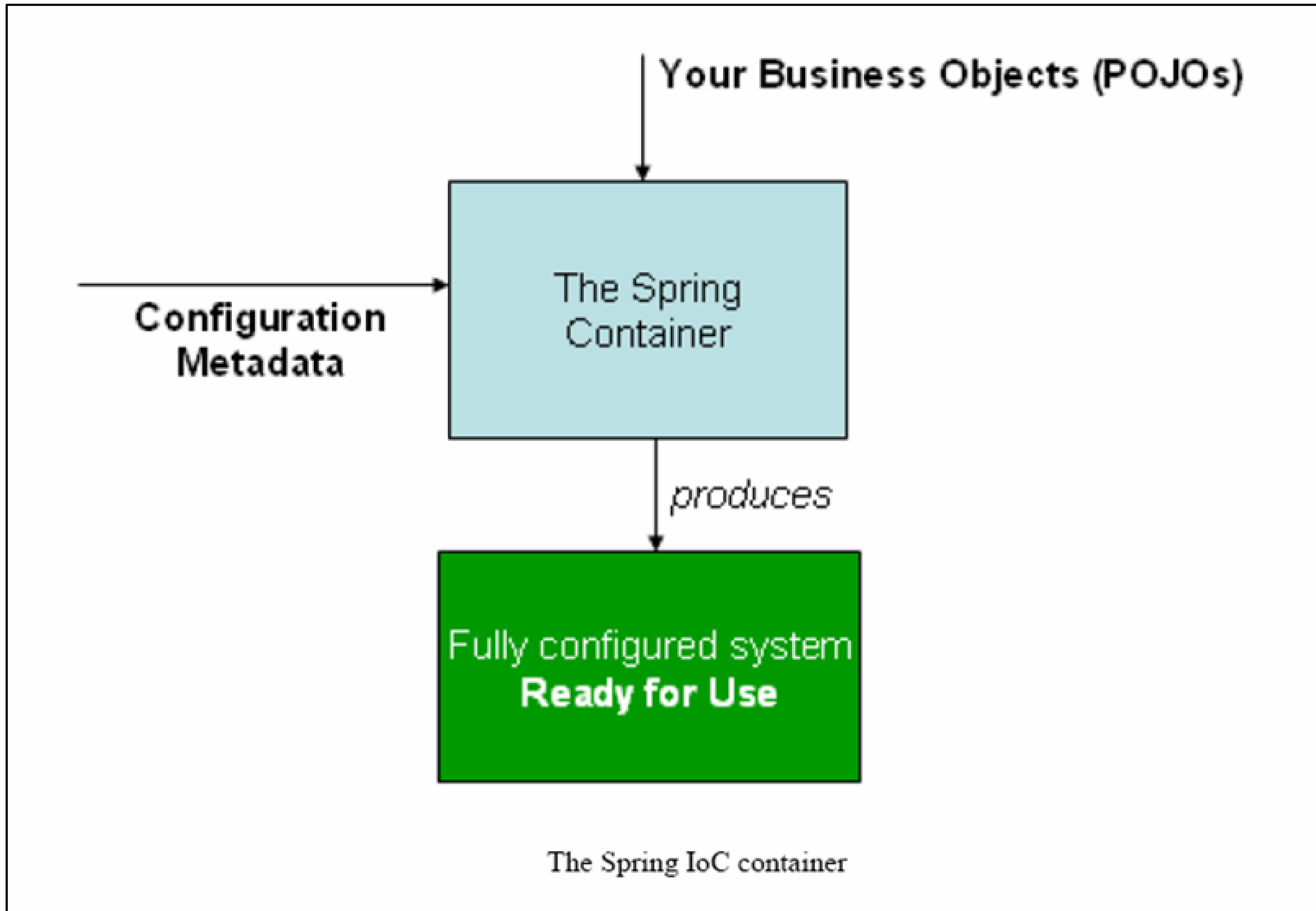
A Basic Spring Application



The Spring IoC container

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Some Bean Classes

- Let's say we had the following types defined
  - An interface, *Teacher*, defining the functionality we want to use
  - A concrete class, *JavaInstructor*, which implemented this interface, and provided the functionality
- Let's look at how to manage them using Spring

```
package com.javatunes.teach;

public interface Teacher {
	public void teach();
}
```

```
package com.javatunes.teach;

public class JavaInstructor implements Teacher {

	public void teach() {
		System.out.println("BeanFactories are way cool");
	}
}
```


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Configuration Metadata

- A **Spring configuration** contains bean definitions
  - They give Spring the information it needs about your beans
  - The bean definitions correspond to actual objects in your application that the Spring container will manage
  - Typically, there are many bean definitions, with dependencies between them
- Beans are configured using ***<bean>*** elements inside a top level ***<beans>*** element, as shown in the example file, *beans.xml*, below

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

<beans xmlns="http://www.springframework.org/schema/beans"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.springframework.org/schema/beans
          http://www.springframework.org/schema/beans/spring-beans-2.0.xsd">

        <bean id="springGuru" class="com.javatunes.teach.JavaInstructor"/>

</beans>
```


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Declaring Beans

- Each bean definition must specify a **package-qualified class name** for the bean
  - This is usually the actual implementation class of the bean (i.e. the class that the container will instantiate)
  - In our example, the ***`class`*** attribute, specifies the implementation as ***`com.javatunes.teach.JavaInstructor`***
  - This tells the container how to instantiate the bean
- In general, a **bean identifier** (or name) is also specified
  - In our example, we used the ***`id`*** attribute, to specify the identifier as ***`springGuru`***
  - This serves as a label for the bean – both in our code and in the configuration files
  - A bean can have multiple names (or aliases)
  - Generally, bean names use camelCase as the convention for bean names (e.g. springGuru)

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The Spring Container

- The Spring container is represented by the interface ***org.springframework.beans.factory.BeanFactory***
  - *BeanFactory* provides a configuration mechanism for managing objects of any nature
  - There are a number of implementations of *BeanFactory* that come with Spring
  - ***XMLBeanFactory***, the most common implementation, uses the XML configuration metadata we just saw for configuration
- The interface ***org.springframework.core.io.Resource*** is used to abstract access to resources (e.g. a config file)
  - Often used to access the XML data to configure a *BeanFactory*
  - ***FileSystemResource*** is a concrete implementation that allows you to easily access resources on the file system
- We'll show a simple example of using these, and cover them in more depth later

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Working With Spring

- At the very highest level, a typical scenario for using Spring includes the following main steps:
- **Create** (XML) **configuration data** for your beans
  - e.g. A file "*beans.xml*" containing the Spring configuration
  - This is the cookbook that tells Spring how to create objects
- **Access the configuration information** in your code using the **Spring resource classes**
  - e.g. Use ***`FileSystemResource`*** to access *beans.xml*
- **Create a bean factory** which gets its configuration data from the resource you created
  - This creates a bean factory tailored to your beans
- **Create beans** using the bean factory
  - e.g. using the ***`BeanFactory.getbean(String)`*** method

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Demo

- Demo Lab 1.2

A Simple Spring Example

- The following code, along with the *beans.xml* configuration file shown earlier, gives a simple example of using Spring
  - We first instantiate a ***FileSystemResource*** to read *beans.xml*
  - We next instantiate an ***XMLBeanFactory*** based on *beans.xml*
  - Lastly, we ask the factory to instantiate the ***springGuru*** bean

```
package com.javatunes.teach;

import org.springframework.core.io.Resource;
import org.springframework.core.io.FileSystemResource;
import org.springframework.beans.factory.BeanFactory;
import org.springframework.beans.factory.xml.XmlBeanFactory;

public class TeachMeSpring {
        public static void main(String[] args) {
                Resource res = new FileSystemResource("beans.xml");
                BeanFactory factory = new XmlBeanFactory(res);
                Teacher teacher =
(Teacher)factory.getBean("springGuru");
                teacher.teach();  // Use our bean
        }
}
```


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Why Bother?

- In this simple example, it looks like we've done quite a bit of work to instantiate a single instance of a single class
  - What is the benefit?
- The main benefit, in this simple example, is that we've **decoupled** our program code **from a dependency on the implementation** class `JavaInstructor`
  - Our code does not need to know the implementation class
  - All we know is that it provides the functionality we need (i.e. implements the `Teacher` interface)
  - We are free to configure the program with any implementation we want, and our code will not change
  - This seems like a simple thing, but it has a lot of benefits, especially when maintaining large systems
- We'll soon see additional capabilities that make Spring useful

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Dependencies and Dependency Injection

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Dependencies Between Objects

- Typically, different objects work together in an OO application
  - For example, Object A will use Object B to accomplish a goal
  - In straightforward applications, Object A will often just create an instance of Object B and use it
  - In that case, Object A **depends on** Object B
- Direct dependencies such as this can lead to several undesirable characteristics in large or complex applications
  - **Rigidity**: Hard to make changes because they affect too many other parts of the system
  - **Fragility**: Changes cause unexpected parts of the system to break
  - **Immobility**: It is hard to reuse functionality in another system because modules can't be disentangled from the application
- We'll show an example of a direct dependency, then show an alternative design approach that uses **Dependency Inversion**

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Example of a Direct Dependency

- In the example below*, *JavaInstructor* creates an instance of *SpringCourseBook* directly
  - *JavaInstructor* **depends** on the details in lower level modules
  - If we decide that Java instructors will get the latest information from the Spring Wiki, instead of from a *SpringCourseBook*, *JavaInstructor* code has to be changed

```
public class SpringCourseBook {
        public String getData() {
                return "Dependencies are not so cool";
        }
}
```

```
public class JavaInstructor implements Teacher {
        SpringCourseBook springBook = new SpringCourseBook();
        public void teach() {
                System.out.println(springBook.getData());
        }
}
```


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Dependency Inversion Principal

- High level or low level modules should not depend upon each other, **instead both should depend upon abstractions**
  - You develop abstractions, for example Java interfaces, that both high level and low level modules depend on
  - High level modules can be written in terms of the abstractions (the interfaces), and not directly on the low level modules
- Using this design strategy has a number of advantages:
  - Allows for the creation of **less coupled components** with a high degree of separation of responsibilities
  - Results in **greater flexibility** since particular implementations can be swapped in and out without affecting other modules
  - Facilitates **reuse** of components since they are less coupled to other parts of an application

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Example of Dependency Inversion

- Both *JavaInstructor* and *SpringCourseBook* depend on ***InfoSource***

```
public interface InfoSource {
        public String getData();
}
```

```
public class SpringCourseBook implements InfoSource {
        public String getData() {
                return "Dependencies are not so cool";
        }
}
```

```
public class JavaInstructor implements Teacher {
        private InfoSource info;
        public void setInfo (InfoSource infoIn) {
      info=infoIn;
  }
        public void teach() {
                System.out.println(info.getData());
        }
}
```


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Example of Dependency Inversion

- In the example code below, *JavaInstructor* is initialized with a specific implementation of *InfoSource* (an instance of *SpringCourseBook*)
  - But *JavaInstructor* only sees this as the *InfoSource* type
  - It would make no difference to *JavaInstructor* if we initialized it with some other type that implemented *InfoSource* – for example an *EJBCourseBook*
  - We've decoupled the modules, and made them more flexible and easier to use, reuse, and maintain

```
public class TeachMeSpring {

  public static void main(String[] args) {
      SpringCourseBook springBook = new SpringCourseBook();
          JavaInstructor myInstructor = new JavaInstructor();
      myInstructor.setInfo(springBook);
      myInstructor.teach();
  }
}
```


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Dependency Injection (DI) in Spring

- Using **Dependency Injection**, Spring allows you to abstract dependencies between modules even more
  - The Spring container can **inject** dependencies into a bean and initialize them when it creates the bean
  - It can inject dependencies via constructors, properties in the bean, or arguments to a factory method
- The dependencies are defined in the Spring configuration file
  - The Spring container uses these dependency definitions to initialize the bean
  - You don't need to explicitly initialize dependencies in your code
- Your bean classes are still normal POJO classes
  - The Spring container only requires that you have the appropriate methods needed to initialize the dependencies (e.g. a setter)
  - There is nothing else special about the bean classes

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Dependency Injection Configuration

- The Spring configuration file below uses DI
  - It declares two beans: *springBook* and *springGuru* that use the class definitions we've just seen
  - The **<property name="info" ref="springBook"/>** element tells the container to **initialize** the *info* property of *springGuru* with an instance of *SpringCourseBook*
  - It uses **setter injection** - calling *JavaInstructor.setInfo()*
  - You don't need to write **any** code for the injection to happen

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

<beans … > <!-- Namespace declarations omitted -->

        <bean id="springBook" class="com.javatunes.teach.SpringCourseBook"/>

        <bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
           <property name="info" ref="springBook"/>
        </bean>

</beans>
```


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Dependency Injection Example

- The example below shows how to use our beans with Spring
  - Notice that all our code is written completely in terms of the **abstract *Teacher* interface**
  - Note also that our code, including the *JavaInstructor* class, **is totally decoupled** from the concrete class *SpringCourseBook*
  - The *JavaInstructor* instance has its *info* property initialized with a *SpringCourseBook* instance by the Spring container
  - The dependency is injected by the container transparently

```
// imports not shown
public class TeachMeSpring {

        public static void main(String[] args) {
                Resource res = new FileSystemResource("beans.xml");
                BeanFactory factory = new XmlBeanFactory(res);
                Teacher teacher =
(Teacher)factory.getBean("springGuru");
                teacher.teach();
        }
}
```


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Advantages of Dependency Injection

- DI **reduces the coupling** between modules **in your code**
  - Coupling is basically a measure of the dependencies
- We've seen this reduction in two ways in our example:
  - `JavaInstructor` is not coupled to `SpringCourseBook`
  - `TeachMeSpring` is not coupled to `JavaInstructor` or `SpringCourseBook`
- The dependencies are still there but **not in the code**
  - The dependency is moved to the spring configuration
  - They're injected into beans without your needing to write code
  - This is also commonly referred to as **wiring** beans together
- This leads to **more flexible** code that is **easier to maintain**
  - At a cost – using Spring, and maintaining the spring configuration
  - This is not a trivial cost, but for larger projects the initial cost of adopting spring can be well worth it

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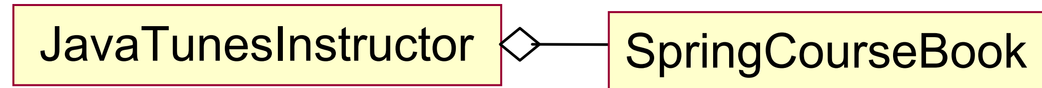
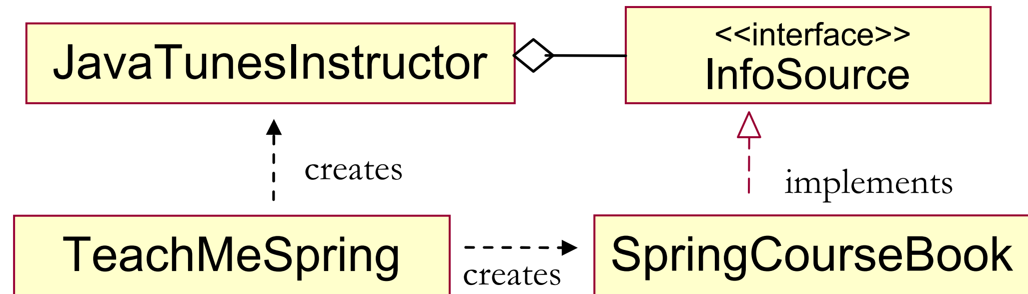
Dependency Injection Reduces Coupling

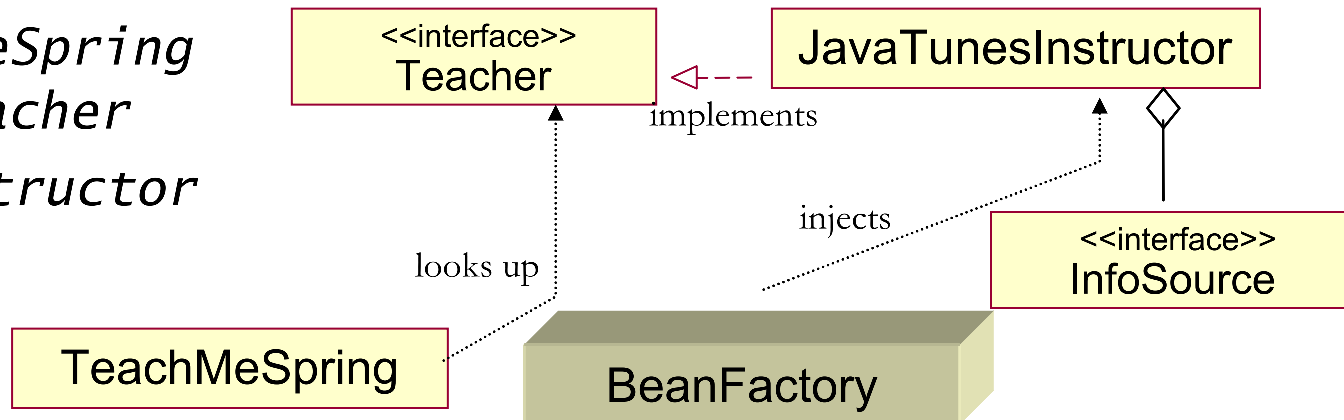
- The simplest case, *JavaTunesInstructor* coupled to *SpringCourseBook*



- *JavaTunesInstructor* coupled to *InfoSource* only
  - *TeachMeSpring* coupled to *JavaTunesInstructor* and *SpringCourseBook*



- Using DI - *TeachMeSpring* only coupled to *Teacher*
  - *JavaTunesInstructor* only coupled to *InfoSource*



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Demo

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Session 7: Spring and the Web

Integration with Java EE

Spring MVC Basics

Forms and View Resolvers

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Integration with Java EE

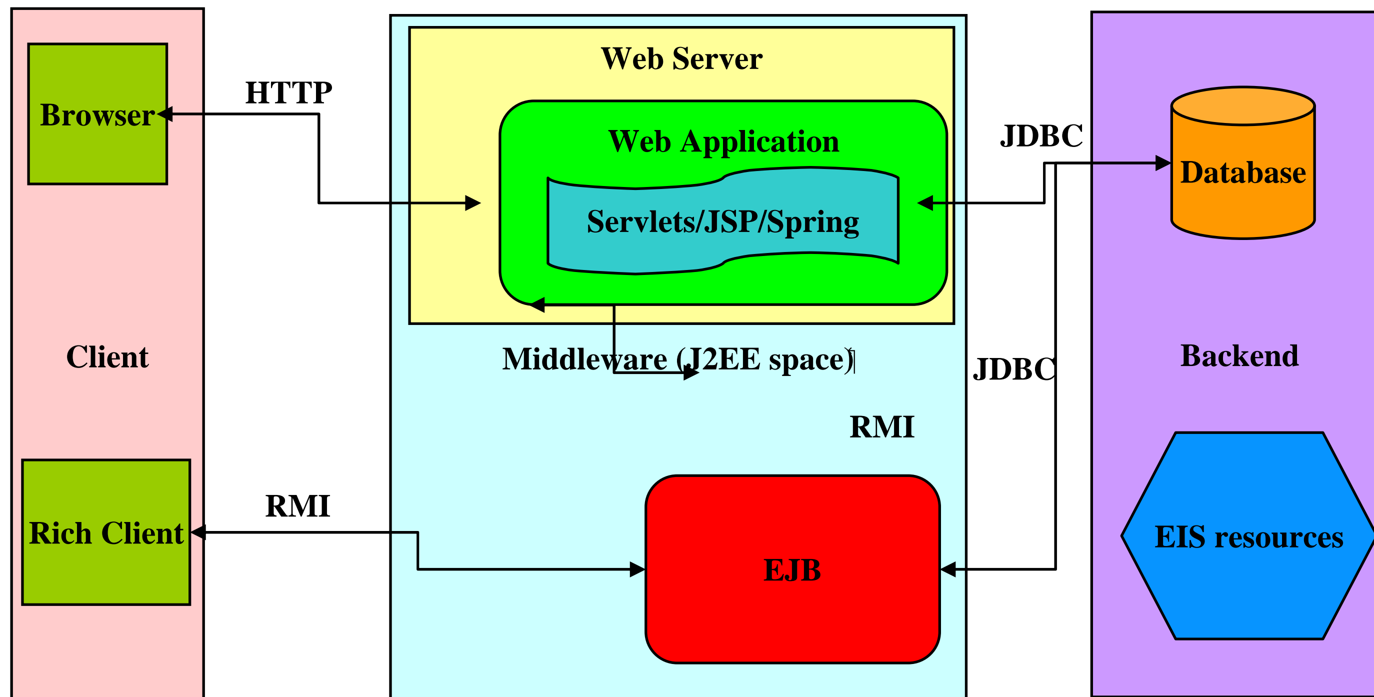
Integration with Java EE

Spring MVC Basics

Forms and View Resolvers

Java EE Web Applications

- Let's start with a brief review of **Web applications** - A standard structure defined in Java EE for organizing applications for the web
  - A collection of **Servlets**, **JavaServer Pages** (JSP), & other files
  - Most frequently collected inside of a Web Archive (WAR) file
    - The standard Java EE way to package up web applications



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Overview

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ApplicationContext and Web Apps

- The simplest way to use Spring from within a Web application is to load an application context, and make it available to your Web application
  - Spring has support for doing this very easily
- The ***ContextLoaderListener*** class can be used to load an application context, which can be accessed in your Web apps
  - This listener automatically loads the Spring application context when the web app is deployed
  - It uses a *<context-param>* element in *web.xml* to define the locations of the Spring configuration files
  - To retrieve the application context, use the static method: ***WebApplicationContextUtils.getWebApplicationContext()*** in your web application code
- The following slides shows examples of doing this

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Configuring ContextLoaderListener

- In the *web.xml* file below, we specify two configuration files, *beans.xml* and *javaTunesSearch.xml* with `<context-param>`
  - We then configure the `ContextLoaderListener`

```
<web-app ... >

<context-param>  <!--  config files for ContextLoaderListener -->
  <param-name>contextConfigLocation</param-name>
    <param-value>
      /WEB-INF/beans.xml
      /WEB-INF/javaTunesSearch.xml
    </param-value>
</context-param>

<listener>  <!-- Load root application context at startup -->
  <listener-class>
    org.springframework.web.context.ContextLoaderListener
  </listener-class>
</listener>

</web-app>
```


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Using the Application Context

- In the servlet definition below, we retrieve the application context using *WebApplicationContextUtils*
  - The context was loaded by the *ContextLoaderListener*
  - We then look up a bean which we can use in our application - just as we did in our earlier non-Web labs
  - The configuration files and *Catalog* beans are from the small non-DB JavaTunes system we used in earlier labs
- You can see - it's very easy to use Spring with Web apps

```
import org.springframework.web.context.support.WebApplicationContextUtils;
import org.springframework.web.context.WebApplicationContext;

public class SearchServlet extends HttpServlet {
  public void doPost(HttpServletRequest request,
      HttpServletResponse response) throws ServletException, IOException {

  WebApplicationContext ctx =
  WebApplicationContextUtils.getRequiredWebApplicationContext(
                                                      getServletContext());
  Catalog cat = (Catalog)ctx.getBean("javaTunesCatalog");
}
```


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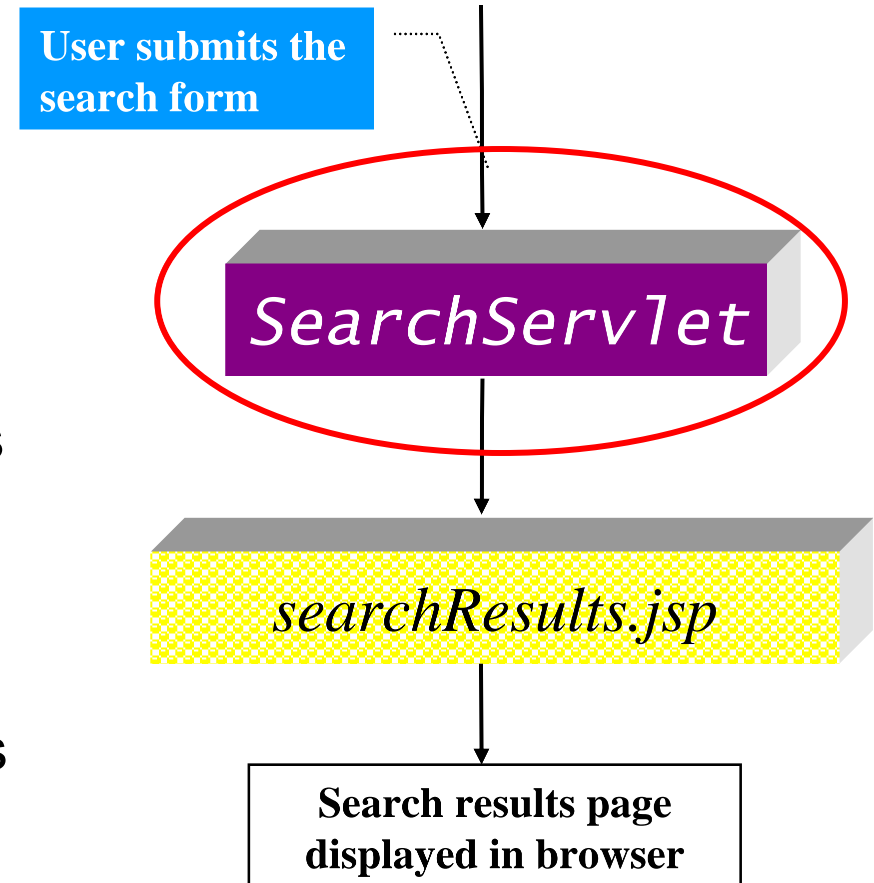
The JavaTunes Online Store

Lab

- The Web application we are creating is a small piece of the JavaTunes online music store
  - It displays a search form
  - The search form sends a request to a servlet that does a search and forwards to a results page that displays the results
  - We are working with the servlet processing the search request
  - The flow for JavaTunes appears at right
- The first thing we'll do is set up the environment and the Tomcat Web server



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Spring MVC Architecture

- Spring uses what is called a **front controller** architecture
  - The front controller is a central servlet that receives all requests, and dispatches them to other components (controllers) to handle
  - It is also completely integrated with the Spring container, and allows you to use all its capabilities
- The main components of a Spring MVC application are:
  - ***DispatcherServlet***: The front controller servlet
  - ***Command Controllers***: Contain logic to handle specific user requests, generate the data needed for a response, and return a response to the appropriate view to handle
  - **Handler Mappings**: Map URLs to resources (controllers)
  - **Views**: Generate HTML Output (JSP, other templates)
  - **View Resolvers**: Process response from controllers and direct the application to the appropriate view (e.g. JSP page)
  - **Model**: Spring managed beans

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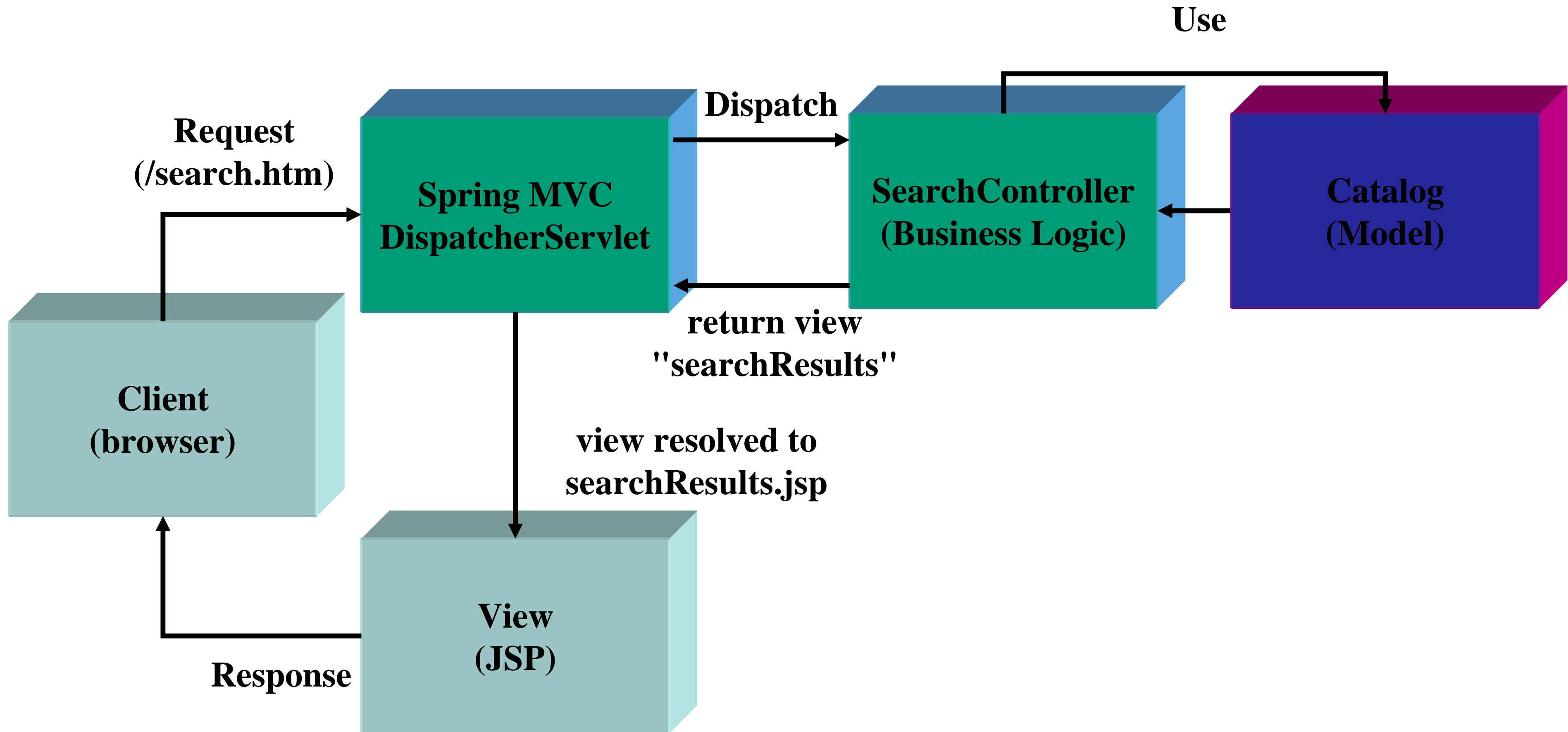
Simple Search App Model - Spring MVC



Command Controllers

- **Command controllers** are one of the key components of Spring MVC
  - The dispatcher servlet forwards requests to command controllers
  - The command controllers execute business logic (possibly using data from the request) and then return a logical view name to the dispatcher servlet
  - The dispatcher servlet resolves the view to an actual destination (e.g. JSP) which is used to render the view
- We'll look at the simplest command controller first:

```
org.springframework.web.servlet.mvc.AbstractController
```

  - Subclasses use this class by defining the following method to handle the request:

```
ModelAndView handleRequestInternal(
                  HttpServletRequest request,
                  HttpServletResponse response)
```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Command Controllers

- The *handleRequestInternal* method is called by Spring to handle the request
  - This method should process the request and return an instance of *org.springframework.web.servlet.**ModelAndView***
  - *ModelAndView* is a simple wrapper class that allows a controller to return a model (holding data for the response) and a view (the resource to use to render the response) in a single value
  - This is made easy to do via the *ModelAndView* constructors, for example, this easy to use one :

```
ModelAndView(String viewName,
             String modelName, Object modelObject)
```

  - The dispatcher servlet looks at the *ModelAndView* instance returned by *handleRequestInternal*
  - It uses the model data to set up the model, and the view name to forward to the resource generating the response

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Very Simple Command Controller

- In the (very simplified) controller below, *SearchController* defines *handleRequestInternal* to:
  - Extract a parameter off the request (the keyword to search for)
  - Get a catalog bean from the spring container
  - Create a *ModelAndView* instance that declares the view as *jsp/searchResults.jsp* *, and includes a model object named *results* that contains the result of the catalog search

```
// imports/package statements not shown
public class SearchController extends AbstractController {

  protected ModelAndView handleRequestInternal(
         HttpServletRequest request, HttpServletResponse response)
         throws Exception {
    String keyword = request.getParameter("keyword");
    WebApplicationContext ctx = getWebApplicationContext();
    Catalog cat = (Catalog)ctx.getBean("javaTunesCatalog");
    return new ModelAndView("jsp/searchResults.jsp",
                              "results", cat.findByKeyword(keyword));
  }
}
```


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Configuring the Command Controller

- We still need to tell the dispatcher servlet that the previous controller is to be used for handling a request
  - By default, the controller uses a strategy that maps controllers to URLs based on the controllers bean name in the Spring configuration
  - If we want the `SearchController` to handle all requests of the form ***/search.htm***, then we could do so by configuring the bean below in *javatunes-servlet.xml* to have the name `/search.htm`
  - If we had a form like that at bottom, when it was submitted, ***`SearchController.handleRequestInternal()`*** would be called by the dispatcher servlet to handle the request
  - We've now taken the first step in learning Spring MVC

```
<bean name="/search.htm"
           class="com.javatunes.web.SearchController"/>
```

```
<form method='post' action='/javatunes/search.htm'>
  <input size='20' type='text' name='keyword'/><br/>
  <input type='submit' name='Submit' value='Search'/>
</form>
```


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A JavaBean Command Class

- Spring MVC command classes are used to hold form data and possibly model data *
  - Below we define a command class to hold our search keyword, and the results collection
  - As you can see, there is nothing special about it - it just has two properties keyword (a *String*) and results (a *Collection*)

```
package com.javatunes.web;
import java.util.Collection;

public class SearchCommand {
  private String keyword;
  public String getKeyword() {return keyword;}
  public void setKeyword(String keyword) {this.keyword = keyword;}

  private Collection results;
  public Collection getResults() {return results;}
  public void setResults(Collection results) {this.results=results; }
}
```


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HandlerMappings

- The handler mapping strategy defines how the *DispatcherServlet* will map a URL to a controller (handler)
  - Until now, we've been using the default handler mapping strategy of *BeanNameUrlHandlerMapping*
  - We can configure other strategies, but configuring the associated bean in *javatunes-servlet.xml*
  - For instance, we can use a *SimpleUrlHandlerMapping* to do the same thing as shown below (e.g. if our *SearchController* bean was named *searchContoller*, not *search.htm*)

```
<bean class=
"org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
  <property name="mappings">
    <value>
      /**/search.htm=searchController
      /**/checkout.htm=checkoutController
    </value>
  </property>
</bean>
```


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Lesson Summary

- The Spring container can be integrated with normal Web applications using Springs ***`ContextLoaderListener`***
  – This listener automatically loads Spring's root application context and makes it available to Web applications
- **MVC** is a standard pattern for creating applications with user interface requirements
  – It organizes functionality into three areas
  – The **model** represents the business domain; the **view** presents the data to users; the **controller** is an intermediary between the model and the view
- Spring uses Spring beans as its model, command controllers as its controllers and normal views (such as JSP) to generate output
  – It also uses the *`DispatcherServlet`* as a front controller to dispatch incoming requests to Spring MVC

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Lesson Summary

- Spring's ***DispatcherServlet*** is configured in *web.xml* like any other servlet
  - The only difference is that its url-mapping uses patterns, such as *.htm, and is applicable to a whole category or requests
- **Command controllers** handle incoming requests
  - They use data from the request, execute business logic, set up the model with data needed by the view, and indicate what resource should be used to render the view
- **Form controllers** are sophisticated command controllers that process form requests
  - They can extract method parameters into JavaBeans (Spring command classes), and have convenient methods to do normal form processing

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Resources

- The **Spring documentation**
  - The reference manual, API docs, and samples
  - They're all available in the full Spring download
- **http://www.springframework.org**
  - The home of the Spring Framework
- **Spring in Action** - Second Edition by Craig Walls
  - An excellent book, full of useful examples and explanations
  - Its big - 700 pages +

- There are many more - these are a great place to start

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