Spring 3.x and Spring MVC/REST

Workshop Overview

- This is an in-depth course covering the use of the Spring 3 framework to build enterprise applications using Java

- The course, at a high level, covers the following areas of Spring technology
  - **Core features of Spring**
  - **Data Access Features**
  - **Transaction Support**
  - **Web Application Support including Spring MVC**
  - **Spring Security Overview**
  - **Building RESTful Services with Spring**
  - **Aspect Oriented Programming (AOP)**

Workshop Objectives

- To understand the Spring framework and use its capabilities, including:
- **Spring Core**: Dependency Injection (DI) and lifecycle management of application objects
  - Using the Spring API and Spring configuration to write Spring programs
  - Configuration covers both XML and annotations
- **Data Access**: Data access via Spring's data support
  - DataSource support
  - Hibernate and JPA-based DAOs
- **Transactions**: Control transactions declaratively with Spring
  - Use the Spring annotations and XML configuration elements
- **Web**: Integrate Spring with Web applications and understand the basic structure and use of Spring MVC
- **Security**: Understand the architecture and basic use of Spring Security
- **REST**: Understand REST principals, and build REST services with Spring
- **AOP**: Use Spring's AOP (Aspect Oriented Programming) capabilities to inject crosscutting concerns

Workshop Agenda

Module 1: **Introduction to Spring**

Module 2: **More About Bean Properties**

Module 3: **The Spring Container and API**

Module 4: **Database Access With Spring**

Module 5: **Transactions**

Module 6: **Web Applications with Spring MVC**

Module 7: **Spring Security Overview**

Module 8: **RESTful Services with Spring**

Module 9: **Aspect Oriented Programming (AOP)**

Typographic Conventions

- Code in the text uses a fixed-width code font, e.g.:

  JavaTeacher teacher = new JavaTeacher()

  – Code fragments use the same font, e.g. *teacher.teach()*

  – We **bold/color** text for emphasis

  – Filenames are in italics, e.g. *JavaInstructor.java*

  – We sometimes denote more info in the notes with a **star ***

  – Longer code examples appear in a separate code box - e.g.

```
package com.javatunes.teach;
public class JavaInstructor implements Teacher {
   public void teach() {
      System.out.println("BeanFactories are way cool");
   }
}
```

Labs

- The workshop has numerous hands-on lab exercises, structured as a series of brief labs
  - Many follow a common fictional case study called **JavaTunes**
    - An online music store
  - The labs are in the course book, and include detailed instructions
- Setup zip files are provided with skeleton code for the labs
  - Students add code focused on the topic they're working with
  - There is a solution zip with completed lab code
- Lab slides have an icon like in the upper right corner of this slide
  - The end of a lab is marked with a stop like this one:

Release Level

Lab

- This manual has been tested with, and contains instructions for, running the labs using the following platforms:
  - **Spring 3.2** (tested with 3.2.2)
    - The material is compatible with Spring 3.1 (see notes)
  - **Spring Security 3.1** (tested with 3.1.3)
  - **Java 6 or 7**
  - **Eclipse Java EE Edition** (any fairly recent edition - tested with 4.2/Juno)
  - **Tomcat 7.0.x** for the Spring/Web material
- Recent similar versions of the software will likely work except for potentially small configuration changes

Module 1: Introduction to Spring

Overview

Spring Introduction

Dependency Injection

Lesson Objectives

- Understand why we need the Spring Framework
- Understand what Spring is, and how it simplifies enterprise application development with Java
- Learn how Spring uses configuration information and Dependency Injection (DI)
  - To manage the beans (objects) in an application
  - To manage bean dependencies

Overview

Overview

Spring Introduction

Dependency Injection

The Challenge of Enterprise Applications

- **Enterprise applications** have many complex requirements
  - Many types, with complex dependencies
  - Persistent data retrieved from / stored to a data store
  - Transactional requirements
  - Remote (distributed) access requirements
  - Web access requirements
- Java / Java EE (Enterprise Edition) provides many capabilities to build enterprise applications
  - Java SE: Basic building blocks like Java primitives and core libraries like Collections
  - Java EE: Enterprise technologies like EJB, Servlets/JSP, JDBC
  - However, there are shortcomings to the standard Java solution

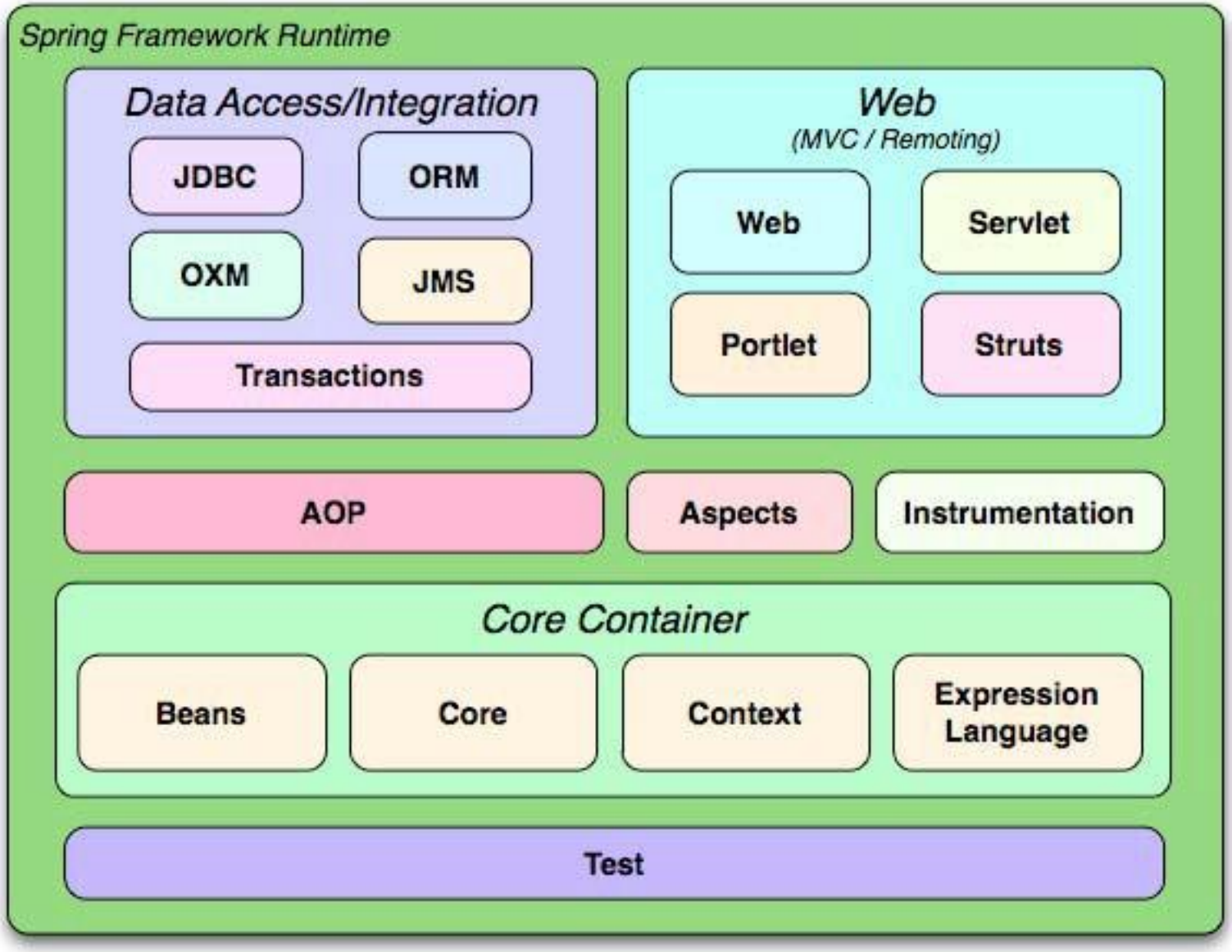
Shortcomings of Java/Java EE

- Java/Java EE can have significant shortcomings, including:
- Little support for **managing the lifecycle of your objects and the dependencies** between them
  - Managing large numbers of objects requires significant effort
- Java EE is large and requires a fairly heavyweight app server
  - Even if using only a subset of capabilities (e.g. Web apps and transactions), the application server generally supports all of them
- Java EE has been difficult to use, and intrusive in its design
  - Not as big an issue now
  - Newer releases, such as EJB 3, are less intrusive

What is Spring?

- **Lightweight framework to build enterprise applications**
  - "Lightweight" meaning non-intrusive in your programming, and allowing you to use only what you need
- It includes the following capabilities
  - A **Dependency Injection** (**Inversion of Control**) container to manage objects and their dependencies
  - A **DAO** package that abstracts JDBC 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
  - A **security** framework for authentication and authorization

The Spring Modules

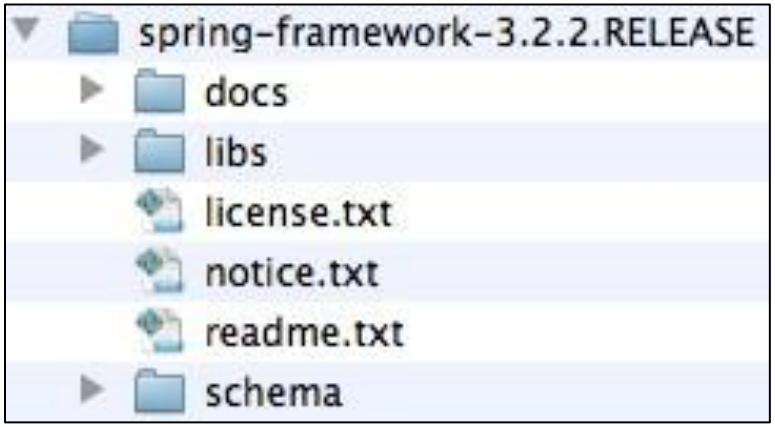


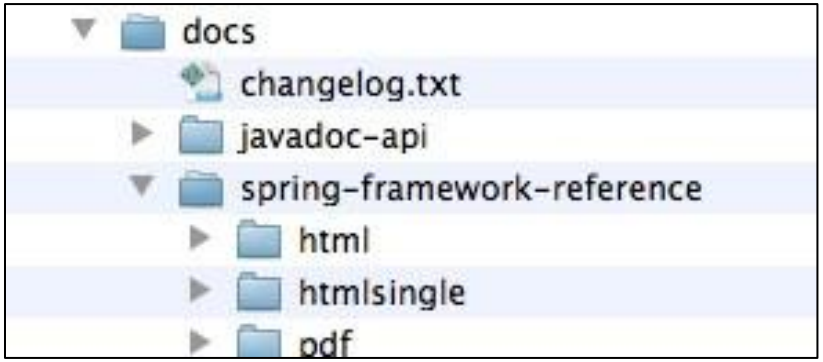
The Spring Distribution

- Spring home page: **http://www.springsource.org/**
  - Can download Spring from this site
- Framework distributed as a set of jar files
  - Each module packaged in its own archive
    - e.g. *spring-beans-3.2.2.RELEASE.jar*
  - The core Spring download has the all the spring module jars, a reference manual, and API docs
- Spring has many dependencies on external technologies
  - e.g. - Apache commons logging, jars for AOP, and more
  - **Not included** in the core Spring download
- **Maven** is commonly used to manage Spring's dependencies
  - Project management tool - can automatically download needed dependencies
  - Maven covered more later

The Spring Distribution

- Below left, is the folder structure of the core distribution
  - Below right, are some of the jars in the libs folder
    - Note that there are source and javadoc jars also
  - At bottom is the docs folder





Lab 1.1 – Setting Up the Environment

Lab 1.1 – Set up the Environment

Lab

- **Overview**: In this lab, we will become familiar with the lab structure, set up our working environment, and test it to make sure it is running well
  - The end goal is to compile and run an application that requires the Spring libraries
- **Objectives**:
  - Become familiar with the lab structure
  - Set up our environment
  - Write and run a simple application that requires Spring
- **Builds on previous labs**: None
- **Approximate Time**: 45-60 minutes

Information Content and Task Content

Lab

- Within a lab, information only content is presented in the normal way – the same as in the student manual pages
  - Like these bullets at the top of the page
- Tasks that the student needs to perform are in a box with a slightly different look – to help you identify them
- An example appears below

Tasks to Perform

- Look at these instructions, and notice the different look of the box as compared to that above
  - Make a note of how it looks, as future labs will use this format
- OK – Now **get out your setup files**; we're ready to start working

Setup Environment

Lab

Tasks to Perform

- Make sure Java is installed
  - Usually in a folder (for Java 7) like *C:\Program Files\Java\jdk1.7.0_nn*
  - If not, then install it - it can be downloaded from:

  http://www.oracle.com/technetwork/java/javase/downloads/index.html

- Check that Spring 3.2 is installed – likely in a folder like:

  C:\spring-framework-3.2.2.RELEASE
  - It is not required - you can use it for reviewing the documentation
  - We supply the needed jars in the setup
  - It can be downloaded from **http://www.springframework.org/download**

Extract the Lab Setup Zip File

Lab

- To set up the labs, you'll need the course setup zip file *
  - e.g.:

  LabSetup_Spring3x_Tomcat-Eclipse_ .zip

- Our base working directory for this course will be ***C:\StudentWork\Spring***
  - This directory will be created when we extract the Setup zip
  - It includes a directory structure and files (e.g., Java files, XML files, other files) that will be needed in the labs
  - All instructions assume that this zip file is extracted to C:\. **If you choose a different directory, please adjust accordingly**

Tasks to Perform

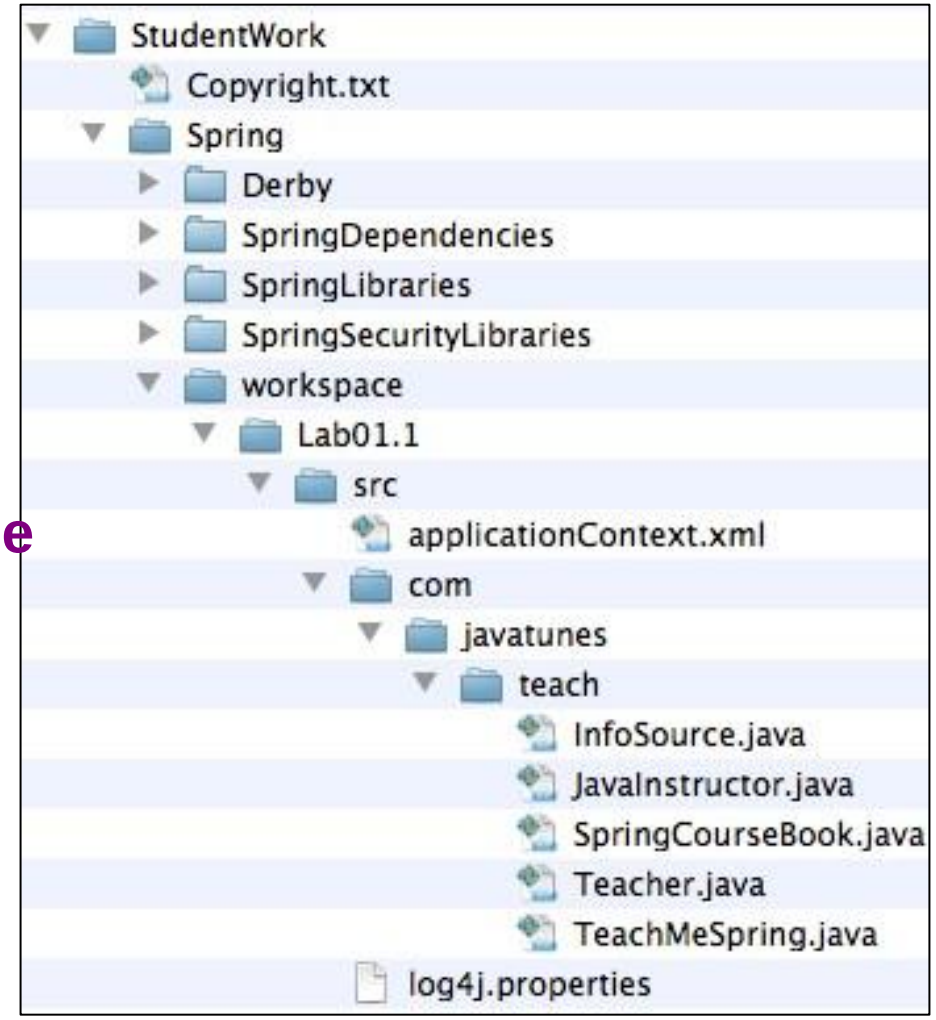
- Unzip the lab setup file to ***C:***
  - This will create the directory structure, described in the next slide, containing files that you will need for doing the labs

Lab Directory Structure

Lab

- **StudentWork\Spring** contains
  - **Derby**: Database files
  - **SpringDependencies:** jars for Spring dependencies
  - **SpringLibraries:** Spring jars
  - **workspace**: Eclipse workspace

- **StudentWork\Spring\workspace** will contain the following folders:
  - **common**: shared files (if any)
  - **LabNN** : Folder for Lab NN
  - **LabNN/src** : Java source
  - **LabNN/bin/** : compiled code (Eclipse's standard location)



General Instructions

Lab

- Root lab folder for this lab is:

  C:\StudentWork\Spring\workspace\Lab01.1

  –Already exists in your workspace

  –You'll create a new Eclipse project in this folder, which contains starter files that we provide

  –In general, all the lab files are under this project/folder and instructions are given relative to this project/folder

- Detailed instructions are included in this lab

  –Including complete **Eclipse** instructions, as well as details about the lab requirements

- Subsequent labs are similar to this lab, so include fewer detailed instructions

The Eclipse Development Environment

Lab

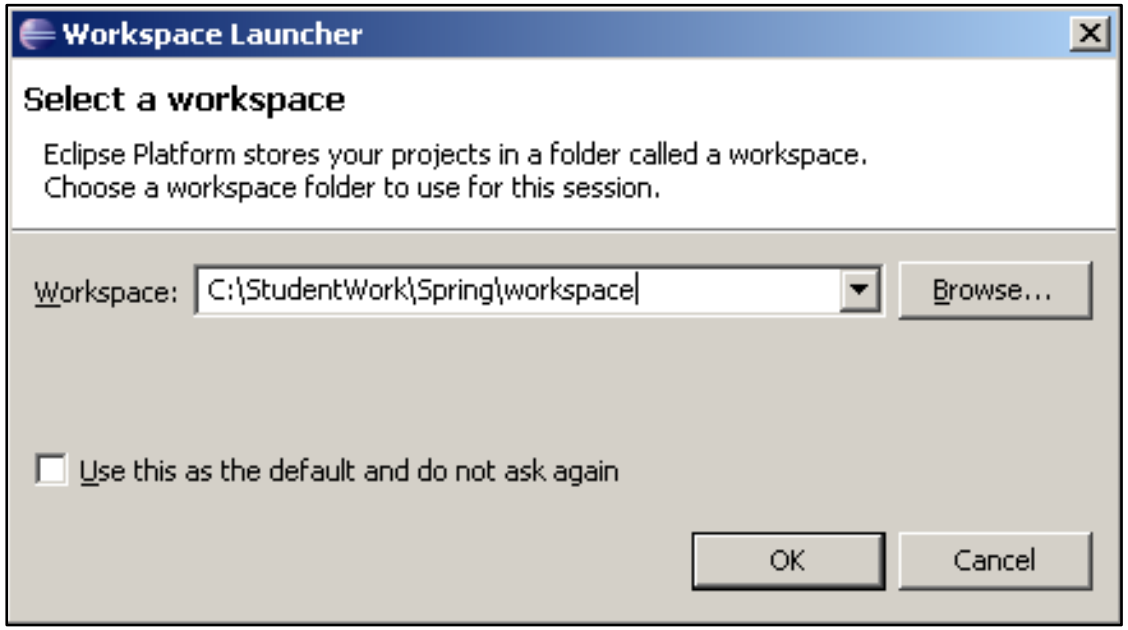
- **Eclipse**: Open source platform for building integrated development environments (IDEs)
  - Used mainly for Java development
  - Can be flexibly extended via plugins to add capabilities
  - **http://www.eclipse.org** is the main website
- This lab includes detailed instructions on using Eclipse
  - Starting it, creating and configuring projects, etc.
- Other labs include fewer Eclipse details - they may just say build/run as previously
  - Just use the same procedures to build/run as in this lab
  - Refer back to these lab instructions as needed

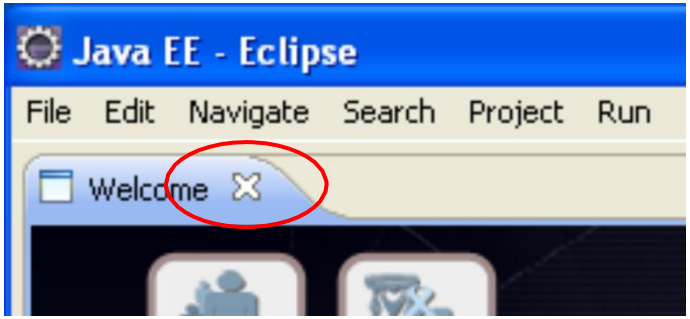
Launch Eclipse

Lab

Tasks to Perform

- Launch eclipse: Go to **c:\eclipse** and run **eclipse.exe**
  - A dialog box appears prompting for workbench location (below left)
  - Set the workbench location to **C:\StudentWork\Spring\workspace**
  - If a different default Workbench location is set, change it
  - Click **OK**
  - **Close** the Welcome screen: Click the X on its tab (below right)



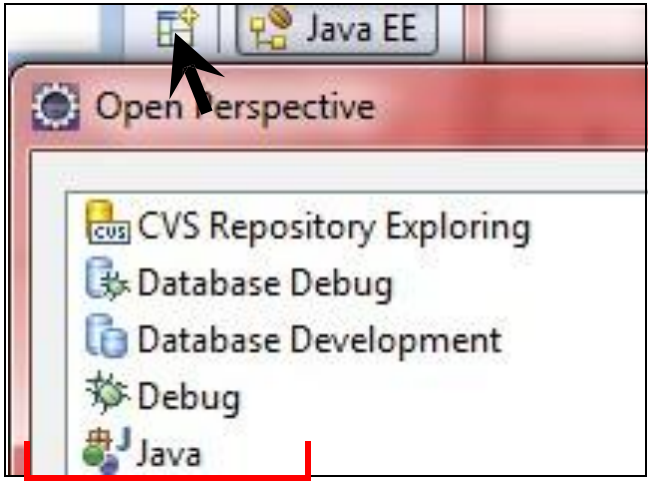


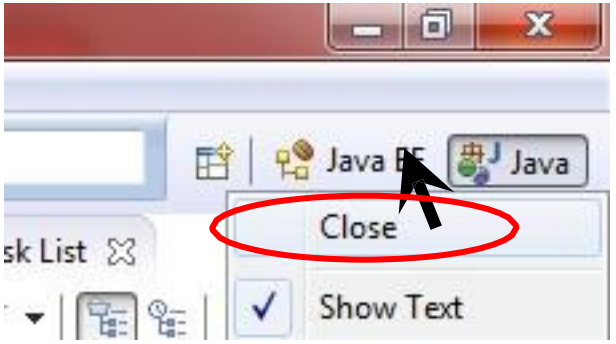
Workbench and Java Perspective

Lab

Tasks to Perform

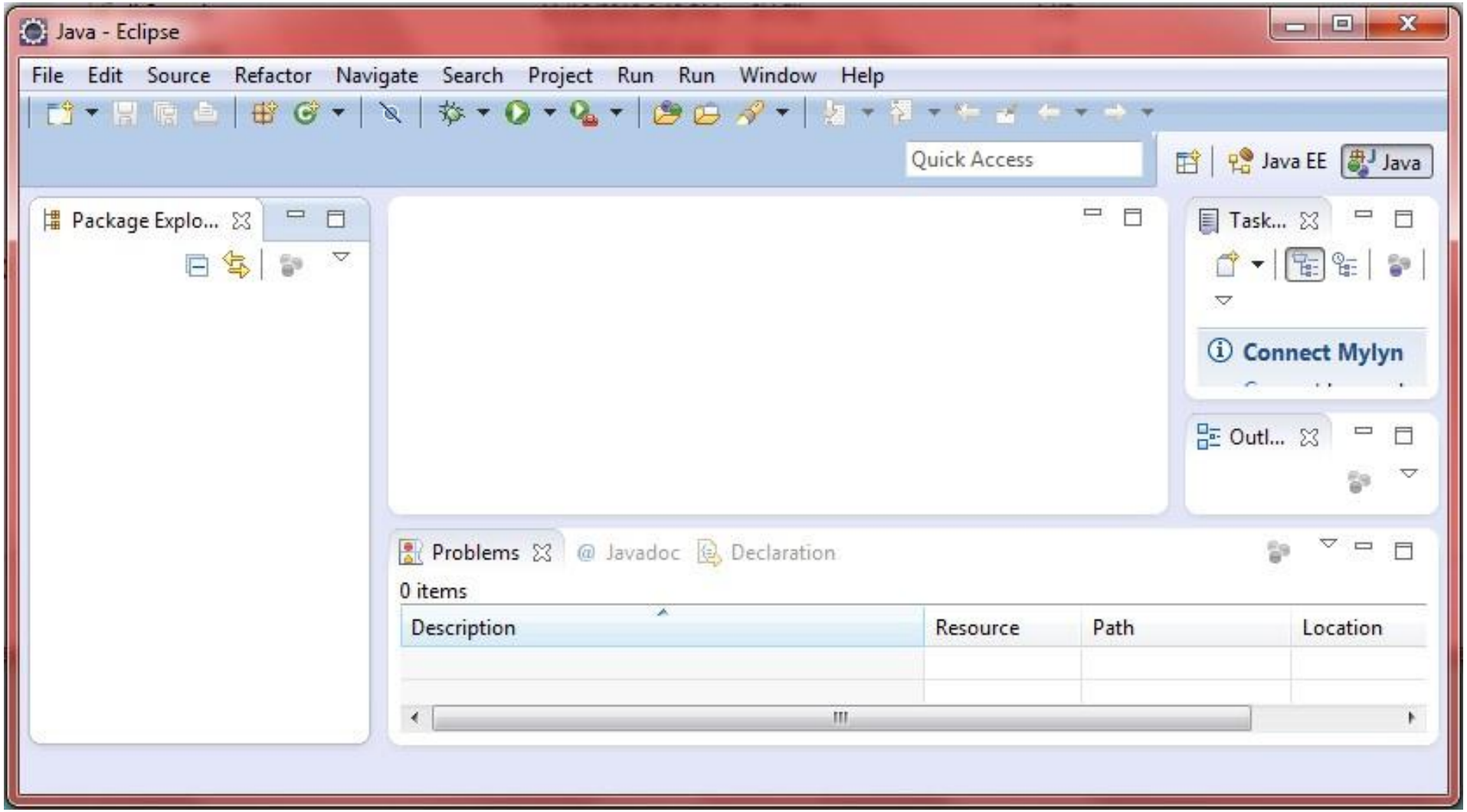
- You should be in a Java EE perspective *
- **Open a Java Perspective: Click the Perspective icon** at the top right of the Workbench, and select Java (see below left)
  - Close the Java EE perspective by right clicking its icon, and selecting close (see below right)
- Unclutter the Java Perspective by closing some views
  - **Close** the Task List, Outline and Hierarchy views (click on the X)
  - Open the Navigator View (**Window | Show View | Navigator**)





The Java Perspective

Lab



Create User Libraries

Lab

- We'll need to include a number of Spring jars in our classpath
  - We include the Spring jars from the Spring distribution in the setup
  - We also supply other external dependencies in a separate folder
  - We'll set these up as a user library for ease of use

Tasks to Perform

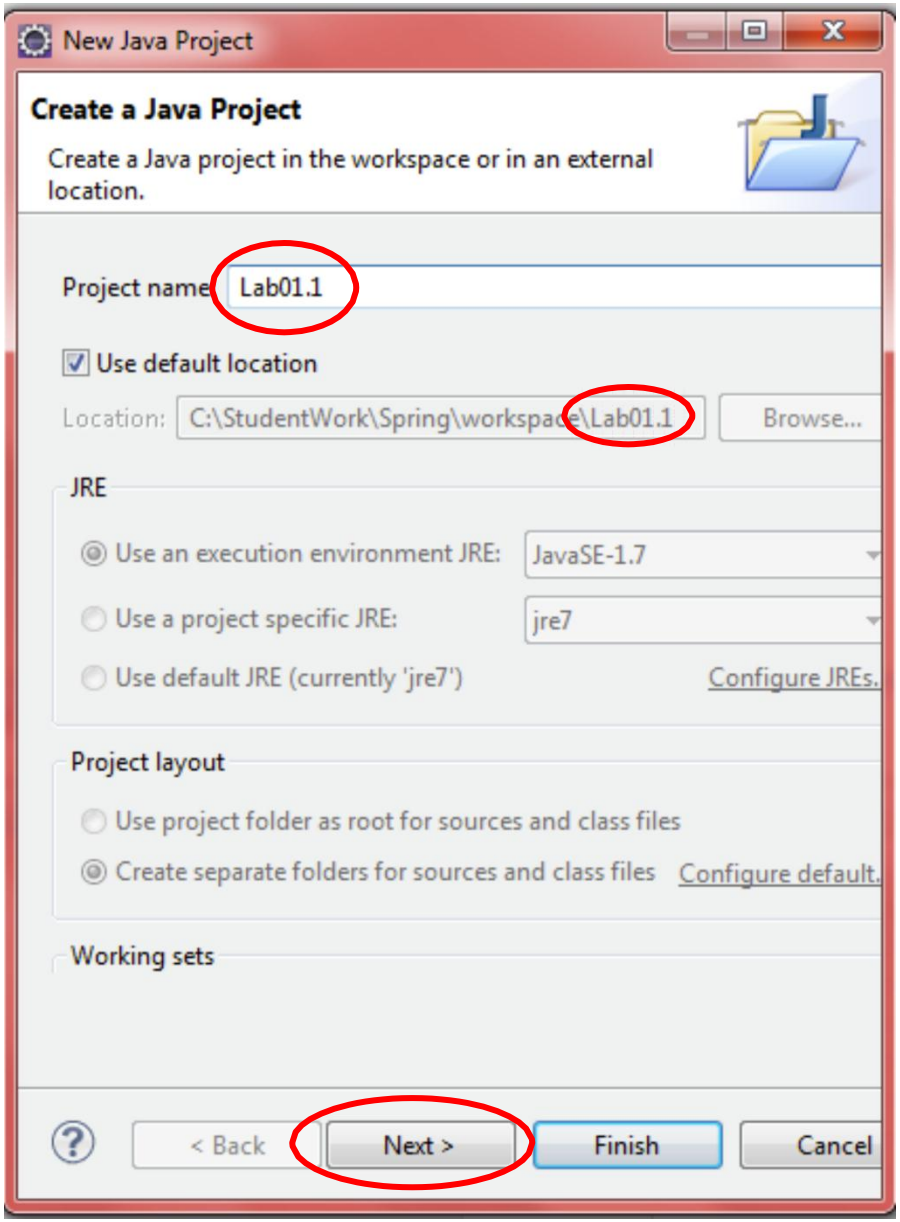
- Go to **Window | Preferences | Java | Build Path | User Libraries**
  - Click **New…** , in the next dialog, call the library **Spring**, and press **OK**
  - Click the **Add External JARs…** button, browse to *StudentWork\Spring\SpringLibraries*, select all the jars in that folder, and click **OK** (see notes)
  - Select the Spring library again, click **Add External JARs…**, browse to *StudentWork\Spring\SpringDependencies,* add in all jars in that folder
- Creates a library with the Spring distribution and dependency jars
  - We'll use it to configure the project build path

Create a Project for our Application

Lab

Tasks to Perform

- Create a **Java Project** *
  - Call the project **Lab01.1**
  - Eclipse will then automatically set the project folder to *Lab01.1*
    - This folder already exists in the workspace
    - It contains a Java project laid out for Eclipse
  - Click **Next**
  - This will bring you to a dialog where you can set the Java Settings for the project

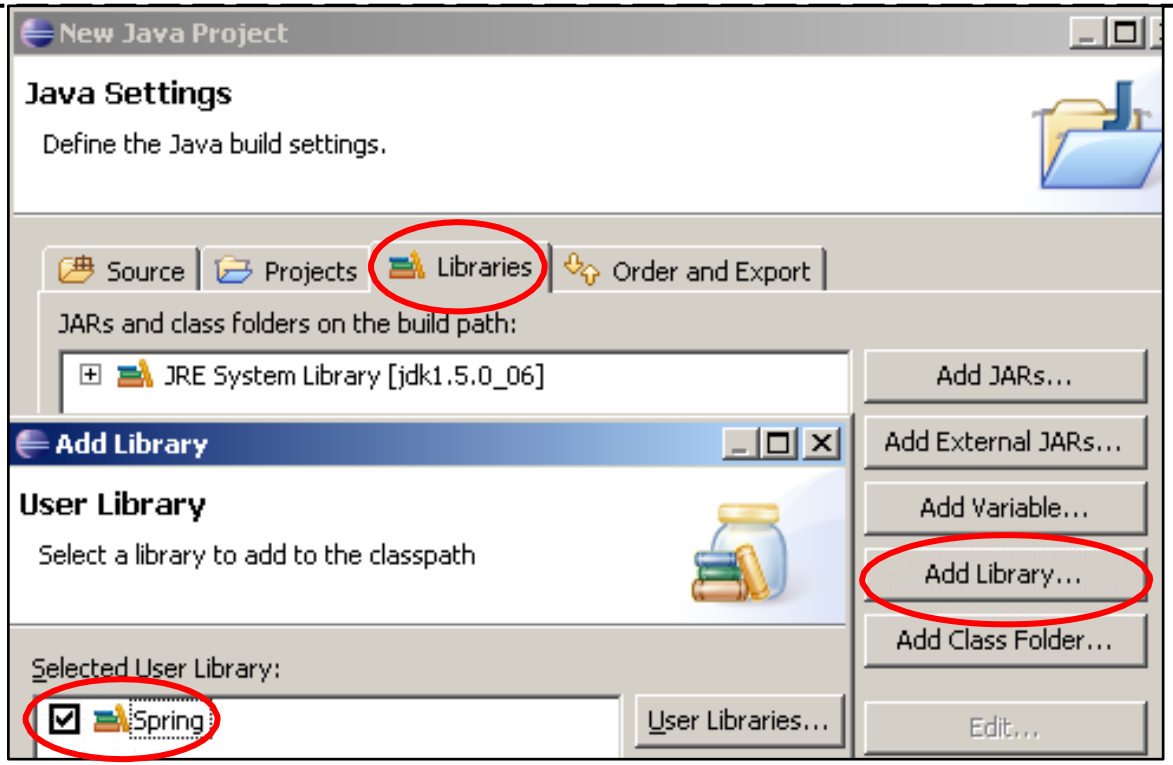


Add the Spring Library to the ClassPath

Lab

Tasks to Perform

- In the **Java Settings** dialog, click the **Libraries** tab *
  - Click the **Add Library** button, and in the dialog that comes up, select **User Library** then click **Next**
  - Check off **Spring**, then click **Finish** in all open dialogs *

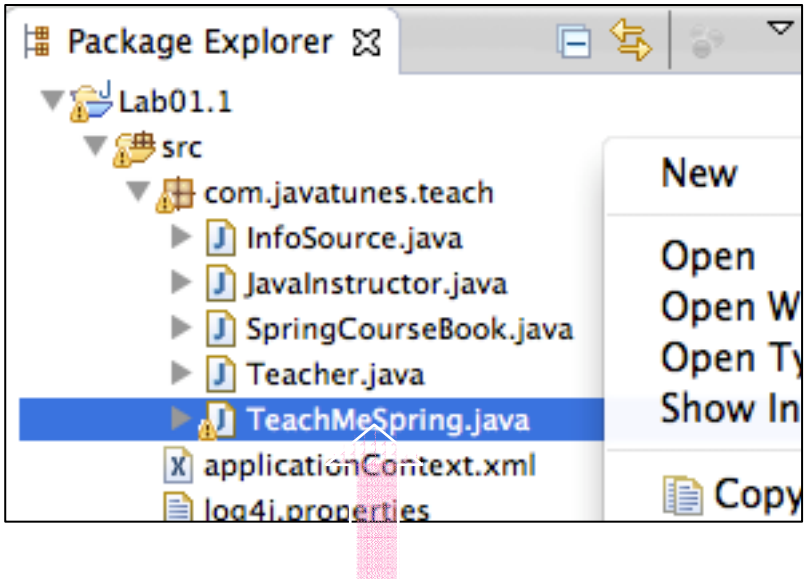


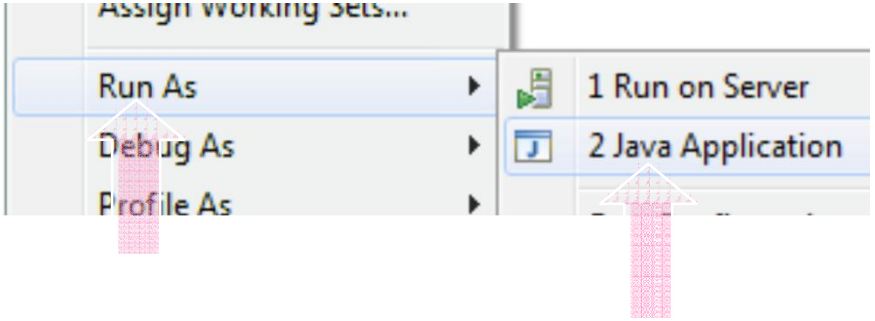
Running the Lab

Lab

Tasks to Perform

- We will use Eclipse to run a skeleton program we supply in *TeachMeSpring.java*
- After a clean build (one that is error-free, but not necessarily warning-free), do the following
  - In the **Package Explorer** pane, right click on *TeachMeSpring.java* (in package com.javatunes.teach under the src folder)
  - Select: **Run As -> Java Application**
  - This will automatically find the main method in *TeachMeSpring* and run it for you

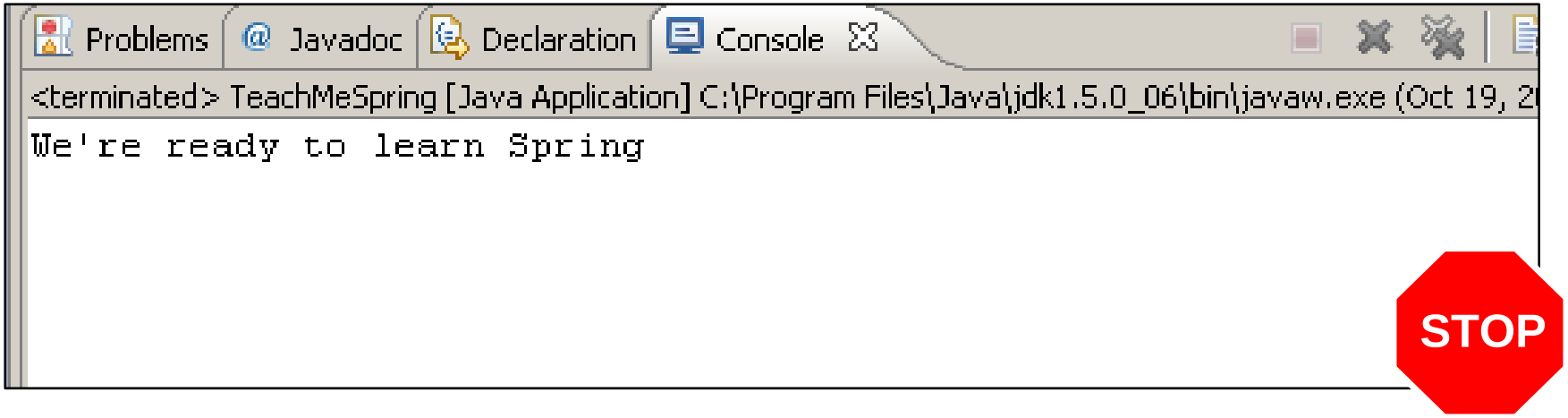




Program Output

Lab

- You should see output in the Eclipse Console view showing the results of running the program
  - Similar to that shown below
  - If you see any exceptions, then you have a problem somewhere
- **Note**: You will follow similar procedures **whenever you have a Java program to run** in the labs
  - The only thing that may change is the program class that you'll need to right click on to run



Spring Introduction

Overview

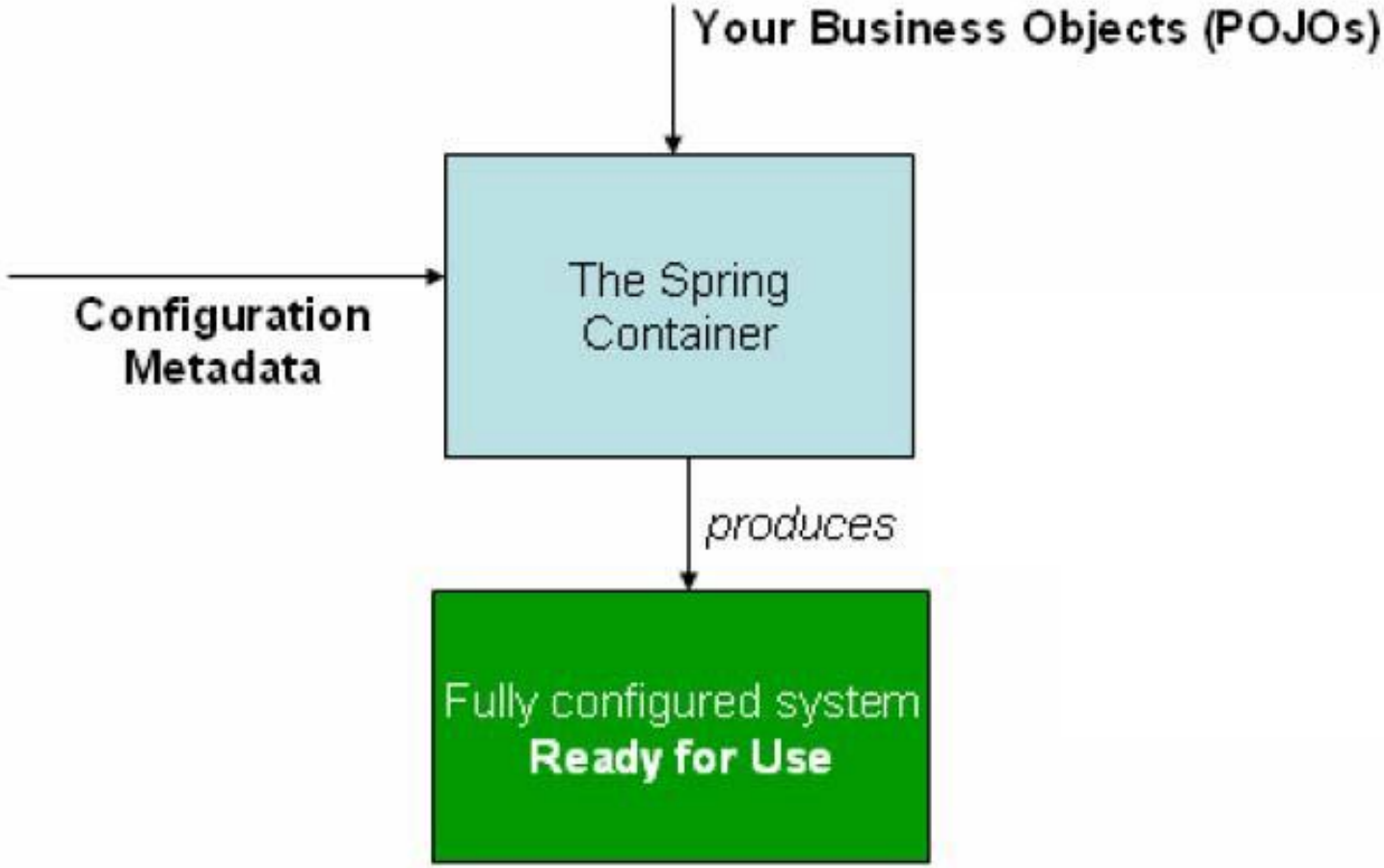
Spring Introduction

Dependency Injection

Managing Beans

- **Managing application objects** is a core Spring capability
- These managed objects are called **beans**
  - Just a **POJO** (Plain Old Java Object)
  - Bean is a common name (e.g. JavaBeans and EJB)
- The Spring **container** manages objects
  - Often called the **Dependency Injection (DI)** or **Inversion of Control** (**IoC)** container
  - **Configuration metadata** is used by the container to **instantiate, configure, and assemble** your beans
  - Generally supplied in simple XML format
- You write a configuration with **bean definitions and dependencies**
  - The container does the work of managing the beans

A Basic Spring Application



The Spring IoC container

Some Bean Classes

- Assume the following types (your business objects)
  - ***Teacher*** interface defining our functionality
  - ***JavaInstructor***: Concrete class, implementing *Teacher*
  - Note: Spring strongly advocates **programming to interfaces** (see notes)
- Let's look at how to manage instances of our types with 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");
   }
}
```

Configuration Metadata

- A **Spring configuration** contains bean **definitions**
  - And information about your beans (the metadata)
  - Bean definitions correspond to actual objects in your app that the Spring container will manage
  - Typically - many bean definitions and dependencies
- Beans are configured with a top level ***<beans>*** element
  - It contains namespace declarations and ***<bean>*** elements as shown in the *applicationContext.xml* file below

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

<!-- The beans namespace is the default one for the document -->
<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-3.1.xsd">

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

</beans>
```

Declaring Beans

- Each bean definition must specify a **package-qualified class name**
  - Usually the bean implementation class (i.e. the class that the container will instantiate)
  - In our example, the ***class*** attribute, specifies the implementation as ***com.javatunes.teach.JavaInstructor***

- In general, a **bean identifier** (or name) is also specified
  - In our example, the ***id*** attribute, specifies the identifier as ***springGuru***
    - It is a label for the bean – both in code and the config file
  - A bean can have multiple names (or aliases)
  - Generally, bean names use camelCase for bean names (e.g. springGuru)

The Spring Container

- Spring container instantiates/configures application objects
  - Provides a configuration mechanism for managing objects
  - And resolves object dependencies based on configuration
- *org.springframework.context.***ApplicationContext**
  - Core API to **access the Spring container** in your code
  - Multiple implementations provided for flexibility, e.g.
  - ***ClassPathXmlApplicationContext***: Commonly used implementation that loads resources from the class path
- *ApplicationContext* extends interface *org.springframework.beans.factory.**BeanFactory***
  - Defines many core methods, but usually not used directly
  - *ApplicationContext* is the recommended API choice

Working With Spring

- High level scenario for using Spring includes the following:

- **Create Spring configuration data** for your beans
  - e.g. In an XML file like *applicationContext.xml*
  - Or via annotations in code (covered later)
  - The "cookbook" telling Spring how to create objects

- **Initialize Spring container, create access point**, e.g.
  - **Create an application context** instance that reads config data
    - It will initialize the beans in the config file
  - Use the context instance to access beans

- **Retrieve beans** via the context and use them
  - e.g. use ***getBean()*** to look up a bean by name
  - *getBean()* is part of *BeanFactory*/*ApplicationContext* API

A Simple Spring Example

- The code below provides a simple Spring example
  - Based on *applicationContext.xml* seen earlier
  - Instantiates a ***ClassPathXmlApplicationContext*** to read *applicationContext.xml* from the classpath to create the spring container
  - Looks up the ***springGuru*** bean from the container and uses it
  - Closes the context (destroying all beans) *

```
package com.javatunes.teach;

import
    org.springframework.context.support.ClassPathXmlApplicationContext;

public class TeachMeSpring {
   public static void main(String[] args) {
      ClassPathXmlApplicationContext ctx = new
           ClassPathXmlApplicationContext("applicationContext.xml");
      // Note that getBean uses Java generics (no casting needed)
      Teacher teacher = ctx.getBean("springGuru", Teacher.class);
      teacher.teach();    // Use our bean
      ctx.close();   // Close the context
   }
}
```

Why Bother?

- The example looks like a lot of work to create a single object !

- Main benefit: We've **decoupled** our code **from a dependency on the implementation** class *JavaInstructor*
  - Our code does not need to know about *JavaInstructor*
  - We just know about the functionality we need
    - i.e. The *Teacher* interface (which *JavaInstructor* implements)
  - We can use any conforming implementation in our configuration
    - Our client code **will not change**
  - This can be very useful for complex systems

- We'll soon see additional capabilities that make Spring useful

Some BeanFactory/ApplicationContext API

- ***boolean containsBean(String)***: returns true if *BeanFactory* contains a bean definition or instance with the given name
- ***<T> T getBean(String, Class<T> requiredType)***: Returns a bean instance, registered under the given name
  - Spring 3 style using Java generics (see notes) and is preferred
- ***Object getBean(String)***: Old style – non generics version
  - Requires cast
- ***Class<?> getType(String name)***: Returns the Class of the bean with the given name
- ***boolean isSingleton(String)***: Determines whether or not the named bean is a singleton
- ***String[] getAliases(String)***: Return the aliases for the given bean name, if any
- Many more methods - view the javadoc for more details

Lab 1.2 – Hello Spring World

Lab 1.2 – Hello Spring World

Lab

- **Overview**: In this lab, we will create and use a Spring context to access a bean instance
  - The end goal is to build a complete (and simple) Spring application and run it
  - This lab uses the *JavaInstructor*, *Teacher*, and *TeachMeSpring* types shown previously in the student manual
- **Objectives**:
  - Become familiar with the different parts of a basic Spring program
  - Write and run a simple Spring application
- **Builds on previous labs**: 1.1
- **Approximate Time**: 20-30 minutes

Writing and Configuring a Bean in Spring

Lab

Tasks to Perform

- Continue to work in the **Lab01.1** project
- Open up the *JavaInstructor.java* file
- The class is in the *com.javatunes.teach* package, under ***src***
- Make sure *JavaInstructor* implements the Teacher interface
  - Remember that we code to interfaces to decouple us from a specific implementation
- Open up the *src/applicationContext.xml* file
  - Click the **Source tab** to edit it
  - Finish up the declaration of the <*bean*> element by declaring:
    - An id of *springGuru*
    - A class of *com.javatunes.teach.JavaInstructor*

Using a Bean in a Program

Lab

Tasks to Perform

- Open up *TeachMeSpring.java*, look for the TODO comments, and add in the following code
  - First, create a *ClassPathXmlApplicationContext* to read *applicationContext.xml*
  - Next, look up the *springGuru* bean from the context
  - Call *teach()* on the *springGuru* bean
  - Finally, call *close()* on the context
- Make sure you have no compilation errors in your code
- **Run** the *TeachMeSpring* program again
  - Run the same way as in previous labs
  - You should see the output from the *teach()* method
- You've successfully configured and used a bean with Spring
  - Congratulations !

Logging and Additional Things (Optional)

- We've provided a *log4j.properties* file in *src*
  - This configures some of the logging that Spring will do
  - You can reduce the logging output by opening this file, and changing the INFO to WARN at the top line of the file:

```
log4j.rootLogger=WARN, stdout
```

  - You can increase the logging by using DEBUG instead

- Other things to try
  - Try looking up the bean by a different name – what happens?
  - Try casting the bean you look up to a *JavaInstructor* instead of a *Teacher*
    - Does this work?
    - Is it a good idea? (see notes)
  - Change your code back to your original solution before going on

Dependencies and Dependency Injection

Overview

Spring Introduction

Dependency Injection

Dependencies Between Objects

- Different objects work together in an OO application
  - e.g., Object A directly uses Object B to accomplish a goal
  - Object A **depends on** Object B

- Direct dependencies can lead to unwanted traits
  - **Rigidity**: Hard to make changes - they affect many other parts of the system
  - **Fragility**: Changes cause unexpected failures in other system areas
  - **Immobility**: Hard to reuse functionality elsewhere - modules can't be disentangled

- We'll show a direct dependency example, then show an alternative approach using **Dependency Inversion**

Example of a Direct Dependency

- Assume *JavaInstructor* uses *SpringCourseBook*
  - Below, *JavaInstructor* creates a *SpringCourseBook* instance directly
  - *JavaInstructor* **depends** on the lower level module details
  - If the data source changes - e.g. to a *SpringWiki*, then *JavaInstructor* code must change (see notes)

```
public class SpringCourseBook { // package statements not shown *
   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());
   }
}
```

Dependency Inversion Principal

- High level or low level modules should **should depend upon abstractions** and not upon each other
  - **Use abstractions**, e.g. **interfaces**, that all modules depend on
  - High level modules are written in terms of abstractions (the interfaces), and not directly in terms of low level modules
  - Dependencies exist, but not exposed in implementation classes

- Using this design strategy has a number of advantages:
  - Facilitates **less coupled components**
    - With a high degree of separation of responsibilities
  - Produces **greater flexibility**
    - Implementations can be swapped without affecting other modules
  - Facilitates **reuse** of components
    - They're less coupled to other parts of an application

Example of Dependency Inversion

- Both *JavaInstructor* and *SpringCourseBook* depend on ***InfoSource*** (an interface) – neither depend on the other

```
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());
   }
}
```

Example of Dependency Inversion

- Below, *JavaInstructor* is initialized with a *SpringCourseBook* instance (that implements *InfoSource*)
  - *JavaInstructor* **only sees this** as the *InfoSource* type
  - We could initialize *JavaInstructor* with any type that implemented *InfoSource* – e.g. a *SpringWiki*
  - 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();
  }
}
```

Dependency Injection (DI) in Spring

- With **Dependency Injection**, Spring lets you abstract dependencies even more
  - The Spring container can initialize and **inject** dependencies into a bean
    - Via constructors, properties in the bean, or arguments to a factory method
- Dependencies **are defined in the Spring configuration**
  - The Spring container uses these dependency definitions to initialize the bean
  - **No need to explicitly initialize dependencies** in your code
- Your bean classes are normal POJO classes
  - You only need appropriate setter methods or constructors needed to initialize the dependencies
  - There is nothing else special about the bean classes

Dependency Injection Configuration

- The Spring configuration below uses DI
  - Declares two beans: *springBook* and *springGuru*
  - *<property name="info" ref="springBook"/>* tells the container to **initialize** the *info* property of *springGuru*
    - Using the instance of *SpringCourseBook* defined above it
  - Uses **setter injection** - calling *setInfo()* on *springGuru*
  - You don't need to write **any** code for the injection to happen

```
<?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>
```

Dependency Injection Example

- The example below shows how to use our beans with Spring
  - Our main code **is decoupled** from *JavaInstructor* - it is written in terms of the ***Teacher* interface**
  - *JavaInstructor*, **is totally decoupled** from the concrete class *SpringCourseBook*, it's written in terms of ***InfoSource***
  - The *JavaInstructor* instance's *info* property is injected with a *SpringCourseBook* instance **by the Spring container**
    - This is transparent to all your code

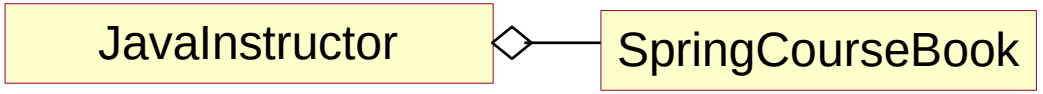
```
// imports not shown
public class TeachMeSpring {

   public static void main(String[] args) {
      ClassPathXmlApplicationContext ctx = new
            ClassPathXmlApplicationContext("applicationContext.xml");
      Teacher teacher = ctx.getBean("springGuru", Teacher.class);
      teacher.teach();
   }
}
```

Advantages of Dependency Injection

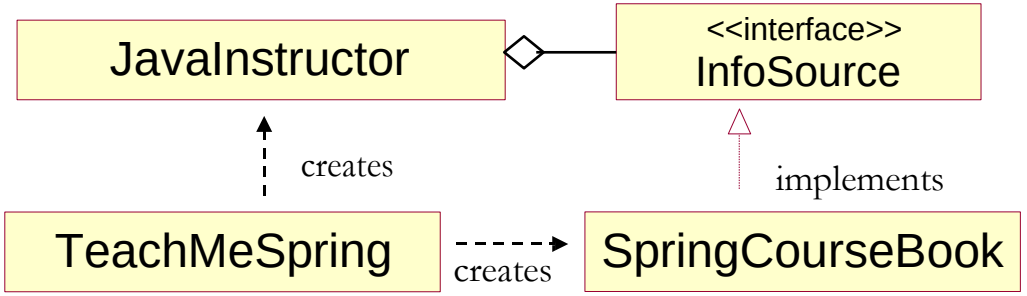
- DI **reduces coupling** between modules **in your code**
  - Coupling is basically a measure of the dependencies
- We've seen this reduction in two ways in our example:
  - *JavaInstructor* is not coupled to *SpringCourseBook*
  - *TeachMeSpring* is not coupled to *JavaInstructor* or *SpringCourseBook*
- The dependencies are still there but **not in the code**
  - Dependencies are **moved to the spring configuration**
  - They're injected into beans without your needing to write code
  - 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

Dependency Injection Reduces Coupling

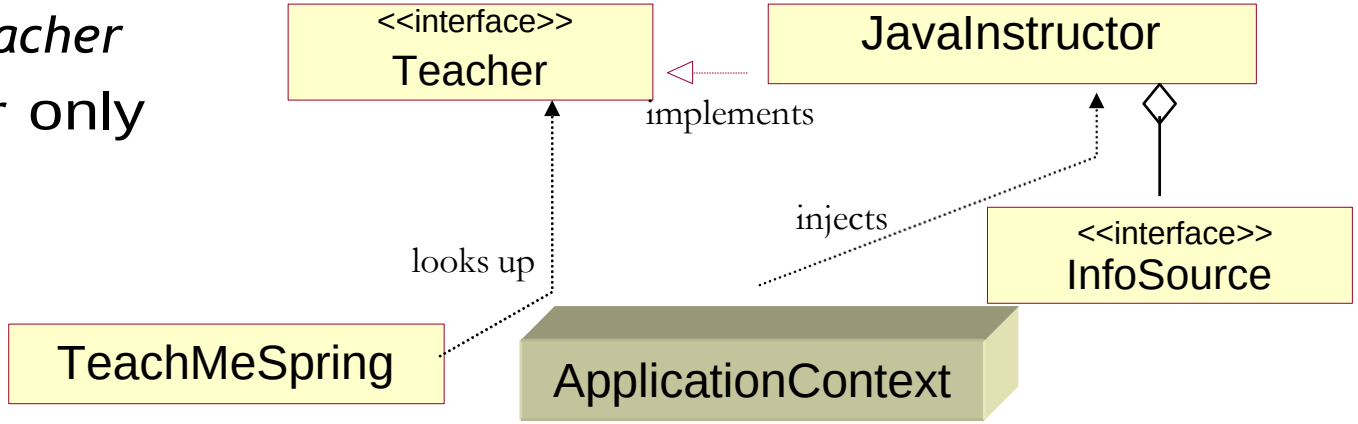
- The simplest case, *JavaInstructor* coupled to *SpringCourseBook*



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



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



Lab 1.3 – Dependency Injection

Lab 1.3 – Dependency Injection

Lab

- **Overview**: In this lab, we'll work with Spring's DI capabilities
  - We will add a property (a dependency on another bean) to the *JavaInstructor* class, and initialize it using Spring DI
  - The main program will not change at all
  - Again, the program is kept very simple so the concepts will be clear
- **Objectives**:
  - Become familiar with Spring DI, and use it in a program
- **Builds on previous labs**: 1.2
- **Approximate Time**: 20-30 minutes

Writing and Configuring a Bean in Spring

Lab

Tasks to Perform

- Continue to work in the **Lab01.1** project
- Open up *SpringCourseBook* for editing
  - Make sure that *SpringCourseBook* implements the *InfoSource* interface
- Open up *JavaInstructor* for editing
  - Add in a property called *info*, of type *InfoSource*
  - You'll need an instance field of type *InfoSource*, as well as a getter/setter method for this field
  - Modify the *teach()* method to print out the data from the *info* properties *getData()* method
- We won't initialize the info property – that will be done with DI

Using a Bean in a Program

Lab

Tasks to Perform

- Open up the *src/applicationContext.xml* file
  - Add in a new bean element for *SpringCourseBook*
    - Give it an id of *springBook*
  - Modify the <*bean*> element for *springGuru* by initializing its *info* property with a <*property*> element
    - Use the *springBook* bean to initialize the *info* property
- **Run** the program as before
  - The output should now be whatever data the *SpringCourseBook* returns
  - The main program doesn't change at all – the *JavaInstructor* dependency on *SpringCourseBook* is completely hidden
  - *JavaInstructor* is also decoupled from *SpringCourseBook*

Additional Things to Try (Optional)

Lab

- In *applicationContext.xml*, try leaving out the initialization of the *springGuru* bean's info property
  - Run your program
  - What happens? Why?

- Change your code back to your original solution before going on

STOP

Review Questions

- What is Spring?
- How does Spring help you to build enterprise applications?
- What is Dependency Injection, and how does it work in Spring

Lesson Summary

- **Spring** is a lightweight framework for building enterprise applications whose capabilities include:
  - Dependency Injection
  - Persistence support (DAO and ORM)
  - AOP capabilities
  - Integration with standard Web technologies
  - An MVC based Web package

- Spring helps build complex enterprise applications
  - Provides a non-intrusive, lightweight solution for managing complex dependencies between Java objects
  - Supplies many of the important capabilities of Java EE in a less complex and lighter weight manner

Lesson Summary

- Spring supports **loose coupling** between components
  - Promotes technique of **coding to interfaces**, rather than concrete implementation classes
  - This by itself is an important design technique,
- Provides support for initialization of beans and their dependencies **through configuration**
  - Can be done using XML configuration files
- **Dependency Injection** is used by the Spring container to inject bean dependencies based on configuration data
  - Allows complete decoupling of your code from concrete implementation types

Module 2: More About Bean Properties

Working with Properties

Collection Valued Properties

Additional Capabilities

Lesson Objectives

- Gain a deeper understanding of Spring's core capabilities related to bean properties and dependencies
- Initialize simple and complex bean properties using Spring configuration
- Understand and use constructor injection, and understand its strengths and weaknesses
- Work with collection valued bean properties
- Understand how Spring supports factory methods
- Understand how autowiring works

Working with Properties

Working with Properties

Collection Valued Properties

Additional Capabilities

Configuring Value Based Properties

- Spring also allows configuration of **value based** properties
  - Containing simple values such as an *int* or *String*
- Similar to configuring dependencies
  - Configure the property value using a **string representation** of the bean property
  - At bottom, we configure a string property of *JavaInstructor* called *favoriteTopic*

```
public class JavaInstructor implements Teacher {
    // Much detail omitted …
    private String favoriteTopic;
    public void setFavoriteTopic (String topic) {
        favoriteTopic = topic;
   }
    public String getFavoriteTopic() { return favoriteTopic; }
}
```

```
<bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
  <property name="favoriteTopic" value="Dependency Injection"/>
  <!-- Other detail omitted … -->
</bean>
```

Using Value Based Properties

- The *favoriteTopic* property is set by the Spring container when the bean is instantiated
  - No dependency on any Spring API in *JavaInstructor*
- These properties are normal Java properties
  - For example, if the *Teacher* interface exposed the *favoriteTopic* property, we could use it as shown below
  - It's transparent to bean users that Spring is involved in initializing a property

```
ClassPathXmlApplicationContext ctx = new
        ClassPathXmlApplicationContext("applicationContext.xml");
Teacher teacher = ctx.getBean("springGuru", Teacher.class);
System.out.println("My favorite topic is " +
                        teacher.getFavoriteTopic());
```

Property Conversions

- Spring automatically converts strings in the configuration to the type of its property in the Java class
  - It uses Java *PropertyEditors*
  - Supports all the standard primitive and wrapper types
  - Below, a *java.lang.**Double*** property (called *age*) is configured
  - The string "*35*" is automatically converted to a *Double* value

```
public class JavaInstructor implements Teacher {
   // Much detail omitted …
   private Double age;
   public void setAge (Double d) {
       age = d;
  }
   public Double getAge() { return age; }
}
```

```
  <bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
    <property name="age" value="35"/>
    <!-- Other detail omitted … -->
  </bean>
```

Constructor Injection

- Properties can be injected using constructors
  - Via *<constructor-arg>* elements in the config file
  - Requires a matching constructor in the implementation class
  - Can initialize both simple properties and bean references

```
public class JavaInstructor implements Teacher {
   private InfoSource info;
   private String favoriteTopic;

   public JavaInstructor(InfoSource infoIn, String topicIn) {
      info = infoIn;
      favoriteTopic = topicIn;
   }
  // Much detail omitted …
}
```

```
   <bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
      <constructor-arg ref="springBook"/>
      <constructor-arg value="Dependency Injection"/>
      <property name="age" value="35"/>
   </bean>
```

Constructor Argument Resolution

- The container tries to resolve constructor elements in the configuration to constructor arguments in the bean definition
  - Can do this in multiple ways
- For example, the configuration shown below will work
  - Uses the *JavaInstructor* constructor seen previously
  - Note how the *springBook* reference is **last** in the configuration, but first in the constructor definition
  - Spring uses the constructor argument **types** first to determine what each *<constructor-arg>* element is for
  - The order is not needed in this case

```
<bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
    <constructor-arg value="Dependency Injection"/>
    <property name="age" value="35"/>
    <constructor-arg ref="springBook"/>
</bean>
```

Constructor Argument Resolution

- Consider the example at bottom though
  - The 2nd and 3rd constructor arguments can't be resolved by type
  - They are just strings in the config file
  - Here, the container will **use the order** in the config file to initialize the last two constructor arguments

```
public class JavaInstructor implements Teacher {
   private InfoSource info;
   private String favoriteTopic;
   private Double age;

   public JavaInstructor(InfoSource infoIn, String topic, Double ageIn) {
      info = infoIn;
      favoriteTopic = topic;
      age = ageIn;
   }
  // Much detail omitted …
}
```

```
   <bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
      <constructor-arg ref="springBook"/>
      <constructor-arg value="Dependency Injection"/>
      <constructor-arg value="35"/>
   </bean>
```

Constructor Argument Resolution

- Consider a new constructor definition:

  *public JavaInstructor(InfoSource infoIn, **Double ageIn, String topic**)*

  – The age argument is now before the topic string

  – The previous configuration entries will throw an exception (the container tries to convert "Dependency Injection" to a *Double*)

- **Specifying the type of the argument** can help argument resolution, as shown below

  – The container must be able to unambiguously resolve the arguments

  – You can also use indices *

```
<bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
    <constructor-arg ref="springBook"/>
    <constructor-arg type="java.lang.String" value="Dependency Injection"/>
    <constructor-arg type="java.lang.Double" value="35"/>
</bean>
```

XML Shortcuts - p: and c: Namespaces

- **p:** (**p-namespace**) allows using attributes to set property values
  - If our *Teacher* type had a "bestSubject" property, we could initialize it using the ***p:bestSubject*** syntax shown below
  - ***-ref*** after the property name would indicate the value is a reference

- **c:** (c-**namespace**) allows using attributes to set constructor args
  - If *JavaInstructor* had a constructor taking an InfoSource, we could initialize it with the ***c:infoIn-ref*** syntax shown at bottom
  - Here we use the -ref suffix to show that the value is a reference

```
<bean  id="springGuru"  class="com.javatunes.teach.JavaInstructor"
       p:bestSubject="Spring"/>
```

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

<bean  id="springGuru"  class="com.javatunes.teach.JavaInstructor"
       c:infoIn-ref="springBook"/>
```

Setter Injection vs. Constructor Injection

- Generally, setter injection is easier to use than constructor injection - however, they both have pros and cons

- **Setter Injection Pros**
  - **Much easier to use** - Multiple property definitions easier than a constructor with many arguments or multiple constructors
  - Can **flexibly choose** which properties to configure
  - Fairly easy to use with inheritance

- **Setter Injection Cons**
  - **Doesn't guarantee property initialization** (if you leave out a property configuration, it will simply remain unitialized)
  - **Requires setter methods** for any property you want to configure
  - **Doesn't support immutable beans** well, since you have to have setters for the properties

Setter Injection vs. Constructor Injection

- **Constructor Injection Pros**
  - **Guarantees properties are initialized** – if constructor argument is left out, you'll get an error when the bean is instantiated
  - **Setter methods not needed** for properties
  - **Immutable beans** easily supported (since setters not required)

- **Constructor Injection Cons**
  - **Constructors can be unwieldy** – Complex and hard to use with large numbers of properties
  - **Constructors offer less flexibility** – Separate constructors needed for different initialization scenarios
  - **More complex XML** for constructor injection than setter injection
    - Especially if type or index arguments are needed

Lab 2.1 – Spring Configuration

Lab 2.1 – Spring Configuration

Lab

- **Overview**: In this lab, we will use Spring in a slightly more complex manner
  - The lab is based on code from the JavaTunes online music store
  - You will configure a *Catalog* bean that provides a search service to search the JavaTunes catalog
  - *Catalog* uses an *ItemDAO* bean to do the actual search
  - You will be required to configure these beans, and dependencies between them, using constructor injection and setter injection
- **Objectives**:
  - Use the Spring configuration file and become more familiar with it
- **Builds on previous labs**: none
- **Approximate Time**: 25-35 minutes

The JavaTunes Online Store

Lab

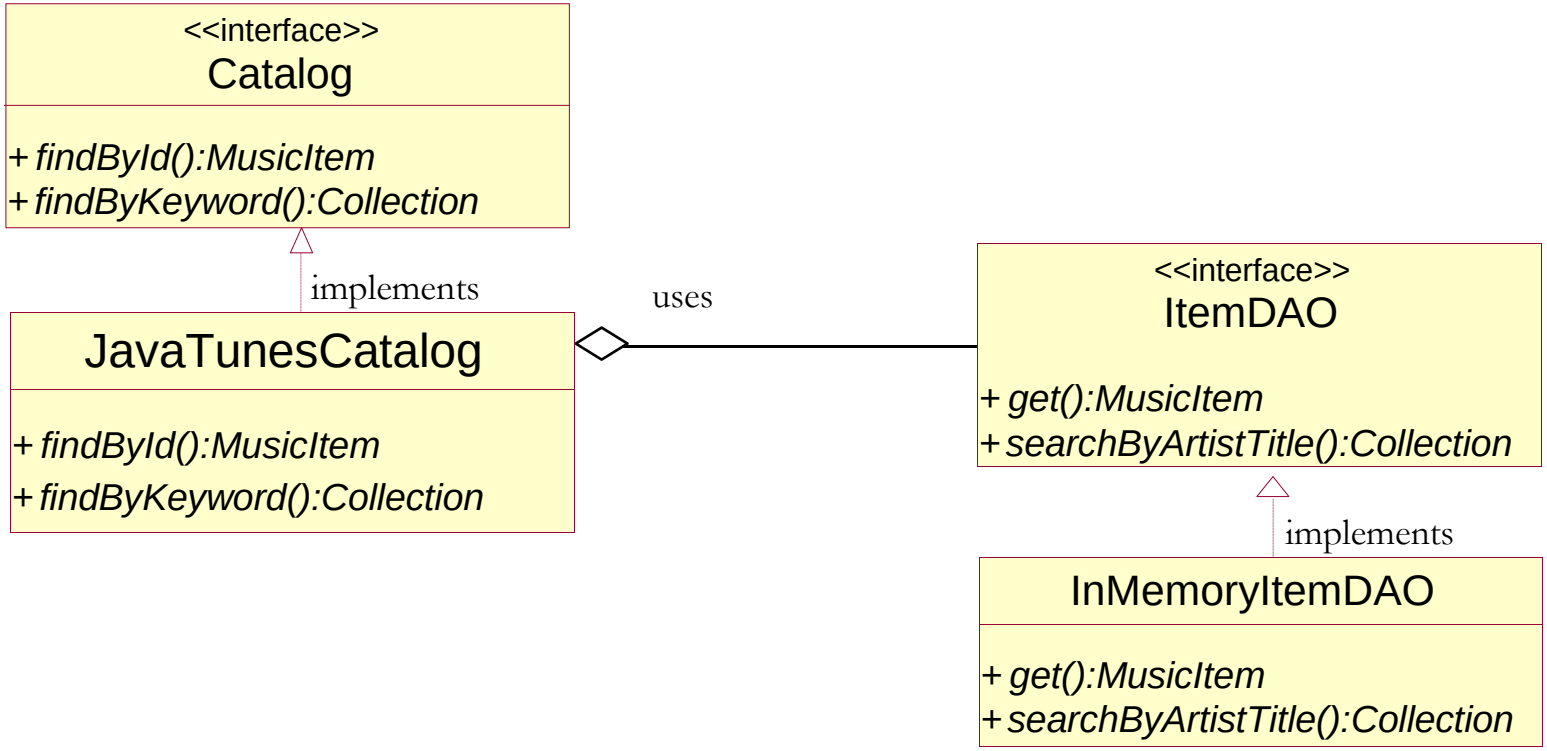
- The application we will be working with is a small piece of the JavaTunes online music store
  - We will be working with the business classes that perform a search, including the following classes:
  - ***com.javatunes.util.MusicItem*** : JavaBean-style value class that represents a music item (e.g. an mp3) for sale
  - ***com.javatunes.catalog.ItemDAO*** : Interface that defines data access for items
  - ***com.javatunes.catalog.InMemoryItemDAO*** : Concrete *ItemDAO* implementation (uses simple in-memory storage)
  - ***com.javatunes.catalog.Catalog*** : Interface that defines the functionality of a catalog in JavaTunes
  - ***com.javatunes.catalog.JavaTunesCatalog*** : Concrete *Catalog* implementation

- We **give you ALL** these classes – you don't need to write them

JavaTunes Class Diagram

Lab

- Shows the relationship between the JavaTunes classes
  - They use the DAO (Data Access Object) Pattern, which provides an abstract interface for data access (see notes)
  - You must wire the relationships up in the Spring configuration
  - There may be additional methods (not shown for simplicity)



Catalog and ItemDAO Interfaces

Lab

- We supply these interfaces - **You don't have to write them**
- They contain the methods shown below
  - *ItemDAO* and *Catalog* have very similar functionality
  - It's because we keep the example simple (see notes)

```
public interface ItemDAO {
  public MusicItem get(Long id);   // Find one MusicItem by id
  // Search for MusicItems containing keyword in title or artist
  public Collection<MusicItem> searchByArtistTitle(String keyword);
}
```

```
public interface Catalog {
    public MusicItem findById(Long id); // Find one MusicItem by id
    // Search for MusicItems containing keyword
    public Collection<MusicItem> findByKeyword(String keyword);
    // Other functionality to be added later …
}
```

JavaTunesCatalog Class

Lab

- We supply this class for you - **You don't have to write it**
- *JavaTunesCatalog* implements *Catalog*
  - It has a constructor and a property that we'll initialize using Spring DI

```
public class JavaTunesCatalog implements Catalog {

    private ItemDAO dao; // Field for dao

    private int maxSearchResults = 0; // maxSearchResults property
    public void setMaxSearchResults(int maxIn) {
        maxSearchResults = maxIn;
    }
    public int getMaxSearchResults() { return maxSearchResults; }

    // Constructor - We require a JavaTunesCatalog to be initialized
    // with an ItemDAO bean when it's created
    public JavaTunesCatalog(ItemDAO daoIn) {
        dao = daoIn;
    }
} // remaining detail omitted ...
```

Lab Preparation

Lab

- The new lab folder where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab02.1

Tasks to Perform

- Close all open files

- Create a new Java project called Lab02.1 in the workspace *
  - See Lab 1.1 instructions on how to do this if you need to
  - Remember to **add the Spring user library**

Implement the Interfaces

Lab

Tasks to Perform

- Open up *MusicItem* and review this class
  - It is a basic JavaBean with properties and very little else
  - There is nothing else you need to do with *MusicItem*
- Open up *InMemoryItemDAO*, and add code so *InMemoryItemDAO* implements *ItemDAO*
  - Review the class briefly also
  - The implementation is not that important – it uses a simple in-memory data store to emulate a database
- Open *JavaTunesCatalog*, and add code so *JavaTunesCatalog* implements *Catalog*
  - Review the class also, looking especially at the constructor and the *maxSearchResults* property
  - These will be initialized by injection using Spring
- Why are we using interfaces here?

Configure the Beans

Lab

Tasks to Perform

- Open *src/applicationContext.xml* and add: *
  - A *com.javatunes.catalog.InMemoryItemDAO* bean definition, with an id of *inMemoryItemDAO* (see notes about bean naming)
    - This requires no injection or other configuration
  - A *com.javatunes.catalog.JavaTunesCatalog* bean definition, with an id of *javaTunesCatalog*
    - This requires that you include a configuration element using constructor injection to pass in the needed *ItemDAO* bean (*inMemoryItemDAO*)
- Open up JavaTunes.java, look for the TODO comments, and add in the following code (see the previous lab code for help)
  - First, create an *ApplicationContext* that reads *applicationContext.xml* from the classpath
  - Next, look up the *javaTunesCatalog* bean from the context
  - Review the code that we've provided that calls the catalog's *findById* and *findByKeyword* methods and outputs the results

Run the Program

Lab

Tasks to Perform

- Make sure you have no compilation errors in your code
- **Run** the program in *JavaTunes.java* (as done previously *)
  - You should see output from the calls to the search methods we've included in the JavaTunes program – in particular, the call to *findByKeyword* on "a" should produce quite a few results
- Once this works, go back to *applicationContext.xml*, and configure a value for the ***maxSearchResults*** property of *javaTunesCatalog*
  - **Run** the JavaTunes program again
  - The output from the call to *findByKeyword* should now be limited to *maxSearchResults* items
- Congratulations – you've configured a complete app
  - You've used both constructor and setter injection

STOP

Collection Valued Properties

Working with Properties

Collection Valued Properties

Additional Capabilities

Working with Collections

- Spring can configure properties containing a collection
  - Four types of collection configuration elements:
  - **<list>**: A list of values, allowing duplicates
  - **<set>**: A set of values, allowing NO duplicates
  - **<map>**: A set of name-value pairs, where name and value can be of any type
  - **<props>**: A set of name-value pairs, where the name and value are both *Strings*

- <*list*> and <*set*> can be used for **array** valued properties or for implementations of *java.util.Collection*
  - The actual bean property does not have to be *List* or *Set*
  - The container enforces the list or set contract

Collection Property Example

- Consider a collection valued property, as shown below
  - The *favoriteTopics* property is now defined as a collection
  - A teacher can now have multiple favorite topics that are contained in this collection property
  - We'll see how to configure this next

```
public interface Teacher {
   // Much detail omitted …
   public Collection<String> getFavoriteTopics();
}
```

```
public class JavaInstructor implements Teacher {
   // Much detail omitted …
   private Collection<String> favoriteTopics;
   public void setFavoriteTopics (Collection<String> topics) {
       favoriteTopics = topics;
  }
   public Collection<String> getFavoriteTopics() { return favoriteTopics; }
}
```

Configuring <list> and <set> Properties

- We can initialize the *favoriteTopics* property using either of the examples shown below
  - The *<list>* element will result in a collection with 3 values
  - The *<set>* element will filter out the duplicate "*Spring*" value, and will result in a collection with 2 values

```
<bean  id="springGuru"  class="com.javatunes.teach.JavaInstructor">
  <property name="favoriteTopics">
    <list>
      <value>Spring</value>
      <value>Java</value>
      <value>Spring</value>
    </list>
  </property>
</bean>
```

```
<property name="favoriteTopics"> <!-- Most details omitted -->
  <set>
    <value>Spring</value>
    <value>Java</value>
    <value>Spring</value>
  </set>
</property>
```

Configuring Collection of Bean References

- Collection properties may also contain references to other beans (dependencies)
  - They are configured similarly to value based collections
  - For example, if *JavaInstructor* had the following Constructor:
    JavaInstructor(Set<InfoSource> infoSources)
  - You could configure it using the configuration elements below

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

<bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
    <constructor-arg>
        <set>
            <ref bean="springBook"/>
            <ref bean="javaBook"/>
        </set>
    </constructor-arg>
</bean>
```

Map Valued Properties

- *Map* valued properties can also be configured with Spring
  - For example, if *JavaInstructor* had the following property: ***Map<String,InfoSource> infoSources;***
  - You could configure it using the configuration elements below

```
<bean id="springBook" class="com.javatunes.teach.SpringCourseBook"/>
<bean id="javaBook" class="com.javatunes.teach.JavaCourseBook"/>
<bean id="totalGuru" class="com.javatunes.teach.JavaInstructor">
  <property name="infoSources">
    <map>
      <entry>
        <key><value>Spring Book</value></key>
        <ref bean="springBook"/>
      </entry>
      <entry>
        <key><value>Java Book</value></key>
        <ref bean="javaBook"/>
      </entry>
    </map>
  </property>
</bean>
```

java.util.Properties Valued Properties

- *java.util.**Properties*** valued properties can also used
  - A *Properties* object holds *String* names and values
  - For example, if *JavaInstructor* had the following property: ***Properties topicExpertise;***
  - Assume this property holds a topic as the key, and a description of the Instructor's expertise as a value
  - You could configure it using the configuration elements below

```
<bean id="totalGuru" class="com.javatunes.teach.JavaInstructor">
  <property name="topicExpertise">
    <props>
      <prop key="Spring">Expert</prop>
      <prop key="Java">Expert</prop>
      <prop key="EJB3">Good</prop>
    </props>
  </property>
</bean>
```

Lab 2.2 – Collection Valued Properties

Lab 2.2 – Configuring Collections

Lab

- **Overview**: In this lab, we will initialize a collection valued property by injection
  - The lab is also based on JavaTunes code
  - It modifies the *InMemoryItemDAO* class so its in-memory storage is initialized by injection, rather than hard coded
- **Objectives**:
  - Use the Spring configuration file to inject a collection valued property
- **Builds on previous labs**: none
- **Approximate Time**: 20-30 minutes

Lab Preparation

Lab

- The new lab folder where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab02.2

Tasks to Perform

- Close all open files

- Create a new Java project called Lab02.2 in the workspace *
  - See Lab 1.1 instructions on how to do this
  - Remember to **add the Spring user library**

Lab Preparation

Lab

Tasks to Perform

- **Open** *InMemoryItemDAO.java* for review
  - **Note that it now has a constructor that receives a collection** representing its in-memory store
  - **You'll need to supply this collection via constructor injection** in the Spring configuration file
  - There is **nothing you need to code** in this class
- **Open** *src/applicationContext.xml*
  - Note the configuration of numerous *MusicItem* beans, with ids of *mi1*, *mi2*, and etc.
  - Go to the *inMemoryItemDAO* bean definition, and add in a constructor argument containing a list of *MusicItem* references
  - Use some of the *MusicItem* beans configured later in the file as the contents of the list (make sure to include the bean with id = mi2, since we search on it in the test program)

Configure the Beans

Lab

Tasks to Perform

- **Run** the program in JavaTunes.java as before *
- If you've configured the constructor argument correctly, your program will run without any exceptions
  - You should see output from the calls to the search methods we've included in the JavaTunes program
- Congratulations – you've configured a complete app
  - You've used both constructor and setter injection

STOP

Additional Capabilities

Working with Properties

Collection Valued Properties

Additional Capabilities

- Factory Methods -

- Spring supports the creation of beans via factory methods
  - First, we consider **static factory methods**
- The ***getInstance()*** method, shown below, is used to create *JavaInstructor* instances
  - Rather than using *new JavaInstructor()*
- The ***<factory-method>*** attribute of *<bean>* tells Spring to use a factory method, as shown at bottom

```
public class JavaInstructor implements Teacher { // Details omitted
   public static JavaInstructor getInstance() { /* ... */ }
}
```

```
<bean  id="springGuru"  class="com.javatunes.teach.JavaInstructor"
       factory-method="getInstance">
  <!-- Most detail omitted -->
</bean>
```

Instance Factory Methods

- Spring also supports **instance factory methods**
  - Often encountered when using factory classes
- ***JavaInstructorFactory***, shown below, has an instance method to produce *JavaInstructor*s
- *<bean>* uses a ***factory-bean*** attribute rather than *class*
  - The factory method is invoked on the specified factory bean **instance**

```
public class JavaInstructorFactory { // Details omitted
    public JavaInstructor getInstance() { /* ... */ }
}
```

```
<bean id="myFactory"
        class=com.javatunes.teach.JavaInstructorFactory"/>

<bean  id="springGuru"
        factory-bean="myFactory"   factory-method="getInstance">
</bean>
```

- Bean Aliases -

- A bean must have at lease one id, but may have more
  - Ids can be specified with the ***id*** or ***name*** attributes
- ***id*** attribute: Lets you specify exactly one id, must follow rules for XML ids - e.g. it can't start with a number
- ***name*** attribute: Can hold multiple values, doesn't have to follow rules for XML ids
  - Multiple values can be separated by a comma (,) semicolon (;) or white space
  - Below, we give a bean 2 names that are not valid XML ids

```
<bean name="1-springBook, 2-javaBook"
      class="com.javatunes.teach.SpringCourseBook"/>

<bean id="springGuru" class="com.javatunes.teach.JavaInstructor">
   <property name="info" ref="1-springBook"/>
</bean>
```

- Bean Definition Inheritance -

- A bean definition (the **child**) can **inherit** configuration data from another bean (the **parent**)
  - Useful when configuration data is common to multiple beans
  - Possible to override some values, or add values

- The ***parent*** attribute is used to specify that a bean inherits configuration data from another bean
  - Inherits the bean class, constructor-args, and all the properties
  - Can override all of these
  - Certain settings always taken from the child *

- An ***abstract="true"*** attribute is available for parent beans
  - The container won't instantiate abstract beans
  - Useful if you're defining the bean ONLY to share configuration

Inheritance Example

- The example below shows both inheritance and overriding

```
<bean id="seniorJavaInstructor" class="com.javatunes.teach.JavaInstructor">
 <property name="infoSources">
      <set>
          <ref bean="springBook"/>
          <ref bean="javaBook"/>
      </set>
   </property>
  <property name="favoriteTopics">
    <list>
      <value>Spring</value>
      <value>Java</value>
      <value>Hibernate</value>
    </list>
  </property>
</bean>
                          <!- Inherit definitions from parent -->
<bean id="springGuru" parent="seniorJavaInstructor">
  <property name="favoriteTopics">  <!-- Override this property -->
    <set>
      <value>Spring</value>
    </set>
  </property>
  <property name="age" value="35"/>
</bean>
```

- SpEL: Spring Expression Language -

- **Spring Expression Language** (**SpEL**) introduced in Spring 3
  - Allows wiring values into beans, including:
    - Values from other bean properties
    - Method return values, including static methods of a non-bean class
    - System properties
- A SpEL expression has the form ***#{expression string}***
  - For example, if our springGuru (Teacher) bean had a "bestSubject" property, we could access it as follows:

    #{springGuru.bestSubject}

    - *springGuru* is a bean id and *bestSubject* is a property of the bean
  - When used in a config file, it would look like the example below
  - When used with annotations, it would like the example at bottom

```
<property name="subject" value="#{springGuru.bestSubject}" />
```

```
@Value( "#{springGuru.bestSubject}" )
private String bestSubject;
```

Other SpEL Capabilities

- Invoke methods on a bean
  - For example, to invoke *pickASubject()* on *springGuru*

```
#{springGuru.pickASubject()}
```

- Access system properties through the predefined *systemProperties* variable
  - For example, to get the *todaysSubject* system property

```
#{systemProperties.todaysSubject}
```

- Access static members of a class using the T (type) operator
  - For example, you can call *java.lang.Math.random()* as follows

```
#{ T(java.lang.Math).random()  }
```

- Can also be used to evaluate expressions in Java programs through the use of *ExpressionParser* and other classes
- See the reference manual for the wide range of SpEL's capabilities

- Autowiring -

- Spring can automatically resolve bean dependencies
  - Called **autowiring**, and can be done four different ways
- **byName** : Attempts to find a bean named exactly the same as the property which needs to be autowired
- **byType** : Attempts to find a single bean whose type matches the type of the property being wired
  - If there is more than one match, a fatal exception is thrown.
  - If there are no matching beans the property is not set.
- **constructor** : Analogous to byType, but applies to constructor args
- **autodetect** : Attempts to wire *constructor* and then *byType* through introspection of the bean class
  - If a default constructor is found, *byType* mode will be applied

Autowiring byName Example

- Autowiring specified via ***autowire*** attribute of *<bean>*
  - The default is *autowire="no"* which specifies no autowiring
  - You specify one of the other four possibilities to trigger autowiring
- Below, the *JavaInstructor* ***info*** property is autowired to the bean named ***info*** (a *SpringCourseBook*)
  - This uses *byName* autowiring

```
public class SpringCourseBook implements InfoSource { /* … */ }
```

```
public class JavaInstructor implements Teacher { // Detail omitted
   private InfoSource info;
   public void setInfo (InfoSource infoIn) {
       info=infoIn;
  }
}
```

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

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

Autowiring byType

- The first example below shows a successful use of *byType*
  - There is one bean of type *InfoSource*, and so it is wired to the *JavaInstructor info* property
- The second example below will fail
  - There are two beans of type *InfoSource*
  - Assumes that *JavaCourseBook* also implements *InfoSource*

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

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

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

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

Pros and Cons of Autowiring

- Autowiring: Saves you the trouble of wiring beans **with XML**
  - Can make your configuration files simpler
  - Can help your configuration files evolve "automatically"
  - Very useful in the common case where there is only one instance of a particular bean type
- Some **disadvantages** to autowiring
  - **Less clear** than explicit wiring
  - **You don't see the exact configuration**, since it's done by the container - creating a place for errors to enter
  - *byName* and *byType* place **requirements and restrictions** on the names or types of beans you can have in a configuration
  - **Can lead to unforeseen results** when you make modifications
    - e.g. if you change the name of a property wired *byName*, behind the scenes it may get wired to something you didn't expect

To Autowire or Not to Autowire

- Autowiring lacks clarity, and may change in unexpected ways as you maintain and evolve your program
  - Tools also do not support autowiring very well

- Because of this, autowiring should be used carefully
  - Very useful in situations where it's not likely to give an error
    - e.g. - where there is only one bean instance of a given type
  - Perhaps avoid it with complex systems where the autowiring may inadvertently change, or where the complexity is confusing

- It is available in the Spring framework, and should be evaluated carefully
  - To make sure it is not likely to introduce subtle bugs

Review Questions

- What capabilities does Spring give you for initializing simple value properties?
- What is constructor injection, and how does it compare to setter injection?
- What capabilities does Spring give you for initializing collection valued properties?
- How does Spring support factory methods?
- What is autowiring?

Lesson Summary

- Spring has simple configuration elements to configure and initialize **value based** properties
  - Spring can automatically convert string values in the configuration into the proper type of a property
    - Using JavaBean *PropertyEditors*
- Spring can also inject properties using **constructors**
  - Uses <*constructor-arg*> elements in the configuration file
  - Requires a constructor be defined in the Java class
  - Container automatically tries to resolve constructor arguments in the config file to the proper arguments in the Java constructor
  - Constructor injection is useful to guarantee that a property is initialized,
  - Setter injection is generally easier and more flexible to use

Lesson Summary

- Spring supports *list*, *set*, *map* and *props* for *collection valued properties*
  - Can be configured in the Spring config file
  - Can hold simple values, bean references, other collections ...
- Spring supports the use of both **static and instance factory methods** to create bean instances
  - Uses additional bean attributes to specify the factory method and, if needed, the factory bean
- With **autowiring**, the Spring container can resolve bean dependencies
  - Can be done *byType*, *byName*, *constructor*, or *autodetect*
  - Ambiguity may be introduced when using autowiring, and should be evaluated carefully

Module 3: The Spring Container and API

ApplicationContext

Bean Scope and Lifecycle

Annotation Driven Configuration

Java-based Configuration

Maven and Spring

Lesson Objectives

- Learn more about the **Spring container**
  - Details of the *ApplicationContext* API
  - Be familiar with the Spring *Resource* classes
- Understand the **lifecycle and scope** of managed beans
  - Configure singleton and prototype beans
  - Work with Spring bean lifecycle events
- Learn how to use **Spring annotations** for configuration

*

ApplicationContext

ApplicationContext

Bean Scope and Lifecycle

Annotation Driven Configuration

Java-based Configuration

Maven and Spring

ApplicationContext Interface

- The *org.springframework.context.***ApplicationContext** interface extends *BeanFactory*,

- Exposes large number of Spring's capabilities, including:
  - **Accessing Resources** like URLS & files - e.g. config files
  - **Message resources with I18N** capability
  - **Publishing events** to managed beans that are listeners
  - **Multiple, hierarchical contexts**

- Generally you'll use *ApplicationContext* rather than *BeanFactory*
  - Builds on *BeanFactory*, and adds additional capabilities
  - Recommended practice is to use *ApplicationContext*
  - Many capabilities not supported by *BeanFactory*

ApplicationContext Implementations

- Two *ApplicationContext* implementations that are commonly used directly,
  - In the *org.springframework.context.support* package
  - ***ClassPathXmlApplicationContext***: Standalone context that loads XML context definition files from the classpath
  - ***FileSystemXmlApplicationContext***: Standalone context that loads XML context definition files from the file system or URLs
- *ApplicationContext* extends *BeanFactory* and inherits all its capability
  - For example, you retrieve a bean using *getBean()*

Constructors

- *ClassPathXmlApplicationContext* and *FileSystemXmlApplicationContext* have a number of similar constructors, shown below
  - They are listed by their arguments:
  - **(String… configLocation)**: Load the configuration from the given XML file(s) and automatically refresh the context (see notes)
  - **(String[] configLocations)**: Load the configuration from the given XML files and automatically refresh the context
  - **(String[] configLocations, ApplicationContext parent)**: Create a new context with the given parent, loading the configuration from the given XML files and automatically refreshing the context.
  - **(String[] configLocations, boolean refresh)**: Load the configuration from the given XML files
  - **(String[] configLocations, boolean refresh, ApplicationContext parent)**: Create a new context with the given parent, loading the configuration from the given XML files

Using an ApplicationContext

- Below, ***ClassPathXmlApplicationContext*** is used to load a definitions file
  - *applicationContext.xml* **must be in the classpath**
  - It's very easy to load multiple files – as shown at bottom
  - You can also use <*import*> in the XML file to import definitions from other XML config files (see notes)

```
package com.javatunes.teach;
import org.springframework.context.support.ClassPathXmlApplicationContext;

public class TeachMeSpring {
   public static void main(String[] args) {
         ApplicationContext ctx =
               new ClassPathXmlApplicationContext("applicationContext.xml");
      Teacher teacher = ctx.getBean("springGuru", Teacher.class);
      teacher.teach();    // Use our bean
   }
}
```

```
// Load configuration from two files
ApplicationContext ctx =
     new ClassPathXmlApplicationContext( "ctx-1.xml", "ctx-2.xml" );
```

Spring Resource Access

- Spring uses its ***Resource*** classes under the hood to access the config info for *ClassPathXmlApplicationContext*
  - They provide extensive functionality for accessing resources
    - e.g. files on the file system
- ant style wildcards can be used to specify config files
  - **conf/**/ctx.xml**: All *ctx.xml* files under any subdir of conf
  - **conf/*-context.xml**: All files in conf, ending in –context.xml
- Can also use the **file:** and **classpath:** prefixes
  - Forces use of the specified loading mechanism
    - Independently of the application context implementation
  - e.g. The following loads definitions from the classpath
    - Even though *FileSystemXmlApplicationContext* is used

```
new FileSystemXmlApplicationContext("classpath:ctx.xml");
```

Built-in Resource Implementations

- Some important *Resource* implementations are listed below
  - All in the *org.springframework.core.io* package:
  - ***ByteArrayResource***: Implementation for accessing a byte array
  - ***ClassPathResource***: Represents a resource which should be obtained from the classpath
  - ***FileSystemResource***: Resource implementation for *java.io.File* handles - Supports resolution as *File*, and *URL*
  - ***UrlResource***: Resource implementation for *java.net.URL* locators. Supports resolution as *URL*, and also as *File* for the "*file:*" protocol

- They provide a standard way to access resources
  - Often wrap an underlying Java class (such as URL) and add additional functionality for ease of use
  - Resource classes are not used that much directly
  - Application context implementations already include this functionality

Lab 3.1 – More about ApplicationContexts

Lab 3.1 – ApplicationContext

Lab

- **Overview**: In this lab, we will work with more of the *ApplicationContext* API
  - We'll use *ClassPathXmlApplicationContext* to load configuration files from the classpath, and to split our configuration into multiple files
- **Objectives**:
  - Use the Spring *ApplicationContext*
- **Builds on previous labs**: 2.2
  - Continue to work in the **Lab02.2** project
- **Approximate Time**: 25-35 minutes

Multiple Configuration Files

Lab

Tasks to Perform

- We will first split up the spring configuration into two files
  - One will contain the DAO bean and the individual item beans
  - The other will contain the catalog bean
- The easiest way to do this is to copy *applicationContext.xml* to a file *inMemoryItemDAO.xml*, then do the following
  - In *applicationContext.xml*, delete all the *MusicItem* bean definitions, and the *inMemoryItemDAO* bean definition
    - Leaving only the *javaTunesCatalog* def
  - In *inMemoryItemDAO.xml* delete the *javaTunesCatalog* def
    - Leaving the *inMemoryItemDAO* and *MusicItem* defs
- In *JavaTunes.java,* pass the two bean definition file names to the *ApplicationContext* constructor

Multiple Configuration Files

Lab

Tasks to Perform

- **Run** your program – it should run as before
- Once your program is running with two config files, then try accessing them in different ways
  - For example, you can use wildcards, or try the file: prefix
    - See notes about wildcards
  - Note that the file: prefix will search for files relative to the root folder of the project
    - Because the program is run in that folder
- **[Optional]**: Look at the javadocs for *ApplicationContext*
  - Try some of the other methods - for example, you can get a bean count and bean names from the methods defined in *ListableBeanFactory*, which *ApplicationContext* implements

STOP

Bean Scope and Lifecycle

ApplicationContext

Bean Scope and Lifecycle

Annotation Driven Configuration

Java-based Configuration

Maven and Spring

Bean Scope

- By default, all Spring configured beans are **singletons**
  - Only one instance created by container
  - Used whenever that bean is needed – whether for dependency injection, or for *getBean()*
- Bean **scope** can configure different behavior
  - Via the *scope* attribute of *<bean>*
- Available Spring scopes:
  - **singleton**: One bean definition produces a **single object instance** per Spring container
    - All requests for that bean return that instance
    - This is the default scope
  - **prototype**: One bean definition produces **multiple object instances**
    - **New instance created** every time a that bean is needed
  - **request, Module**
    , global Module
    Only valid in the context of a web- aware Spring ApplicationContext,

Bean Scope

and not covered now

Specifying Bean Scope

- The *springGuru* bean is scoped as ***prototype*** in the example below
  - A new instance is created every time *springGuru* is used
  - The two *springGuru* references in the example cause the container to instantiate **two instances** of *JavaInstructor*

```
<!-- Much detail omitted -->
<bean id="springGuru" class="com.javatunes.teach.JavaInstructor"
      scope="prototype">
</bean>

<bean id="someCourse" class="com.javatunes.teach.JavaCourse">
   <property name="teacher" ref="springGuru"/>
</bean>
<bean id="anotherCourse" class="com.javatunes.teach.JavaCourse">
   <property name="teacher" ref="springGuru"/>
</bean>
```

Inner Beans

- An **inner bean** is defined inside a *<property>* or *<constructor-arg>* element
  - Anonymous and don't need an id
  - Not referred to by name, but accessed through the property
  - Always scoped as prototype (no prototype attribute needed)
  - The containing bean owns the inner bean completely

- *springGuru* below, uses an inner bean for its *info* property
  - The info bean has no id declared
  - Only accessed through *JavaInstructor.getInfo()*

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

Compound Names

- **Compound property names** can be used to access nested beans
  - Consider a *TeacherData* type with a *name* (*String*), and *age* (*Double*) properties, and *JavaInstructor* as defined below
  - At bottom, we use ***data.age*** to access the *age* property within the *data* bean

```
public class JavaInstructor {
   private TeacherData data;
   public void setData(TeacherData dataIn) {
      data = dataIn;
   }
   public TeacherData getData() { return data; }
}
```

```
<bean  id="springGuru"  class="com.javatunes.teach.JavaInstructor">
   <property name="data">
      <bean   class="com.javatunes.teach.TeacherData"/>
   </property>
   <property name="data.age" value="35"/>
</bean>
```

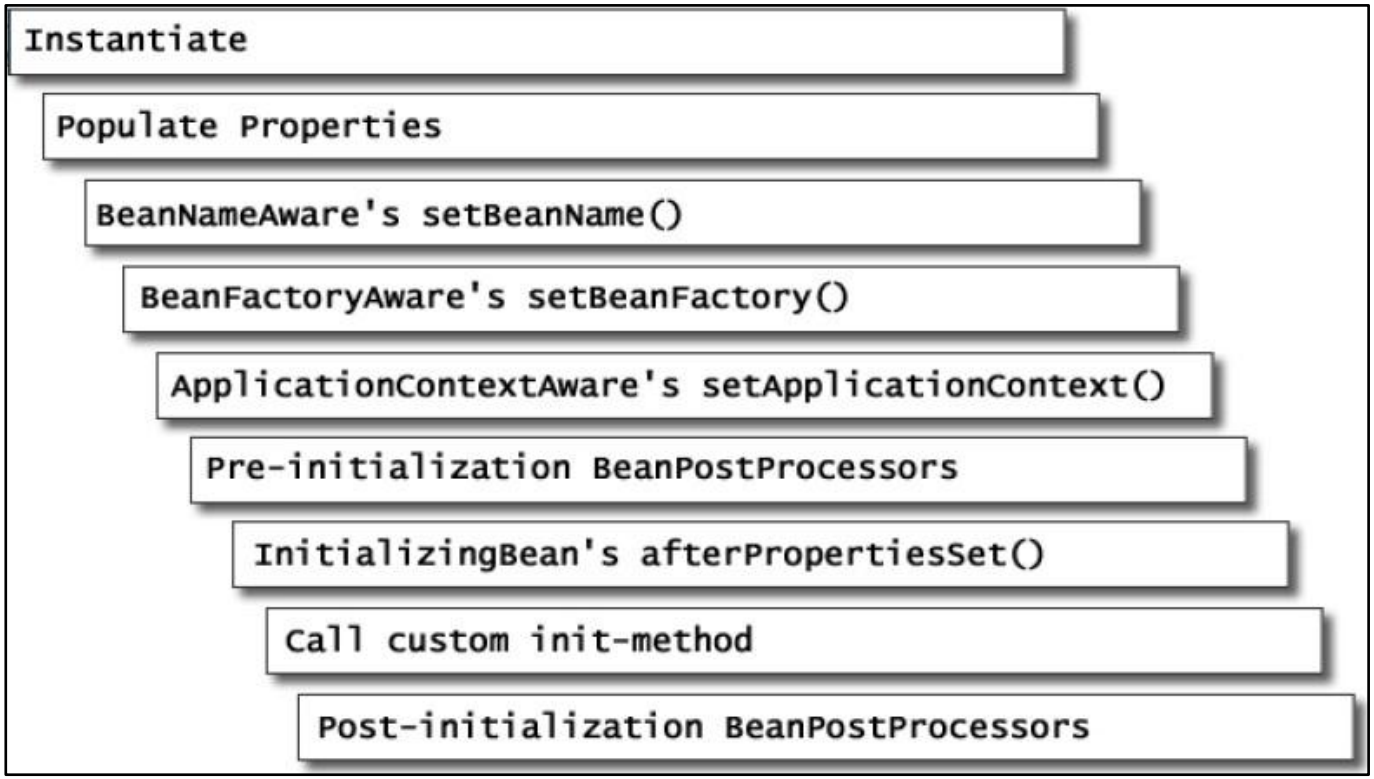
Depends On

- Dependencies are usually expressed by having one bean injected into the property of another
  - So the container naturally knows about the dependency
- Sometimes there are **less direct dependencies**
  - For example, static initializers that must be triggered
    - Like a database driver registration
- A bean with a ***depends-on*** attribute forces initialization of the other bean(s) before its own initialization
  - Below, *instructorDAO* will be created first

```
<bean  id="springGuru"  class="com.javatunes.teach.JavaInstructor"
       depends-on="instructorDAO">
</bean>

<bean id="instructorDAO" class="com.javatunes.teach.InstructorDAO"/>
```

Bean Creation Lifecycle

- Beans have a fairly sophisticated lifecycle within a Spring container
  - You can interact with parts of this lifecycle
  - Below, we show the steps in a typical bean's lifecycle when created
  - Spring interfaces are used to participate in the lifecycle



Bean Creation Lifecycle Details

- **Instantiation**: Container creates the bean instance
- **Populate properties**: Container injects bean's properties
- **Set bean name**: If bean implements *BeanNameAware*, call *setBeanName()* passing in bean's name
- **Set bean factory**: If bean implements *BeanFactoryAware*, call *setBeanFactory()* passing in the bean factory
- **Set application context**: If bean implements *ApplicationContextAware*, call *setApplicationContext()*
- **Postprocess**: If there are any *BeanPostProcessor*s, call their *postProcessBeforeInitialization()* methods
- **Initialize bean**: If bean implements *InitializingBean* , call *afterPropertiesSet()*. If bean has a custom init method, call it
- **Postprocess**: If there are any *BeanPostProcessors*, call their *postProcessAfterInitialization()* methods
- Bean is ready to use !

Using the Lifecycle Interfaces for Beans

- All lifecycle interfaces follow the same structure
  - For a bean implementing a lifecycle interface, its method is called at the appropriate time in the lifecycle
  - Below is an example using *ApplicationContextAware*
  - *setApplicationConext()* will be called with the owning context of the bean instance passed in
  - The bean instance can save it to do things – for instance look things up in the context

```
// Most detail omitted …
import org.springframework.context.ApplicationContextAware;

public class JavaInstructor implements Teacher,
                                        ApplicationContextAware {
   ApplicationContext ctx;
   void setApplicationContext(ApplicationContext ctxIn) {
     ctx = ctxIn;
   }
}
```

Bean Destruction Lifecycle

- One callback, *DisposableBean.destroy()*, for bean destruction
  - If bean implements *DisposableBean*, *destroy()* is called upon instance destruction
  - e.g. When the container shuts down
- Beans can have a custom destroy method for the same purpose
  - Called when bean is destroyed
  - Declared using the *destroy-method* attribute in the *<bean>* element
  - Below, *JavaInstructor* defines a destroy method called *cleanup*
- The example below also defines definition init method called *init*
  - The int method is called when the instance is created

```
<!-- Much detail omitted -->
<bean id="springGuru" class="com.javatunes.teach.JavaInstructor"
        scope="prototype"
        init-method="init" destroy-method="cleanup">
```

BeanPostProcessor

- You can define post processors involved in a beans lifecycle
- Done by defining a class implementing ***BeanPostProcessor***
  - This interface defines two methods:

```
Object postProcessBeforeInitialization(
                    Object bean, String beanName)
Object postProcessAfterInitialization(
                    Object bean, String beanName)
```

- Configuring a bean implementing *BeanPostProcessor* triggers calls on its methods for **every** bean created by the container
  - At the postprocess point in the lifecycle shown earlier
  - You can define as many *BeanPostProcessor*s as you want

@PostConstruct and @PreDestroy

- You can also use standard Java lifecycle annotations
- *@PostConstruct* annotated methods called where *InitializingBean.afterPropertiesSet()* would be
- *@PreDestroy* annotated methods called where *DisposableBean.destroy()* would be
- Can mix and match these mechanisms
  - Can also use both, e.g. define *afterPropertiesSet()* , and annotate a method with *@PostConstruct*
  - Both will be called, with the *@PostConstruct* method called before *afterPropertiesSet()*
- Annotations are convenient, but the interfaces have more capability

Event Handling

- *ApplicationContext* can notify beans of application events
  - Beans receive events if they implement *ApplicationListener*
  - The interface is parameterized, so only events of the appropriate type are received (*ApplicationEvent* in the example below)
- The container itself publishes events (see notes)
  - User beans can also publish custom events by calling *publishEvent()* on the *ApplicationContext*

```
public interface ApplicationListener<E extends ApplicationEvent> {
  void onApplicationEvent(E event); // Handle an event
}
```

```
public class MyListener
                    implements ApplicationListener<ApplicationEvent> {
  void onApplicationEvent(ApplicationEvent event) {
    System.out.println(event);
  }
}
```

Lab 3.2 – Bean Lifecycle

Lab 3.2 – Bean Lifecycle

Lab

- **Overview**: In this lab, we will work with the bean lifecycle
  - We will declare some of our beans as inner beans
  - We will work with some of the lifecycle callbacks Spring provides
- **Objectives**:
  - Use inner beans
  - Become more familiar with the bean lifecycle and the interfaces Spring provides to work with them
- **Builds on previous labs**: 3.1
- **Approximate Time**: 25-45 minutes (depending on optional parts)

Using Inner Beans

Lab

Tasks to Perform

- Continue to work in the **Lab02.2** directory
- Open up the *inMemoryItemDAO.xml* file
  - Replace the bean references passed to the *InMemoryItemDAO* class with inner beans as follows
  - In the *<constructor-arg>* for the *inMemoryItemDAO* bean, delete all the *<ref>* elements within the *<list>* element
  - Move all the *<bean>* elements for the *MusicItem* beans from the top level of the file into the *<list>* element
- **Run your program again** – it should work as before
  - In *JavaTunes.java*, try to look up one of these inner beans by id (if you look, they all still have ids – mi1, mi2, …)
  - The lookup should fail, since the container won't assign ids to the inner beans, even if you include them in the configuration
  - **Comment out** or delete this lookup once you've seen the exception

Bean Lifecycle Callbacks

Lab

Tasks to Perform

- **Open *JavaTunesCatalog.java*** for editing
- **Modify** *JavaTunesCatalog* so it implements *InitializingBean*
  - This is in the *org.springframework.beans.factory* package
  - You'll need to add the following method from this interface:
    public void afterPropertiesSet()
    - Just print out a message so we can see it was called
  - Add a similar print statement to *setMaxSearchResults()*, so we can see when it is called relative to *afterPropertiesSet()*
- **Add** the following method to *JavaTunesCatalog*:
  public void init() – Just have it print out a message also
- **Edit *applicationContext.xml***, and add in an *init-method* attribute to *javaTunesCatalog*, specifying the *init()* method
- **Run your application again** – you should be able to see the messages from the lifecycle methods

[Optional] Bean Lifecycle Callbacks

Lab

[Optional] Tasks to Perform

- You can change your logging level to warn if you want to see the callback output more easily (see notes)
- If you have time, try working with some of the other lifecycle callback interfaces – for example, you can try:
  - Working with the destroy bean callbacks
  - Adding in global post processors by defining a class that implements *BeanPostProcessor*, and declaring a bean of that class in the *applicationContext.xml* file
  - All the callback methods you define should print out a message so you can see that it has been called
- Look at the other lifecycle callbacks, and try any that seem interesting to you

[Optional] Application Event

Lab

[Optional] Tasks to Perform

- If you have time, have *JavaTunesCatalog* implement the *ApplicationListener<ApplicationEvent>* interface
  - Define ***onApplicationEvent****(ApplicationEvent event)*
  - Have this method get the classname of the event (*event.getClass().getName()*) and print it out
  - You'll see that the container publishes some events
- Call *close()* on the context (in *JavaTunes.java* at the very end of the program)
  - You should see an additional event being called

STOP

Annotation Driven Configuration

ApplicationContext

Bean Scope and Lifecycle

Annotation Driven Configuration

Java-based Configuration

Maven and Spring

Annotations in Spring

- **Annotations for configuration** introduced in Spring 2.x +
  - Usable in place of, or in addition to, XML configuration
  - We'll show an example, then explain them
- ***@Required*** on a setter indicates the property must be set in the configuration
  - Otherwise, the container throws an exception
  - Below, we specify ***info* MUST be initialized by dependency injection** in the configuration

```
import   org.springframework.beans.factory.annotation.Required;
public class JavaInstructor implements Teacher { // Detail omitted
   private InfoSource info;

   @Required
   public void setInfo (InfoSource infoIn) {
      info=infoIn;
   }
}
```

Enabling Spring Annotations

- *@Required* is detected by a bean post-processor
  - ***RequiredAnnotationBeanPostProcessor*** must be configured as a bean to use *@Required* (see below)
- Other annotations exist, and require other post-processors *
  - Can all be configured via ***context:annotation-config*** (see bottom)
  - You can configure individual beans, but that's usually not done

```
<bean class=
"org.springframework.beans.factory.annotation.RequiredAnnotationBeanPostProcessor"
/> <!-- Individual post-processor configuration example -->
```

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:context="http://www.springframework.org/schema/context"
  xsi:schemaLocation="http://www.springframework.org/schema/beans
    http://www.springframework.org/schema/beans/spring-beans-3.1.xsd
    http://www.springframework.org/schema/context
    http://www.springframework.org/schema/context/spring-context-3.1.xsd">

      <context:annotation-config/>
</beans> <!-- tag configuration example -->
```

@Component and Auto-Detecting Beans

- ***@Component***: Indicates a class is a component
  - i.e. a Spring managed bean
  - In package *org.springframework.stereotype*
  - Called a "stereotype" annotation
- Spring can scan for and **auto-detect** annotated beans on the classpath
  - Which are registered as normal beans in the application context
  - XML definition isn't necessary
- ***<context:component-scan>*** in the XML configuration enables auto scanning
  - Also enables all capabilities of *context:annotation-config*
  - ***basePackage*** attribute lists packages to include in the scan

```
<context:component-scan base-package="com.javatunes"/>
```

Annotation-based Bean Definition and DI

- ***@Resource*** can specify dependency injection
  - Usable on a field or on a setter method
  - It's a standard annotation in ***javax.annotation*** (in Java 6+ JDK)
  - The *name* element usable to specify name of the bean to be injected
  - Can also inject well-known resources like the application context
- Below, *JavaInstructor* is declared as a bean with ***@Component***
  - We inject the app context and *springBook* bean via ***@Resource***

```
import  javax.annotation.Resource;
import org.springframework.stereotype.Component;

@Component("springGuru") // Specify id (default is class name )
public class JavaInstructor implements Teacher { // Detail omitted
   private InfoSource info;
   @Resource // Inject application context
   private ApplicationContext ctx;

   @Resource(name="springBook") // Assumes springBook bean exists
   public void setInfo (InfoSource infoIn) { info=infoIn; }
}
```

Complete Declarations Using Annotations

- Below, we show two annotation-based bean definitions

```
package com.javatunes.teach;
import org.springframework.stereotype.Component;

@Component("springBook") // Declare as bean with name springBook
public class SpringCourseBook implements InfoSource {
   public String getData() {
      return "Dependencies are not so cool";
   }
}
```

```
package com.javatunes.teach;
import org.springframework.stereotype.Component;
import javax.annotation.Resource;

@Component("springGuru")
public class JavaInstructor implements Teacher { // Detail omitted
   @Resource(name="springBook") // Inject springBook bean
   private InfoSource info; // Don't even need a setter
}
```

XML Config for Annotations and Scanning

- Below, is the Spring configuration for the previous bean examples
  - The ***component-scan*** element configures the auto-scanning
    - It is part of Spring's *context* namespace
    - The ***base-package*** attribute declares that the auto-scanning should include classes in *com.javatunes* and its sub-packages
    - You may also include filters in the component-scan element *
  - No explicit bean definitions shown - but you can also have them
  - XML configuration overrides annotation-based configuration

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:context="http://www.springframework.org/schema/context"
  xsi:schemaLocation="http://www.springframework.org/schema/beans
    http://www.springframework.org/schema/beans/spring-beans-3.1.xsd
    http://www.springframework.org/schema/context
    http://www.springframework.org/schema/context/spring-context-3.1.xsd">

     <context:component-scan base-package="com.javatunes"/>

</beans> <!-- tag configuration example -->
```

Other Stereotype Annotations

- Other stereotype annotations that are detected in auto-scanning include:
  - ***@Controller***: Class is a controller (e.g. Web controller)
  - ***@Repository***: Class is a repository (e.g. DAO)
  - ***@Service***: Class is a stateless service (e.g. service façade)
    - All are specializations of *@Component* indicating some additional functionality
- You can define your own annotations
  - Include *@Component* in their definition to detect them with auto-scanning
- You can declare the bean scope using ***@Scope***
  - e.g. *@Scope("singleton")* - which is the default

@Resource - Additional Uses

- *@Resource* usable to resolve well known dependencies
  - The annotated resource is injected by the container, e.g.

```
@Resource
private ApplicationContext context;
```

- *@Resource* usable without a name element for bean injection
  - Container first tries to resolve using the name of the field
  - Next, tries to resolve using type matching
  - Below, the container first tries to resolve via *name=info*, and if that fails tries to resolve by type with an *InfoSource* bean

```
@Resource
private InfoSource info;
```

- *@Resource* also usable to inject method arguments
  - Optional elements give info on resolving dependency

@Autowired

- ***@Autowired*** provides for annotation-based autowiring
  - Mainly for type-driven injection
- At bottom, we show a simple autowiring example
  - The bean of type *InfoSource* is injected into the *info* field
  - Could annotate the setter method with almost the same result *
- Can be applied to :
  - **Constructors, fields, setter methods**: Normal injection
  - **To a method** with arbitrary name and arguments: All arguments are autowired with a matching bean (see notes)
    - These "config" methods called after constructor/field injection
  - **Collection or Array**: Injects all beans of a type

```
import  org.springframework.beans.factory.annotation.Autowired;
public class JavaInstructor implements Teacher { // Detail omitted
  @Autowired // Injects matching bean (e.g. our springBook bean)
   private InfoSource info;
}  // Remaining detail omitted …
```

@Autowired Examples

- Below, we see autowiring applied to an array
  - Injects ALL beans of type *InfoSource* into the *sources* field
  - *sources* could also be declared a *Collection<InfoSource>*
- At bottom, we see an autowired config method *setSources*
  - The method is called **at bean creation**, and its arguments injected

```
public class JavaInstructor implements Teacher {
   @Autowired // Injects all beans of type InfoSource
   private InfoSource[] sources;
}   // Most detail omitted …
```

```
public class JavaInstructor implements Teacher {
   private InfoSource info;
   private ExamSource tester: // Assume a bean of this type declared

   @Autowired
   public void setSources (InfoSource infoIn, ExamSource examIn) {
      info=InfoIn;
      tester=examIn
   }
}   // Most detail omitted …
```

Qualifiers

- Spring's ***@Qualifier*** gives you some control over injection
  - You associate a qualifier with an autowire, to narrow the type matches
  - Assume we had multiple beans implementing *InfoSource*
  - We could add a qualifier element to one, as shown below
  - In our autowiring, we could then specify the qualifier to narrow the injection, as shown at bottom

```
import org.springframework.beans.factory.annotation.Qualifier;
@Component
@Qualifier("Java")
public class SpringCourseBook implements InfoSource {
   public String getData() {
      return "Dependencies are not so cool";
   }
}
```

```
public class JavaInstructor implements Teacher {
   @Autowired
   @Qualifier("Java") // Narrow injection to bean with Java qualifier
   private InfoSource info;
}  // Most detail omitted, including imports …
```

Lifecycle Annotations

- Methods annotated with lifecycle annotations are called during the bean instance lifecycle (creation/destruction)
  - ***@PostConstruct***: Called after instance is created
  - ***@PreDestroy***: Called before the container destroys instance
    - Standard Java EE annotation in ***javax.annotation*** package
  - Can be used for resource management where needed

```
// import/package statements not shown
@Component("springGuru")
public class JavaInstructor implements Teacher { // Detail omitted
   @Resource(name="springBook")
   private InfoSource info; // Don't even need a setter
   @PostConstruct
   public void init() { /* … */ }
   @PreDestroy
   public void cleanUp { /* … */ }
}
```

Annotation Configuration - Pro / Con

- Pros:
  - Can make configuration **simpler and faster** - configuration closer to bean definition, easier to manage than XML
  - **Annotations**, plus **component scanning**, plus **autowiring** can make configuration much smaller and easier
  - Very good for **quick prototyping**
  - **Refactoring** can be easier
- Cons:
  - **More tightly coupled components**, config changes **need recompile**
  - **Only one bean instance per type** can be configured
  - **Configuration is scattered** among many different files
    - Harder to manage and get an overall view of structure (tool support needed)
    - With XML, configuration is externalized and centralized
  - **Components less reusable** - annotations per type, not per instance
  - Can make **testing harder**

A Note on the XML Configuration

- Spring provides XML Schema based configuration
  - Includes custom namespaces and tags with complex behavior
    - Beyond simple bean definitions and injection
  - e.g. the *context:* namespace we just used
- The Spring namespaces include:
  - ***aop***: Configures AOP support
  - ***beans***: The standard bean tags we've seen already
  - ***context***: Configures ApplicationContext related things
  - ***jee***: JEE related configuration such as looking up a JNDI object
  - ***jms***: Configures JMS related beans
  - ***lang***: Exposing objects written in language like JRuby as beans
  - ***tool***: Adds tooling-specific metadata
  - ***tx***: Configures transaction support
  - ***util***: Common, utility configuration issues

A Brief Note on Annotations

- Standard Java mechanism to **add metadata** to source code
  - They're like comments – except the compiler is aware of them
- Uses @ for declaration and use of annotation types
  - There is a syntax for declaring annotations, using them in declarations, a class file representation, and an API to read them
- Annotations do not directly affect program semantics
  - i.e., they are not executable code
- Annotations affect how tools treat the annotated declarations
  - Which may affect the semantics of a running program
  - For instance, the Spring container reads the annotations on ***@Component*** annotated beans
  - Based on that, it treats it as a bean definition

Annotation Definition Example

- Most programmers won't have to define one - but it's easy
  - Here's a simplified version of the *@Repository* declaration
  - An at-sign (@) precedes the interface keyword
  - Each method declaration defines an *element* of the annotation
  - The simplified *Repository* annotation below has one element
    - *value*
    - If you supply an unnamed element to an annotation, then it is assigned to the "*value*" element (this is part of the Java 5 spec)

```
@Component // Signifies that this is a Component
public @interface Repository {
  //The name to use for the bean in the Spring container
  String value() default "";
}
```

Lab 3.3 – Spring Annotations

Lab 3.3 – Using Annotations

Lab

- **Overview**: In this lab, we will use the Spring annotations to configure all our beans, and any dependencies
  - We'll need to annotate all our beans
  - We'll need to configure the container to recognize the DI annotations, and do the auto-scanning
  - The lab is based on the earlier *TeachMeSpring* labs
- **Objectives**:
  - Write a small application using Spring annotations
- **Builds on previous labs**: none
- **Approximate Time**: 25-45 minutes (depending on optional parts)

Lab Preparation

Lab

- The new lab folder where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab03.3

Tasks to Perform

- Close all open files
- Create a new Java project called Lab03.3 in the workspace *
  - See Lab 1.1 instructions on how to do this if you need to
  - Remember to **add the Spring user library**

- **Open** the file ***applicationContext.xml*** for editing
  - Note how the context namespace is already included
  - Add in the XML ***component-scan*** elements (example in earlier slides)
  - Specify the scanning of the ***com.javatunes*** package

Add Annotations and Run

Lab

Tasks to Perform

- **Open** the file *SpringCourseBook.java* for editing
  - Add the ***@Component*** annotation, and specify a bean name of ***springBook*** (you'll need to import *Component*)
- **Open** the file *JavaInstructor.java* for editing
  - Add the ***@Component*** annotation, and specify a bean name of ***springGuru*** (you'll need to import *Component*)
  - Add the ***@Resource*** annotation to the info field, with a resource name of ***springBook*** (you'll need to import *Resource*)
- **Review and run** the program in ***TeachMeSpring.java ****
  - It should run as previously - all the DI and bean lookup works as before

Autowiring

Lab

Tasks to Perform

- In *JavaInstructor*, remove *@Resource*, and annotate the info field so it is autowired (this should work fine)
  - Run the program again to see that it works
- **Optional**: See how autowiring can fail
  - We supply another *InfoSource – RubyCourseBook*
  - Open this class and annotate it as a component
  - Run the program again – it should fail with an exception because you now have multiple candidate *InfoSource* beans for an autowiring
- **Optional**: Use qualifiers
  - Add a qualifier to *SpringCourseBook*, and to the info autowiriring
  - Run the program again – it should work how *
- **Optional**: Try adding in some of the lifecycle annotations
  - They can just print out some text to show when they're called
  - Run the program and look at the output

STOP

Java-based Configuration

ApplicationContext

Bean Scope and Lifecycle

Annotation Driven Configuration

Java-based Configuration

Maven and Spring

Java Configuration Overview

- Spring 3 introduced a Java-based Spring configuration,
  - It decouples the configuration from the bean definitions
  - *@Configuration* annotated classes contain configuration info
    - They replace XML definition files, and similarly **decouple the configuration** from the bean class definitions
  - *@Bean* annotated methods that return a bean define the bean
  - This example configures the same bean as the XML at bottom

```
import org.springframework.context.annotation.Bean;
import org.springframework.context.annotation.Configuration;

@Configuration
public class TeachConfig {

  @Bean
  public Teacher springGuru() {
    return new JavaInstructor();
  }
}
```

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

Using Java-based Configuration

- *AnnotationConfigApplicationContext* is used to recognize *@Configuration* classes
  - At its most basic, you simply pass in the configuration class
    - Can pass in multiple classes also (comma separated)
  - Note how the bean lookup is exactly the same
  - This context also recognizes *@Component* stereotypes

```
import
org.springframework.context.annotation.AnnotationConfigApplicationContext;

public class TeachMeSpring {

  public static void main(String[] args) {
    AnnotationConfigApplicationContext ctx =
      new AnnotationConfigApplicationContext(TeachConfig.class);
      Teacher teacher = ctx.getBean("springGuru", Teacher.class);
      teacher.teach();
  }
}
```

Dependency Injection

- Wiring a bean is done by referring to its *@Bean* method
  - The example below wires the *springBook* bean into the *springGuru*'s info property – the same as the XML at bottom

```
@Configuration
public class TeachConfig {

   @Bean
   public Teacher springGuru() {
      JavaInstructor ji = new JavaInstructor();
      ji.setInfo(springBook());
      return ji;
   }

   @Bean
   public InfoSource springBook() {
      return new SpringCourseBook();
   }
}  // This is equivalent to the XML config below
```

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

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

More on How it Works

- An *@Configuration* class **is metadata**
  - Much like an XML file – just a different format
- *@Bean* methods **aren't called like normal methods**
  - Interpreted as metadata indicating a bean definition
  - "Calling" the method in a config class specifies an injection
- Wiring in another *springBook* bean (see below) **uses the same bean instance** (since by default a bean is a singleton)
  - Confusing if looked at as regular Java
    - It seems to create a new instance – but it doesn't (see notes)
  - Remember – this is **metadata**, not executable code

```
// Rest of @Configuration class not shown (same as on previous slide)
@Bean
public Teacher javaWhiz() {
  JavaInstructor ji = new JavaInstructor();
  ji.setInfo(springBook());
  return ji;
}
```

Dependencies Between Configuration Classes

- *@Configuration* classes can have **dependencies** on beans from other *@Configuration* classes
  - You can inject them, like any defined bean, as shown below
    - *TeachConfig* uses the *springBook* bean

```
@Configuration
public class TeachConfig {
   @Autowired // or @Resource(name="springBook")
   private InfoSource springBook;
   @Bean
   public Teacher springGuru() {
      JavaInstructor ji = new JavaInstructor();
      ji.setInfo(springBook);
      return ji;
   }
}
```

```
@Configuration
public class BookConfig {
   @Bean
   public InfoSource springBook() { return new SpringCourseBook(); }
}
```

Other Usage Scenarios

- An *@Configuration* class can import another
  - For example, to import a class *BookConfig*:

```
@Configuration
@Import(BookConfig.class)
public class TeachConfig { ... }
```

- An *@Configuration* class can import an XML config file
  - For example, to import a file *otherConfig.xml*:

```
@Configuration
@ImportResource("classpath:otherConfig.xml")
public class TeachConfig { ... }
```

Classpath Scanning

- *AnnotationConfigApplicationContext* can use classpath scanning, as shown below
  - *scan()* takes a package name (or multiple names), just like *context:component-scan*
  - Note: You must call *refresh()* on the context after scanning, so that the beans are initialized
- An *@Configuration* class can be declared in XML (see notes)
  - So you can use an *@Configuration* centric or XML centric approach, and mix in the other approach

```
public class TeachMeSpring {

  public static void main(String[] args) {
    AnnotationConfigApplicationContext ctx =
                                  new     AnnotationConfigApplicationContext();
    ctx.scan("com.javatunes.teach");
    ctx.refresh();
    // Rest of code the same ...
  }
}
```

Other @Bean Capabiliites

- A bean can specify a scope other than the default singleton
  - Using *@Scope*, as shown below

```
@Bean
@Scope("prototype")
public Teacher springGuru() { /* ... */ }
```

- A bean can specify a name

```
@Bean(name="springGuru") // Bean is named springGuru
public Teacher getTeacher() { /* ... */ }
```

- You can even have multiple aliases using a string array

```
@Bean(name={ "springGuru", "javaWhiz" })
```

  - The example uses the standard Java array initialization syntax

- You can specify init / destroy methods

```
@Bean(initMethod="init", destroyMethod="cleanup")
```

  - Called at appropriate times when instance created

Java-based Configuration - Pro / Con

- Pros:
  - **No XML**, Java used for configuration, fairly compact and readable
  - Configuration is **external to bean code**
  - Full control over object creation (e.g. two beans of same type is easy)
  - Refactoring friendly – uses normal Java tools
  - Type safety – the compiler checks most things (unlike in XML, where there are a lot of strings and many errors, like misspelling a classname, are often not caught until runtime)
- Cons:
  - Yet another way of configuring Spring that developers have to learn
  - Somewhat obscure syntax
  - Changes require **recompilation**
  - Relatively new, and may still need some time for tooling and for refining its capabilities

[Optional] Lab 3.4 – Java-based Config

Lab 3.4 – Java-based Configuration

Lab

- **Overview**: In this lab, we will use Spring's new Java-based configuration to configure all our beans, and dependencies
  - We'll create a separate *@Configuration* class to do the configuration
  - The lab is based on the earlier *TeachMeSpring* labs
- **Objectives**:
  - Write a small application using Java-based configuration
- **Builds on previous labs**: none
- **Approximate Time**: 20-45 minutes (depending on optional parts)

Lab Preparation

- The new root lab directory where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab03.4

Tasks to Perform

- **Close** all open files and projects

- Create a new Java project called Lab03.4 in the workspace *
  - See Lab 1.1 instructions on how to do this if you need to
  - Remember to **add the Spring user library**

- **Open** the file ***applicationContext.xml*** for review
  - Note the ***annotation-config*** elements
  - Nothing you need to do in this file

Add Annotations and Run

Lab

Tasks to Perform

- **Open** the file *TeachConfig.java* for editing
  - Add the ***@Configuration*** annotation to it, and add code to specify:
    - An *InfoSource* bean named ***springBook*** using *SpringCourseBook* to create the bean
    - A *Teacher* bean named ***springGuru*** using *JavaInstructor* to create the bean – you will need to set its *info* property using the *springBook* bean
- **Open** the file *TeachMeSpring.java* for editing
  - Create an *AnnotationConfigApplicationContext* that uses TeachConfig for its configuration
- **Run** the program in ***TeachMeSpring.java***
  - It should run as previously - all the DI and bean lookup works as before

Optional Things to Try

Lab

[Optional] Tasks to Perform

- In *TeachConfig*, add an init method declaration for the *JavaInstructor* bean def
  - Specify the init() that already exists in *JavaInstructor*
  - Run the program and see that it is called (it prints a console message)
- In TeachMeSpring.java, use classpath scanning via the *AnnotationConfigApplicationContext*
  - Rather than explicitly naming the config file
  - Scan the *com.javatunes* package – remember to call *refresh()*
  - Run the program to see it work
- Create a new config class named *BookConfig*
  - Move the declaration of the *springBook* bean into this class
  - Inject the *springBook* bean into the *TeachConfig* class for use in creating the *JavaInstructor*
  - Run your program and see that it works

STOP

Maven and Spring

ApplicationContext

Bean Scope and Lifecycle

Annotation Driven Configuration

Java-based Configuration

Maven and Spring

About Maven

- **Maven**: Tool for building and managing Java projects
  - **POM** (Project Object Model - an XML file) used for configuration
  - Maven automates the build process (and much more)
- Maven can **automatically download dependencies**
  - As configured in the POM, and downloaded as part of build
  - Default: Download via http from the **maven central repository**

    http://repo.maven.apache.org/maven2/
- Maven is the **de-facto standard for Spring** builds
  - Well supported by Spring
  - **No other easy way** to manage Spring dependencies (see notes)
- We **supplied the dependencies** for most of the labs
  - So you don't have to deal with maven in them
  - We used maven to figure out the needed dependencies

How We'll Work With Maven

- **Goal**: Understand how maven supplies Spring dependencies
  - This is important for Spring developers to be familiar with
  - We'll work within the context of our lab environment
  - We will NOT give an in-depth coverage of maven
- We'll use maven for **dependency management only**
  - We'll continue to use Eclipse for building projects and running programs
  - Maven has related capabilities (and more), which we won't use
- **We'll use the Maven for Eclipse** plugin to work with maven
  - We won't use maven directly (e.g. from the command line)
- We won't require maven for most of the labs
  - As it may not be available in all lab environments

The POM (Project Object Model)

- The **POM** is an XML file containing information and configuration details about a maven project
  - Typically in a file ***pom.xml***
- The example below contains some required POM properties
  - It also includes a single dependency on a Spring module
  - We'll cover the details next

```
<project>
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.javatunes.spring</groupId>
  <artifactId>Lab03.5</artifactId>
  <version>1.0</version>

  <dependencies>
    <dependency>
      <groupId>org.springframework</groupId>
      <artifactId>spring-context</artifactId>
      <version>3.2.2.RELEASE</version>
    </dependency>
  </dependencies>
</project>
```

POM - Required Elements

- The POM elements in the example below are required
  - ***project***: The root element
    - This element includes namespaces - omitted in the example
  - ***modelVersion***: The model version maven should use
    - Should be 4.0.0 for current versions of maven
  - ***groupId***: The id of your project's group
  - ***artifactId***: The id of the project
  - ***version***: The version of the project
  - ***groupId:artifactId:version*** uniquely identifies the project
    - This is called the fully qualified artifact name

```
<project>
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.javatunes.spring</groupId>
  <artifactId>Lab03.5</artifactId>
  <version>1.0</version>
</project>
```

POM - External Dependencies

- The POM below declares a single external dependency
  - On ***spring-context*** (One of the core Spring artifacts)
    - Referenced via its fully qualified artifact name
    - Note: We use a property for the Spring version to change it easily
  - Based on this POM, maven will **automatically include** the Spring context jar (and its dependencies) in your project

```
<project> <!-- Previous detail omitted -->

  <properties>
    <org.springframework.version>3.2.2.RELEASE</org.springframework.version>
  </properties>

  <dependencies>
    <dependency>
      <groupId>org.springframework</groupId>
      <artifactId>spring-context</artifactId>
      <version>${org.springframework.version}</version>
    </dependency>
  </dependencies>

</project>
```

Maven Artifacts for Spring

- Listed below are some common Spring artifacts
  - They are in the maven repository with GroupId *org.springframework*
    - Can be used as dependencies in your POMs

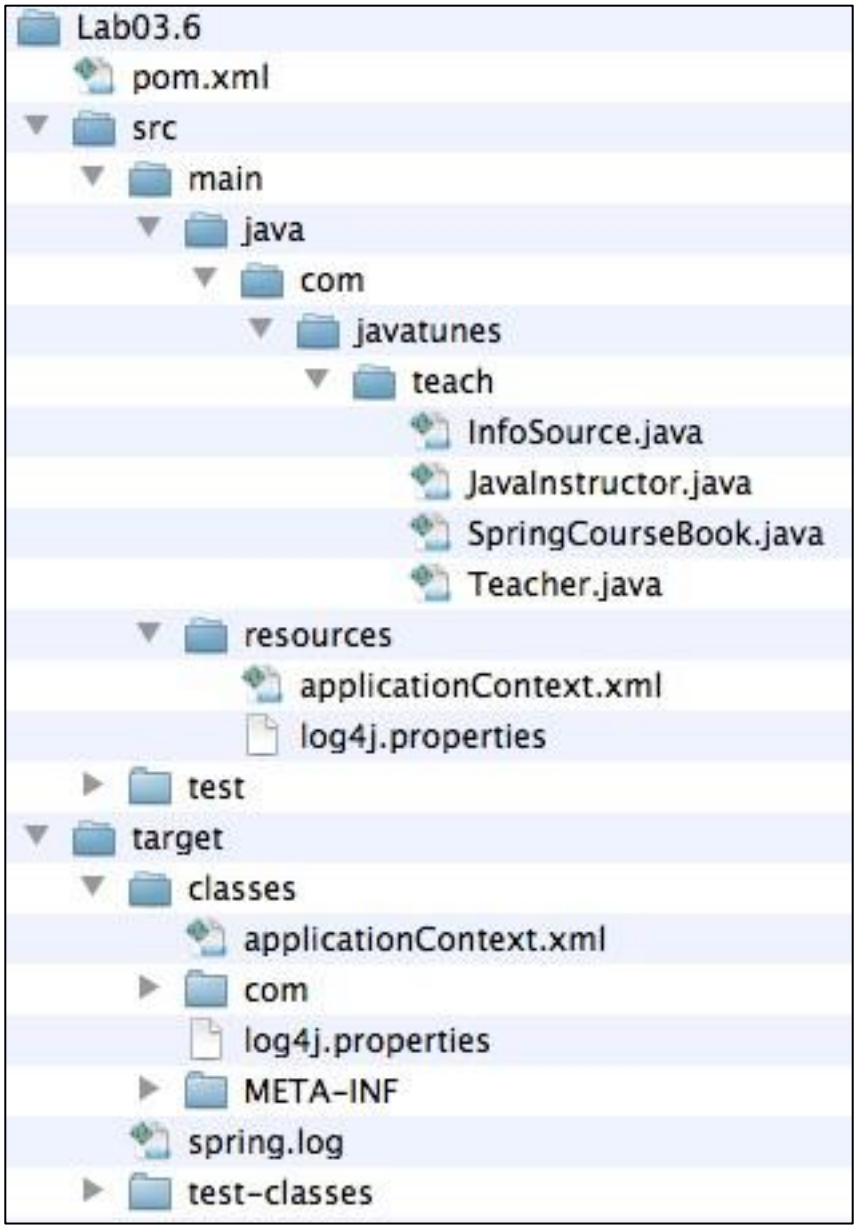
- **spring-aop**: Aspect Oriented Programming (AOP) Framework
- **spring-beans**: Bean Factory and JavaBeans utilities
- **spring-context**: Application Context
- **spring-core**: Core utilities used by other modules
- **spring-expression**: Expression Language (depends on spring-core)
- **spring-instrument**: Instrumentation for AOP
- **spring-jdbc**: JDBC Data Access Library (e.g. JdbcTemplate)
- **spring-orm**: Object-to-Relation-Mapping (ORM) integration e.g. JPA
- **spring-tx**: Spring transaction management
- **spring-web**: Web application development utilities
- **spring-webmvc**: Spring MVC for Servlet Environments

Repositories

- Maven looks for external dependencies in a repository
  - A repository holds build artifacts and dependencies
- By default, maven looks in your local repository
  - In ***~/.m2/repository*** - the default location
- Dependencies not in the local repository are downloaded from a remote repository
  - They are then put in your local repository
  - Default remote repository, "The Maven Central Repository" at: ***http://repo.maven.apache.org/maven2/***
- You can configure all of this differently
  - The details are beyond the scope of this course

Maven Project Structure

- The standard structure for a standalone Java project in Maven
  - **Root folder**: *pom.xml*
  - ***src/main/java***: Java source files
  - ***src/main/resources***: Resources that should be on classpath (e.g. config files like *applicationContext.xml*)
  - ***src/test***: Test source files
    - We put our main class to run our Spring programs under this folder
  - ***target***: Build output
- Web projects have an additional folder - for JSPs, html, etc
  - ***src/main/webapp***



Eclipse / Maven Integration

- Done with **Maven Integration for Eclipse** plugins
  - Consists of two plugins - m2e and m2e-wtp
  - Available via the Eclipse update sites:

  http://download.eclipse.org/technology/m2e/releases

  http://download.eclipse.org/m2e-wtp/releases/

- Capabilities include:
  - **Dependency management** for Eclipse build path based on Maven's *pom.xml*
  - **Automatic downloading** of the required dependencies from the remote Maven repositories
  - Quick fixes in the Java editor for looking up required dependencies/jars by the class or package name
  - We'll use a few of these capabilities in the labs

The Lab

- The lab allows you to see maven at work
  - It will be used to download all your project dependencies and include them on the build path
  - There is no coding in the lab - it's solely to work with maven
- You'll need to do the following
  - Install the m2e-wtp plugin (which also installs the m2e plugin)
  - Create a Java project
  - Convert the project to a maven-based project
  - Set up *pom.xml* (which we provide) and update the project
- **You need internet access** to the Eclipse update sites, and the maven central repository
  - Otherwise, you'll need to skip the lab

[Optional] Lab 3.5 – Using Maven

Lab 3.5 – Using Maven

Lab

- **Overview**: In this lab, we will create a Java Project that uses maven for its dependency management
  - As part of that, we'll install the Eclipse m2e and m2e-wtp plugins
  - We'll also create a project, and convert it to a maven project

- **Objectives**:
  - Become familiar with using Maven from within Eclipse
  - Use maven for Spring dependency management

- **Builds on previous labs**: None

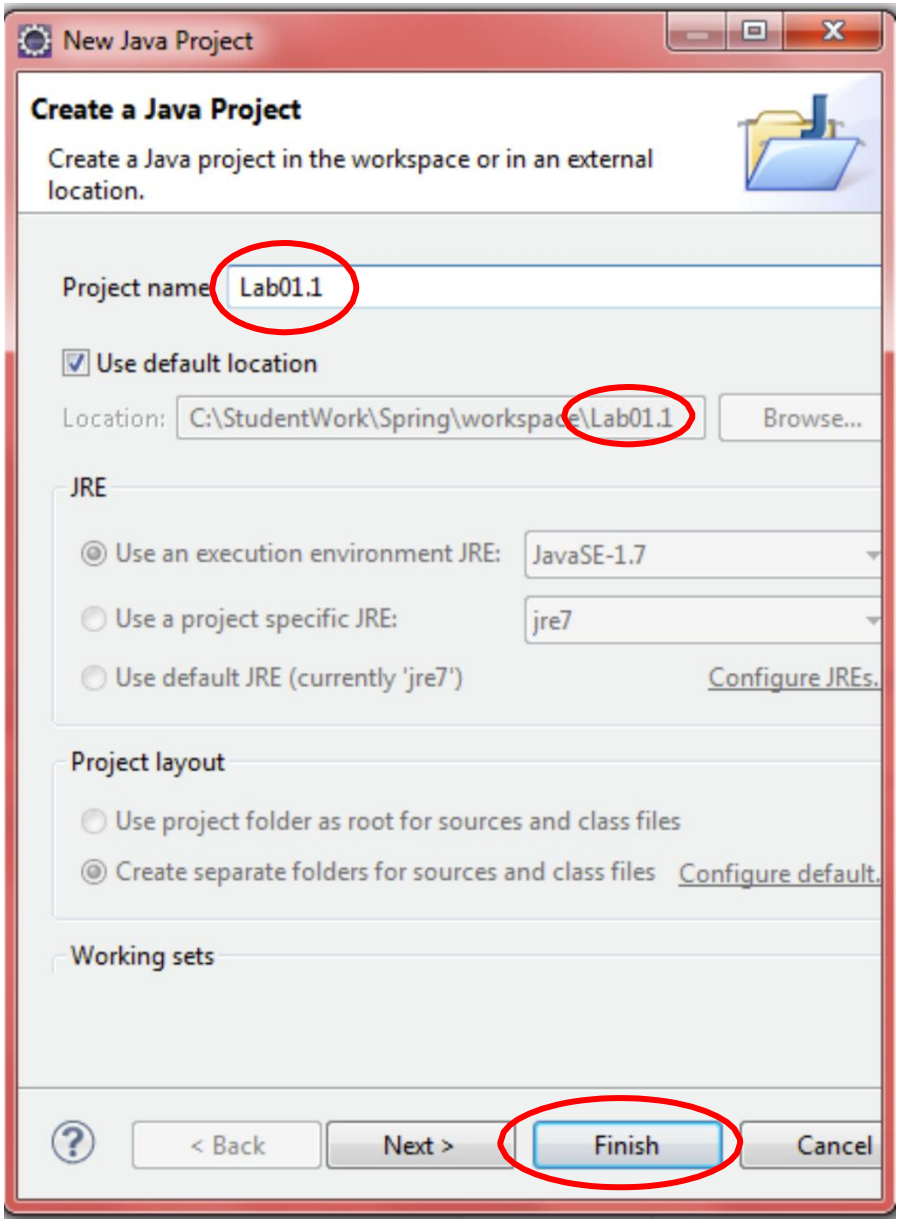
- **Approximate Time**: 35-45 minutes

Create a Project for our Application

Lab

Tasks to Perform

- Create a **Java Project** *
  - Call the project **Lab03.5**
  - Eclipse will then automatically set the project folder to *Lab03.5*
    - This folder already exists in the workspace
    - It contains a Java project laid out for Eclipse / Maven
  - Click **Finish**
- Ignore any errors
  - We still need to configure the Spring dependencies (via maven)



Add Maven Support to Eclipse

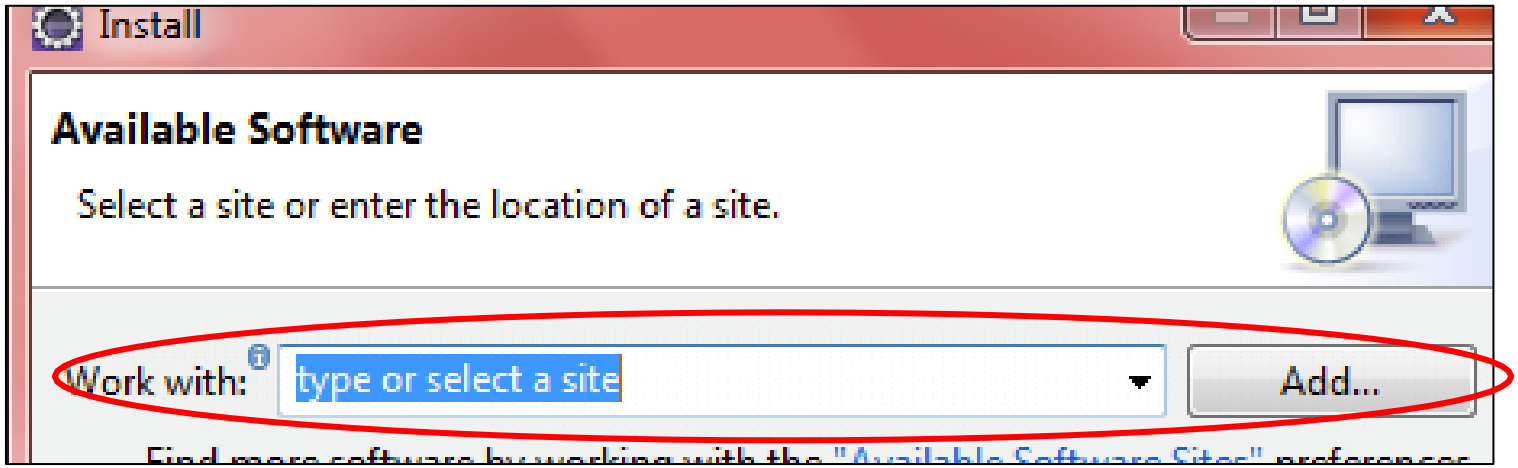
Lab

- Done by installing the m2e and m2e-wtp plugins
- If **unable to install m2e** or **access the maven central repository**, you'll need to skip the lab

Tasks to Perform

- See notes if **using a proxy server**
- Go to **Help | Install New Software …**
  - In the resulting page, click the **Add…** button to add the maven site
  - Call the site Maven, and set the URL to the below (see notes):

    http://download.eclipse.org/m2e-wtp/releases/



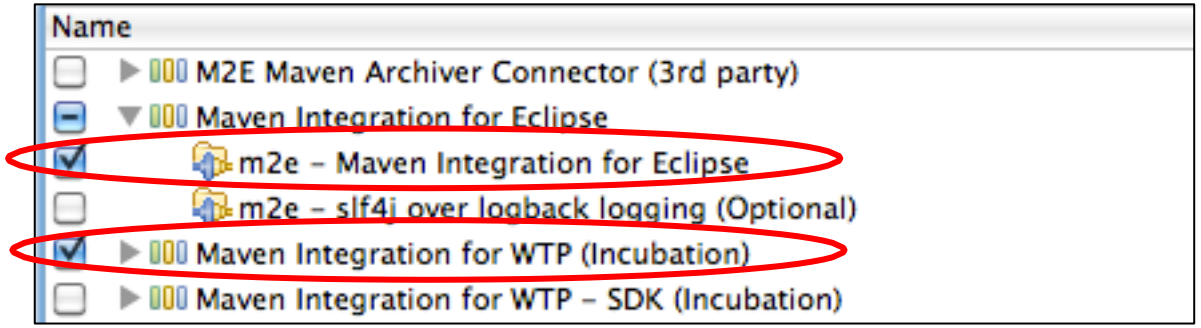
Add Maven Support to Eclipse

Lab

Tasks to Perform

- Click **OK**, expand the Maven Integration for Eclipse plugin, and check the **m2e** item (see below)
- Check the **Maven Integration for WTP** checkbox also
- Click **Next** until you see a license agreement - accept it, click **Finish**
- The m2e and m2e-wtp plugins for Eclipse should now install
- **Restart** Eclipse when prompted

- Go to **Window | Preferences | Maven**
  - Uncheck **Download repository index updates on startup**
  - Which can take a lot of time, and is not needed for the class



Add Maven Support to Project

Lab

Tasks to Perform

- The supplied files are already structured as a Maven Java project
  - We must add in Eclipse support for maven, as follows
- Right click on the project in Project Explorer, select **Configure | Convert to Maven Project**, click **Finish**
  - You can leave the default values for Group Id, etc. as we will replace the generated *pom.xml* with our own
- In the project, **delete the generated *pom.xml*** (in the project root)
  - **Rename** the supplied *pom.xml.txt* file to *pom.xml* (Right click, Rename)
- Open *pom.xml* for review (see next slide for excerpts)
  - Note that all **projects are configured to use Java 7** in the *maven-compiler-plugin* configuration section
  - Note the dependency elements for spring and log4j
  - Right click on project, select **Maven | Update Project** (pick up changes)

Review pom.xml

Lab

Tasks to Perform

- Open *pom.xml* for review
  - Select the *pom.xml* tab (excerpts shown at right)
  - Note the dependency on **spring-context**
  - Pulls in the spring context jar and all its dependencies
  - There is also a dependency on log4j (not shown here)
- Note the maven-compiler-plugin config (see notes)
  - **If not using Java 7**, then **revise** the source/target values to your Java level (e.g. 1.6 for Java 6)

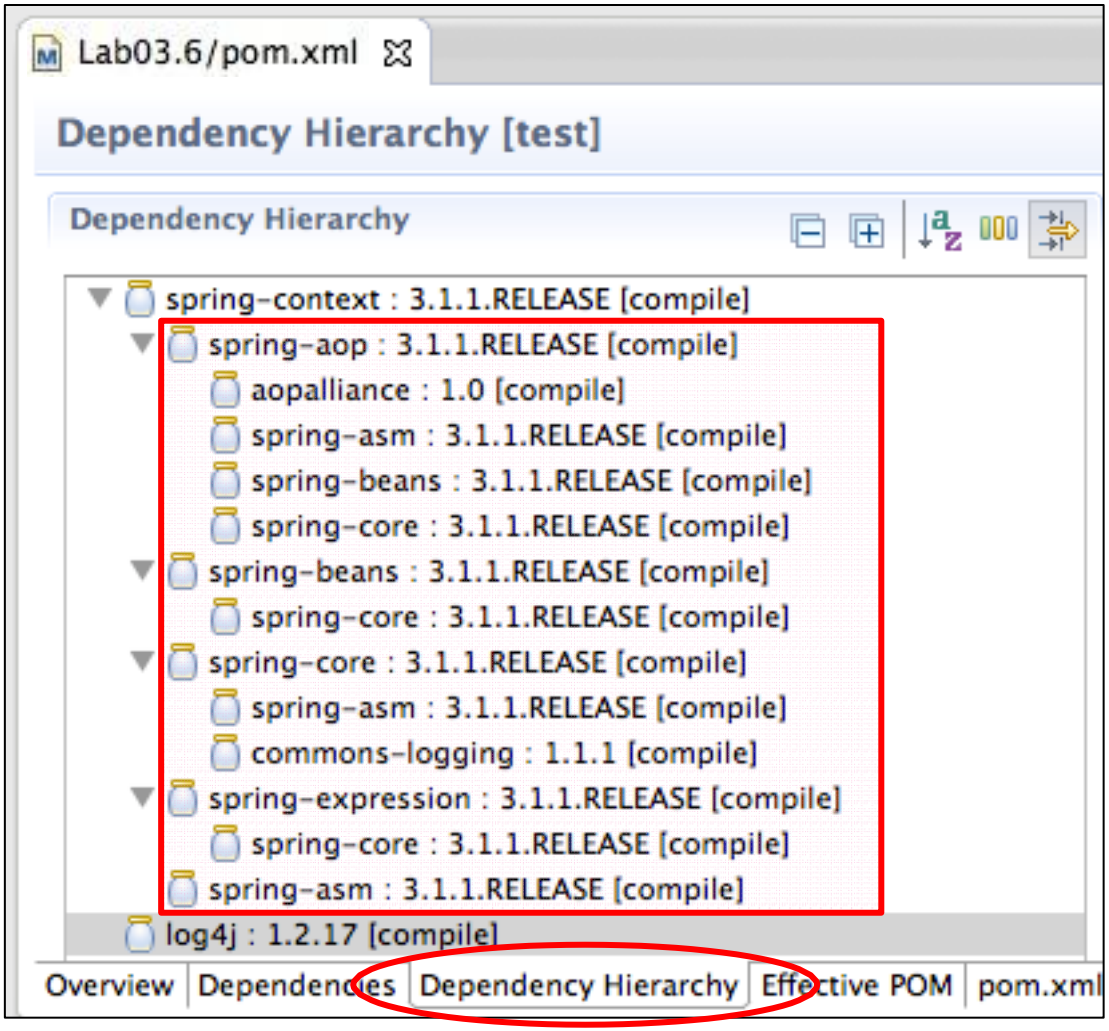
```
<properties>
  <org.springframework.version>
        3.2.2.RELEASE
   </org.springframework.version>
</properties>

<dependencies>
  <dependency>
   <groupId>org.springframework</groupId>
   <artifactId>spring-context</artifactId>
   <version>
      ${org.springframework.version}
    </version>
  </dependency> <!-- detail omitted -->
<dependencies>

<plugin>
  <artifactId>
      maven-compiler-plugin
   </artifactId>
  <version>2.3.2</version>
  <configuration>
   <source>1.7</source>
   <target>1.7</target>
  </configuration>
</plugin>
```

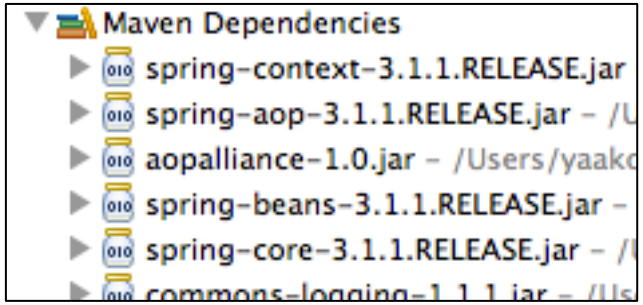
Maven Only: Review pom.xml

Lab

Tasks to Perform

- Click the **Dependency Hierarchy** tab of *pom.xml*
  - Note the jars that are dependencies of spring-context (at right)
- You can also look at the **Maven Dependencies** node in Package Explorer
  - You'll see the jars in the project that were pulled in by maven (below)

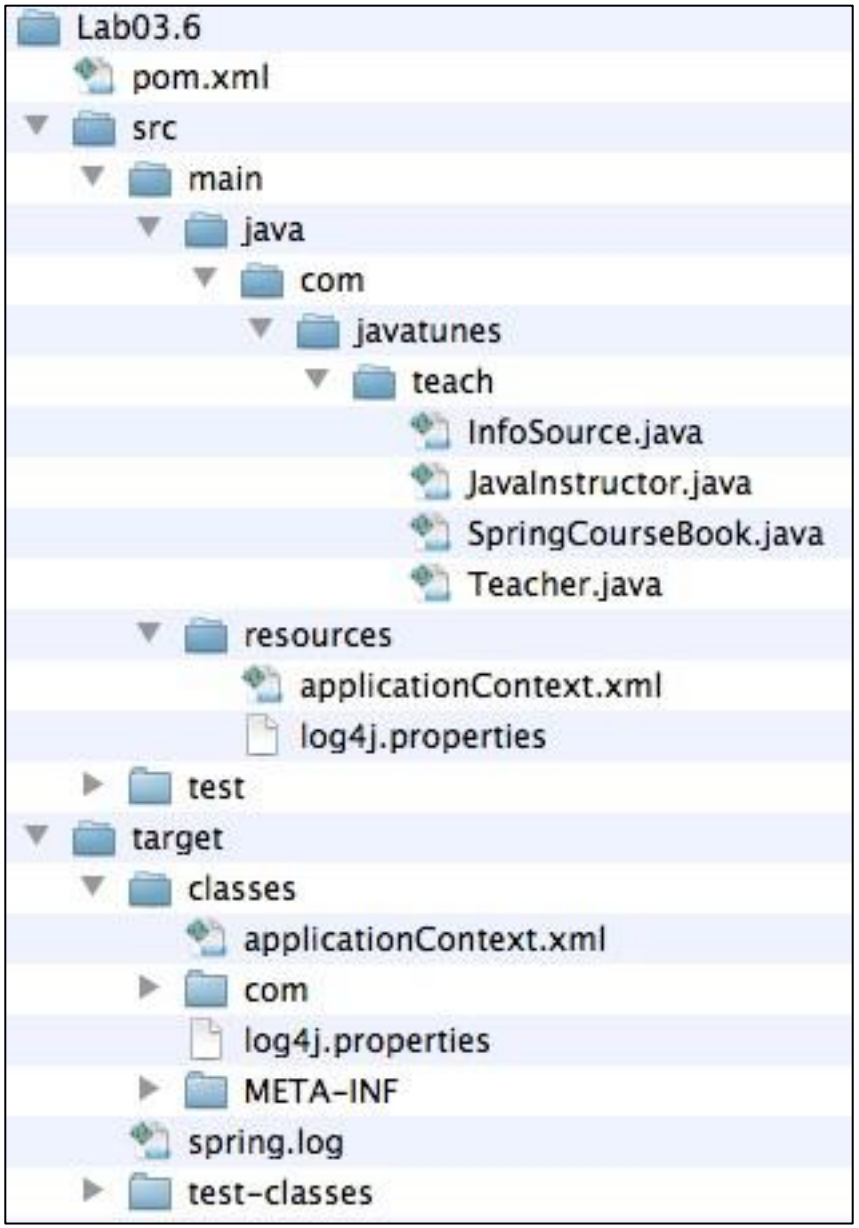




Project Structure (Maven/Eclipse)

Lab

- Follows maven/Eclipse Java project structure
  - **Root folder**: *pom.xml*
  - ***src/main/java***: Java source files
  - ***src/main/resources***: Resources that should be on classpath (e.g. config files like *applicationContext.xml*)
  - ***src/test***: Test source files
    - We put our main class to run our Spring programs under this folder
  - ***target***: Build output (only if using maven)

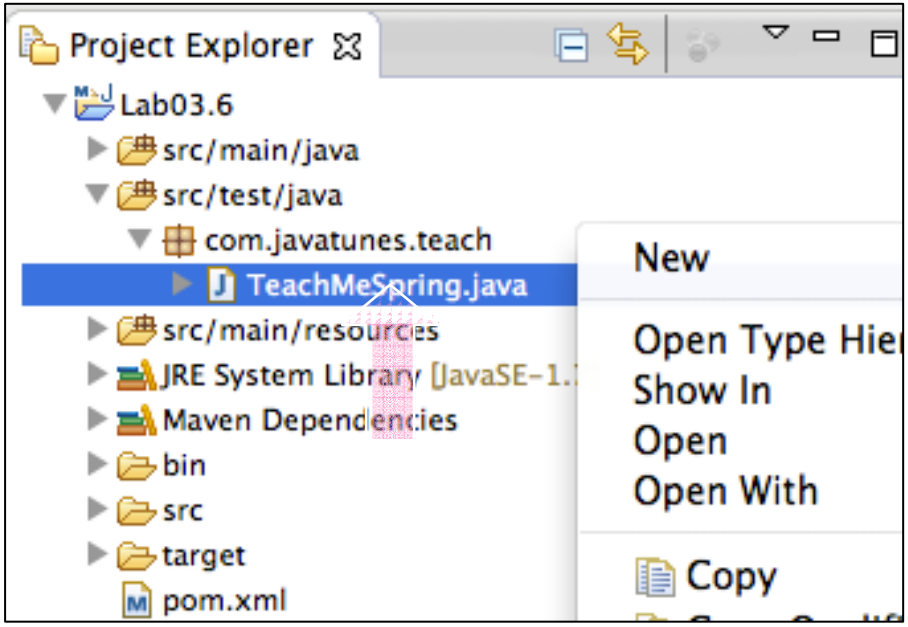


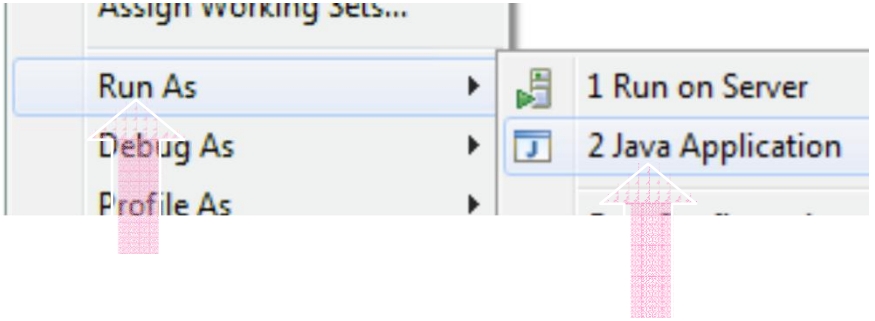
Running the Lab

Lab

Tasks to Perform

- We use Eclipse to run a program we supply in *TeachMeSpring.java*
  - This is basically unchanged from non-maven projects
- After a clean build do the following
  - In the **Package Explorer** pane, right click on *TeachMeSpring.java* (in package com.javatunes.teach under the src/test/java folder)
  - Select:
    Run As -> Java Application
  - This will automatically find the main method in *TechMeSpring* and run it for you





Program Output

Lab

- You should see output in the Eclipse Console view showing the results of running the program
  - This is the same as with non-maven projects
- That's it - you've used maven to manage your dependencies
  - Note that you didn't need to add in the Spring user library

Problems @ Javadoc Declaration Console

```
<terminated> TeachMeSpring [Java Application] /Library/Java/JavaVirtualMachines/1.7.0u4.jdk/Contents/Home/bin/java (Jan 16, 2013 2:0
2013-01-16 14:04:53,489 INFO [org.springframework.context.support.ClassPathXmlApplicationContext] - Refresh
2013-01-16 14:04:53,551 INFO [org.springframework.beans.factory.xml.XmlBeanDefinitionReader] - Loading XML
2013-01-16 14:04:53,819 INFO [org.springframework.beans.factory.support.DefaultListableBeanFactory] - Pre-i
Dependencies are not so cool
```

STOP

Review Questions

- What is an *ApplicationContext* and how is it different from a *BeanFactory*
- What capabilities does Spring give you to access your program resources?
- What is the scope of a bean?
  - What are the different scopes that Spring gives you for working with beans (not including web-based scopes)?
  - What is an inner bean?
- Describe the lifecycle of a bean managed by the Spring container - What are lifecycle events?
- How does Spring use annotations for defining beans and DI?
  - What other annotations does it support?

Lesson Summary

- The Spring *ApplicationContext* extends *BeanFactory*, and provides the full Spring container functionality
  - Includes the ability to help you access program resources, work with resource bundles, load multiple contexts, and publish events to beans
  - *ClassPathXmlApplicationContext* and *FileSystemXmlApplicationContext* are two common implementations of this interface used in standalone applications

- Spring also provides a complete set of resource access classes
  - Provides resource access (files, urls, etc) in a flexible and powerful way from different locations such as the file system, the classpath, or via a URL
  - Common implementations are *ClassPathResource*, *FileSystemResource*, and *UrlResource*

Lesson Summary

- Spring easily defines both **singleton** and **prototype** scope beans
  - **Singleton bean**: Container creates a single bean instance for a given id
  - **Prototype bean**: Container creates a new instance for each request of a bean with a given id
  - **Inner** beans are associated with the containing bean
    - They are anonymous, and always have prototype scope

- Beans have a sophisticated lifecycle within the Spring container
  - Many lifecycle steps, e.g. instantiating the bean, populating the properties, and calling Spring specific callbacks
  - Spring provides interfaces, such as *ApplicationContextAware*, that allow beans to participate in their lifecycle
  - The interfaces define callback methods from the container that are called at the appropriate time in the lifecycle

Lesson Summary

- Spring provides ***@Component*** to declare beans via annotations
  - It also supports ***@Resource*** for Dependency Injection
  - Supports ***@PostConstruct*** / ***@PreDestroy*** lifecycle callbacks
- **Java-based configuration** was added in Spring 3
  - Can eliminate almost all XML configuration
  - Uses ***@Configuration*** on configuration classes
  - Uses ***@Bean*** on methods that are bean definitions
  - It is a flexible and powerful alternative to XML configuration
- **Maven**, a tool for building and managing Java projects, can be used to manage spring dependencies
  - The **POM** (*pom.xml*) is used for configuration of your project
  - Maven can then download all dependencies and build a project
  - Maven can be integrated with Eclipse via Eclipse plugins

Module 4: Database Access With Spring

Overview

Using Spring with Hibernate

Using Spring with JPA

Note: The Hibernate and JPA sections are independent. You can skip whichever you're not using

Lesson Objectives

- Understand the DAO pattern, and how Spring supports it
- Be familiar with Spring's datasource support
- Be familiar with the Spring Support for Hibernate and JPA

Overview

Overview

Using Spring with Hibernate

Using Spring with JPA

DAO Support

- A **DAO** (**Data Access Object**) can encapsulate DB code
  - One typical approach to deal with the complexity
  - Puts DB functionality **in one place**, making it easier to manage
  - **Encapsulates** DB access
    - Internals not accessible to clients
  - **Insulates your other code** from database details
    - Making clients much simpler
- Spring has extensive support for DAOs
  - We'll focus on Hibernate and JPA-based DAOs
  - We won't cover plain JDBC-based DAOs - no longer widely used
- We'll also look at Spring's datasource support

Datasources

- *javax.sql.DataSource* is standard Java way to manage DB connections
  - It's a connection factory for the underlying physical DB
  - It's configured with connection information
  - Provides connections to client code (via *getConnection()*)

- Spring classes for working with *DataSource*s include:
  - *DriverManagerDataSource*: Simple non-connection pooled implementation of *DataSource*
    - Suitable for testing/development
    - Includes properties for common configuration – e.g. *driverClassName*, *url*, *username*, *password*
  - *JndiObjectFactoryBean*: For general purpose JNDI look up
    - Can be used to look up an existing *DataSource* in JNDI

Configuring the DataSource

- Below, we configure a *DataSource*
  - The ***personnelDataSource*** bean contains DB connection info *
    - It is a Spring ***DriverManagerDataSource***
  - The ***employeeDAO*** bean has the datasource injected
    - It is a ***JdbcEmployeeDAO***, as shown previously
  - The datasource is typically injected into a DAO

```
<bean id="personnelDataSource"
   class="org.springframework.jdbc.datasource.DriverManagerDataSource">
   <property name="driverClassName"
             value="org.apache.derby.jdbc.ClientDriver"/>
   <property name="url"
             value="jdbc:derby://localhost:1527/PERSONNEL"/>
   <property name="username" value="guest"/>
   <property name="password" value="password"/>
</bean>
```

Looking up a DataSource in JNDI

- Often useful, especially in JEE environments
  - Simple to do with the ***jee*** namespace as shown below
  - The ***resource-ref="true"*** attribute signals Spring to look in the local environment
    - i.e. prefix *java:comp/env* to the JNDI name
  - You can do the same lookup with *JndiObjectFactoryBean* *

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

<beans xmlns="http://www.springframework.org/schema/beans"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:jee="http://www.springframework.org/schema/jee"
    xsi:schemaLocation="http://www.springframework.org/schema/beans
        http://www.springframework.org/schema/beans/spring-beans-3.1.xsd
        http://www.springframework.org/schema/jee
        http://www.springframework.org/schema/jee/spring-jee-3.1.xsd">

    <jee:jndi-lookup id="personnelDataSource" jndi-name="/jdbc/personnelDS"
            resource-ref="true">

</beans>
```

[Optional] Using Spring with Hibernate

Overview

Using Spring with Hibernate

Using Spring with JPA

Hibernate Overview

- Hibernate is an Open Source, ORM (Object-Relational Mapping) framework for Java
  - It provides **ORM capability** for using a **Java OO domain model** to manage a relational database
  - Hibernate provides a metadata driven approach to ORM

- Global configuration done in a Hibernate configuration file
  - Typically called ***hibernate.cfg.xml***
  - For example, you usually configure a ***Module Factory*** representing a single database in this configuration fil
- Mappings for individual classes appear in their own mapping file, for instance ***Employee.hbm.xml***
  - In this mapping file you would configure the mapping of the *Employee* class to the database

Typical Hibernate Configuration File

- Here we show a simplified configuration file
  - To illustrate what it looks like
    - We assume that you already know basic Hibernate

```
<!-- Other detail omitted -->
< Module
-factory>
  <!-- Database Connection Settings -->
  <property  name="hibernate.connection.username">guest</property>
  <property  name="hibernate.connection.password">password</property>
  <property  name="hibernate.connection.url">
      jdbc:derby://localhost:1527/PERSONNEL</property>
  <property  name="hibernate.onnection.driver_class">
      org.apache.derby.jdbc.ClientDriver</property>

 <!-- SQL Dialect -->
  <property  name="hibernate.dialect">
      org.hibernate.dialect.DerbyDialect</property>
  <!-- Specify a mapping resource -->
  <mapping    resource="com/javatunes/persist/Employee.hbm.xml"/>/
  Module
  -factory>
```

Using Hibernate Directly

- *Module*
  Factory and *Module*
  are two core Hibernate interfaces
  - *Module*
    Factory is configured to connect to a DB, and gives you
    Module
    s for that DB
  - A **Module**
    is used to interact with the DB
  - We show a (very simplified) example below

- Note that in later examples using Spring we'll ignore transactions
  - We'll get to transactions later

Using Hibernate Directly

```
// much code omitted ...
// Create the Module
factory based on configuration shown previously Module
Factory sf = new Configuration().configure().build Module
Factory();
 Module
s = sf.open Module
();                                    // Create a
Module
s.beginTransaction();
Long id = new Long(1);
Employee e = (Employee)s.get(Event.class,id);
System.out.println("Retreived Employee: " + e.getName());
s.getTransaction().commit();
s.close();
sf.close();
```

Spring Support for Hibernate

- Spring supports Hibernate by providing Hibernate specific versions of the core Spring JDBC classes
  - They provide abstractions of the Hibernate types, and simplify the details of working with them
  - The structure is the same as that used for Spring JDBC
  - Spring 3.1+ supports Hibernate 3 and 4

- The Spring Hibernate 3 packages are:
  - ***org.springframework.orm.hibernate3***: Main package defining integration between Spring and Hibernate
  - ***org.springframework.orm.hibernate3.annotations***: Provides support for Hibernate 3 (JPA) annotations
  - ***org.springframework.orm.hibernate3.support***: Defines support classes for working with Hibernate 3

Local

- ***Local Module***
  FactoryBean: *FactoryBean* that creates a Hibernate *SesssionFactory*
  - This is the usual way to configure a shared Hibernate *Module*
    Factory in a Sping context
  - Useful, even when not using *HibernateTemplate*

- Has properties for Hibernate-based configuration, including:
  - ***dataSource***: DataSource used by the Module Factory
  - ***mappingLocations***: Collection of Hibernate mapping resources, such as *com/javatunes/persist/Employee.hbm.xml*
  - ***hibernateProperties***: Hibernate specific properties, such as *hibernate.dialect*
  - ***configLocation/configLocations***: Location of Hibernate

Local

XML config file(s) for using Hibernate style configuration

Configuring a Hibernate

```
<!-- Datasource config not shown - similar to previous config -->
<bean  id="personnelDataSource">  ...  </bean>

<bean  id="personnel Module
   Factory"  class="org.springframework.orm.hibernate3.Local Module
   FactoryBean">
   <property  name="dataSource"  ref="personnelDataSource"/>
   <property  name="mappingResources">
      <list>
         <value>com/javatunes/persist/Employee.hbm.xml</value>
      </list>
   </property>
   <property name="hibernateProperties">
      <props>
         <prop key="hibernate.dialect">
                org.hibernate.dialect.DerbyDialect</prop>
      </props>
   </property>
</bean>
```

Contextual

- Hibernate 3 introduced contextual Module s
  - *Module Factory.getCurrent Module ()* provides a Module associated with the "current" context
  - Initially this required JTA
    - The Module context is a JTA transaction
  - Hibernate 3.1 added support for Java SE
    - It scopes the Module to a TX using the thread of execution

- Contextual Module s **ease management and propagation of a Hibernate Module**

Contextual

- This was one of *HibernateTemplate*'s main responsibilities
- You can write a Hibernate DAO **without using Spring APIs**
- You don't need a row mapper, since Hibernate does that

Spring Free DAO

- The example below doesn't use the Spring API
  - You can still use Spring to inject the Module factory
  - It does throw Hibernate specific exceptions, not Spring ones
    - *HibernateTemplate* would throw Spring exceptions
- You can use any other Spring capabilities
  - For example, Spring managed transactions (covered later)

```
package com.javatunes.persist;
import org.hibernate. Module                                                    Factory;

public class HibernateEmployeeDAO implements EmployeeDAO {
    private Module                                                    Factory Module
  Factory; // get/set methods not shown

  public Employee searchById(Long id) {
    return (Employee)get Module
        Factory().getCurrent Module
        ().get( Employee.class, id);
    }
}
```

What Approach to Use

- There are multiple approaches to using Spring with Hibernate
  - They are both powerful frameworks, with some overlapping capabilities
- Choose the approach that makes most sense for you
  - For example, if you may switch to a different persistence framework, you can use *HibernateTemplate* to insulate you from the change
  - If you're committed to Hibernate, using contextual Module s directly in the DAO is easy
    - It also does not add any coupling to Spring in the DAO
- You can use Spring DI and transaction support with either approach

[Optional] Using Spring with JPA

Overview

Using Spring with Hibernate

Using Spring with JPA

Template Support for JPA

- JPA: Standard Java ORM mapping specification
  - Similar to Hibernate – uses annotations for mapping
  - An *EntityManager* executes persistent operations
- Spring supports **JPA** similarly to how it supports Hibernate
  - Providing classes that help create JPA based DAOs
  - These are in the package *org.springframework.orm.jpa*
- Spring provides classes for managing/injecting JPA persistence units and entity managers, and we cover these
  - Considered best practice in integrating Spring and JPA
- Old style templates also supported, including *JpaTemplate* and *JpaDaoSupport*
  - These are no longer recommended for Spring / JPA integration

Managing the EntityManager

- Spring supports management and injection of an *EntityManager* (*EM*) and/or *EntityManagerFactory* (*EMF*)

- Multiple ways to accomplish this – via JNDI lookup, or via the two classes below
  - Both in the package *org.springframework.orm.jpa*
  - ***LocalContainerEntityManagerFactoryBean***: Creates a container managed *EMF*
    - Flexible configuration, container managed EM
  - **JNDI lookup**: Looking up of an *EMF* in a Java EE environment using standard Spring/JNDI capabilities
  - ***LocalEntityManagerFactoryBean***: Creates an *EMF* suitable for standalone programs (only)
    - Least flexible in terms of configuration

LocalContainerEntityManagerFactoryBean

- Gives full control over EMF configuration
  - Appropriate for fine-grained customization
  - Supports datasource configuration and load-time weaving
- May conflict with built in JPA capabilities in a Java EE server
  - JNDI lookup generally more appropriate for Java EE
- Supports local and global transactions
- Example configuration shown below
  - It assumes the default *META-INF\persistence.xml*
  - Configure a different persistence unit location with the *persistenceXmlLocation* property

```
<beans>
  <bean id="personellEmf" class=
 "org.springframework.orm.jpa.LocalContainerEntityManagerFactoryBean">
  <property name="dataSource" ref="employeeDataSource"/>
  </bean>
</beans>
```

Container-Managed EntityManager

- *LocalContainerEntityManagerFactoryBean* provides a **transaction-scoped container-managed** entity manager
  - Generally, you inject an EM into a JPA-based DAO
  - A persistence context is associated with, and scoped to, the transaction's lifetime
  - Spring propagates the persistence context associated with the current transaction
  - When the transaction finalizes, the persistence context is flushed (if necessary) and then closed
  - This is the default behavior – you can specify differently (see notes)

- You use standard JPA annotations to inject the EM
  - Similar to how JPA is used in Java EE environment (where the EM can also be injected)

JEE: Obtaining an EntityManager From JNDI

- In Java EE, you can use Spring JNDI lookup for EMF lookup
  - Depends on the Java EE container for:
    - Autodetecting persistence units (i.e via *META-INF\persistence.xml* files in application jars)
    - Defining ENC locations (JNDI names) in the Java EE deployment descriptors using persistence-unit-ref
- Persistence unit deployment done by the Java EE server
  - As is *DataSource* configuration and integration of *EM* transactions with the JTA environment
  - Spring just retrieves the *EMF*, and injects it
    - May also manage transactions (via *JtaTransactionManager*)

```
<beans>
  <jee:jndi-lookup id="employeeEmf"
                   jndi-name="persistence/PersistenceUnit"/>
</beans>
```

LocalEntityManagerFactoryBean

- *LocalEntityManagerFactoryBean* creates an *EMF*
  - Suitable for JPA-only environments
  - Uses the JPA provider's autoscanning in a Java SE environment to detect persistent classes
  - Generally requires only the persistence unit name (from JPA's *persistence.xml*) be specified
  - Below, we show configuration with a persistence unit named "*events*"
  - Very little configuration available for this bean
    - No support for global transactions, nor support for integration with JPA providers that need to specify a JVM agent for weaving *

```
<bean id="eventEmf"
    class="org.springframework.orm.jpa.LocalEntityManagerFactoryBean">
  <property name="persistenceUnitName" value="events"/>
</bean>
```

Additional Spring Configuration

- Additional configuration required for Spring/JPA integration
- **Annotation Scanning** – Spring post-processors must be configured to scan for standard JPA annotations
  - For injecting the EM
  - Done easily with the following element (as seen earlier):

```
<context:annotation-config/>
```

- **Vendor Adaptor**: Configures Spring/JPA-provider integration
  - Supports common configuration properties, including:
    - Should SQL traces be logged
    - The database platform
    - Should the schema be generated in the DB when the app starts
- The next slide shows both these configuration elements
  - Assuming a Hibernate-based JPA provider

Spring Configuration Example

- To use *LocalContainerEntityManagerFactoryBean*

```
<beans ...> <!-- See notes about namespaces -->

  <context:annotation-config/>

  <bean id="vendorAdapter" class=
      "org.springframework.orm.jpa.vendor.HibernateJpaVendorAdapter">
    <property name="databasePlatform"
              value="org.hibernate.dialect.DerbyDialect"/>
    <property name="showSql" value="true"/>
    <property name="generateDdl" value="false"/>
  </bean>

  <bean id="personellEmf" class=
      "org.springframework.orm.jpa.LocalContainerEntityManagerFactoryBean">
    <property name="dataSource" ref="employeeDataSource"/>
    <property name="persistenceUnitName" value="javatunes"/>
    <property name="jpaVendorAdapter" ref="vendorAdapter"/>
  </bean>
</beans>
```

JPA Data Access Object

- A JPA-based DAO is shown below
  - Spring recognizes *@PersistenceContext*, and injects the EM
    - Thanks to the post-processors we configured (see notes)
  - If a TX and associated persistence context is present, the persistence context is associated with the injected EM
    - Otherwise a new persistence context is created
  - That's it – no Spring code in your DAO, and no need to manually propagate the EM – we'll see how useful this is shortly

```
public class JpaEmployeeDAO implements EmployeeDAO {
   @PersistenceContext
   private EntityManager em;   //get/set methods not shown

   public Employee searchById(Long id) {
      return  em.find(Employee.class,id);
   }
}
```

Extended Persistence Context

- Sometimes a persistence context should live longer than a transaction
  - In that case, you must create the EM yourself, and not inject it
  - You generally inject an entity manager factory (using *@PersistenceUnit*), and use it to create the EM
  - You are responsible for controlling the lifecycle of the EM in your code - e.g. closing it when you're done (see notes)
- The code fragment at bottom shows creation of the EM
  - You would close it when you're done with it

```
public class JpaEmployeeDAO implements EmployeeDAO {
   @PersistenceUnit
   private EntityManagerFactory emf;  //get/set methods not shown
   private EntityManager em;

   public JpaEmployeeDAO {
      em    =    emf.createEntityManager();
   }
}
```

Lab – Integrating Spring and JPA

Lab

- **Overview**: In this (optional) lab, we will work with the Spring/JPA integration, including
  - Setting up a database and configuring a datasource bean in spring
  - Configuring persistence annotation processing
  - Setting up a *LocalContainerEntityManagerFactoryBean* bean
  - Finishing a JPA-based DAO that injects an EM
- **Objectives**: To work with the Spring/JPA integration
- **Builds on previous labs**: None
  - You will work in a new project and directory for this lab
- **Approximate Time**: 35-45 minutes
- **Note**: We will be using the Derby database (Apache open source)
  - Originally Cloudscape, it was put into open source by IBM

Review of Lab Classes

Lab

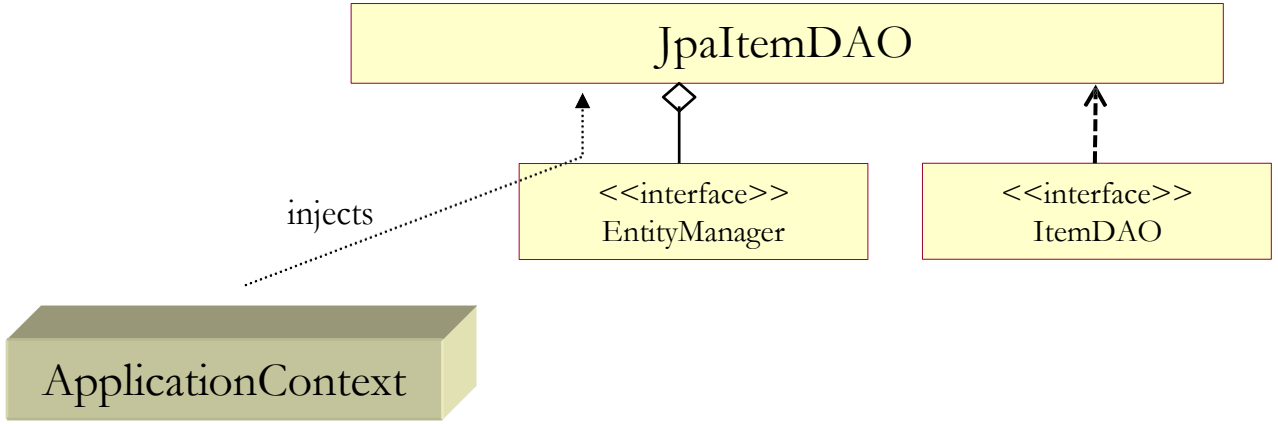
- You will work with the JavaTunes classes in this lab, including:
  - ***com.javatunes.util.MusicItem*** : JavaBean-style value class that represents a music item (e.g. CD, mp3 …) for sale
  - ***com.javatunes.catalog.ItemDAO*** : Interface that defines data access for JavaTunes items
  - ***com.javatunes.catalog.Catalog*** : Interface that defines the functionality of a catalog in JavaTunes
  - ***com.javatunes.catalog.JavaTunesCatalog*** : Concrete *Catalog* implementation

- You'll also need to finish the DAO implementation we supply:
  - ***com.javatunes.catalog.persist.JpaItemDAO*** : Concrete *ItemDAO* implementation that access a database using JPA
  - See the next slide

Our Lab Classes

Lab

- ***JpaItemDAO*** (Implements *ItemDAO*): JPA based MusicItem DAO – Has EM injected
  - Encapsulates JPA code, uses injected EM for persistence operations
- ***JavaTunes***: Top level test program
  - Uses *JavaTunesCatalog*
  - The catalog implementation uses a JPA-based DAO - but this is transparent, as it's injected as an *ItemDAO*



Lab Preparation

Lab

- The new root lab directory where you will do all your work is:

  C:\StudentWork\Spring\workspace\Lab04.1

Tasks to Perform

- Close all open files and projects
- Create a new Java project called Lab04.1 in the workspace *
  - See Lab 1.1 instructions on how to do this if you need to
  - Remember to **add the Spring user library**
- Review the jars in the Spring library (in your Eclipse project)
  - Note these jars, which are required by Spring/JPA and Hibernate
    - spring-orm-n.n.n.RELEASE.jar: This is the Spring orm jar
    - hibernate-*.jar: Hibernate jars
    - slf4j-*.jar: slf4j support required for Hibernate logging
    - *derbyclient-n.n.n.n.jar*: This is the derby driver jar
    - Many other jars required by Hibernate/JPA

Setup/Create the Derby Database

Lab

Tasks to Perform

- Start the Derby database server
  - Execute ***dbStart.cmd*** (you can double-click on it)
  - This starts a standalone Derby server that can accept network connections to the database
  - You should see output like that below in the command window

```
Derby Server
Security manager installed using the Basic server security policy.
Apache Derby Network Server - 10.3.1.4 - (561794) started and ready to accept co
nnections on port 1527 at 2007-10-29 21:02:05.656 GMT
```

- Create the database
  - Execute ***dbCreate.cmd*** (you can double-click on it)
  - This creates the **JavaTunesDB** database which we'll use in the labs*
  - (you can ignore a DROP TABLE error, if you see it)

Using an SQL Command Tool

Lab

- **ij** is Derby's SQL command line tool
  - It allows us to create database objects and view and manipulate database data, without having to write code to do so
  - Most database packages provide such a tool

Tasks to Perform

- Execute ***dbSQL.cmd*** to run ij (you can double-click on it)
  - This command file is set up to connect to the correct DB
  - Using ij, you can browse the DB
  - Execute the query shown below to see the items in the DB

```
ij> select * from item;
    ... Lots of output ...
ij> exit;
```

Finish Spring Configuration

Lab

Tasks to Perform

- Open src***applicationContext.xml*** (The Spring configuration file)
  - Take note of the context namespace in the *<beans>* element
- Add in the ***<context:annotation-config/>*** element
  - This **enables annotation scanning**
- Finish the ***javatunesDataSource*** bean definition
  - Note that *javatunesDataSource* is a ***DriverManagerDataSource***
  - The Derby driver class is ***org.apache.derby.jdbc.ClientDriver***
  - The DB URL is ***jdbc:derby://localhost:1527/JavaTunesDB***
  - The username is ***guest***, the password is ***password***
- We will be using Hibernate as our JPA provider
  - Finish the ***vendorAdapter*** bean definition as follows:
  - Set the *class* to *org.springframework.orm.jpa.vendor.* ***HibernateJpaVendorAdapter***
  - This **configures the Hibernate provider for JPA**

Finish Spring Configuration

Lab

Tasks to Perform

- Finish the *javatunesEmf* bean definition, which configures our entity manager factory, as follows:
  - Set the *class* to: *org.springframework.orm.jpa.LocalContainerEntityManagerFactoryBean*
  - Set the *dataSource* property to *javatunesDataSource*
  - Set the *persistenceUnitName* property to *javatunes*
  - Set the *jpaVendorAdpater* to *vendorAdapter*
  - This finishes configuration for our EMF
- Review *src\META-INF\persistence.xml* also
  - The JPA persistence unit configuration
- That's it for configuration
  - You've configured a data source, the JPA provider (via the vendor adapter), and the EMF

Finish DAO and Test Program

Lab

Tasks to Perform

- Open ***JpaItemDAO.java*** (This is our DAO implementation)
  - Review the code – this is a DAO that encapsulates the JPA code
  - It uses an injected EM for its persistence functionality
  - You need to finish the code in this DAO as described below
- Add the ***@PersistenceContext*** annotation on the EM declaration so it will be injected
  - Notice that we don't have to initialize the EM – it will be injected into the DAO, and we simply use it within the class
  - Finish the *find(Long id)* method
    - It should simply call the entity managers find, then return the results it gets
- Note that the DAO is purposely kept very simple, with one method
  - We just include enough to demonstrate the Spring/JPA integration

Finish DAO and Test Program

Lab

Tasks to Perform

- Open ***JavaTunes.java*** for review
  - It already contains code that uses a catalog bean
  - The catalog bean now uses a JPA-based DAO, but this is transparent to the client
- **Run** the JavaTunes program and view the output
  - It should successfully find the item - done with the DAO and its injected JPA entity manager
  - That's it – you've successfully configured and used a JPA-based DAO that uses an injected EM

STOP

Review Questions

- What is a Data Access Object (DAO), and how is it used?
- How does Spring support Hibernate?
- How does Spring support JPA?

Lesson Summary

- A **DAO** encapsulates database access and insulates the rest of your application code from dealing with database details
  - It also gathers all the DB code in one place, making it easier to manage

- **Spring** provides a rich selection of types to help you create DAOs
  - It manages most of the low-level details of working with JDBC, such as acquiring and releasing connections
  - It also provides a fine-grained runtime exception hierarchy that is used instead of the checked *SQLException* from JDBC

Lesson Summary

- Spring has extensive support for using ORM technologies like **JPA** and **Hibernate**

- For Hibernate, Spring supports the configuration of Module Factory's
  - Which easily integrates with other Spring beans, such as datasources
  - It depends on contextual Module s for Module propagation

- For JPA, Spring supports the injection of entity managers or entity manager factories
  - It also has support for configuring the entity manager factory
  - This makes it extremely easy to integrate Spring and JPA – for the most part, the Spring support is transparent – the entity manager is injected

Lesson Summary

with the standard Java annotations

Spring Transaction Management
XML Configuration

Lesson Objectives

- Understand and configure Spring transaction managers
- Understand how declarative transaction management works
- Use Spring declarative transaction management with both annotations and XML configuration

LEARNINGPATTERNS

Spring Transaction Management

Spring Transaction Management

XML Configuration

Transaction (Tx) Overview

- **Transaction**: A collection of actions on the state of a system
  - Transformation of a system from one consistent state to another
  - The collection of actions must conform to the **ACID** properties below
- **A**tomicity: All of the work in a transaction is saved or none is saved
  - For example, all the actions in a bank transfer must occur
- **C**onsistency: A transaction is a correct transformation of the state
  - e.g., In a bank transfer the source account is debited the same amount the destination account is credited
- **I**solation: Even though transactions execute concurrently, it appears to each transaction that they occur sequentially
  - e.g., A bank transfer should be able to ignore any other transactions reading and writing the bank accounts
- **D**urability: Once a transaction completes successfully (commits), its changes to the state survive failures – like a server crash

Transaction Lifecycle

- A transaction is begun by the client or system
  - Thereafter, program operations are part of the transaction
  - All operations performed by other programs in the service of this program are part of the transaction
- **Committing** declares the operations to be complete & correct
  - Once the transaction commits, its effects are durable
- **Rolling back** undoes the operations
  - The system can cause a rollback if it detects some failure
- Transactions allow easy modularizing of a system
  - Each module is a transaction (or sub transaction)
  - If all goes well, the transaction commits and all the modules move to a new (durable) state
  - If something fails, the transaction is rolled back

Transaction Managers

- Spring **transaction managers** abstract the underlying transaction resource controlling transactions
  - Your code is not coupled to a particular transaction implementation
  - The transaction manager delegates to the underlying resource
    - They do NOT handle the transaction themselves
- Spring supplies a number of transaction managers
  - For many environments, including direct JDBC, Hibernate, Java EE, and JPA
- Each transaction manager requires appropriate resources
  - e.g., the JDBC transaction manager requires a *DataSource*,
  - The resources are generally configured in the Spring config

Configuring Transaction Managers

- In the examples below, we show two configuration examples
  - *DataSourceTransactionManager* - for a single JDBC *DataSource*
  - *HibernateTransactionManager* for a Hibernate *Module Factory*
  - That's all that's needed to configure them

```
<bean id="personnelDataSource"
 class="org.springframework.jdbc.datasource.DriverManagerDataSource">
    <!-- Detail not shown --> </bean>

<bean id="transactionManager" class=
    "org.springframework.jdbc.datasource.DataSourceTransactionManager">
   <property name="dataSource" ref="personnelDataSource"/>
</bean>
```

```
<bean id="personnel Module
   Factory" class="org.springframework.orm.hibernate3.Local Module
   FactoryBean">
   <!-- Detail not shown --> </bean>

<bean id="transactionManager" class=
    "org.springframework.orm.hibernate3.HibernateTransactionManager">
```

Configuring Transaction Managers

```
    <property  name=" Module
    Factory"  ref="  personnel Module
    Factory  "/>
</bean>
```

JTA Transaction Manager

- Spring provides ***JtaTransactionManager*** to support JTA transactions
  - JTA (Java Transaction API) is a standard part of the JEE spec
  - Available in all Java EE servers
- It's very easy to configure a *JtaTransactionManager*, as shown below
  - The *tranasctionManagerName* property allows configuration of a JNDI lookup name for the JEE server's transaction manager *

```
<bean   id="transactionManager"
  class="org.springframework.transaction.jta.JtaTransactionManager">
    <property   name="transactionManagerName"
                value="java:/TransactionManager"/>
</bean>
```

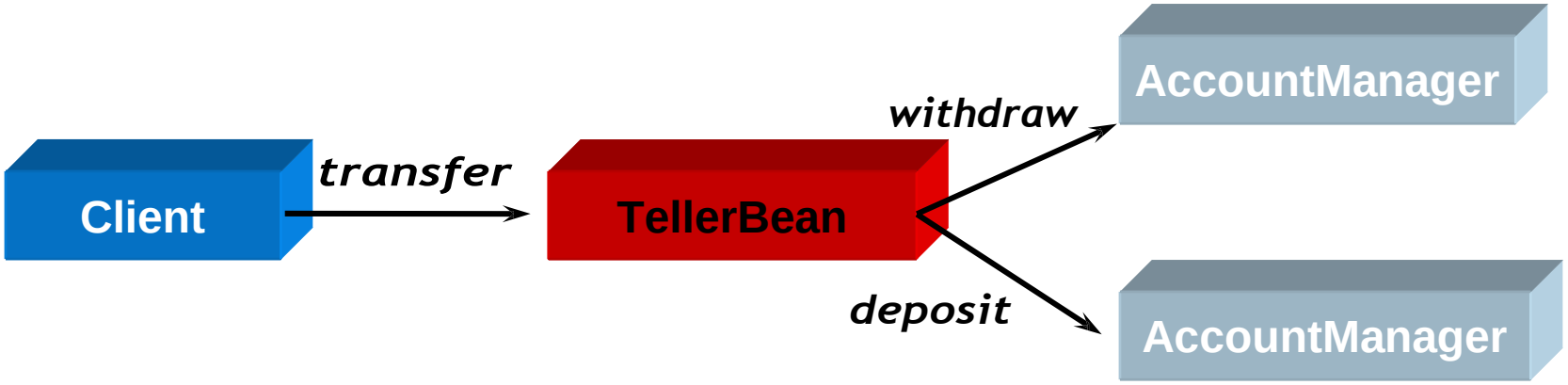
Spring Declarative Transaction Management

- Spring allows you to **declare** a bean's transactional behavior
  - Rather than coding to an API to explicitly control the transaction
  - You define transaction **boundaries** across which a transaction **propagates**, and where transactions can be affected
  - We'll cover the behavior first, then look at adding it to your code
- Based on **Spring AOP**
  - Spring intercepts the method calls and adds in TX behavior
- TX declarations often done with annotations
  - Which requires the configuration below (from the tx namespace)

```
<tx:annotation-driven
                    transaction-manager="transactionManager"/>
```

Spring Transactional Scope

- The **scope** of a transaction is comprised of all the beans in the TX
  - A transaction **propagates** from a bean to other beans that it invokes on
  - The transaction also propagates to resources used from a bean (e.g. a database connection)
  - In the simple banking example below, if a TX is started in *TellerBean*, it will propagate to the *AccountManager* beans
  - If one of the beans accesses a database, the TX will propagate to it



Transaction Propagation

- The transaction context an invocation runs is determined by:
  - **Transaction attributes**: e.g. REQUIRED
  - **The current transactional state**: Is a transaction active
  - There are transaction attributes for **propagation**, **isolation**, and **timeout** of transactions, and for **read-only** transactions
  - We'll cover the TX attributes next
- Depending on the above, the container may
  - **Start a transaction**, if one is not active
  - **Propagate an existing transaction** from one bean invocation to another
  - **Suspend** an existing transaction (to prevent its propagation)
  - This ensures all beans participate in a transaction appropriately

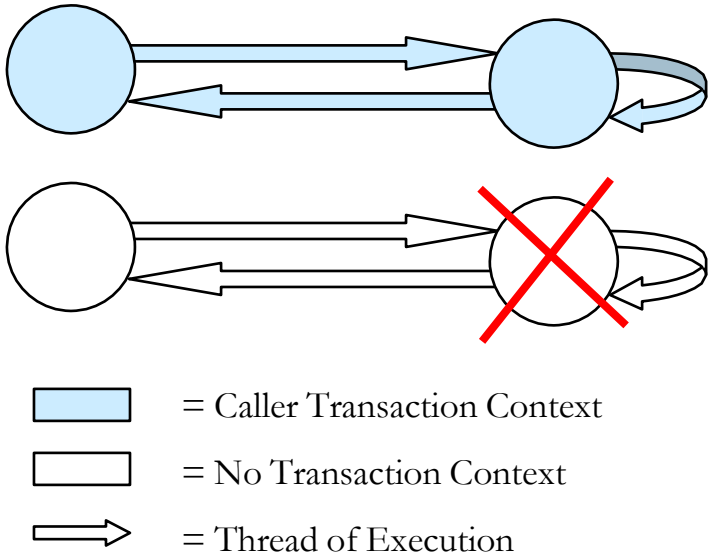
Transaction Attributes for Propagation

- Spring supports the following transaction attributes controlling TX propagation
  - *MANDATORY*
  - *NESTED*
  - *NEVER*
  - *NOT_SUPPORTED*
  - *REQUIRED*
  - *REQUIRES_NEW*
  - *SUPPORTS*

- These can be specified at both a bean & method level
  - **Bean level**: The default for all methods in a bean
  - **Method level**: Behavior for the specific method
    - Overrides any bean level declaration

MANDATORY

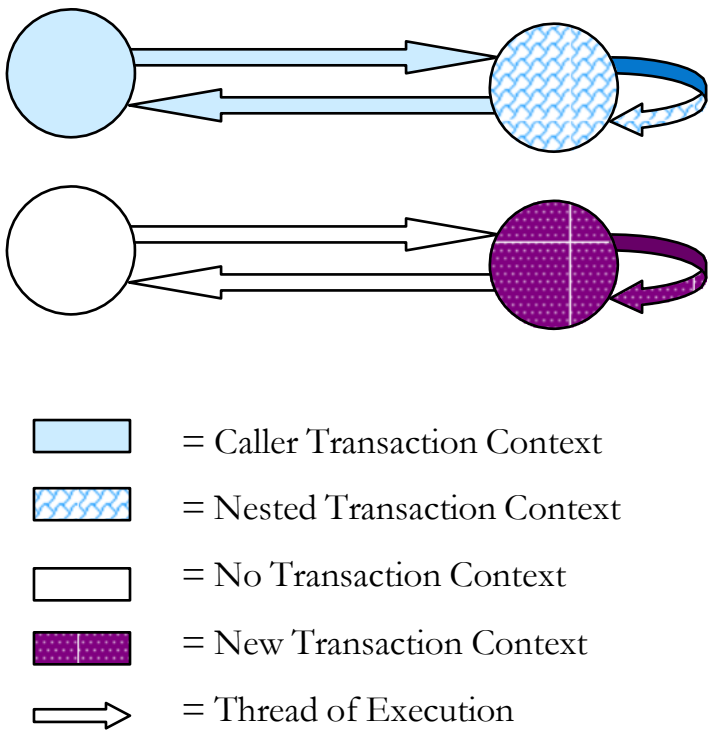
- Invocation **must** occur within the scope of the caller's TX
  - If the client tries to invoke the bean without a TX context, the container throws the *TransactionRequired* exception



- a) Incoming TX propagated by invocation on second bean
- b) No incoming TX, ERROR, exception thrown !

NESTED

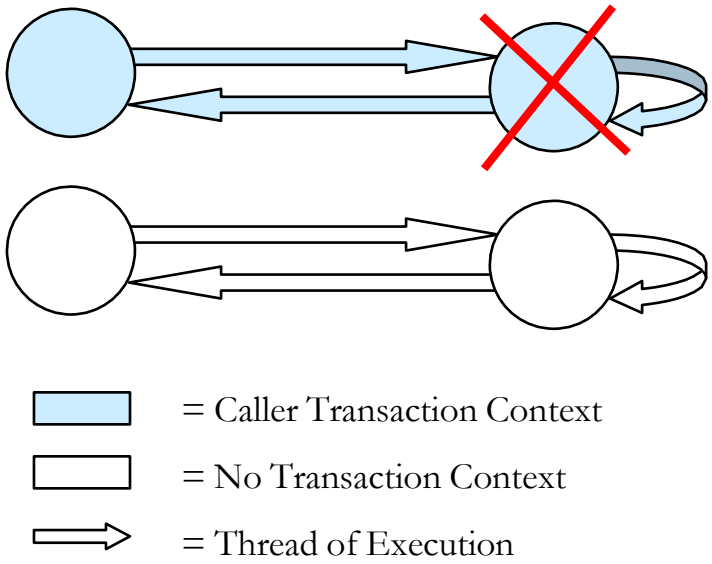
- Invocation always occurs in a TX context
  - If a client is associated with a TX, a nested TX is started
  - If a client is not associated with a TX, a new TX is started



- a) Nested TX started, invocation occurs in nested TX
- b) No incoming TX, so invocation occurs in new TX

NEVER

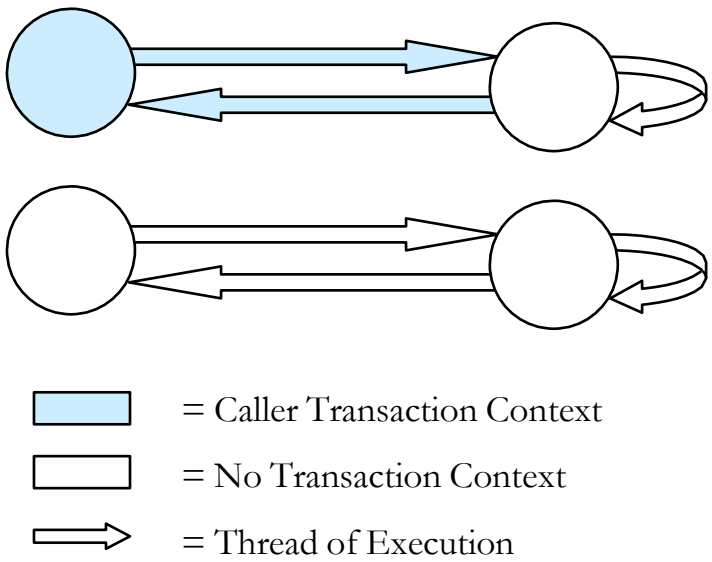
- Caller is **required** to call the bean method **outside** the scope of a TX
  - Container invokes bean without a TX context



- a) Incoming TX, ERROR, exception thrown
- b) No incoming TX, and no TX in invocation

NOT_SUPPORTED

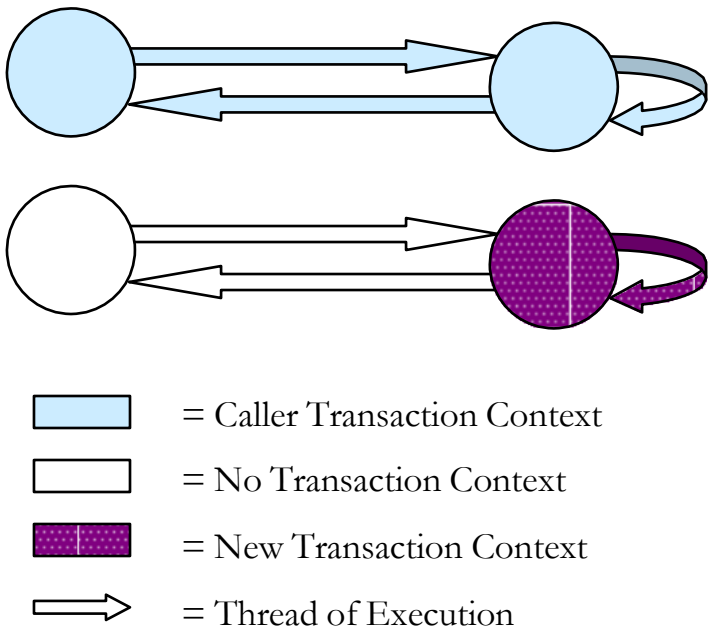
- Invocation should **not** be executed within a TX
  - A container should always invoke the bean outside a TX
  - If a client calls within a TX, the TX is suspended, the method is executed, and then the TX is resumed
  - The suspended TX context is not passed to resources invoked from the object



- a) Incoming TX suspended in invocation on second bean
- b) No incoming TX, and no TX in invocation

REQUIRED

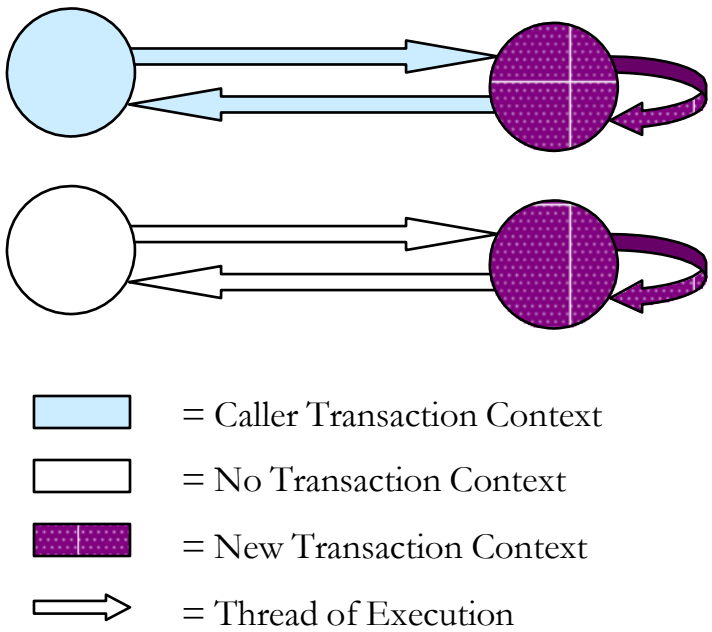
- If caller is in a TX, the bean method is invoked in that TX context
- If caller is not in a TX, bean method is invoked in a new TX
  - The container attempts to commit the TX when the method call completes



- a) Incoming TX propagated by invocation on second bean
- b) No incoming TX, so invocation occurs in new TX

REQUIRES_NEW

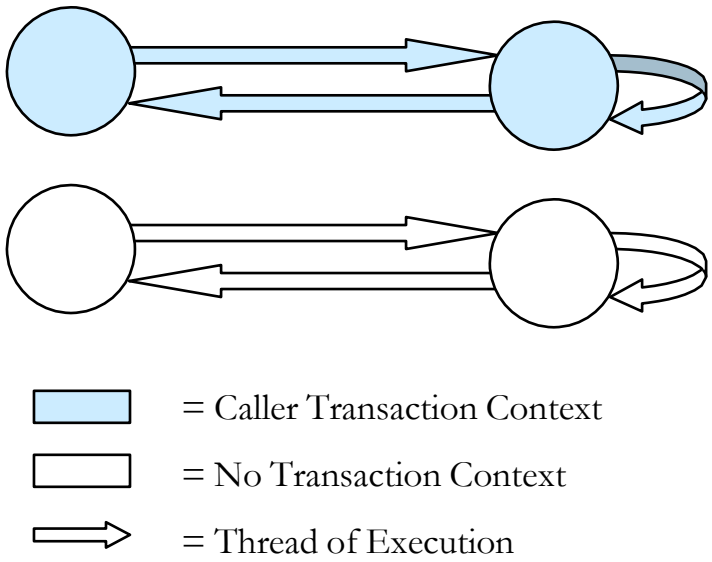
- Invocation always occurs in a new TX context
  - The container starts a new TX before invoking a method, and attempts to commit it when the method returns
  - If a client is associated with a TX, it is suspended before the new TX is started, and resumed when it completes



- a) Incoming TX suspended, invocation occurs in new TX
- b) No incoming TX, so invocation occurs in new TX

SUPPORTS

- The bean method is invoked in the **caller's** TX scope
  - If the caller has a TX context, it is passed in
  - If the caller doesn't have one, then there is no TX context

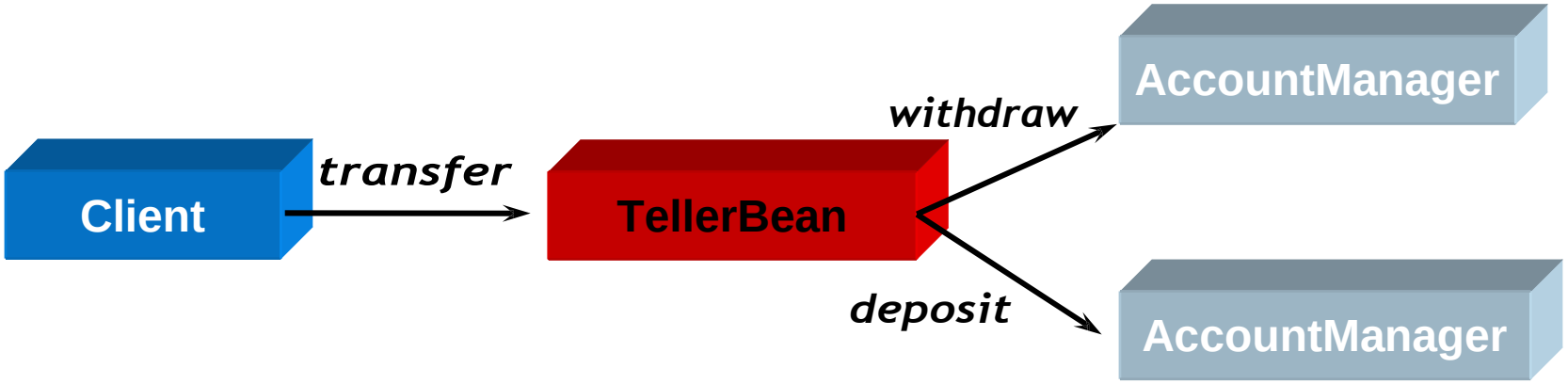


- a) Incoming TX propagated by invocation on second bean
- b) No incoming TX, and no TX in invocation

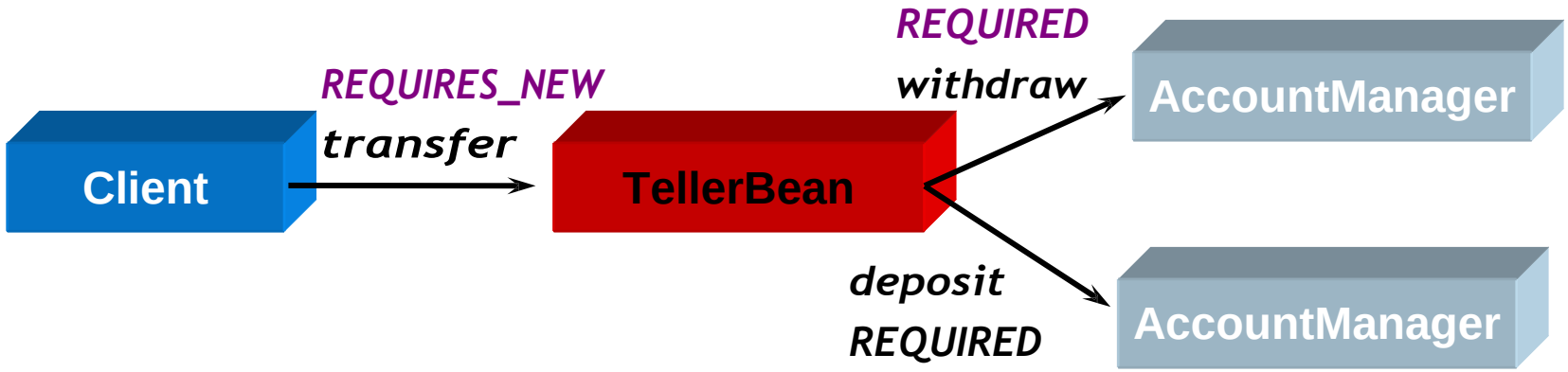
Transaction Example

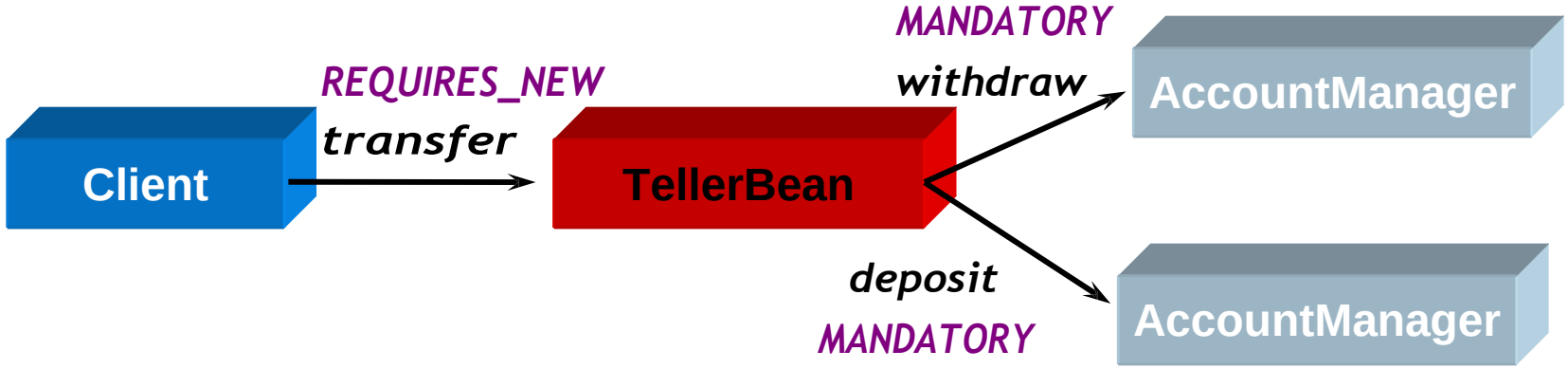
- A transfer involves two account objects
  - You withdraw from one, deposit to another
  - How do you do this in one transaction?

- One way to do this is to create a teller Module bean that has a *transfer* method calling *withdraw* on the "from" account and *deposit* on the "to" account

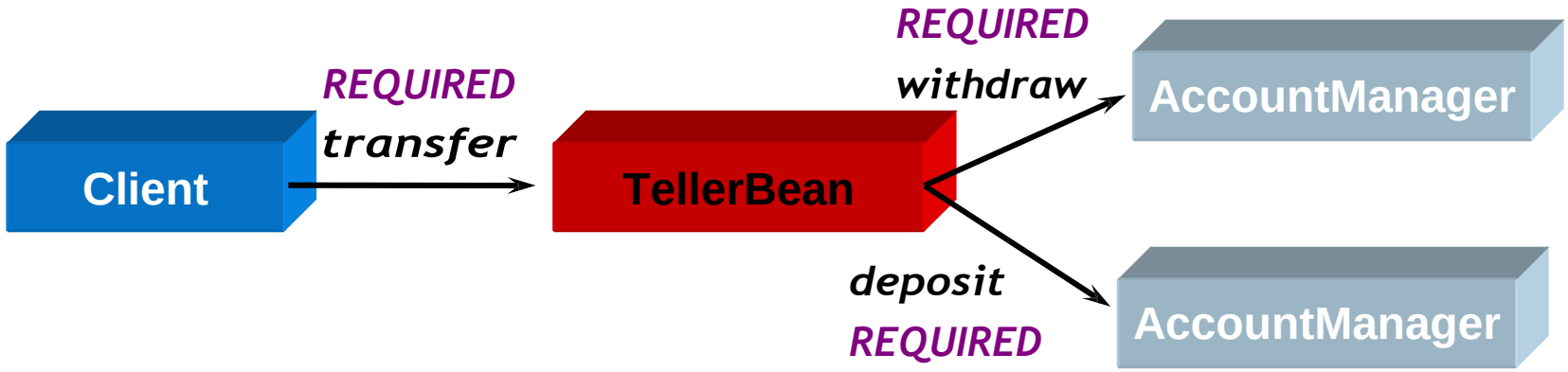


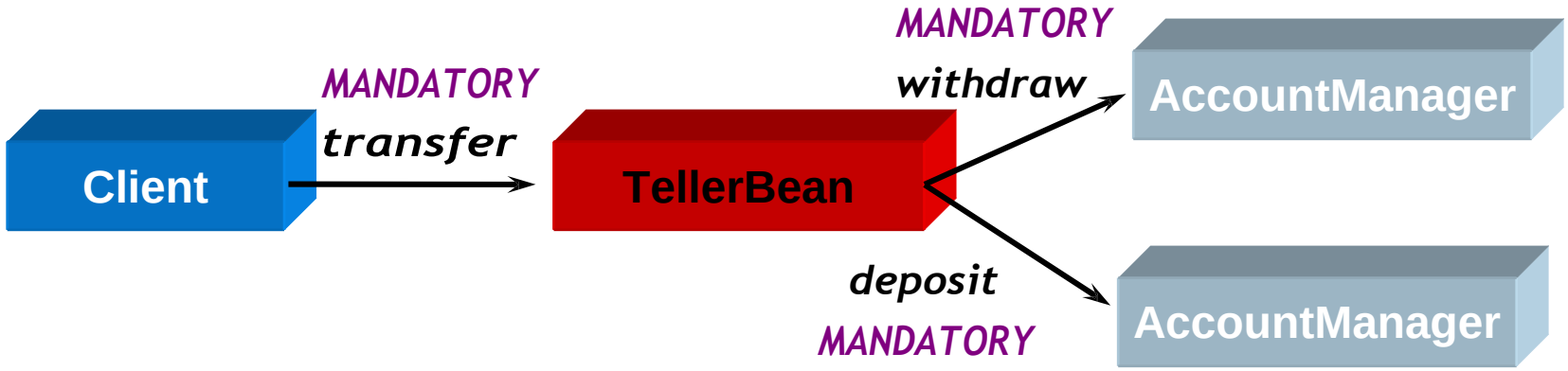
Transaction Attributes – Some Choices





Transaction Attributes - Some Choices





Specifying Transaction Attributes

- Transaction attributes can be declared with Spring annotations
  - In package: *org.springframework.**transaction.annotation***
- **@Transactional** is the main annotation
  - It describes transaction attributes on a method or class
- Two enumerations also defined in the package
  - ***Isolation*** defines supported transaction isolation levels
  - ***Propagation*** defines transaction propagation behaviors
- Declarative transactions makes programming much simpler
  - No need to code to a potentially complex API
  - Removes need for transactional code mixed with business code
- Numerous facets to this control
  - We'll look at TX propagation first

Specifying Transaction Attributes

- Below, *JdbcEmployeeDAO* methods are given a default TX propagation of ***SUPPORTS***
  - We override this in *create()* with a propagation of ***REQUIRED***
  - *create()* **always** runs within a transaction
  - The search methods run in the caller's TX scope
  - Declaring TX behavior is **easy** !

```
import    org.springframework.transaction.annotation.Propagation;
import    org.springframework.transaction.annotation.Transactional;

@Transactional(propagation=Propagation.SUPPORTS)
public class JdbcEmployeeDAO extends JdbcDaoSupport
                                        implements EmployeeDAO {
  public Employee searchById(int id) { /* Details not shown */ }
  public Collection searchByName(String name) { /* … */ }

  @Transactional(propagation=Propagation.REQUIRED)
  public int create(Employee emp) { /* Details not shown */ }
}
```

Additional Transactional Attributes

- Other transactional attributes of *@Transactional* include:
- ***Isolation isolation***: Degree of isolation this TX has from the work of other transactions
  - DEFAULT, READ_COMMITTED, READ_UNCOMMITTED, REPEATABLE_READ, SERIALIZABLE
- ***int timeout***: how long (seconds) the tx may run before timing out
- **boolean readOnly**: true if the transaction is read-only.
  - A read-only TX does not modify any data
  - Sometimes a useful optimization (such as when using Hibernate)
- Below, we set *readOnly* status & *timeout* for *searchByName()*

```
@Transactional(readOnly=true, timeout=10)
public Collection searchByName(String name) { /* … */ }
```

Transactional Attributes Guidelines

- Generally, TX annotations are placed on a **concrete class**
  - Not on an interface, which may not work in all situations *
  - Only **public methods** work with the TX annotations
    - Assuming the proxy-based implementation (details covered later)
- Your annotated classes should **implement an interface**
  - This allows the use of JDK dynamic proxies (see notes)
  - This is fairly standard when using Spring anyway
- Proxy mode (the default) is limited
  - Self-invocations will not be wrapped in transactions, even if annotated
  - We'll cover this later

Rolling Back and Exceptions

- By default, Spring marks a TX for rollback if an unchecked (e.g. runtime) exception is thrown
  - This is the recommended way to trigger a rollback
  - The container will catch an unhandled exception, and mark the active TX for rollback
  - Checked exceptions do not trigger a rollback by default

- Refine rollback behavior with the following *@Transactional* elements
  - ***Class[] noRollbackFor***: Classes that should NOT trigger a rollback
  - ***String[] noRollbackForClassName***: Names of classes that should NOT trigger a rollback
  - ***Class[] rollbackFor***: Classes that SHOULD trigger a tx rollback
  - ***String[] rollbackForClassName***: Names of classes that SHOULD trigger a rollback

Lab 5.1 – Spring Transactions

Lab – Spring Transactions

Lab

- **Overview**: In this lab, we will work with the Spring transaction capabilities, including
  - Configuring annotation driven transactions in the Spring config
  - Adding transactions to a bean
  - Working with different transactional behavior
  - The lab uses Spring's JDBC support to provide an environment where we can work with the transaction support
- **Objectives**: To work with the Spring transaction support
- **Builds on previous labs**: None
  - You will work in a new project and directory for this lab
- **Approximate Time**: 35-45 minutes

Lab Preparation

Lab

- The new root lab directory where you will do all your work is:

  C:\StudentWork\Spring\workspace\Lab05.1

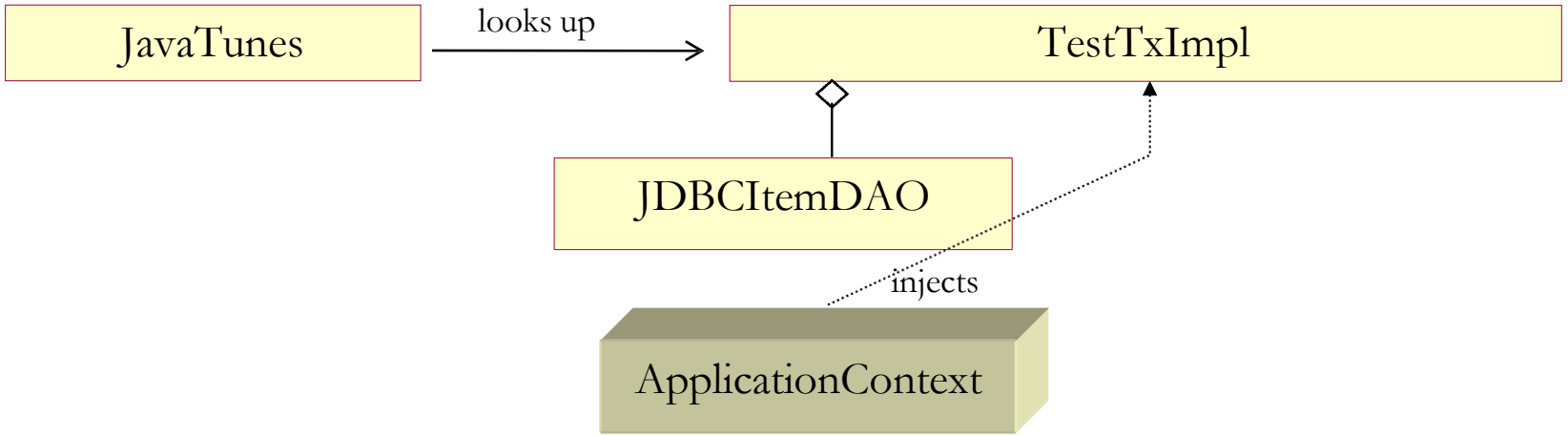
Tasks to Perform

- Close all open files and projects
- Create a new Java project called Lab05.1 in the workspace
  - See Lab 1.1 instructions on how to do this if you need to
  - Remember to **add the Spring user library**
- Make sure that the database is running
  - See Lab 4.1 if you need details on starting the DB

Our Lab Classes

Lab

- ***JDBCItemDAO*** (implements *ItemDAO*): JBDC-based DAO
  - DAOs have new method *blowUp()* which throws a runtime exception (we'll use it to roll back a transaction)
- ***TestTxImpl*** (implements *TestTx*): Test bean that has a *MusicItemDAO* injected
  - One method, *runTest()*, that first calls *create()*, then calls *blowUp()* on the DAO
- ***JavaTunes***: Top level driver program



Finish Spring Configuration

Lab

Tasks to Perform

- Open ***applicationContext.xml*** (The Spring configuration file)
  - Take note of the tx namespace in the *<beans>* element
- Add in a **DataSource transaction manager bean** (see notes)
  - The *dataSource* property should refer to the *javatunesDataSource* bean that is already present in the config file
  - This bean integrates the spring transactions with your DataSource
- Add in the ***tx:annotation-driven*** element (see notes)
  - The transaction-manager attribute should refer to the transaction manager you just created
  - This element enables annotation driven transactions
- Note the declaration of the *JdbcItemDAO* bean we supply

Persistence Context Propagation

Lab

Tasks to Perform

- Open ***TestTxImpl.java*** and review the *runTest()* method
  - It simply uses its injected *MusicItemDAO* bean to call *create()*, then *blowUp()*
- Open ***JavaTunes.java*** for review – note that it looks up a TestTx bean, and calls *runTest()* on it
  - It then searches for the item created in *runTest()* (via *create()*)
- **Run** the program, and look at the console output
  - You should see that a new music item was created
  - *create()*'s transaction finalizes before *blowUp()* is called

```
Created container
Exception thrown in TextTxImpl: Blowup
*** searchByKeyword for 'Transaction' found the following: ***

com.javatunes.util.MusicItem: id=22: num=CD599 title=Transaction Blues artist=We are Commi
*** searchByKeyword - Transaction finished ***
```

Transaction Rollback

Lab

Tasks to Perform

- In ***TestTxImpl.java*** annotate *runTest()* with ***@Transactional*** and the proper propagation so a transaction is **REQUIRED**
- **Run** the program again, and look at the console output
  - There should not be any new items created – no matter how many times you run the program
  - We're running in the context of the transaction started in *runTest()*
    - The call to *blowUp()* rolls this tx back
    - The call to *create()* is running in the same tx, so it rolls back also

```
Created container
Exception thrown in TextTxImpl: Blowup
*** searchByKeyword for 'Transaction' found the following: ***

com.javatunes.util.MusicItem: id=22: num=CD599 title=Transaction Blues artist=We are Commi
*** searchByKeyword - Transaction finished ***
```

Creating a New Transaction

Lab

Tasks to Perform

- In ***JdbcItemDAO.java*** annotate *create()* with ***@Transactional*** with the proper propagation to require a NEW transaction
- **Run** the program again, and look at the console output
  - You should now see that an additional item was created
  - Since the call to *create()* runs in its own transaction, the call to *blowUp()*, which rolls back its transaction, has no effect on *create()*
- You can see how easy it is to control TX behavior with Spring

```
Exception thrown in TextTxImpl: Blowup
*** searchByKeyword for 'Transaction' found the following: ***

com.javatunes.util.MusicItem: id=22: num=CD599 title=Transaction Blues artist=We are Commit
com.javatunes.util.MusicItem: id=26: num=CD599 title=Transaction Blues artist=We are Commit
*** searchByKeyword - Transaction finished ***
```

[Optional] Look at TX Flow

Lab

[Optional] Tasks to Perform

- If you have time, use *TransactionSynchronizationManager* to get information about the TX flow
  - It's in *org.springframework.transaction.support*
  - We already include some output using this in the starter code
  - Use ***getCurrentTransactionName()*** in different places in your code to get the current transaction name, and output it to the console
  - This can help you see what TX is active - which is helpful in getting an understanding, and can also be helpful in debugging
  - This class is generally not used in user code, but can be useful when learning or debugging

```
System.out.println("TextTxImpl.runTest: " +
    TransactionSynchronizationManager.getCurrentTransactionName());
```

Spring Proxies and Direct Invocation

- Spring transactions are based on Spring AOP
  - Spring AOP, by default, works via proxies
  - The method invocation is intercepted, and the TX is added in
  - This affects TX behavior, as described below
- You must access an object **through a proxy** for transactions to work
  - i.e. - Via a reference originally looked up from the application context
  - Otherwise, the container can't add in the TX behavior
- If you are in a class, and call another method on the same class, **the invocation won't include any new TX behavior**
  - Because the invocation is through the *this* reference, not through a proxy

Example – Invoking Directly

- What happens when *empDAO.createAll()* is called
  - *create()* called multiple times, and it's set to REQUIRES_NEW

```
import    org.springframework.transaction.annotation.Propagation;
import    org.springframework.transaction.annotation.Transactional;

public class JdbcEmployeeDAO implements EmployeeDAO {

  @Transactional(propagation=Propagation.REQUIRED)
  public void createAll(Collection<Employee> employees) {
    for (Employee emp : employees) {
      create(emp); // Call create() directly
    }
  }
  @Transactional(propagation=Propagation.REQUIRES_NEW)
  public int create(Employee emp) { /* Details not shown */ }
}
```

```
EmployeeDAO empDAO = (EmployeeDAO)ctx.getBean("employeeDAO");
Collection<Employee> emps = // Initialized in some manner …
empDAO.createAll(emps);   // What happens here
```

Example – Invoking Directly

- *create()* has a *REQUIRES_NEW* TX attribute in the example
  - In the example, **that TX is NOT activated**
  - The call to *create()* goes through the ***this*** reference
  - That is **not a proxy**, so proxy-based behavior doesn't run
  - It may be possible to refactor your code to solve this
    - Cumbersome, not always possible
  - Better solution - configure Spring AOP / TX so proxies are not used
- You can configure Spring to use **load-time weaving**, which doesn't have this issue, via:

  <context:load-time-weaver/>

  - Replaces the proxy-based behavior

Load-Time Weaving

- Load-Time weaving (LTW) weaves aspects into class files as they are loaded into the JVM
  - So the aspects (including TX) become part of the class file
  - Not dependent on Spring proxies
  - Based on AspectJ capabilities that are integrated into Spring
- The configuration below configures load-time weaving
  - ***mode="aspectj"*** configures Spring to weave classes at load-time with Spring's AspectJ transaction aspect
  - ***aspectj-weaving="on"***: Specifies AspectJ weaving be used, even if there are no AspectJ configuration files
    - *META-INF\aop.xml* files (see notes)

```
<tx:annotation-driven  mode="aspectj"/>

<context:load-time-weaver  aspectj-weaving="on"/>
```

Spring's Load-Time Weaving

- *context:load-time-weaver* registers a number of LTW-related beans
  - Enables LTW by utilizing the existing support in many common app servers, with no other changes
  - Including JBoss, GlassFish, WebSphere, Weblogic, and others
- Using it in a Java SE environment requires adding support for class instrumentation (to weave the byte code)
  - Can be done by starting the JVM with a Java agent provided with Spring, as shown below
  - Not applicable to application server environments

```
-javaagent:C:\spring-framework-3.2.2.RELEASE\libs\
                    spring-instrument-3.2.2.RELEASE.jar
```

[Optional] Lab 5.2: Load-Time Weaving

Lab: Load-Time Weaving

Lab

- **Overview**: In this lab, we will enable load-time weaving for our program
  - Using the Java agent approach, since we're in a Java SE environment
  - We'll then test some code that will not work in a proxy-based approach (since it uses self-invocation)
- **Objectives**: Configure and use Spring's load-time weaving for TX support
  - Test load-time weaving
- **Builds on previous labs**: 5.1
- **Approximate Time**: 20-30 minutes

Test Self-Invocation and TX Behavior

Lab

Tasks to Perform

- Open *JdbcItemDAO* for editing
  - Uncomment the *runTest()* method
  - This method calls *create()*, then *blowUp()* using self-invocation
- Open *ItemDAO* for editing
  - Uncomment the *runTest()* method
- Open JavaTunes for editing
  - Comment out the block of code calling *test.runTest()*
  - Uncomment the block of code calling *dao.runTest()*
  - Your program now calls the code that uses self-invocation
- **Run** your program again
  - You should not see any new items created
  - Even though create() is annotated with REQUIRES_NEW, the call is not being wrapped in a transaction, since it's called via self-invocation
  - Self-invocation does not work in a proxy-based environment

Add Load-Time Weaving

Lab

Tasks to Perform

- Open src***applicationContext.xml*** (The Spring configuration file)
  - In the ***tx:annotation-driven*** element, add the following attribute to turn on AspectJ load-time weaving

    mode="aspectj"
  - Add in the following element to configure the load-time weaving

    <context:load-time-weaver aspectj-weaving="on"/>
- Open the Run Configuration for your program
  - Menu item **Run | Run Configurations**, then choose the JavaTunes run configuration for this program (It will have a project of Lab05.1)
  - Click on the arguments tab, and add the following in the VM arguments (with no newlines or spaces included)
    - Note: The **hyphen (-) before javaagent must be included**

-javaagent:C:\spring-framework-3.2.2.RELEASE\libs\spring-instrument-3.2.2.RELEASE.jar

  - Adjust accordingly for different versions or install locations

Test Self-Invocation and TX Behavior

Lab

Tasks to Perform

- **Run** your program again
  - You **should** see new items created
  - Self-invocation will work with load-time weaving
- You may also that your program starts/runs more slowly
  - Instrumenting the classes, and running the instrumented classes has a noticeable amount of overhead

STOP

[Optional] XML Configuration

Spring Transaction Management

XML Configuration

Specifying Transactions Using XML

- Spring supports TX specification with XML
  - Via tags in *tx* and *aop* namespaces
  - We'll go (very) briefly into some of the details here
- Below, is an example TX configuration using XML
  - ***<tx:advice>***: Defines the transactional semantics of methods
  - ***<tx:attributes>***: Contains transactional attributes
  - ***<tx:method>***: Specifies the TX attributes of the named method(s)
    - Below, methods with names that start with *create* or *search* have **REQUIRED** TX propagation
    - The search methods are read-only

```
<tx:advice id="defaultDaoAdvice">
  <tx:attributes>
    <tx:method name="create*" propagation="REQUIRED"/>
    <tx:method name="search*" propagation="REQUIRED"
               read-only="true"/>
  </tx:attributes>
</tx:advice>
```

Spring Transactions and AOP

- Spring's XML configuration is based on **AOP** configuration
  - AOP (Aspect Oriented Programming) **encapsulates crosscutting concerns** in one place called **aspects**
  - Covered in depth in the Module on AOP

- Key AOP concepts:
  - **Aspect**: A module holding cross-cutting concerns
  - **Advice**: Action taken by an aspect (its functionality)
  - **Joinpoint**: Point in program execution (e.g. method call), where advice may run
  - **Pointcut**: Specification matching joinpoints. Advice runs at any joinpoint matching its pointcut
  - **Advised (target) object**: An object being advised by an aspect
  - **Weaving**: The combining of aspects with the rest of your app

Defining a Pointcut

- **Joinpoint**: Point in program execution (e.g. method call), where advice may run
  - For TX purposes, they are the places where TX attributes may be applied
- A **pointcut** is a specification that matches joinpoints
  - Basically, it specifies locations in your code (the joinpoints)
  - Defined by a ***pointcut*** element, and an AspectJ expression specifying the joinpoint
  - The id becomes the name of the pointcut
  - The AspectJ expression specifies which joinpoints are of interest
  - Below, we specify a pointcut called ***anyTeach()***, that will match "**any execution of a method called teach**"

```
<aop:config>
  <aop:pointcut id="anyTeach" expression="execution(* teach(..))"/>
</aop:config>
```

Linking Advice With Pointcuts

- TX advice must be associated with a pointcut to run
- AOP pointcuts are used, as shown below
  - ***defaultDAOOperation*** defines a (broad) pointcut applying to any method of any type with DAO in the type's name
    - e.g. *JdbcItemDAO*
  - *<aop:advisor>* associates the pointcut to *defaultDaoAdvice*
  - *JdbcEmployeeDAO*'s *create* and *search** methods (seen earlier) will now run with *defaultDaoAdvice*'s TX attributes
    - Since the class has DAO in its name

```
<aop:config>
  <aop:pointcut id="defaultDAOOperation"
                expression="within(*..*DAO*)"/>
  <aop:advisor  pointcut-ref="defaultDAOOperation"
                advice-ref="defaultDaoAdvice"/>
</aop:config>
```

<tx:method> Attributes

- *<tx:method>* includes the following attributes:
  - ***name***: The method names to associate the tx attributes with
    - Wildcards (*) can be used in method names - e.g. on*Event, create*
  - Attributes corresponding to their *@Transactional* counterparts
    - ***propagation***: The transaction propagation behavior
      - default = REQUIRED
    - ***isolation***: The transaction isolation level, default = DEFAULT
    - ***timeout***: transaction timeout value (sec.) default = -1
    - ***read-only***: Is transaction read-only? default = false
    - ***rollback-for***: Exceptions that will trigger rollback; Value is comma-delimited list of classnames
    - ***no-rollback-for***: Exceptions that will NOT trigger rollback; Value is comma-delimited list of classnames

Why Use XML Configuration

- XML configuration of TX behavior is very powerful
  - It's easy to create a pointcut matching many methods in many classes
  - Allows you to broadly apply TX behavior in a very concise way
  - Annotating all those classes is potentially much more work
- However, it is also **fragile and unpredictable**
  - Changing the name of a class (e.g. from *MyDAO* to *MyDao*) might change the TX behavior, with no indication
    - Other than incorrect behavior !
- You must understand AOP in general, its capabilities, and its issues to use this properly
  - The AOP Module
    in this course contains more information

Review Questions

- What are Spring transaction managers?
- What is declarative transaction management, and how does it work?
- How do you use declarative transaction management in Spring?

Lesson Summary

- Spring **abstracts your program** from the underlying transaction resource via the use of transaction managers
  - Spring has transaction managers for most major environments
  - Resources: JDBC connection, JTA transaction manager, etc.
- Spring supports **declarative specification** of TX behavior
  - Rather than explicitly coding to an API
  - The container propagates a TX from one bean to another based on TX attributes on the bean classes
  - Some attributes include: propagation, isolation, timeout, read-only, rollback-for, no-rollback-for
- **Annotations** or **XML configuration** can be used to declare the TX attributes

LEARNINGPATTERNS

Module 6: Web Applications with Spring MVC

Integration with Java EE

Spring MVC Basics

Forms and Command Objects

Lesson Objectives

- Integrate the Spring container with regular Java Web Applications (first section)

- Understand what Spring MVC is, its goals, and its architecture
  - Learn how to configure the Spring MVC *DispatcherServlet*
  - Use Command Controllers to handler requests
  - Use View Resolvers to map logical names to actual resources (e.g. JSP)
  - Use Spring MVC's support for forms including command classes and form controllers
  - Understand how Spring uses Handler Mappings to map URLs to controllers

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LEARNINGPATTERNS

Integration with Java EE

Integration with Java EE

Spring MVC Basics

Forms and Command Objects

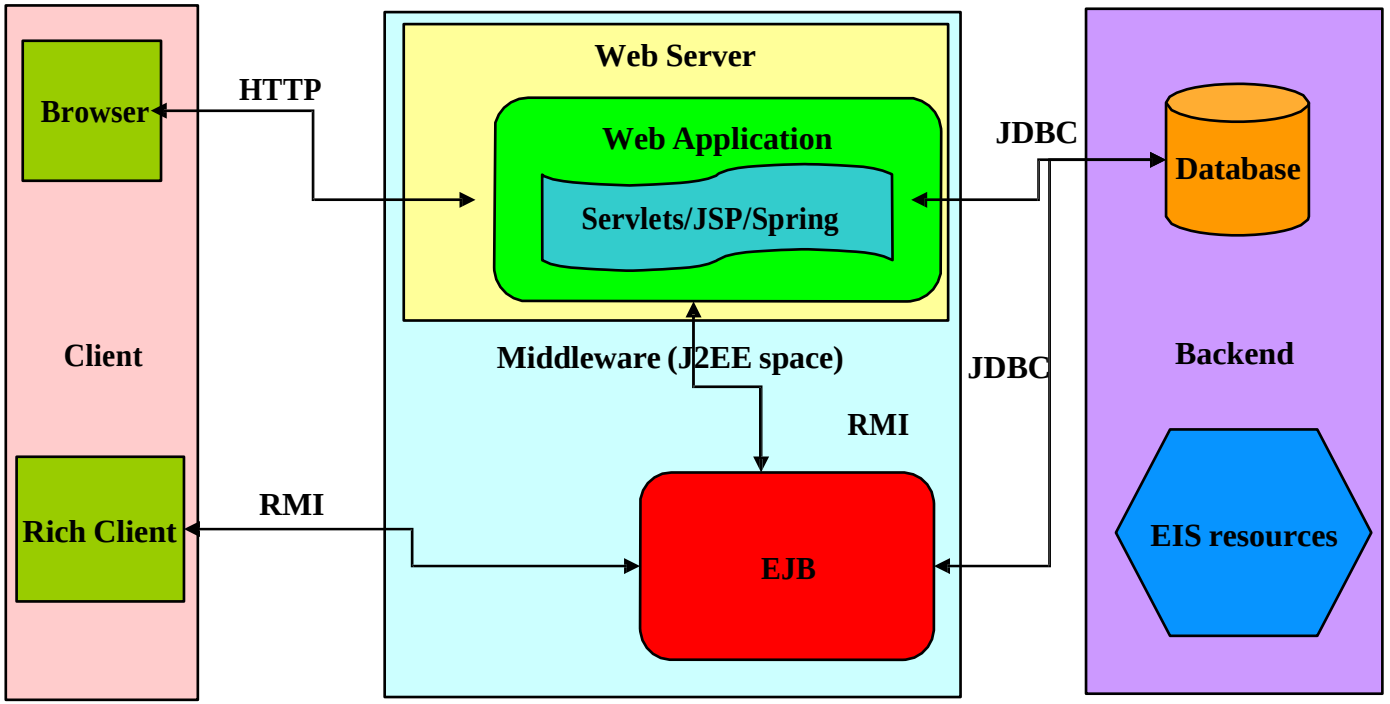
Additional Details

Spring and Java EE

- **Java EE** (**Enterprise Edition**): Standard Java architecture for building scalable, distributed, reliable, Enterprise apps
  - Enterprise Edition basically means "Server Side" Java
- Spring can complement or replace many parts of Java EE
  - Often useful to integrate existing web apps with Spring
  - Fairly easy to use **Spring beans and DI** with Java EE Web apps
  - We'll look at this first - it is used for Spring MVC integration also
- We'll look at **Spring MVC** after this
  - Powerful web framework to build complex web apps more easily

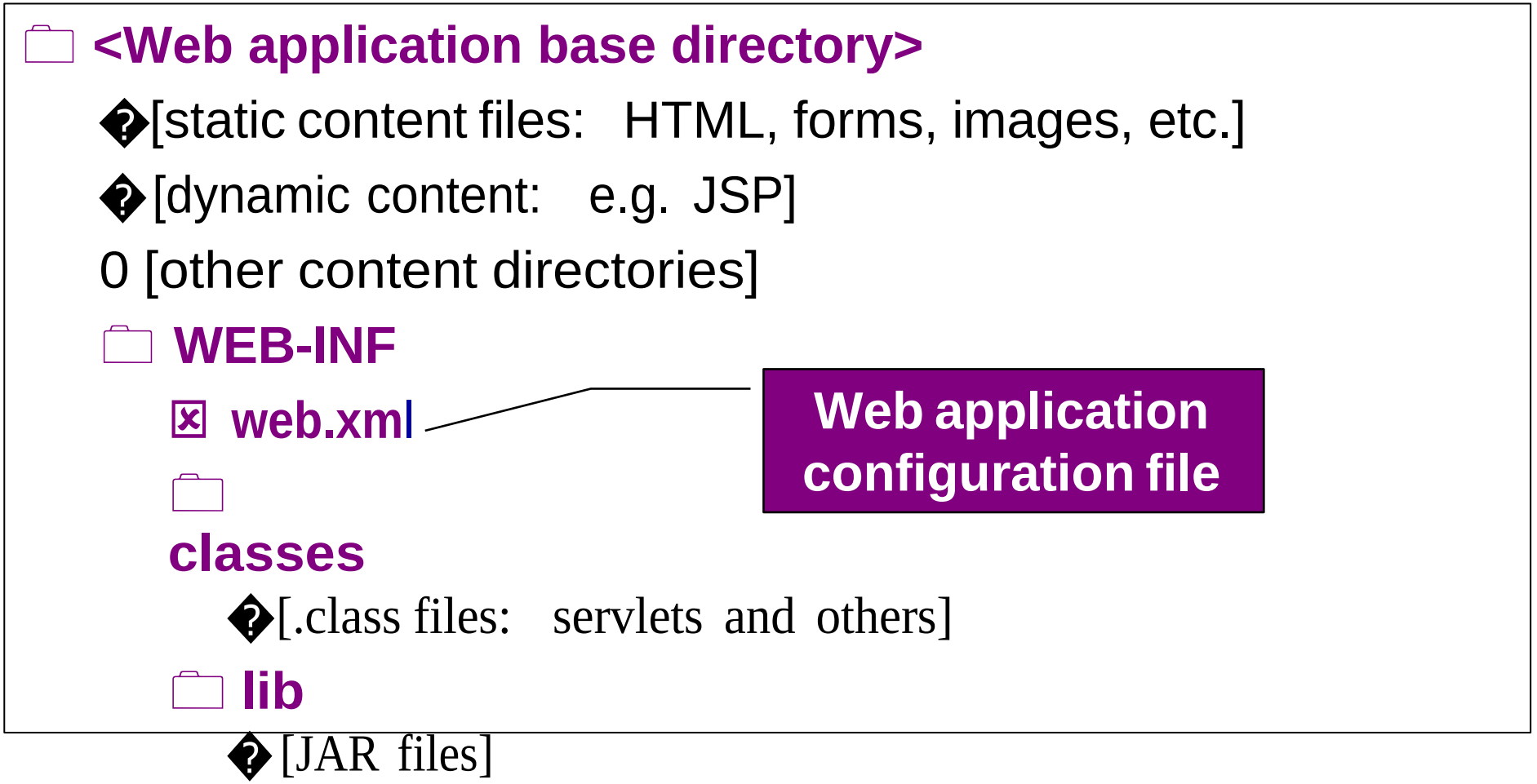
Overview of Java EE Web Applications

- Standard structure defined in Java EE
  - A collection of **Servlets**, **JavaServer Pages** (JSP), & other files
  - Most frequently collected inside of a Web Archive (WAR) file
    - The standard Java EE web app packaging



Web Application Structure

- Java web apps are organized in the standard structure below



Web Application Components

- **Servlets**: Java components that run on the server
  - Servlets run **in response to client requests**
  - Defined by extending class ***javax.servlet.HttpServlet*** and overriding ***doGet()/doPost()***

- **JSP**: JavaServer Page - contains dynamic and static content
  - **Template Data** consists of regular text, HTML, XML ...
  - **Dynamic Data** is generated anew for each request - e.g from custom tags in the JSP

- **web.xml**: Deployment descriptor for web app
  - Contains configuration information for the web app
  - For example, the servlets and their mappings

ApplicationContext and Java Web Apps

- Spring's ***WebApplicationContext*** provides integration with the Java Web container
  - This is a context tailored for Web app use
- Spring's ***ContextLoaderListener*** makes loading the context easy
  - Automatically loads the context when the web app is deployed
  - You can define the Spring configuration file locations using a *<context-param>* element in *web.xml*
- ***WebApplicationContextUtils*** class is used to access the context in your web app code
  - Via the static method ***getWebApplicationContext()***
  - If using standard Java Web apps
  - The following slides shows examples of doing this

Configuring ContextLoaderListener

- The *web.xml* below configures the *ContextLoaderListener*
  - It specifies *applicationContext.xml* and *inMemoryItemDAO.xml* as config files via *<context-param>*

```
<web-app ... >

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

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

</web-app>
```

Using the Application Context

- Below, we retrieve the context via *WebApplicationContextUtils*
  - This is the context loaded by the *ContextLoaderListener*
  - Bean look up is the same as in non-web related code
  - The example assumes the same configuration and beans as in our JavaTunes labs earlier in the course
- You can see - it's very easy to use Spring with Web apps
  - For other frameworks, like Spring MVC, integration is even easier *

```
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  =  ctx.getBean("javaTunesCatalog",  Catalog.class);
}
```

LEARNINGPATTERNS

Lab 6.1 – Spring and the Web

Lab 6.1 – Spring and the Web

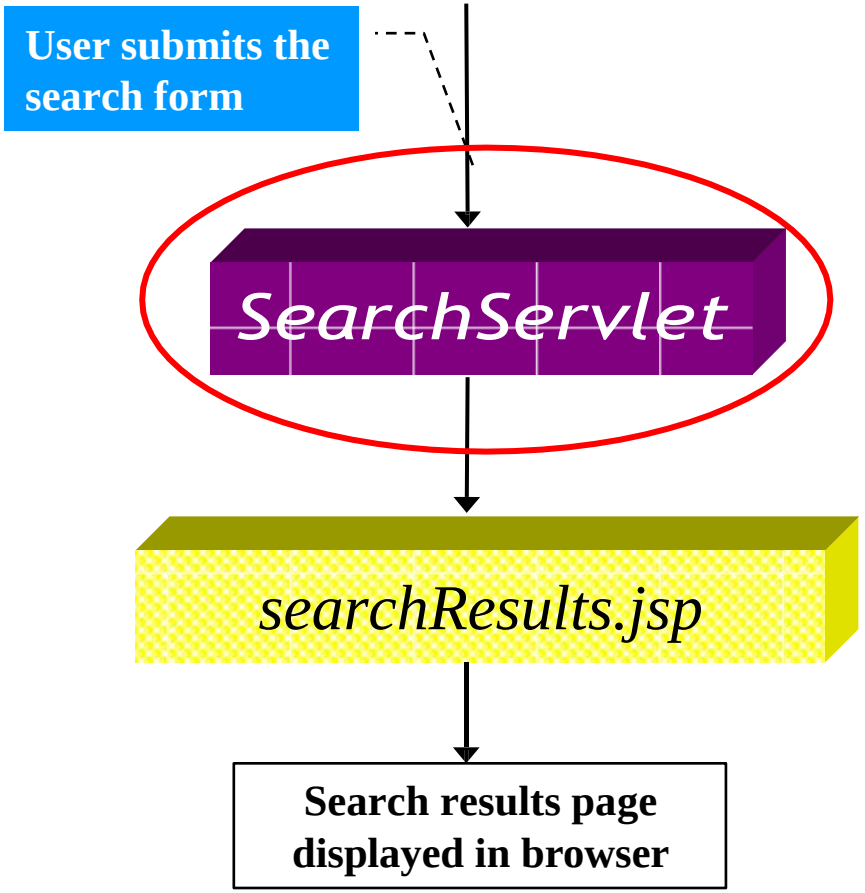
Lab

- **Overview**: In this lab, we will integrate the Spring container with a regular Java Web application
  - We will need to set up our Web server (Tomcat)
  - We will then configure the *ContextLoaderListener* in *web.xml*, and use the application context in a servlet
    - We'll look up a Spring bean (a catalog) that's used in a JSP page
- **Objectives**:
  - Configure *ContextLoaderListener*
  - Use an application context from a servlet
- **Builds on previous labs**: none
- **Approximate Time**: 30-40 minutes

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



Eclipse and Web Projects

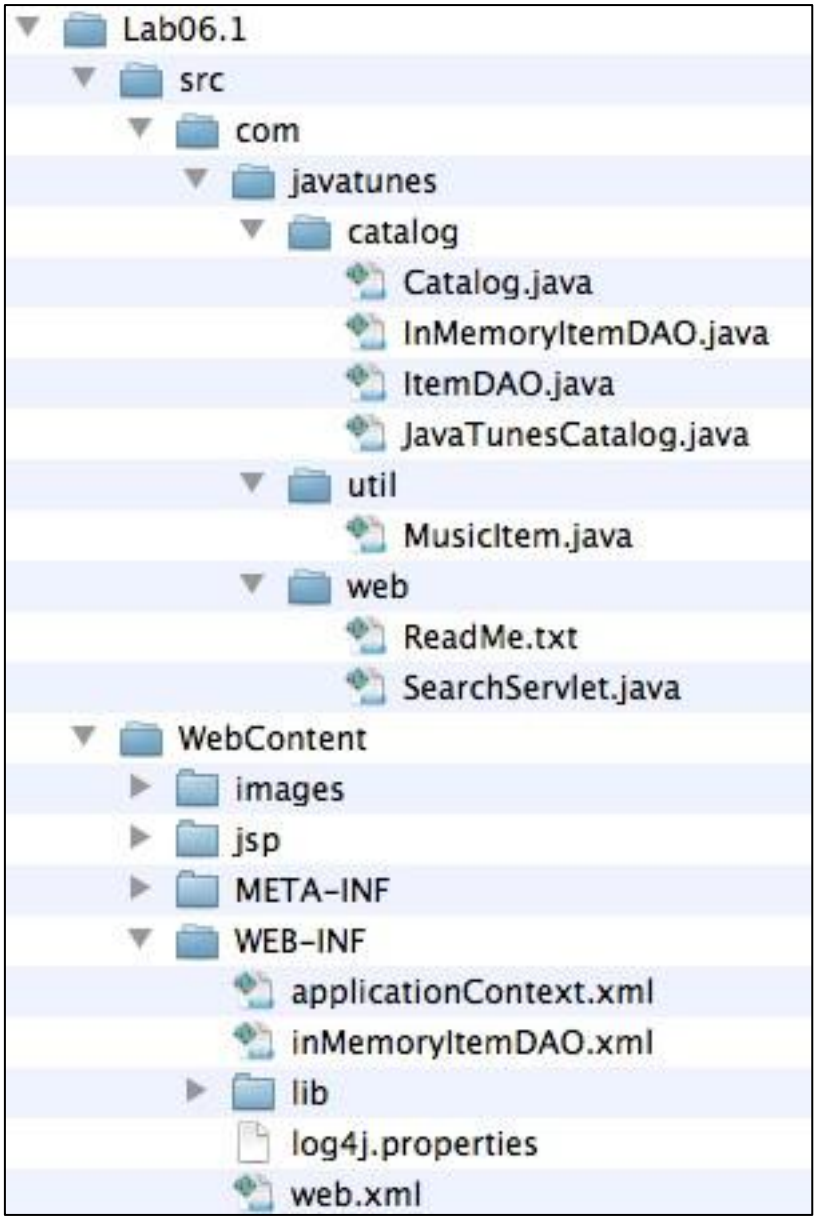
Lab

- **Dynamic Web Projects** used for Java Web apps in Eclipse
  - These contain servlets, JSP pages, and static resources (HTML)
  - Web-specific project properties can be establish when creating the project
  - *web.xml* has a custom editor for ease of use
- Projects are organized in the following folders
  - **src**: Contains all Java source files
  - **WebContent**: Contains all Web resources
  - **WebContent\WEB-INF**: Same as Java EE WEB-INF
    - Also contains Spring configuration files, other config files
  - This is different from a standard Java EE Web app
    - When deployed, a standard WAR is build

Lab Directory Structure

Lab

- The labs in this section are structured as follows:
  - **LabNN** : Directory for Lab NN
  - **LabNN/src/** : Java source
  - **LabNN/WebContent/** : jsp, HTML
  - **LabNN/WEB-INF/**: web.xml, other config files
  - **LabNN/WEB-INF/lib**: jar files needed by the Web app



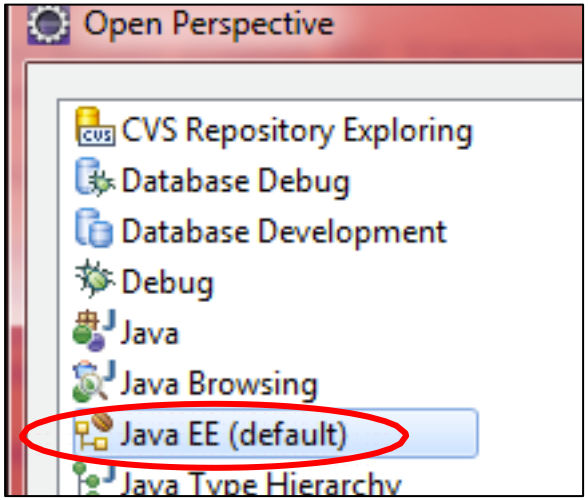
Lab Preparation

Lab

- The root lab directory where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab06.1
  - This is a new lab directory which already exists in your workspace

Tasks to Perform

- **Close** all open files and projects
- Open the Java EE perspective, by clicking the Perspective icon at the top right of the Workbench, and select **Java EE**
  - This perspective is well suited for these labs



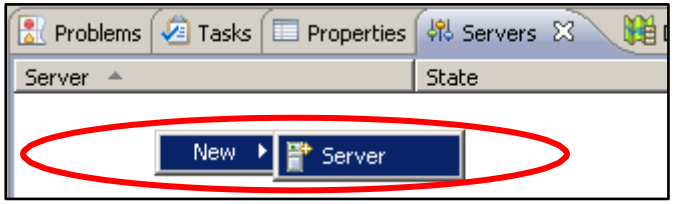
Creating a Server

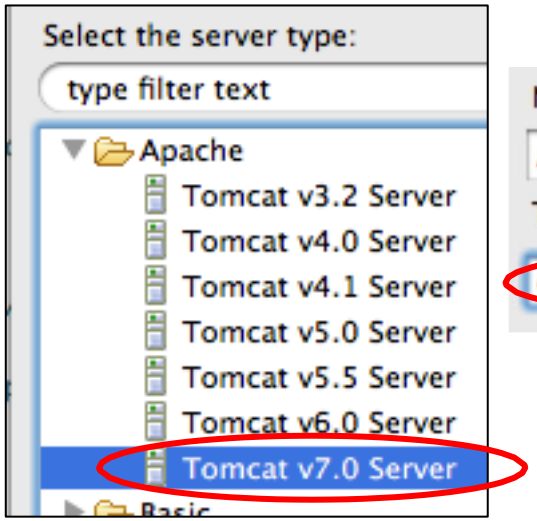
Lab

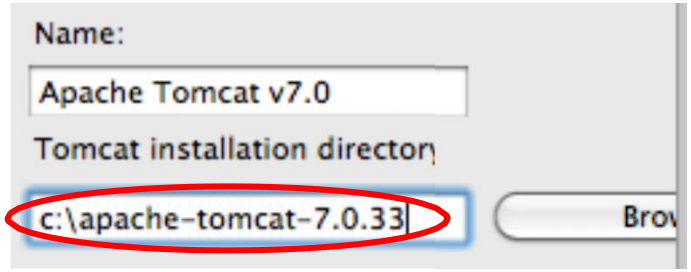
- We will use Tomcat to run our Web applications - first we need to create a server in Eclipse *

Tasks to Perform

1. Go to the Servers view, right click, and select **New | Server**
2. In the next dialog, select **Apache | Tomcat V7.0** * and click **Next**
3. In the next dialog, browse to your **Tomcat install directory**, click **OK**, and then **Finish** *







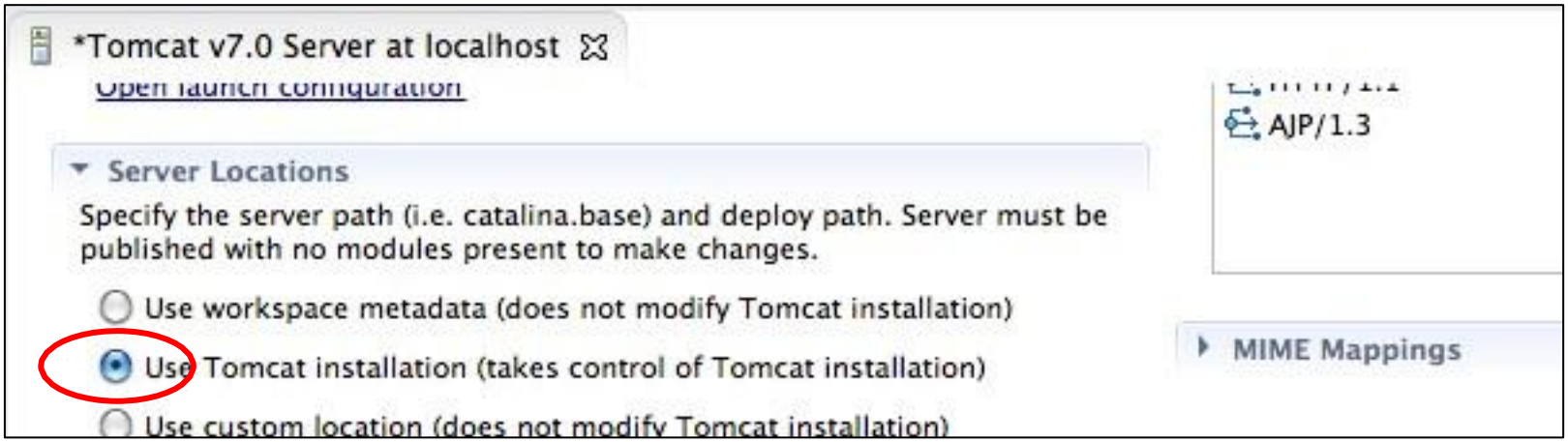
Configure Server

Lab

- We will reconfigure the deploy location for our server
  - This will help prevent Eclipse deploy issues we've seen (see notes)

Tasks to Perform

- In **Servers view**, double click on the Tomcat server
  - The server configuration should open in the editor pane
  - Check the "Use Tomcat installation" choice (see below)
  - Save the configuration

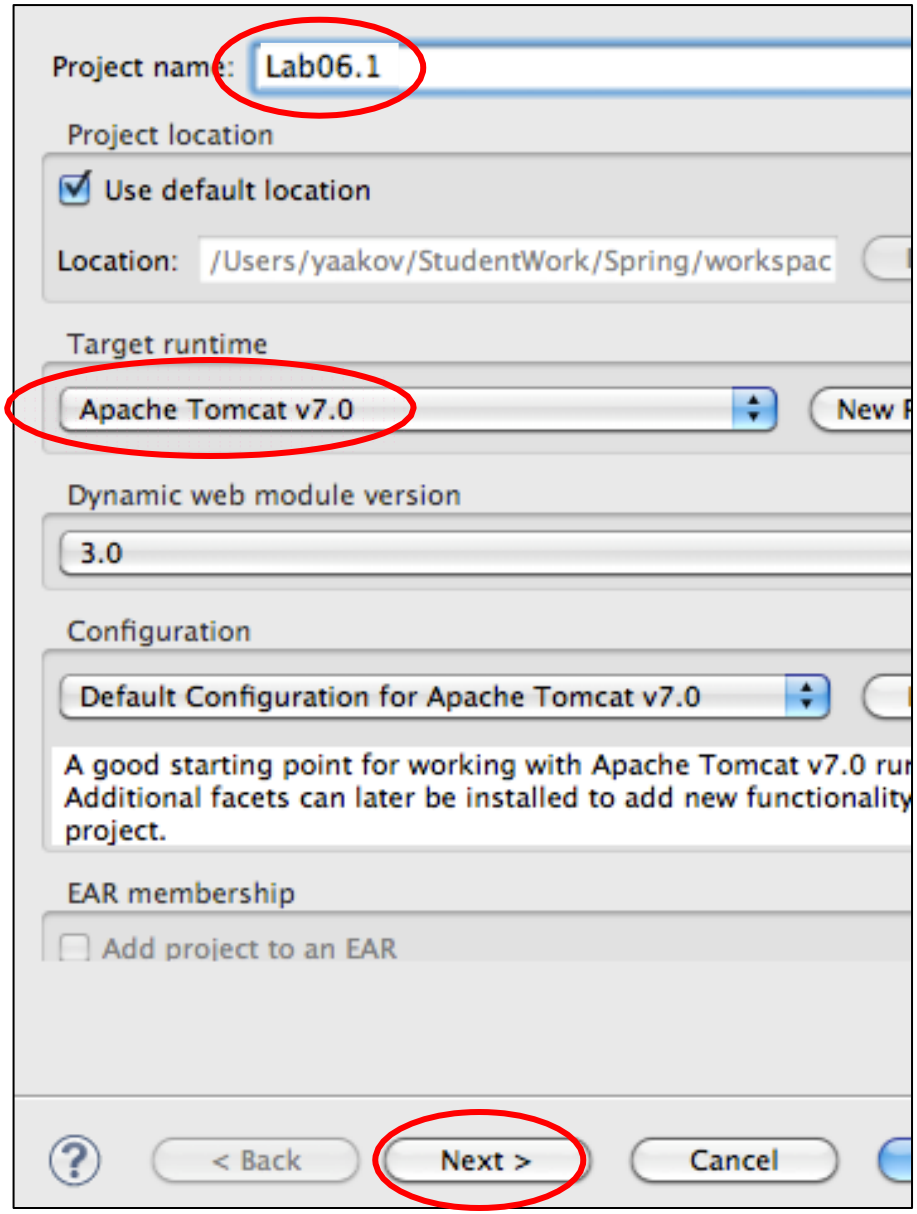


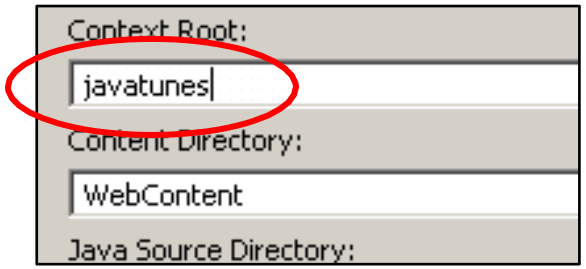
Create a Web Project

Lab

Tasks to Perform

- Create a new Dynamic Web project (as at right)
  - **File | New | Dynamic Web Project** *
  - Call it **Lab06.1 ***
  - Make sure the **Tomcat runtime** is selected and Click **Next**
- In the next dialog, change the Context Root to **javatunes** (**all lower case** - as below)
  - Click **Finish**





Configure Build Path

Lab

- We need to add the Spring library (including the web support) to our project classpath to allow the Web app to compile/run properly

Tasks to Perform

+Right click on the project in Project Explorer, select **Build Path | Configure Build Path**, add the Spring library as for other projects

+Next, click **Deployment Assembly** in the left pane (for configuring Web app deployment dependencies)

- Click **Apply** if prompted to save modifications
- Click **Add | Java Build Path Entries** click **Next**, select the **Spring** library, click **Finish**, then **OK**

+Review the jars in the Spring library (in your Eclipse project)

- Note the jars that support the Spring/Web integration
  - e.g. jars from Spring like spring-web-3.2.2.RELEASE.jar, and the spring-web-servlet jar
  - There are others in the dependencies we supply - e.g. the JSTL jar

Configure ContextLoaderListener

Lab

Tasks to Perform

- Note: All Web content (JSP files, WEB-INF folder, …) appears in the Project Explorer pane under the **WebContent** folder
- Open up *WEB-INF\web.xml* for editing
  - Locate the *<context-param>* element and add in the values for the elements shown below:
  - *<param-name>*: *contextConfigLocation*
  - *<param-value>*:
    /WEB-INF/applicationContext.xml
    /WEB-INF/inMemoryItemDAO.xml
  - Locate the *<listener>* element and add in the following value for the *<listener-class>* element:

org.springframework.web.context.ContextLoaderListener

Finish SearchServlet

Lab

Tasks to Perform

- Open *com.javatunes.web.**SearchSevlet*** for editing
  - Notice the Spring imports for the web context classes
  - Find ***doPost()***, & initialize the *WebApplicationContext* by calling the static ***WebApplicationContextUtils*** method ***getRequiredWebApplicationContext()*** (See manual slides)
  - Pass in a servlet context retrieved via *getServletContext()*
- Review the rest of the *doPost()* code
  - It uses the context to look up a *Catalog*
  - It uses the catalog to do keyword based search
    - Using a keyword from a search form a web page
  - Search results are put on the request under the name "results"
  - The request is forwarded to */jsp/searchResults.jsp* for display *

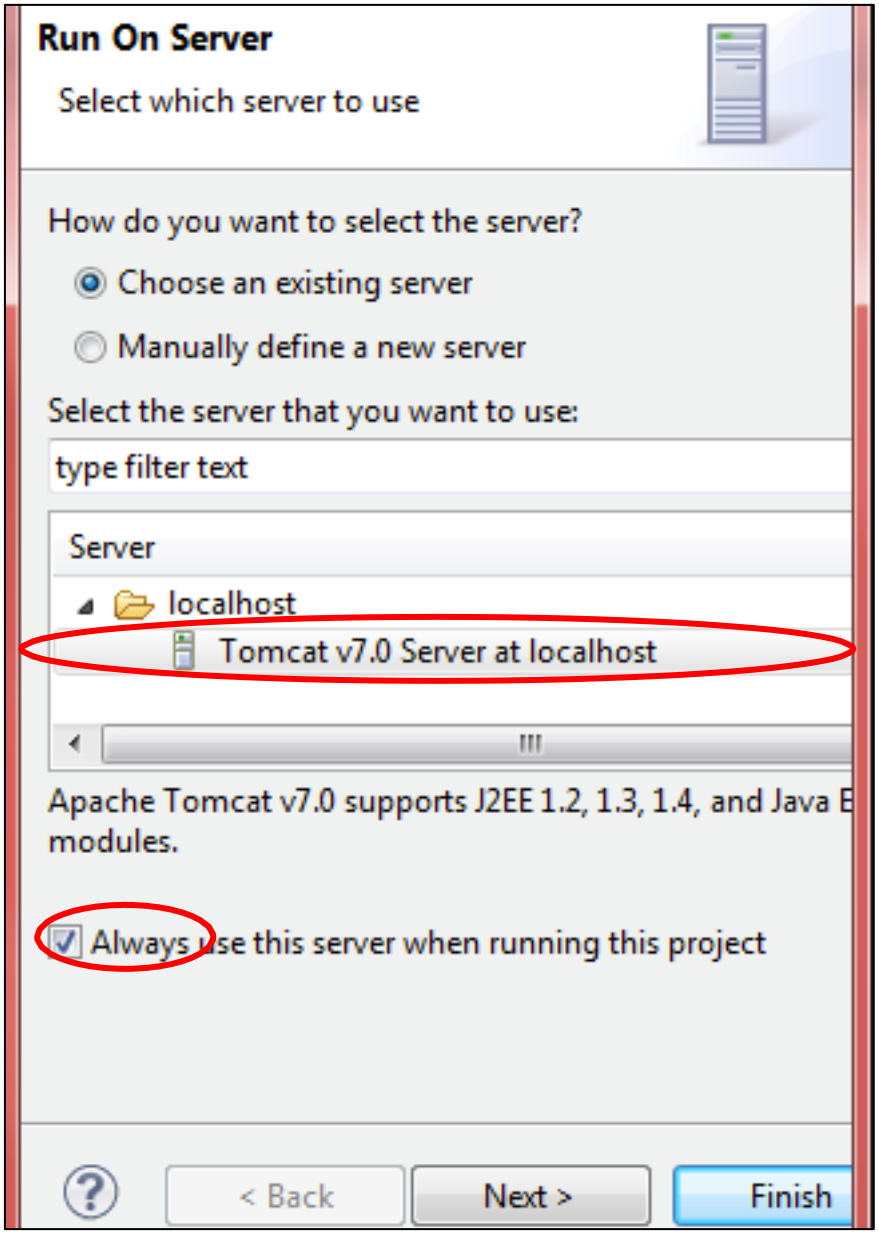
Deploying an Application

Lab

Tasks to Perform

- To deploy to the server, right click on the Lab06.1 project, and select **Run As | Run on Server**
- In the next dialog box select your existing **Tomcat** server
- Also select **Set server as project default**, as we will always use this server
- Click **Finish**

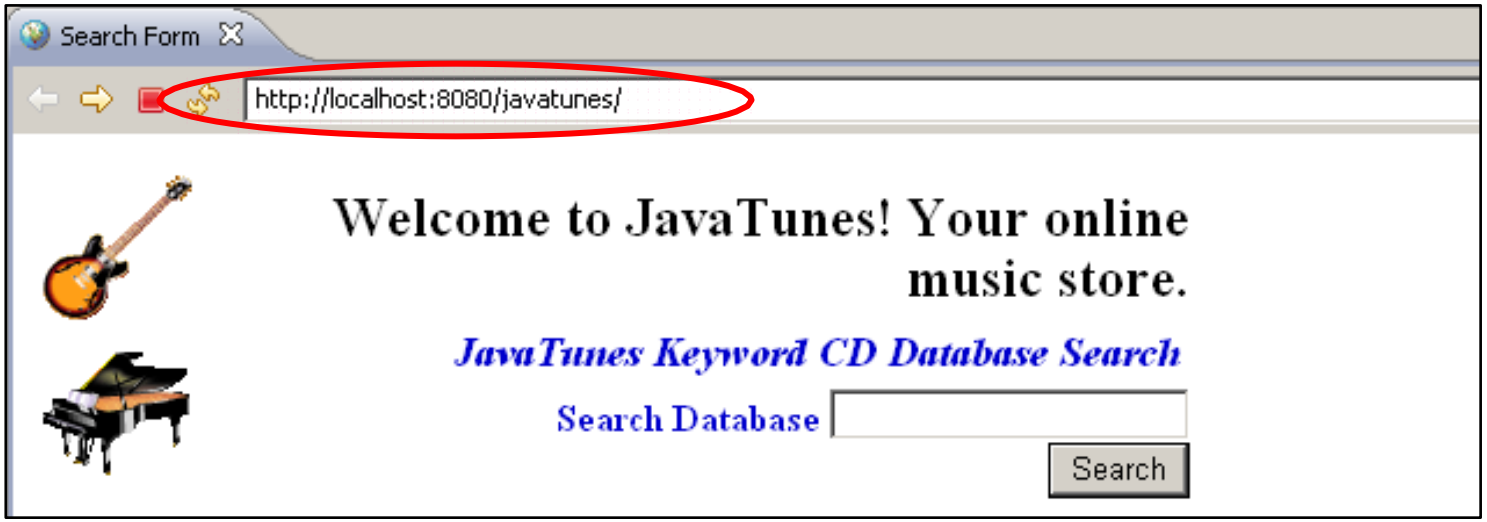
- Note that running a Web app on the server will automatically start the server



Viewing the Web Application

Lab

- Eclipse should open a browser for you onto the Web app
  - At: *http://localhost:8080/javatunes*
- Note: Eclipse uses the system default browser, often IE, and IE **can be misleading** as it caches pages, and it's hard to clear the cache
  - If you ever feel your having browser issues, open an external browser viewing the same URL (see notes about setting the browser in Eclipse)



Test Your Application

Lab

Tasks to Perform

- The **javatunes** web app, displays a search form - so type in the letter "a" to search on and submit the form
  - The *SearchServlet* will be invoked, use your Spring beans to do the search, and then forward to a JSP to display the results
  - That's it - you're using Spring in a Web application

Server Startup

Lab

- You can open the **Console** view to see output from the server startup and web app deployment
  - This can be useful to look for exception stack traces
  - Note that server startup may take some time, especially the first time you start the server
  - You can also look at the server status in the **Servers** view

Markers | Properties | Servers | Data Source Explorer | Snippets | Console

```
Tomcat v7.0 Server at localhost [Apache Tomcat] C:\Program Files\Java\jre7\bin\javaw.exe (Dec 19, 2012 2:04:45 PM)
Dec 19, 2012 2:04:48 PM org.apache.coyote.AbstractProtocol start
INFO: Starting ProtocolHandler ["ajp-bio-8009"]
Dec 19, 2012 2:04:48 PM org.apache.catalina.startup.Catalina start
INFO: Server startup in 2216 ms
2012-12-19 14:05:24,561 DEBUG [org.springframework.beans.factory.support.DefaultListableBeanFactory] -
JavaTunesCatalog:findByKeyword - nn
maxSearchResults = 20
Dec 19, 2012 2:05:24 PM org.apache.jasper.compiler.TldLocationsCache tldScanJar
```

STOP

LEARNINGPATTERNS

Spring MVC Basics

Integration with Java EE

Spring MVC Basics

Forms and Command Objects

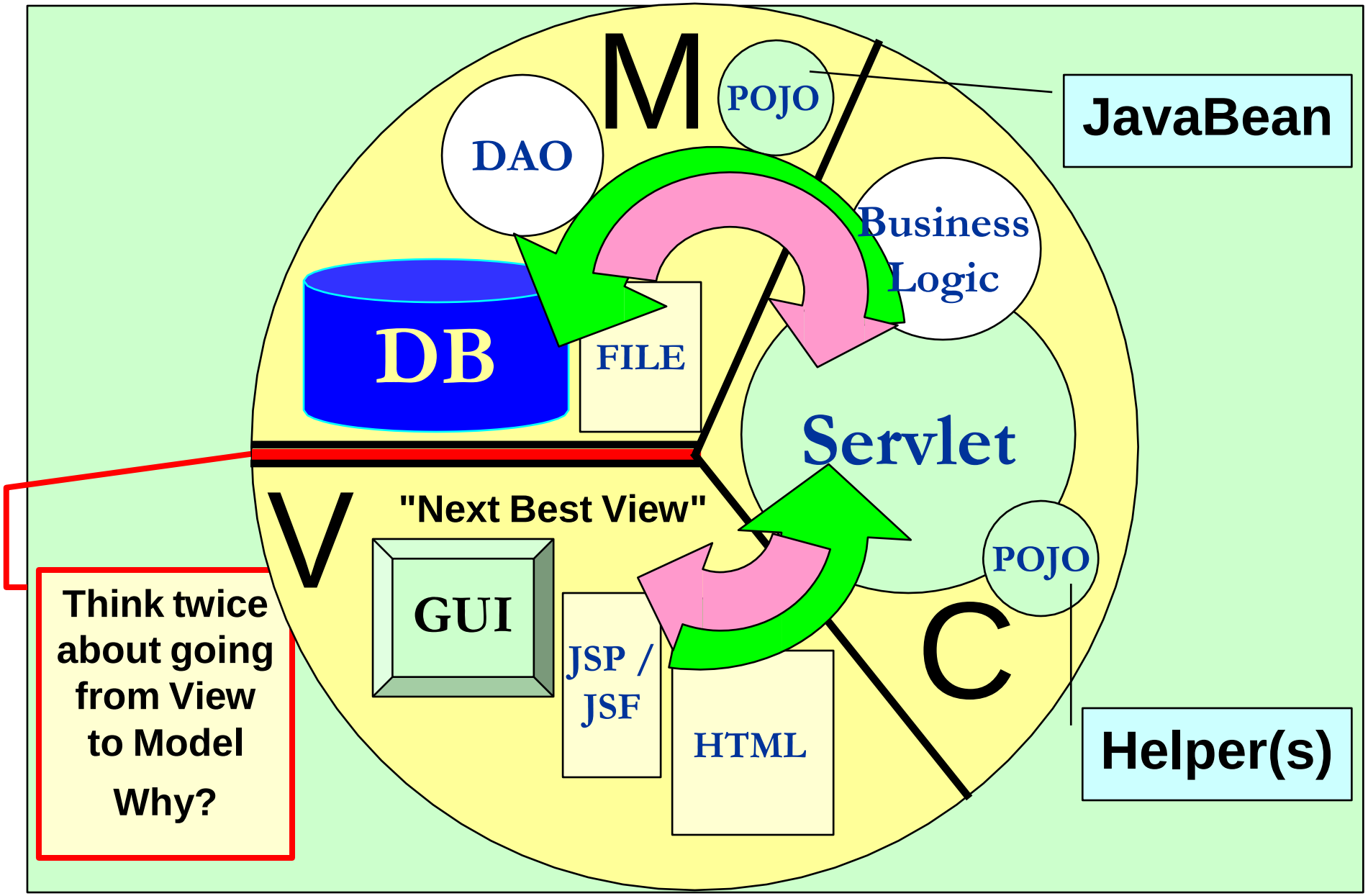
What is Spring MVC?

- A Java Web app framework based on **M**odel **V**iew **C**ontroller (MVC)
  - Originally created due to shortcomings of Servlets/JSP
    - Current JSF (JavaServer faces) has much capability, but some are not happy with it
  - If you're using Spring, Spring MVC is a viable alternative
- Overall goals for Spring MVC
  - **Simplify** web app creation
  - Provide a **strong MVC framework** with clearly defined roles (controller, command object, view resolver, etc)
    - Thus encouraging good architecture
  - **Integrate** easily with the rest of Spring
  - Build on **standard Java EE** (servlets/JSP, custom tags, JavaBeans)
  - Flexibly integrate with additional template technologies (e.g. Velocity)

General MVC Architecture

- **M**odel **V**iew **C**ontroller
  - Standard pattern for creating applications with user interfaces
- **Model**: Representation of the business domain
  - Independent of user interface or application flow
  - In Java EE typically consisting of data, business objects, JavaBeans for storing state and data transfer, and other components (e.g. EJB)
- **View**: Way of representing the data to a human user
  - In Java EE something that generates HTML
    - Often a **JSP** or **JSF** page
    - Other resources such as images, charts, etc.
- **Controller**: Intermediary between Model and View
  - In Java EE **Servlets** are the core controller components
    - May be encapsulated, such as with JSF controllers
  - Controls user flow through the application, and invokes business logic

MVC Pattern flow

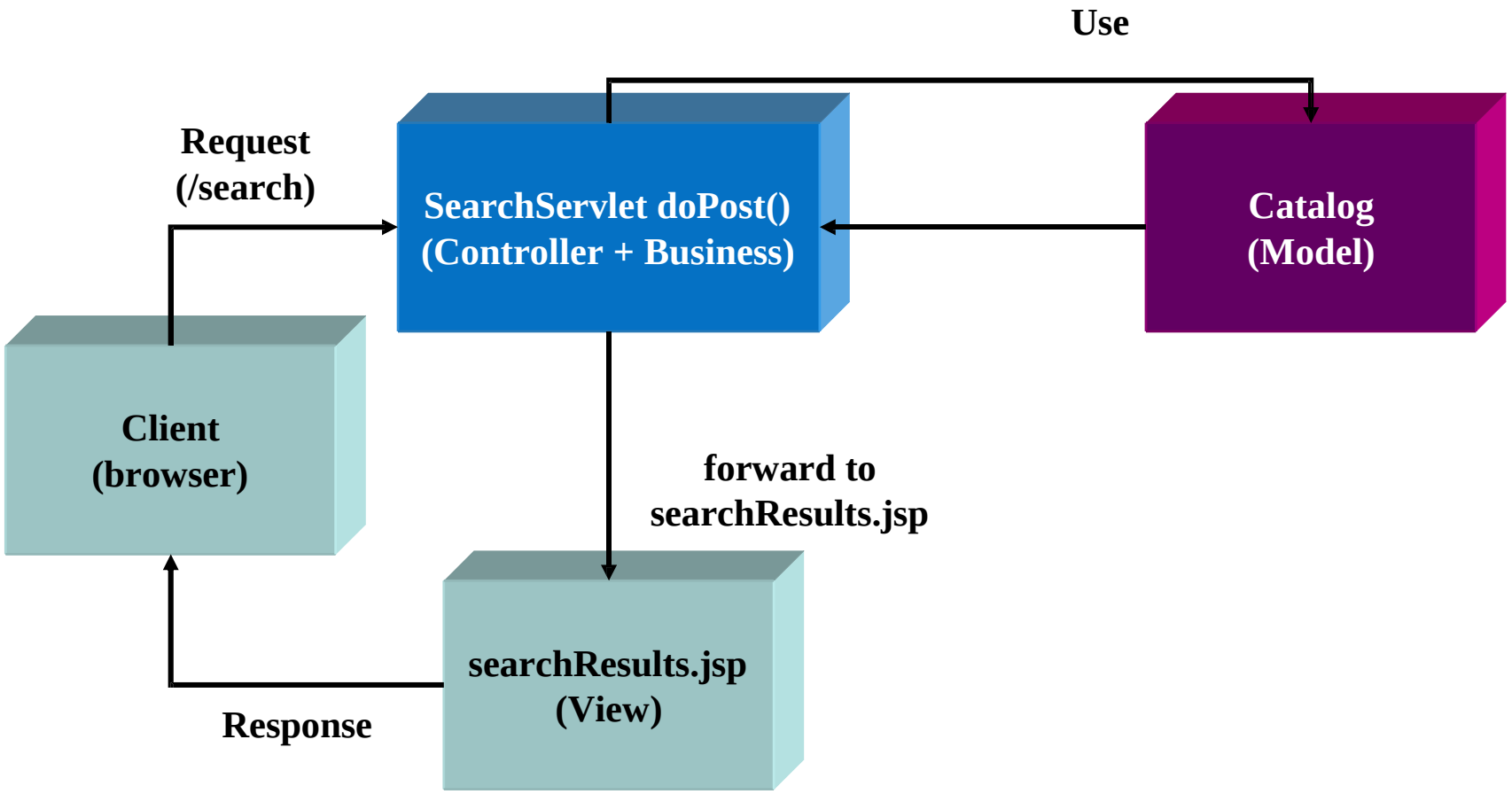


Spring MVC Architecture

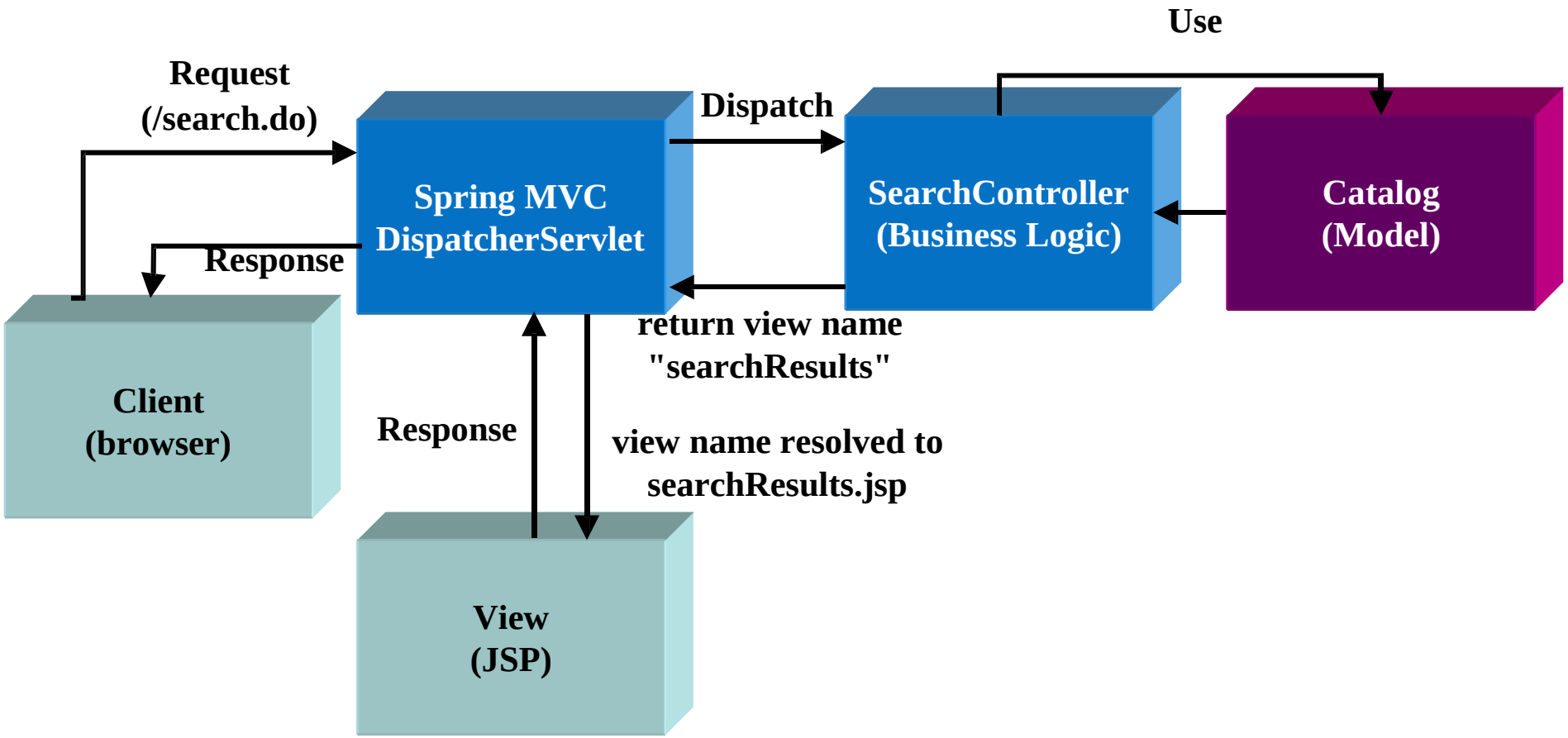
- Spring uses a **front controller** architecture
  - The front controller is a central servlet that receives all requests, and dispatches them to other components (controllers) to handle

- The main components of a Spring MVC application are:
  - ***DispatcherServlet***: The front controller servlet
  - ***Controllers***: Handle specific user requests, generate the data for response, return a response to determine the view
  - **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

Simple Search App Model - Servlets/JSP



Simple Search App Model - Spring MVC



DispatcherServlet

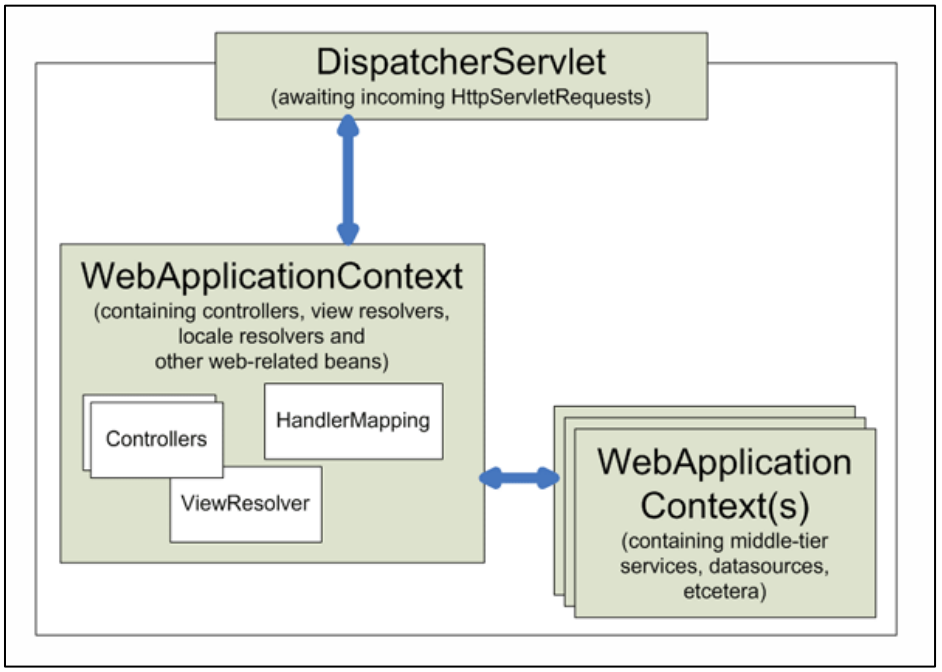
- ***DispatcherServlet***: Front controller for Spring MVC
  - The integration point between Spring MVC and the Web container
  - It's a standard servlet
- *DispatcherServlet* must be configured in *web.xml*
  - To map appropriate requests to the *DispatcherServlet*
  - Typically, a pattern such as ***.do*** is used
  - Requests with a .do suffix (e.g. ***logon.do***) are handled by Spring MVC

```
<servlet>
    <servlet-name>springmvc</servlet-name>
    <servlet-class>
      org.springframework.web.servlet.DispatcherServlet
    </servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>

  <servlet-mapping>
    <servlet-name>springmvc</servlet-name>
    <url-pattern>*.do</url-pattern>
  </servlet-mapping>
```

DispatcherServlet Initialization

- The *DispatcherServlet* has its own *WebApplicationContext*
  - Initialized by the framework when the servlet is initialized
  - The default config file is: WEB-INF***[servlet-name]-servlet.xml***
  - In our example, it will look for WEB-INF***springmvc-servlet.xml***
  - This file **must** be present for Spring MVC to initialize



Controllers

- **Controllers**: Spring MVC component to **handle requests**
  - Dispatcher servlet forwards requests to controllers
  - Shields you from low level APIs (e.g. servlet API), interprets user input, generates a model, and directs response to a view
- Controllers are **Annotation-based** POJOs - the API includes:
  - ***@Controller***: Indicates the annotated class is a web controller
    - Stereotype of *@Component* - usually auto-detected via scanning
    - In package ***org.springframework.stereotype***
  - ***@RequestMapping***: Maps requests to a controller class/method
    - In package ***org.springframework.web.bind.annotation***
  - ***RequestMethod***: enum of HTTP request methods (e.g. GET)
- **Component scanning** must be enabled to use these
  - Using ***context:component-scan*** as seen earlier

A Very Simple Controller

- The simple Logon*Controller* below (handling a logon), receives requests of the form ***/logon.do***
  - ***@RequestMapping("/logon")*** specifies the base URL handled
  - ***@RequestMapping(method = RequestMethod.GET)*** specifies that ***get()*** will be used to handle HTTP GET requests
  - The return value ***/jsp/logon.jsp*** specifies the new view for the user

```
import org.springframework.stereotype.Controller;
import org.springframework.web.bind.annotation.RequestMapping;
import org.springframework.web.bind.annotation.RequestMethod;

@Controller
@RequestMapping("/logon")
public class LogonController {

  @RequestMapping(method = RequestMethod.GET)
  public String get() {
    return "/jsp/logon.jsp";
  }
}
```

Control Flow

- A */logon.do* request results in the following flow
  - ***DispatcherServlet* receives** the request
    - Based on the *.do mapping in *web.xml*
  - It forwards the request to ***LogonController.get()***
    - Based on the *@Controller* and *@RequestMapping* in the controller
    - *get()* returns a value of */jsp/logon.jsp*
  - *DispatcherServlet* generates the resulting view
    - Based on the value */jsp/logon.jsp*
    - Generally, logical view names are used, not file names or paths
    - We'll see this being done shortly
- That's all there is for this simple controller
  - We'll look at more functionality soon

LEARNINGPATTERNS

Lab 6.2 – Spring MVC Basics

Lab 6.2 – Spring MVC Basics

Lab

- **Overview**: In this lab, we'll use some very basic Spring MVC capabilities to implement the same functionality as the last lab
  - We'll first set up the *DispatcherServlet* to handle web requests
  - Next we'll create a very simple controller to handle a request for a search form
  - We'll run our application to see these pieces at work, and in future labs we'll enhance it to use more Spring MVC capability
- **Objectives**:
  - Configure *DispatcherServlet*
  - Create a controller
- **Builds on previous labs**: none
- **Approximate Time**: 25-35 minutes

Lab Preparation

Lab

- The (new) root lab directory where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab06.2

Tasks to Perform

- Remove Lab06.1 from the server *, and close all open files/projects
- Create a new Dynamic Web project called Lab06.2
  - See Lab 6.1 instructions if you need more detail on this
  - Remember to **set the context root** to javatunes
- Right click on the project in Project Explorer and select **Build Path | Configure Build Path** and add in the Spring library as before
  - Next, click **Deployment Assembly** in the left pane (for configuring Web app deployment dependencies)
  - Click **Apply** if prompted to save modifications
  - Click **Add | Java Build Path Entries** click **Next**, select the **Spring** library, click **Finish**, then **OK**

Configure DispatcherServlet

Lab

Tasks to Perform

- Open *WEB-INF**web.xml** for review and editing
  - See notes on logging configuration review
  - Locate the `<servlet>` element for the springmvc servlet and add in the following value for the `<servlet-class>`

```
org.springframework.web.servlet.DispatcherServlet
```

  - Locate the `<servlet-mapping>` element for the javatunes servlet and add in the following value for the `<url-pattern>`

```
*.do
```

  - This maps the dispatcher servlet to any URL ending with *.do
- Open *WEB-INF**springmvc-servlet.xml** for editing
  - Note how Spring's context namespace for is already included
  - Add in the XML element for the `component-scan` elements and specify the scanning of the `com.javatunes` packages (see notes)

Configure DispatcherServlet

Lab

Tasks to Perform

- **Open** *com.javatunes.web.SearchController* for editing
  - It will handle HTTP GET requests to */search.do* URLs
- Add annotations to *SearchController* to declare it a controller class, and to map it to the request */search.do*
  - You will need two annotations
- Add annotations to *get()* so that it handles an HTTP GET request
  - Have it return a value so the */jsp/searchForm.jsp* page is displayed as the view
  - This JSP page is already given to you, and includes a search form for performing a search, which we'll use in the next lab
- To deploy to the server, right click on the Lab06.2 project, and select **Run As | Run on Server** and deploy as in Lab 6.1

Test Your Results

Lab

Tasks to Perform

- A browser should open on: *http://localhost:<8080>/javatunes*
  - This shows a very simple home page that contains a link to /search.do
  - Click this link, it should take you to the search form JSP page
  - This shows that your controller class is being used
- When the link for search.do is clicked, the dispatcher servlet receives the request (a GET), and delegates it to your *SearchController.get()* method
  - The return value of *get()* is used to generate the view
- You can see how simple it is to build a controller using Spring MVC
- Note: **Doing a search is NOT yet implemented**
  - It will not work until the next lab

STOP

@RequestParam – Parameter Binding

- **@RequestParam** binds request parameters to controller method arguments
- Assume two request parameters for a logon: name and password
  - They can be bound to method args as shown in the example below
- ***@RequestParam*** has two other optional elements (see notes)
  - ***required***: Whether parameter is required
  - ***defaultValue***: Default value if no value on request

Example: ***@RequestParam(value="password", required="false")***

```
// Part of LogonController - most detail omitted
@RequestMapping(method = RequestMethod.POST)
public String processLogon(
   @RequestParam("name") String name,
   @RequestParam("password") String password) {
   // Do logon processing - all detail omitted
   return "/jsp/welcome.jsp";
}
```

Returning Model Data

- Handler methods can return model data for use by the view
  - A number of model classes are supplied to hold this data
- *ModelAndView* holds both view information and model data
  - It's in package (*org.springframework.web.servlet*
  - Generally used as a return value from a controller method
  - Has constructors/methods to get/set view, & add attributes to the model
  - Some common constructors / methods include:
  - *ModelAndView(String viewName, String modelName, Object modelObject)*
    - Create an instance with the given view name, model name, and model data
  - *ModelAndView addObject(String attributeName, Object attributeValue)*
    - Add an attribute to the model with the given name
  - See notes for more methods

Returning Model Data

- The example below uses the constructor shown previously to create a *ModelAndView* instance and returns it
- *DispatcherServlet* will do the following
  - Extract the data from the model map
  - Make model attributes available to the view
    - e.g. put them on the request where they can be accessed via JSP EL variables
  - Forward to a view page based on the view value

```
@RequestMapping(method = RequestMethod.POST)
public ModelAndView processLogon(
   @RequestParam("name") String name,
   @RequestParam("password") String password) {
   // Assume checkLogon defined elsewhere - detail not shown
   Principal p = checkLogon(name,password);
   return new ModelAndView("/jsp/welcome.jsp", "principal", p);
}
```

The JSP Pages

- Below, we show a logon form and the resulting welcome page
  - At this point, they're plain JSP pages, with no Spring functionality
- The logon submission form:
  - Submits to **logon.do**
  - Includes **name** and **password** parameters
- The welcome page uses the Principal object that the controller method adds to the model

```
<!-- Logon submission page -->
<form method='post'
        action='${pageContext.request.contextPath}/logon.do'>
  <input size='20' type='text' name='name'/>
  <input size='20' type='password' name='password'/>
  <input type='submit' name='Submit' value='Logon'/>
</form>
```

```
<!-- Welcome page -->
Welcome ${principal.name}
```

Other Handler Method Capabilities

- Handler methods annotated with *@RequestMapping* allow other arguments that will be automatically initialized, including:
  - **Request** or **response** objects from Servlet API
  - **Module** object: The *Http Module*
  - *java.util.Locale*: Current request Locale
  - *InputStream*/*Reader*: Raw stream/reader exposed by servlets
  - *OutputStream*/*Writer*: Raw stream/writer exposed by servlets
  - *@RequestHeader* annotated parameter: Specific header
  - *@CookieValue* annotated parameter: Specific cookie
- Return values can include:
  - *ModelAndView*, as seen earlier
  - *Model* object, with view name implicitly generated from requests
  - *Map* object, with view name implicitly generated from request

Other Handler Method Capabilities

– ***View*** object, with model implicitly determined

Example – Other Handler Capabilities

- In the example below, we show an example of using some of the additional capabilities of handler methods

```
// Access HttpServletRequest and HttpServletResonse Objects
@RequestMapping("/getServletObjects")
public void displayServletInfo(
   HttpServletRequest request, HttpServletResponse response)
   { System.out.println(request.getParameter("password"); }


// Access Module
object and cookie with Module
id
@RequestMapping("/display Module
Info") public void display Module
Info(
   Http Module
   the Module
   , @CookieValue("J MODULE
   ID") String sessID)
   { /* … */ }
```

Example – Other Handler Capabilities

```
// Access request header values
@RequestMapping("/displayHeaderInfo")
public void displayHeaderInfo(
    @RequestHeader("Accept-Encoding") String encoding,
    @RequestHeader("Keep-Alive") long keepAlive) { /* … */ }
```

Lab 6.3 – Parameters and Models

Lab 6.3 – Parameters and Models

Lab

- **Overview**: In this lab, we'll extend the functionality of our web app to do the following:
  - Extract a request parameter
  - Return a model object that will be used to generate the resulting view
- **Objectives**:
  - Extract a request parameter with *@RequestParam*
  - Use *ModelAndView* to return a model
- **Builds on previous labs**: Lab 6.2
  - Continue working in your Lab06.2 project
- **Approximate Time**: 20-30 minutes

Finish the Controller

Lab

Tasks to Perform

- **Open** *com.javatunes.web.SearchController* for editing
- We configure a Catalog bean, as seen in earlier labs, in the Spring context
  - Inject this bean into *SearchController* using *@Autowired*
    - Just declare a field of type Catalog, and apply the *Autowired* annotation to it * – we'll use it in our handler method
- Add a new method, *processSearch()* to the controller
  - It should be called for an HTTP POST
  - It should have a *String* argument to hold the keyword, that is initialized by a "keyword" parameter on the request
  - Generate the search results by calling *Catalog.findByKeyword* on the catalog object using the keyword parameter
  - If should return a *ModelAndView* object that
    - Specifies a view of *jsp/searchResults.jsp*
    - Includes a model attribute with the name *results* and the search results

Finish JSP and Run

Lab

Tasks to Perform

- Open *jsp/searchHeader.jspf*, and set the action to be ***search.do*** (which will cause the form submission to end up at our SearchController to handle)
- **Restart** the server so your changes are picked up
  - Right click on the server, select **Restart**
- Browse back to: *http://localhost:<8080>/javatunes*
  - Click on the link for the search form, then type in the letter "a" to search on and submit the form
  - The DispatcherServlet will invoke *SearchController*, which will use a catalog do the search, and then return a *ModelAndView* instance initialized with the collection (with name "results") and a view
  - The *DispatcherSerlvet* will then use the *ModelAndView* instance to put the collection on the request with the name "results", and forward to the view
- You should see your search results displayed

STOP

View Resolvers

- It's better practice to use **logical view names** (e.g. *welcome*), rather than hard-coded pages (e.g. */jsp/welcome.jsp*)
- **View Resolvers** in Spring MVC support this
  - Used by the dispatcher to map logical names to actual files
  - ***InternalResourceViewResolver*** is a commonly used one
    - In package: *org.springframework.web.servlet.view*
  - Lets you specify a standard **prefix** / **suffix** added to the logical names to determine the final view page
  - In the example below, this resolver maps ***searchResults*** to the view page ***/jsp/searchResults.jsp***

```
<bean id="jspViewResolver" class=
    "org.springframework.web.servlet.view.InternalResourceViewResolver">
  <property name="viewClass"
            value="org.springframework.web.servlet.view.JstlView"/>
  <property name="prefix" value="/jsp/"/>
  <property name="suffix" value=".jsp"/>
</bean>
```

Controller Using Logical Names

- Controllers now use logical view names (not file names)
  - Below, the two controller methods return logical view names
  - These will be mapped by the view resolver to actual files
  - Note that *get()* is used to initially generate the logon view

```
@Controller
@RequestMapping("/logon")
public class LogonController {

  @RequestMapping(method = RequestMethod.GET)
  public String get() { return "logon"; }

  @RequestMapping(method = RequestMethod.POST)
  public ModelAndView processLogon(
    @RequestParam("name") String name,
    @RequestParam("password") String password) {
    // Assume checkLogon defined elsewhere - detail not shown
    Principal p = checkLogon(name,password);
    return new ModelAndView("welcome", "principal", p);
  }
}
```

Other View Resolvers

- ***BeanNameViewResolver***: Maps a view name to a bean
  - For rendering view with a Java class, rather than JSP - see example at bottom which maps view name "*welcome*" to the *WelcomeView* bean
- ***XmlViewResolver***: Uses external XML file to map views to beans
  - Externalizes bean mappings for views to an XML file
  - Default XML file is */WEB-INF/views.xml*
- ***ResourceBundleViewResolver***: Uses external properties files to map views to beans
  - Allows for localization / internationalization

```
<!-- Configure the bean name view resolver -->
<bean  id="viewResolver"
  class="org.springframework.web.servlet.view.BeanNameViewResolver"/>

<!-- WelcomeView class used to generate view for view name "welcome" -->
<bean  id="welcome"  class="com.javatunes.web.WelcomeView"/>
```

LEARNINGPATTERNS

Lab 6.4 – View Resolvers

Lab 6.4 – View Resolvers

Lab

- **Overview**: In this lab, we'll add a view resolver to our configuration
  - The controller will now use logical view names, rather than actual JSP pages
- **Objectives**:
  - Work with *InternalResourceViewResolver*
  - Use logical names in handler methods
- **Builds on previous labs**: Lab 6.3
  - Continue working in your Lab06.2 project
- **Approximate Time**: 15-20 minutes

Add a View Resolver

Lab

Tasks to Perform

- Open *WEB-INF\springmvc-servlet.xml* for editing
  - Add a definition for an *InternalResourceViewResolver* bean
  - Use a prefix of */jsp/*, and a suffix of *.jsp*
  - Maps, for example, the logical view name *search* to */jsp/search.jsp*
- **Open** *com.javatunes.web.SearchController* for editing
  - Modify both the *get()* and *processSearch()* methods to return logical view names instead of hard coded JPS pages
- Restart the server (Right click on server, Restart)
- Test your Web app again starting from *http://localhost:8080/javatunes*
  - It should all work exactly as before

STOP

LEARNINGPATTERNS

Forms and Command Objects

Integration with Java EE

Spring MVC Basics

Forms and Command Objects

Spring MVC Form Tags

- Spring MVC uses form tags to give forms access to model attributes
  - *<form:form>* renders an HTML 'form' tag and exposes a model object as a binding path to inner tags for binding
    - *modelAttribute='logon'* exposes the logon object within the form *
    - It puts the object in the *PageContext* for access by inner tags
  - *<form:input>* renders an HTML 'input' text tag
    - *path='name'* binds that input element to the *logon.name* property
  - The initial form view **must** be generated via a controller, and the form's action comes from the URL associated with that controller
    - *LogonController* uses *get()* to direct a GET of *logon.do* to this page

```
<!-- Logon submission page /jsp/logon.jsp -->
<%@ taglib prefix="form"
        uri="http://www.springframework.org/tags/form"  %>
<form:form modelAttribute='logon'>
  <form:input size='20' path='name'/>
  <form:input size='20' path='password'/>
  <input type='submit' name='Submit' value='Logon'/>
</form>
```

A JavaBean Command Class

- Spring MVC "command classes" hold form data and possibly model data *
  - The *Logon* class below holds a logon name, password, and a *Principal* object (the result of a successful logon)
  - It is a POJO that follows JavaBean conventions for properties
    - With three properties and their get/set methods

```
package com.javatunes.web;
import    java.security.Principal;

public class Logon {
   private String name;
   private String password;
   private Principal principal;

   public String getName() {return name;}
   public void setName(String nameIn) {this.name = nameIn;}
   // Other get/set methods not shown
}
```

Working with Model Classes

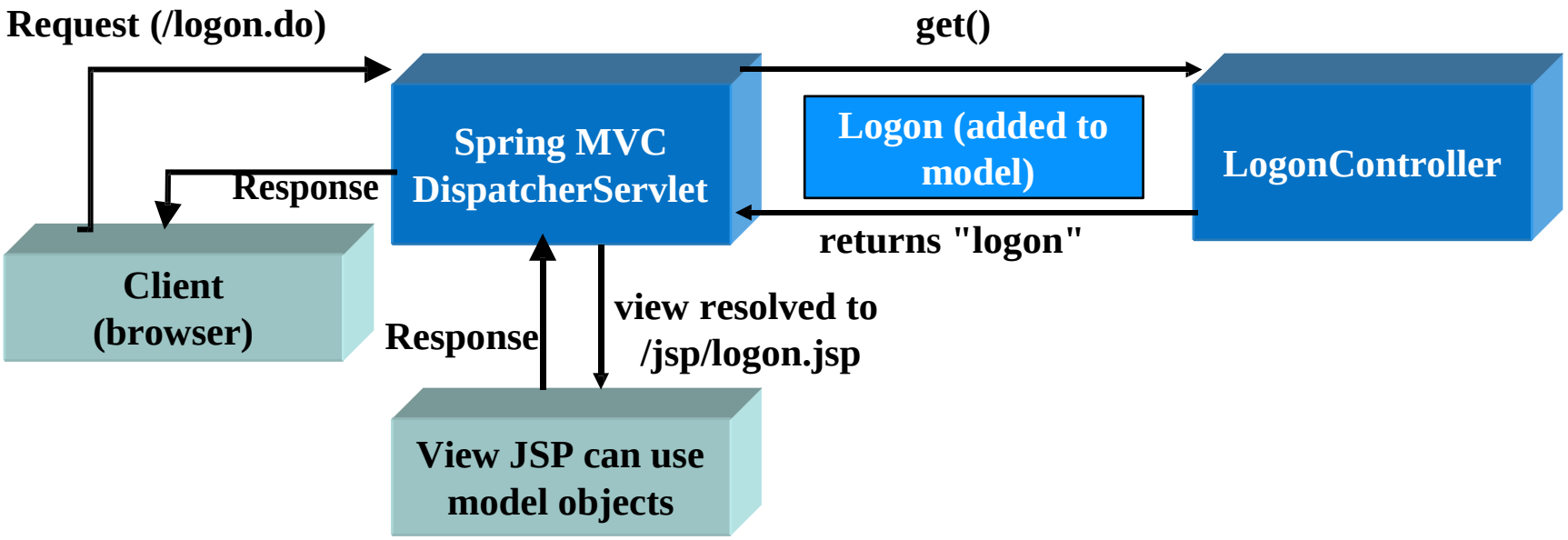
- *@ModelAttribute* binds a method parameter to a model attribute
  - Used to to expose a command object to a web view by annotating handler method parameters
  - This will cause a command object to be created (if not already present in the model) and bound to the parameter
- The example below binds an instance of *Logon* into the model
  - It is available to the Web views – note how we initialize it in *get()*

```
@RequestMapping(method = RequestMethod.GET)
public String get(@ModelAttribute("logon") Logon l) {
   l.setName("Jane Doe");  // Can initialize the model if you want
   return "logon";    // Return the view name
}

@RequestMapping(method = RequestMethod.POST)
public String processLogon(@ModelAttribute("logon") Logon l) {
   // Assume checkLogon defined elsewhere - detail not shown
   l.setPrincipal(   checkLogon(l.getName(),l.getPassword())   );
   return "welcome";
}
```

Request Handling Flow

- The diagram below shows the flow for initial form rendering
- The JSP at bottom shows *welcome.jsp* (result of a logon)
  - Note: The principal object is now a property in the *logon* bean
  - Before the principal basically was the model




```
<!-- Welcome page - previously used ${principal.name} -->
Welcome  ${logon.principal.name}
```

Exposing Reference Data in the Model

- *@ModelAttribute* can be used to expose reference data
  - By annotating a controller method, as shown below
  - The example adds a model attribute "*previousNames*"
    - Containing a list of previous logon names - used to populate a select
  - The *Logon* class would need a *previousName* property for this

```
@ModelAttribute("previousNames")
public Collection<String> populateLogonNames() {
   ArrayList<String> names = new ArrayList<String>();
   names.add("");
   names.add("James  Gosling");
   names.add("Jimmy G");
   return names;
}
```

```
<form:form modelAttribute='logon'>
   <form:input size='20' path='name'/>
   <form:input size='20' path='password'/>
   <form:select path="previousName" items="${previousNames}"/>
   <input type='submit' name='Submit' value='Logon'/>
</form>
```

LEARNINGPATTERNS

Lab 6.5 – Forms and Command Objects

Lab 6.5 – Forms and Command Objects

Lab

- **Overview**: In this lab, we'll expand on the Spring MVC functionality that we use by using the form tag library, and an associated command object to handle the form submission
  - We'll modify our controller to use the command objects
  - This will be used in our JavaTunes web app to handle the search functionality
- **Objectives**:
  - Use the Spring MVC form tags
  - Bind model attributes (command objects) to request parameters
- **Builds on previous labs**: none
- **Approximate Time**: 25-35 minutes

Lab Preparation

Lab

- The (new) root lab directory where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab06.5

Tasks to Perform

- Remove Lab06.2 from the server *, and close all open files/projects
- Create a new Dynamic Web project called Lab06.5
  - See Lab 6.1 instructions if you need more detail on this
  - Remember to **set the context root** to javatunes
- Right click on the project in Project Explorer and select **Build Path | Configure Build Path** and add in the Spring library as before
  - Next, click **Deployment Assembly** in the left pane (for configuring Web app deployment dependencies)
  - Click **Apply** if prompted to save modifications
  - Click **Add | Java Build Path Entries** click **Next**, select the **Spring** library, click **Finish**, then **OK**

Finish the Controller

Lab

Tasks to Perform

- Open *com.javatunes.web.**Search*** for review
  - This is a command class with three properties – a keyword (*String*), artist (*String*) and search results (*Collection<MusicItem>*)
- Open *com.javatunes.web.**SearchController*** for editing
  - Note how *get()* and *processSearch()* both have parameters of type Search
  - Annotate the parameters in both methods with *ModelAttribute* so that they are bound to a model attribute named "search"
- Finish *get()* by initializing the keyword to "*Diva*"
  - This value will show up in the initial rendering of the form
- Finish *processSearch()* as follows:
  - Extract the keyword from the search object, and use it to search
  - Add the results into the search object

Finish the JSP Pages

Lab

Tasks to Perform

- Open *jsp\searchHeader.jspf* for editing (it contains the search form)
  - Note the taglib for the Spring MVC form tag library at the top
  - Modify the opening *form* tag to include the form tag library prefix, and to bind to the command with a name of "*search*"
  - Modify the closing *form* tag to include the form tag library prefix
  - Finish the *form:input* tag's path attribute to bind to the "keyword" property of the command object

- Open *jsp\searchResults.jsp* for editing (the search results)
  - The search command bean is available in the results view also
  - Finish the *c:forEach* tag's items attribute by initializing it to refer to the results property of the search bean

Form Initialized and Rendered

Lab

- We can see the results below
  - We've browsed to *search.do*, and the response to that request has been generated by the form in *searchForm.jsp*
  - Note how the keyword field has been initialized to "Diva"

Test Your Application

Lab

Tasks to Perform

- Deploy to the server as you did earlier (restart the server)
- Open a browser on: *http://localhost:<8080>/javatunes*
  - Click the link to go to the search form – you should see your default search term of "Diva"
  - Do a search – you should see the same results we've seen before
  - Congratulations - you've made a simple, but complete, Spring MVC app
- **Optional**: Add reference model data to the application
  - In *SearchController*, annotate *populateArtists()* so it adds an attribute named "*artists*" into the model
  - In *SearchController*, add code to *processSearch()* to test for and use the artist property if it has a value of greater than 0 length
  - In searchHeader.jspf, uncomment/complete the *form:select* to bind to the artist property, and initialize the items from the artists attribute
  - Run the application again and test this functionality

STOP

Review Questions

- How do you integrate the Spring container with normal web applications?
- What is MVC?
- What are the architecture and main components of Spring MVC?
- How do you configure Spring's *DispatcherServlet*?
  - What does its URL mapping look like?
- What does a command controller do?
  - How is it invoked?
- How do controllers help you process forms?
  - What role to Spring command classes play in this?

Lesson Summary

- The Spring container integrates with normal Web applications via Springs ***ContextLoaderListener***
  - It automatically loads Spring's root application context and makes it available to Web apps
- **MVC**: A common pattern for organizing apps with user interfaces into three areas of functionality
  - **Model**: Representing the business domain
  - **View**: Presenting the data to users
  - **Controller**: An intermediary between the model and the view
- Spring implements MVC as follows:
  - Spring beans used as model
  - Normal view pages (e.g. JSP) as view
  - Command controllers as its controllers

Lesson Summary

- Spring's ***DispatcherServlet*** is a normal servlet configured in *web.xml*
  - Its url-mapping uses patterns, e.g. *.do
  - This mapping is applicable to a whole category of requests
  - It acts as a front controller to the web app
- **Controllers** handle incoming requests
  - They access request data, execute business logic, set up the model with data, and indicate the next view to render
- Controllers can easily process form requests
  - They can bind method parameters to command classes to gain access to the form data
- **Annotations** are considered best practice for configuration
  - They make configuration very simple

LEARNINGPATTERNS

Module 7: Spring Security Overview

Spring Security

- Provides security services for Spring / Java EE apps
- Comprehensive support for **authentication** (identifying users)
  - HTTP Basic, Digest, Form-Based, X.509 client certificate
  - Integration with common containers (Tomcat, JBoss, etc)
  - LDAP, JAAS, and much more
- Authentication supported in different areas
  - Authorizing Web requests
  - Authorizing invocations on a bean
  - Accessing domain objects
- Fairly simple XML configuration
  - Much improved from previous releases

Spring Web Security - web.xml

- Spring security can be easily used to protect Web apps
  - Via the *web.xml* and Spring configuration files
- ***web.xml*** uses a filter specifying the URLS to protect
  - This provides a hook into the Spring security system
  - Below, we use ***DelegatingFilterProxy*** (a supplied Spring class) to protect all URLS in the Web app
    - Via a **/*** url-pattern

```
<filter>
  <filter-name>springSecurityFilterChain</filter-name>
  <filter-class>
      org.springframework.web.filter.DelegatingFilterProxy
  </filter-class>
</filter>

<filter-mapping>
  <filter-name>springSecurityFilterChain</filter-name>
  <url-pattern>/*</url-pattern>
</filter-mapping>
```

Spring Web Security - Spring Configuration

- Web security is configured in the Spring config file
  - Using the ***<http>*** element (in the Spring security namespace)
  - Below, ***<http>*** is used with the ***auto-config*** attribute
    - This sets up a default configuration to enable security easily
  - ***<intercept-url>*** specifies request URLS to apply security to
    - ***/**** specifies all URLs in the application
    - The ***access*** attribute requires users to be in the ROLE_USER role

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:security="http://www.springframework.org/schema/security"
  xsi:schemaLocation="http://www.springframework.org/schema/beans
    http://www.springframework.org/schema/beans/spring-beans-3.1.xsd
    http://www.springframework.org/schema/security
    http://www.springframework.org/schema/context/spring-security-3.0.xsd">

  <security:http auto-config="true">
    <security:intercept-url pattern="/**" access="ROLE_USER" />
  </security:http>
</beans>
```

Spring Web Security - Spring Configuration

- You define users with an **authentication provider**
  - These check the validity of credentials (e.g. name/password)
  - Configured in XML via ***<authentication-provider>***
- Authentication providers depend on a **user details service** to get/store authentication information
  - The ***user-service*** variant defines this info in the config file *
  - Below, we define users jane and john with passwords and roles

```
<security:authentication-manager>
  <security:authentication-provider>
    <security:user-service>
      <security:user name="jane" password="password"
                     authorities="ROLE_USER, ROLE_ADMIN" />
      <security:user name="john" password="password"
                     authorities="ROLE_USER" />
    </security:user-service>
  </security:authentication-provider>
</security:authentication-manager>
```

More <security:http> Capabilities

- *<http>* has a number of configuration attributes, including
  - ***lowercase-comparisons*** : Convert URLs to lower case?
  - ***realm***: Realm name if basic authentication is used
  - ***access-denied-page***: Forwarding page for failed access
- *<http>* also has sub-elements for configuration, including:
  - ***<http-basic>***: Basic authentication (used if forms not enabled)
  - ***<form-login>***: Form login configuration, including login page, login processing url, default target, url, etc.
  - ***<anonymous>***: Enables anonymous principals
  - ***<logout>***: Enables logout and its configuration
  - ***<intercept-url>***: URL patterns for security - with attributes:
    - ***pattern***: The URL path to match
    - ***method***: HTTP method to match (used in combination with pattern)
    - ***access***: Roles to allow access to
    - ***channel***: Can be "http", "https", or "any" to define access allowed

Other User Details Services

- **Database-based** variants are available
  - User/authority info stored in a DB with a specified schema *
  - Provided by jdbc-user-service
  - Easily accessed by configuring a datasource, then using it in the authentication provide

```
<!-- securityDataSource configured elsewhere -->
<security:authentication-provider>
  <security:jdbc-user-service
            data-source-ref="securityDataSource"/>
</security:authentication-provider>
```

- **LDAP-based** variants are available
  - Can configure mapping of user name to LDAP DN
  - Can configure binding of user to LDAP directory
  - Can configure mapping of LDAP groups to authorities

LEARNINGPATTERNS

Lab 7.1 – Spring Web Security

Lab 7.1 – Spring Web Security

Lab

- **Overview**: In this lab, we'll explore Spring security
  - We'll use it to add security to the JavaTunes Web application form previous labs
- **Objectives**:
  - Become more familiar with Spring security
  - Use Spring security to enforce access to a Web application
- **Builds on previous labs**: none
- **Approximate Time**: 20-30 minutes

Lab Preparation

Lab

- The (new) root lab directory where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab07.1

Tasks to Perform

- Remove Lab06.5 from the server *, and close all open files/projects
- Create a new Dynamic Web project called Lab07.1
  - Remember to set the context root to javatunes
- Right click on the project in Project Explorer and select **Build Path | Configure Build Path** and **add in the Spring library** as before
  - Also add all the jars in *StudentWork\Spring\SpringSecurityLibraries*
    - See notes for details on adding the jars
    - These jars are a subset of the full Spring security distribution
  - Also add the **Spring library and all the spring security jars** via the **Deployment Assembly** (see notes for details)

Configure Application

Lab

Tasks to Perform

- Open *WebContent\WEB-INF**web.xml*** for editing
  - Find the *<filter>* element for the Spring security filter
  - Finish *<filter-mapping>* so security is applied to all requests
- Open *WebContent\WEB-INF**applicationContext.xml*** for editing
  - Ignore errors in this file until you finish this part of the lab
  - Note the security namespace declaration at the top
  - Finish ***<security:http>*** so auto-config is true
  - Finish ***<security:intercept-url>*** so it applies to all requests, and access is granted to users in ROLE_USER
  - Find the ***<security:authentication-provider>***
  - Finish the two user elements with name, password, & authorities
  - At least one user should contain the ROLE_USER authority

Test Your Application

Lab

Tasks to Perform

- Deploy to the server as you did in Lab 6.1 (restart the server)
- Browse to: *http://localhost:<8080>/javatunes*
  - You'll be prompted for a username/password - enter the data for the user that has the ROLE_USER authority
  - You should be forwarded to the JavaTunes home page
- Try logging out (browse to **javatunes/j_spring_security_logout**)
  - Log in again with invalid information, or with a non ROLE_USER user
  - You should be prompted for another login
- Add ROLE_ANONYMOUS to the roles in *applicationContext.xml*
  - Redeploy, and access the app in the browser - you should be able to access it without logging in now (you should log out first)
- **Optional**: set ***auto-config="false"*** in *<security:http>*
  - Try adding in ***<security:http-basic/>*** to the *<http>* and run the app - you'll see that the login uses HTTP basic now

STOP

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Test Your Application

Lab

Method Security

- Method security is very simple, and can be added three ways
  - Via **annotations** on your bean class
  - Via **AspectJ** pointcut expressions
  - Via **XML** configuration on a bean definition

- **Annotations** are enabled via the configuration element below
  - Enables Spring specific annotations (***@Secured***)
  - Enables JSR-250 annotations (***@RolesAllowed***, ***@DenyAll***, ***@PermitAll***)
  - These annotations are usable on your Spring bean classes
  - Access specified in terms of roles in your authentication provider

```
<security:global-method-security secured-annotations="enabled"
                                 jsr250-annotations="enabled"/>
```

Method Security - Annotations

- Below, ***@Secured*** secures a bean class from our labs
  - It specifies that only users in ROLE_USER can access any methods of the class
  - You can also annotate individual methods
  - The security runtime will now check and enforce these access requirements on bean invocations

```
import    org.springframework.security.annotation.Secured;
// Other imports, details omitted
@Secured("ROLE_USER")
public class JavaTunesCatalog implements Catalog { /* … */ }
```

- Below, we show usage of **JSR-250** annotations
  - Useful if you don't want Spring specific code in your beans

```
import    javax.annotation.security.RolesAllowed;
// Other imports, details omitted
@RolesAllowed("ROLE_USER")
public class JavaTunesCatalog implements Catalog { /* … */ }
```

Method Security - Pointcut Expressions

- Pointcut expressions can apply security to a wide-range of code
  - Use *<protect-pointcut>* and the AspectJ expression language in the Spring configuration
  - Below, we declare that only ROLE_USER users can access **any method** in *com.javatunes.catalog.Catalog*
  - Multiple *<protect-pointcut>* elements are allowed
  - That's all that's needed to protect these method invocations
  - This is very powerful, and should be used very carefully

```
<security:global-method-security>
  <security:protect-pointcut
    expression="execution(*  com.javatunes.catalog.Catalog.*(..))"
    access="ROLE_USER"/>
</security:global-method-security>
```

Method Security - XML Configuration

- XML can configure security for a particular bean declaration via **<intercept-methods>**
  - Letting you set protections on an individual bean
  - Below, we specify that all methods in the javaTunesCatalog bean that start with find, can only be accessed by ROLE_USER users
  - This allows simple security configuration within the bean definition
  - Not as powerful as pointcut declarations, but easier to use and understand

```
<bean id="javaTunesCatalog"
        class="com.javatunes.catalog.JavaTunesCatalog">
  <security:intercept-methods>
    <security:protect method="find*" access="ROLE_USER" />
  </security:intercept-methods>
</bean>
```

LEARNINGPATTERNS

Lab 7.2 – Method Security

Lab 7.2 – Method Security

Lab

- **Overview**: In this lab, we'll add method security to a bean
- **Objectives**:
  - Add method security to a bean using Spring Security
- **Builds on previous labs**: 7.1
- **Approximate Time**: 15-25 minutes

Tasks to Perform

- Continue to work in the **Lab07.1** directory
- Open ***applicationContext.xml*** for editing
  - Add in a ***<security:global-method-security>*** element that allows both Spring and JSR250 security annotations
- Open ***JavaTunesCatalog.java*** for editing
  - Add an annotation to allow ROLE_USERS to access the entire bean - use a Spring or JSR-250 annotation

Test Method Security

Lab

Tasks to Perform

- **Restart** Tomcat & browse to http://localhost:8080/javatunes again
  - Login as a ROLES_USER, and do a search - it should succeed
- **Change** the security annotation to require **ROLES_ADMIN** users
  - **Restart** Tomcat and logout (javatunes/**j_spring_security_logout**)
  - Login with a non-admin user, then search - **access will be denied** !
- **[Optional]** Comment/remove the *<global-method-security>* in *applicationContext.xml* and the annotations in *JavaTunesCatalog*
  - In *applicationContext.xml*, add a new *<global-method-security>* with a ***protect-pointcut*** element and a pointcut expression
    - Have it specify that only ROLE_ADMIN users can invoke any *com.javatunes.catalog.Catalog* method
    - See earlier examples in the slides
  - **Restart** Tomcat, login as a non-admin user, then do a search
  - You should see **access denied**

Test Method Security

Lab

Tasks to Perform

- **[Optional]** Comment out the pointcut security declaration
  - In *applicationContext.xml*, add an ***<intercept-methods>*** element to the bean def for *javaTunesCatalog* to specify only ROLE_ADMIN access
  - **Restart** Tomcat, login as a ROLE_USER, then do a search
  - You should see **access denied**

- If Spring security is installed, you can look at the documentation
  - It is likely in a folder like *C:\spring-security-3.1.3.RELEASE*
  - The documentation is in the docs folder

STOP

LEARNINGPATTERNS

Module 8: RESTful Services with Spring

REST Overview

REST and Spring MVC

Client-Side Access to RESTful Service

Common REST Patterns

Module 8: RESTful Services with Spring

- Understand what REST and RESTful services are
- Learn how to implement RESTful services using Spring
- Learn how to create RESTful clients with Spring's RestTemplate
- Create RESTful service implementations, and use them from Java clients

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LEARNINGPATTERNS

REST Overview

REST Overview

REST and Spring MVC

Client-Side Access to RESTful Service

Common REST Patterns

Overview of REST

- REST stands for **Re**presentational **S**tate **T**ransfer
  - A set of principles on **defining and accessing resources** on a network (e.g. the Web)
  - No official REST specification
  - We'll describe some generally accepted principles here
- REST focuses on **resources** identified by **URI**s (Web links)
  - **Data centric**, not API centric
  - Interactions are **stateless** between requests
  - Resources have a **simple, uniform interface**
    - Limited set of well defined operations - **GET**, **POST**, **PUT**, **DELETE**
    - Defined set of content types (e.g. plain text, XML, JSON)
  - Radically different from RPC (e.g. SOAP)

REST Details

- REST services are **stateless**, and systems communicate by **transferring representations of resources**
  - Every request carries the information needed to carry it out
- RESTful resources are **uniquely identified by URI**
  - Consider the URI to be a **noun** (the resource being accessed)
- REST uses only a few methods - based on HTTP:
  - **GET** - A read - retrieves the resources representation
  - **POST** - A create - creates a new resource
  - **PUT** - An update - pastes a changed copy over the original
  - **DELETE** A delete - Removes the data associated with the resource
  - Consider the method to be a **verb** (the action)

Example: Accessing REST Resources

- URIs are used to access REST-based resources
- Consider a REST service to maintain a list of customers
  - To retrieve all customers, you might use the URI below

http://foo.com/crm/rest/customers

  - **http://foo.com/crm**: The Web app base URI
  - **/rest**: URI for all REST services in this app
    - Mapped in *web.xml* (e.g. the Spring MVC dispatcher servlet)
  - **/customers**: The REST "noun" (the resource to access)
  - **GET**: The verb (assuming this is a GET request)
  - We'll abbreviate this in the form ***<webapp>****/rest/customers*
- A representation of all the customers is returned
  - e.g. the id, name, and address of each customer
  - This could be in many forms – text, XML, JSON, etc

What is a REST Service Interface?

- A set of URIs, associated verbs, their effects, and response
- Consider our customer URI and its possible methods / effects

  <webapp>/rest/customers

  – A **GET** request would return a list of all customers
    - In whatever format the implementers defined (e.g. XML)
  – A **POST** request would create a new customer
    - The request would include the customer information in the request body
- In contrast, a SOAP service might define operations like:
  – getUser, addUser, removeUser, updateUser, listUsers

URI Templates for Client Data

- **URI Templates** are URIs with embedded variables
  - Variables are denoted with ***{variableName}***, as shown below

    *<webapp>/rest/customers/**{id}***

  - The above example is a URI Template
  - ***{id}*** is an embedded variable
  - Clients **fill in the variables with data** to produce a complete URI

    *<webapp>/rest/customers/**123***

- They provide a **structural description** of a service interface
  - They describe the form of the URIs defined for the service
  - Can be used by REST processors to process REST requests
    - A request URI is compared to a URI template to determine the resource being addressed, and to extract the variable data
  - See notes for details

REST URI with a URI Template

- Consider the URI Template below, and the methods it supports
  - It includes an embedded variable for the customer id

<webapp>/rest/customers/{id}

  - e.g. *<webapp>/rest/customers/**123***
  - **GET** returns the customer with the id (potentially as XML)
  - **DELETE** deletes the customer with the id
  - **PUT** modifies the customer with the id using the request contents

- The customer id is extracted from the URI
  - Based on the URI Template that describes where the variable is
  - For the URI above, the GET processor would extract the value 123 as the id
    - Perhaps using it to look up a customer and generate a response

Summary of REST Characteristics

- REST uses **simple representations** (e.g. XML, text, JSON) rather than SOAP messages
- REST has a **small number of fixed methods** (GET, etc)
  - It has many different resources (identified by different URIs)
    - e.g., accessing different customers just a GET on a different URI
- The **interaction is very simple**
  - The request looks like **GET /crm/rest/customers/123**
  - The response is a simple document
- REST exchanges can be cached with existing HTTP mechanisms
- References to other resources can be represented as simple hyperlinks

Comparison of REST and SOAP

- REST **is simpler** than SOAP
  - Uses common concepts and existing infrastructure (HTTP/Web)
  - Small learning curve, and closer in design to the Web itself
  - SOAP is much more complex
- REST is **HTTP based**
  - SOAP is transport agnostic – e.g. SOAP over JMS exists
- REST is basically **point-to-point**
  - SOAP allows for distributed communications with multiple intermediary nodes
- REST **has no standards for security, reliable messaging**
  - However, REST can leverage existing HTTP standards
  - SOAP has a lot of additional capabilities available
- **REST is newer than SOAP**
  - SOAP has become an accepted standard for Web services

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REST and Spring MVC

REST Overview

REST and Spring MVC

Client-Side Access to RESTful Service

Common REST Patterns

Spring Support for REST

- REST support builds on top of Spring MVC, including:
  - ***@RequestMapping*** maps RESTful URIs to standard controllers
  - ***@PathVariable*** supports URI templates
  - ***@RequestBody*** binds incoming HTTP data to Java objects
  - ***@ResponseBody*** binds return values to the response body
  - **HTTP Method conversion** supports GET, POST, DELETE, PUT
  - **New views** support XML and JSON response representations
  - We'll go into detail on most of these

- Generally, you would map the Spring MVC Dispatcher servlet to a URL specifically for REST requests
  - e.g. ***/rest/****
  - All such requests would be dispatched via the dispatcher servlet

A Simple RESTful Controller Example

- Below, we illustrate a simple controller to handle RESTful URIs
  - We'll explain how this works next - some detail is omitted now
- *CustomerController* maps to requests of the form *<webapp>/rest/**customers***
- *getAllCustomers()* maps to URIs of the form ***/customers***
- *getCustomer()* maps to URIs of the form ***/customers/123***
  - The 123 value would be bound to the *Long id* parameter

```
@RequestMapping("/customers")
public class CustomerController {

  @RequestMapping // Find/return all customers
  public String getAllCustomers() { … }

  @RequestMapping("/{id}") // Find/return a single customer
  public String getCustomer(@PathVariable Long id) { … }
}
```

Using @RequestMapping and @PathVariable

- ***@RequestMapping*** maps a REST URI to a controller
  - It supports URI Template matching
  - ***@PathVariable*** binds a controller method parameter to a URI Template variable
- Below, */customers/{id}* specifies a RESTful URI
  - It has a URI Template with a variable named ***id***
  - ***@PathVariable*** binds the id method parameter to this variable
    - Based on matching the variable name to the parameter name
  - This matches a URI of the form *<webapp>/customers/123*
    - In this request, *123* will be bound to the *id* method parameter
    - Generally, a controller uses the parameter values in processing a request, then generates an appropriate response (covered soon)

```
@RequestMapping("/{id}")
public String getCustomer(@PathVariable Long id) { }
```

@ResponseBody for Generating a Response

- ***@ResponseBody*** indicates that a return value should be used to directly generate a response
  - Instead of being used as a view name as in Spring MVC, or as a model object of some sort
- A return value is **automatically converted** to a representation appropriate for the client
  - The representation must satisfy the client request's ***Accept* header**
  - e.g. a ***text/xml*** accept header results in **XML** being returned
  - If there's no Accept header, any representation may be used
  - Spring provides **Http message converters** for this conversion
    - It ships with a number of different converters

@ResponseBody Example

- Below, we show ***@ResponseBody*** applied to *getCustomer()*
  - *getCustomer()* first finds a customer
    - Based on the id extracted from the URI template (detail not shown)
  - It returns the string value of the customer (using *toString()*)
  - The string is used directly to create the response body
    - We use a simple string now to get us started
    - We'll show how to use other representations later

```
@RequestMapping("/{id}")
@ResponseBody
public String getCustomer(@PathVariable Long id) {
   Customer result = … // Find a Customer (not shown)
   return    result.toString();
}
```

Additional URI Mapping Capabiliites

- **Multiple URI Templates** in a URI
  - /customers/fname/{fname}/lname/{lname}
  - /customers/{fname}/{lname}
    - Both URI Templates above have two variables
    - The first example includes literal path elements - a common technique to disambiguate URIs (see notes)
- **Specification of variable names** in *@PathVariable*
  - For when method parameter names don't match variable names
  - The matching is based on the URI Template variable name
  - Below, the *fname* variable value is used to initialize *firstName*

```
@RequestMapping("/fname/{fname}/lname/{lname}")
public String getCustomer(
        @PathVariable("fname") String firstName,
        @PathVariable("lname") String lastName)
{ /* Detail omitted */}
```

LEARNINGPATTERNS

Lab 8.1 – A Simple REST Service

Lab 8.1 – A Simple REST Service

Lab

- **Overview**: In this lab, we will create a simple REST service
  - We'll use URL Templates and *@RequestMapping* to map request URIs to controllers
  - We'll use *@ResponseBody* to indicate that the return value should be used directly to generate the response
  - We'll simply invoke the service from a browser to test it
- **Objectives**:
  - Become more familiar with REST
  - Use Spring MVC to create a simple REST service
  - Test the service using a browser
- **Builds on previous labs**: none
- **Approximate Time**: 25-35 minutes

Lab Preparation

Lab

- The (new) root lab directory where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab08.1
- We will create a REST service to work with our previous JavaTunes types - it will support two URIs of the forms shown below
  - ***/items*** : Get all the items in the JavaTunes catalog
  - ***/items/5*** : Get the item with the id of 5

Tasks to Perform

- Remove any projects from the server *, close all open files/projects
- Create a new Dynamic Web project called Lab08.1
  - See Lab 6.1 instructions if you need more detail on this
  - Remember to set the context root to javatunes
  - Remember to add the Spring user library to the build path and also via the **Deployment Assembly** (see notes)

Finish the Controller

Lab

Tasks to Perform

- In *web.xml*, review the ***/rest/****** mapping for the dispatcher servlet
- Open *ItemsController.java* (in package *com.javatunes.rest*)
  - Review the class briefly
  - It contains an injected Catalog object
  - It declares two methods that will be used as controllers
- Add annotations to accomplish the following
  - Map the entire class to the ***/items*** URI
  - Configure ***getAllItems()*** as a controller, also mapped to ***/items***
  - Configure ***findItemById()*** as a controller, mapped to a URI of the form ***/items/1***, using a URI Template with a name of id
    - Add an annotation to bind the URI Template variable to the "id" parameter that is already present in the method
  - Annotate both methods so that the return value is used to generate the response

Deploy and Test

Lab

Tasks to Perform

- To deploy to the server, right click on your server in Servers view
  - Select **Add and Remove…**
  - In the next dialog, select the Lab08.1 project, click **Add**, then **Finish**
  - Right click on your server in Servers view again, and select **Restart**
- Open a browser on: *http://localhost:8080/javatunes/**rest/items***
  - This should show the string representation of all the items
  - This is being handled by the *getAllItems()* controller
  - Note that we're using a browser as a client for simplicity in this lab
- Browse to: *http://localhost:8080/javatunes/**rest/items/1***
  - This should show the string representation the item with id == 1
  - This is being handled by the *findItem(Long id)* controller
  - The id parameter is being initialized from the URI template in the request
- It's easy to write and invoke REST services, as you can see

STOP

More Complex Response Objects

- Return data is often more complex than a string
  - For example, a Java object of some type
- These are automatically converted to a suitable representation for the client request (e.g. into XML or Json)
  - Conversion based on the **Accept headers** of the client request
  - Spring MVC provides **HTTP message converter** for this
- Below, *getCustomer()* returns a customer object
  - It is converted to an appropriate representation for the request

```
@RequestMapping("/{id}")
@ResponseBody
public Customer getCustomer(@PathVariable Long id) {
   Customer result = … // Find a Customer (not shown)
   return  result;
}
```

HTTP Message Converters

- Spring ships with a number of message converters
  - Used to convert to/from a representation
  - Common converters include:
    - ***StringHttpMessageConverter***: Reads all media types
      - Writes to *text/plain*
    - ***Jaxb2RootElementHttpMessageConverter***: Reads and writes XML (*text/xml* or *application/xml*)
      - Supports all JAXB annotated objects (*@XmlRootElement*)
      - Registered if **JAXB libraries on classpath** (present in Java 6+)
    - ***MappingJacksonHttpMessageConverter***: Reads and writes JSON (*application/json*) to/from Java objects or *HashMaps*
      - Registered if **Jackson JSON library on classpath**
- HTTP Message Converters must be registered
  - Use ***mvc:annotation-driven*** in your configuration (see notes)

Returning an XML Representation

- Requirements for returning an XML representation from a controller include:
  - JAXB libraries must be on the classpath
    - Almost always true today, since they're part of Java 6 +
  - *Jaxb2RootElementHttpMessageConverter* must be registered
    - Generally via *mvc:annotation-driven* in the config file
  - Request must include *text/xml* or *application/xml* in the Accept header
  - The returned object must be a JAXB type
    - e.g., one annotated with *@XmlRootElement*
- Returning Java **collections** in an XML representation is somewhat cumbersome
  - They have to be wrapped in a JAXB-annotated object
  - We'll show an example of this in the lab

Returning a JSON Representation

- **JSON** (JavaScript Object Notation) is a lightweight data interchange format
  - It is based on the JavaScript object/array structure
- Requirements for returning a JSON representation include:
  - Jackson JSON library must be on the classpath
    - Downloadable from *http://wiki.fasterxml.com/JacksonDownload*
  - ***MappingJacksonHttpMessageConverter*** must be registered
    - Via ***mvc:annotation-driven*** as before
  - Request must include *application/json* in the Accept header
- JSON is more commonly requested from a browser script
  - e.g. by JavaScript code running in a browser

Narrowing Controller Mappings

- *@RequestMapping* supports a ***headers*** element to narrow the primary mapping of a controller
  - Consists of sequence of *My-Header=myValue* pairs
  - A request is matched only when each header has the given value
- *getCustomer()* below is only matched if the request accepts either *text/xml*, *application/xml*, or *application/json*
  - Note: we use ***value=*** to specify the URI (see notes)

```
@RequestMapping(value = "/{id}", headers={
    "Accept=text/xml, application/xml, application/json"})
@ResponseBody
public Customer getCustomer(@PathVariable Long id) {
  Customer result = … // Find a Customer (not shown)
  return result;
}
```

LEARNINGPATTERNS

Lab 8.2 – Returning XML and JSON

Lab 8.2 – Returning XML and JSON

Lab

- **Overview**: In this lab, we will work with a REST service returning more complex representations
  - We'll return an XML representation, which will require annotating the return types with JAXB annotations
  - We'll return a JSON representation, which will require adding the Jackson libraries to the classpath
- **Objectives**:
  - Produce XML and JSON representations from a RESTful service
- **Builds on previous labs**: none
- **Approximate Time**: 25-55 minutes (depending on optional parts done)

Lab Preparation

Lab

- The (new) root lab directory where you will do all your work is:
  C:\StudentWork\Spring\workspace\Lab08.2
- We will work with our previous REST service, and add support for XML and JSON representations

Tasks to Perform

- Remove any projects from the server, close all open files/projects
- Create a new Dynamic Web project called Lab08.2
  - See Lab 6.1 instructions if you need more detail on this
  - Remember to set the context root to javatunes
  - Remember to add the Spring user library to the build path and also via the **Deployment Assembly** (see notes if you need details)
- Review the jars in the Spring library (in your Eclipse project)
  - Note the jars that support JSON (see notes)

Finish the Configuration and Controller

Lab

Tasks to Perform

- Open WEB-INF*springmvc-servlet.xml* (the Spring config file)
  - Add in an *<mvc:annotation-driven>* element to register the message converters we'll be using
  - Note: the *mvc:* namespace is already included
- Open *MusicItem.java* (in package *com.javatunes.util*)
  - Add an *@XmlRootElement* annotation (to enable marshaling to XML)
  - From package *javax.xml.bind.annotation*
- Open *ItemsController.java* for editing
  - Change the return value of *findItem()* from *String* to *MusicItem*

    ```
    public MusicItem findItem(...)
    ```

  - Change the return statement to return the object, not a string

    ```
    return cat.findById(id);
    ```

  - Upon a request, the returned object can now be marshaled to XML

Deploy and Test

Lab

Tasks to Perform

- To deploy to the server, right click on your server in Servers view
  - Select **Add and Remove…**
  - In the next dialog, select the Lab08.2 project, click **Add**, then **Finish**
  - Right click on your server in Servers view again, and select **Restart**
- Browse to: *http://localhost:8080/javatunes/**rest/items/1***
  - This should now show the **XML representation** of the result
  - The return value is JAXB annotated, and the request (from the browser) includes Accept headers for XML (see notes)
- Browse to: *http://localhost:8080/javatunes/**rest/items***
  - This will show the **JSON representation** of the result
  - The return value, a collection, is NOT JAXB annotated, so the JSON conversion is used instead
  - Note the JSON structure

[Optional] Additional Things to try

Lab

Tasks to Perform

- Only do any optional parts if time permits (there are quite a few)
- Open *ObjectWithList.java* for review (in *com.javatunes.util*)
  - *ObjectWithList* is a JAXB annotated wrapper we supply - see notes
- Change the value returned in *getAllItems()*
  - Wrap the collection in an *ObjectWithList* before returning it

```
return  new ObjectWithList(results);
```

- **Restart** the server, and try to browse to *javatunes/rest/items* again
  - You should now see an XML representation of the data (see notes)
- We supply a rest-client program to invoke RESTful services *
  - It allows us more control over the request than a browser
  - You can try it as described below and on the following slides
- Open a command prompt in StudentWork\Spring\rest-client
  - Run the program in the jar file there, e.g.

```
java -jar  restclient-ui-3.1-jar-with-dependencies.jar
```

[Optional] Additional Things to try

Lab

Tasks to Perform

- In the rest-client GUI, do the following
  - Set the URL to *http://localhost:8080/javatunes/rest/items*
  - Click the **Header** button under the URL, and add a header with *key* = *Accept*, and *Value* = ***application/json***
    - Just fill in the Key / Value fields in the GUI, and press the **+** sign
  - Make the request (click the **green arrows** to the right of the URL)
  - You should see a **JSON representation** returned
  - Change the Accept header value to ***application/xml***, and make the request again - you should see the **XML representation**
- Add an Accept header to *getAllItems()* specifying XML only

  *@RequestMapping(**headers={"Accept=application/xml"}**)*
  - **Restart** the server, and make the request with the rest-client specifying ***application/json***
  - You should see a **404** (Not Found) return - there is no controller matching the request URI and accept headers

[Optional] Additional Things to try

Lab

Tasks to Perform

- Modify *getAllItems()* to return the collection directly, instead of wrapping it in *ObjectWithList*, as shown below

  return results;

  – Make the request with the rest-client specifying *application/**xml***

  – You should see a **406** (Not Acceptable) status code

    - This means that the resource identified by the request is not capable of generating a response which is acceptable according to the accept headers

  – i.e. - There is a controller matching the request URI and accept headers

    - However, the controller can't generate the required response type, because the bare collection can't be mapped to XML

- That's it - you've worked with both XML and JSON representations

  – You've seen some of the subtleties of generating them, and of issues that might arise with various kinds of requests

STOP

LEARNINGPATTERNS

Client-Side Access to RESTful Service

REST Overview

REST and Spring MVC

Client-Side Access to RESTful Service

Common REST Patterns

REST Client Requirements

- Several standard requirements for any REST client, including:
  - **Create a connection** to the server hosting the services
  - **Set headers** for a request (e.g. Accept headers)
  - **Set URI Template Variables** / add request parameters
    - e.g. for the REST service */customers/{id}* you could start with a base URI of *http://foo.com/crm/rest/customers*
    - You need to add the id to the base - e.g. by concatenating a string
  - **Invoke** the REST service
  - **Extract** any results, possibly converting them to a Java object
- Can be done with standard Java classes
  - But it's tedious and lengthy
- Spring's ***RestTemplate*** takes care of the boilerplate code
  - Similarly to other templates, e.g. database access

RestTemplate Overview

- ***org.springframework.web.client.RestTemplate*** provides high level methods for invoking REST services
  - Handles connectivity requirements
  - Supports creation of URIs, including URI Templates
  - Converts to/from Java objects to other representations
    - e.g. XML or JSON
  - Supports all HTTP methods (GET, POST, PUT …)
- Below, *RestTemplate* accesses our customers service
  - ***RestTemplate.getForObject*** retrieves a customer by id
  - Note the URI Template (*{id}*) expanded from a value in the call (*"123"*)

```
String URI = "http://foo.com/crm/rest/customers/{id}";
RestTemplate rt = new RestTemplate();
Customer found = rt.getForObject(URI, Customer.class, "123");
```

getForObject() Details

- ***getForObject()*** performs a GET request for a Java object
  - Hence the name *getForObject*
- *getForObject()* signature (1 of 3 variations):

```
public <T> T getForObject(
    String url,                          // The request URL
    Class<T> responseType,               // Response type
    Object... urlVariables)              // URI Template values
  throws RestClientException
```

  - The ***url*** can include URI Template Variables
  - ***responseType*** is used to automatically convert the response
    - Uses HTTP message converters - as for the service side
  - ***urlVariables*** is used to expand the URI Template Variables
    - It is a varArgs value - see notes

Conventions for RestTemplate Methods

- Each HTTP method has corresponding *RestTemplate* methods
- Naming conventions indicate the HTTP method / return type
  - Consider ***getForObject()***
  - 1st part (***get***): Indicates HTTP GET is used
  - Last part (***Object***): Indicates return type is object
- Here is another get example (details covered later)

```
ResponseEntity<T> getForEntity( String url,
        Class<T> responseType, Object... urlVariables)
```

  - In this case, the response type is *org.springframework.http.**ResponseEntity***
  - It wraps the return object to allow access to HTTP the headers

RestTemplate Method Variations

- Each HTTP method is supported by many *RestTemplate* methods
  - Allowing for convenient usage under different situations
  - The *getForObject* variations are listed below
    - *url* and *responseType*, described previously, are not described again here

*T getForObject(**URI url, Class<T> responseType**)*

- Used when there are no URL Template vars to expand

*T getForObject(String url, Class<T> responseType, **Object... urlVariables**)*

- *urlVariables*: **varArgs** list of values to expand URL template vars
- Values are assigned by their order in the url

*T getForObject(String url, Class<T> responseType, **Map<String,?> urlVariables**)*

- *urlVariables*: **Map** of values to expand URL templates vars
- Consist of key (string) / value pairs - values are keyed by name

getForObject() Using Map

- In the example below, there is a URI Template with two variables
  - We use a map to supply the variable values
  - The map is name-based, and doesn't depend on the order of variables or values
  - Useful where multiple variables are present

```
    public static void main(String[] args) {
      RestTemplate rt = new RestTemplate();
      String URI =
       "http://foo.com/crm/rest/customers/fname/{fname}/lname/{lname}";
      Map<String,String> varsMap = new HashMap<String,String>();
      varsMap.put("fname",   "Jane");
      varsMap.put("lname", "Doe");
 Customer found = rt.getForObject(URI, Customer.class, varsMap);
}
```

Other RestTemplate Methods

- Examples of other *RestTemplate* methods include:

  void ***delete****(String url, Object... urlVariables)*

  –Delete the resources at the specified URI

  T ***postForObject****(String url, Object request, Class<T> responseType, Object... uriVariables)*

  –Create a new resource by POSTing the given object to the URI

  void ***put****(String url, Object request, Object... urlVariables)*

  –Create a resource by PUTting the given object to the URI

  –We'll cover some of these other methods in more detail later

LEARNINGPATTERNS

Lab 8.3 – A Client with RestTemplate

Lab – A Client with RestTemplate

Lab

- **Overview**: In this lab, we will write a client that uses *RestTemplate* to invoke a RESTful service
  - We'll use the services from our previous labs
  - We'll start simply, and in later labs look at more capability
- **Objectives**: Use RestTemplate to invoke a RESTful service
- **Builds on previous labs**: None
  - You will work in a new project and directory for this lab
- **Approximate Time**: 35-45 minutes

Lab Preparation

- New lab folder: **C:\StudentWork\Spring\workspace\Lab08.3**

Tasks to Perform

- Close all open files
- Create a new Java project called Lab08.3 in the workspace *
  - See Lab 1.1 instructions on how to do this
  - **Do not** switch to a Java Perspective if prompted
- Remember to **add the Spring user library** while creating the project as follows
  - **Click** *Next*, and in the Java Settings dialog, **click** the *Libraries* tab *
  - **Click** the *Add Library* button, and in the dialog that comes up, **select** *User Library* then **click** *Next*
  - **Check off** *Spring*, then **click** *Finish* in all open dialogs

Complete Client Code

Lab

Tasks to Perform

- Open *TestRest.java* for editing (package *com.javatunes.rest.client)*
  - Add the following code - look for the `// TODO` comments
- Look for the definition of *ID_URI*, and finish it by appending a URI Template variable for an item id to the *BASE_URI* variable
  - So we can call our REST service at a URI like *<webapp>/items/**2***
- In ***main()*** , do the following (see the TODO comments)
  - Create an instance of *RestTempate*
  - Use *RestTemplate.getForObject()* to get a *MusicItem*
    - Use *ID_URI* as the URI, *MusicItem.class* as the response type, and a single id value (a string) for the url variables
- **Run** the TestRest program and view the results
  - Right click on *TestRest.java*, select **Run As | Java Application**
  - You should see output showing your item in the console window
    - See notes about **viewing the correct console**

Complete Client Code

Lab

Tasks to Perform

- In *main()*'s next code section, use *getForObject()* to get a *MusicItem* as a string
  - Use a response type of *String.class*, and uri and uri variables as in the last call
- **Run** the TestRest program again and view the results
  - You should see output showing your item in the console window
  - It should show a JSON representation of the item
  - This is because RestTemplate is sending the following Accept header
    - Accept: text/plain, application/json, */*
  - Since json is listed, it is chosen as the representation
  - We'll see how to change this (if you want) later
- Next in *main()*, use a **map** to pass the URI variable's values
  - The other parameters should be the same as in the first call
- **Run** the program again and view the results

[Optional] Get a Collection

Lab

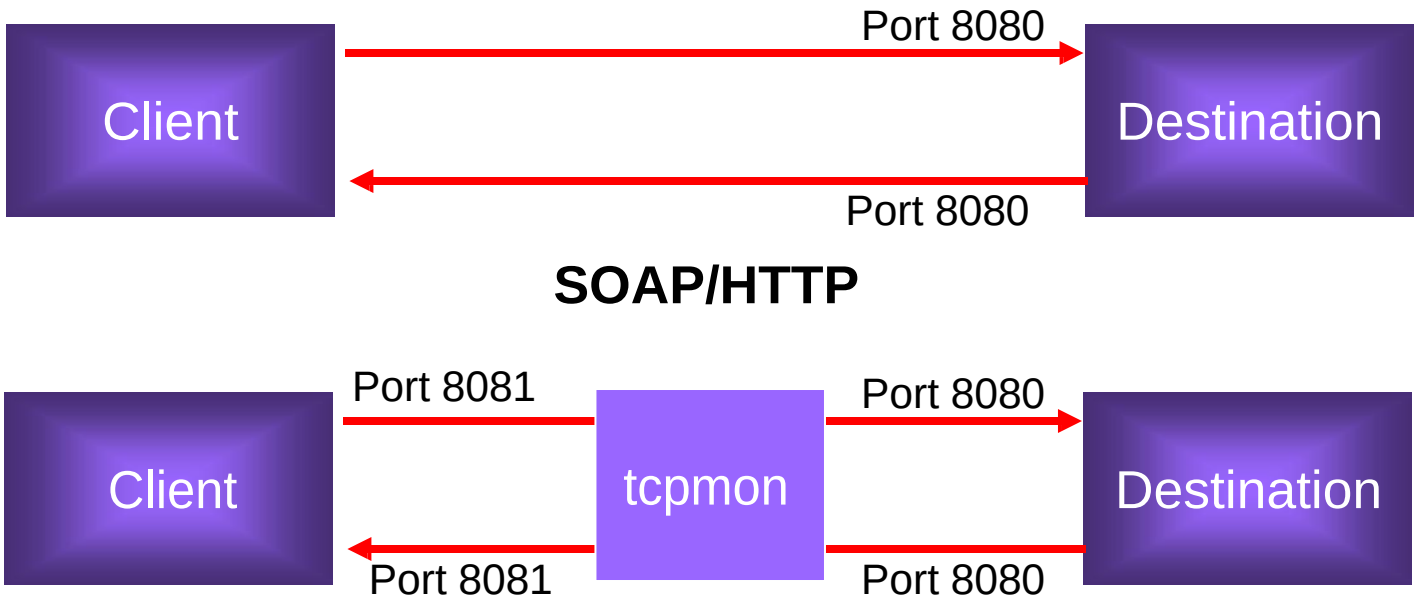
Tasks to Perform

- Back in your service, make sure that *getAllItems()* returns the bare list
  - Remove the setting of the *Accept* header to XML if you added that
  - The service should now return a JSON representation
- Back in the client, in the next code section, use *getForObject()* to get all the items
  - Use a URI of *BASE_URI*, and response type of *Collection.class*
  - No URL variable values are passed in (*BASE_URI* doesn't specify any URI Template variables)
- **Run** the TestRest program again and view the results
  - You should see a JSON string version of all the items in the collection
- You can see how easy it is to use *RestTemplate*
  - We'll go into more of its capabilities later

[Optional] tcpmon Overview

Lab

- tcpmon allows you to intercept TCP/IP messages
  - You simply give it a listen port and a target port, and it will sit in the middle of the requester and responder



[Optional] Use tcpmon

Lab

- You can optionally use tcpmon to view all the traffic between client and server
  - You'll see your REST services at work, and see what requests are being made, and what data is being transferred
  - This is not required, but useful to get a feel of how REST works

Tasks to Perform

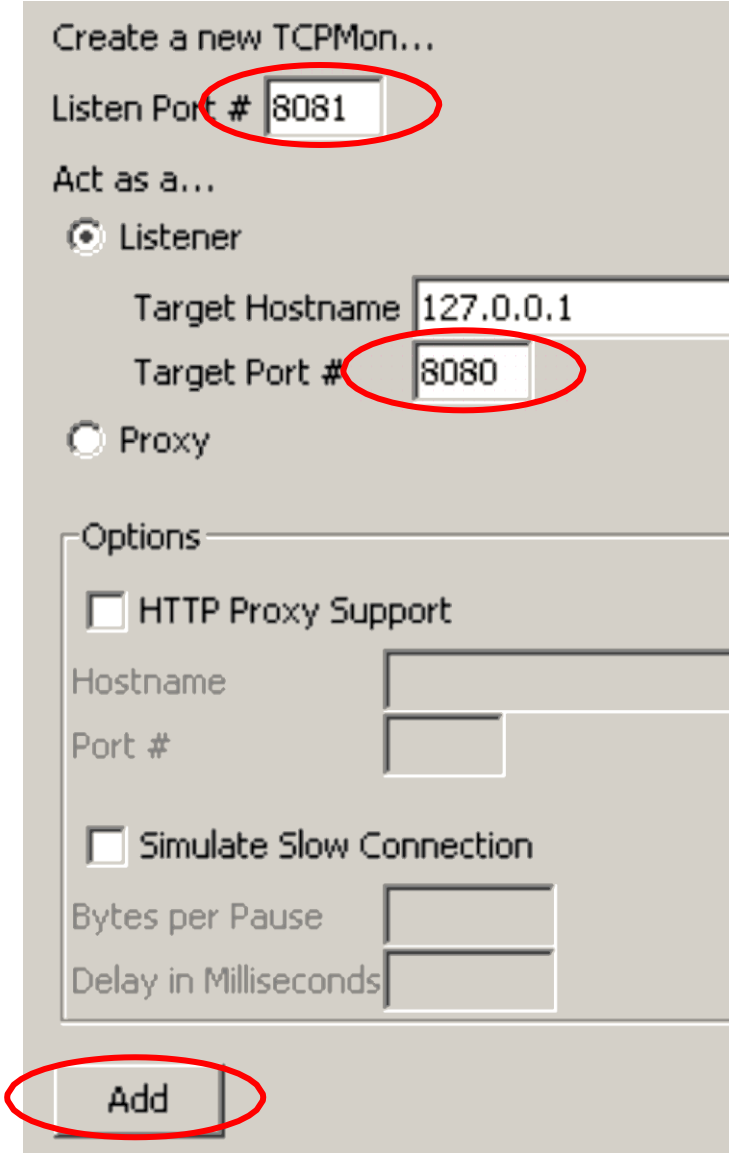
- Go to ***C:\StudentWork\SPRING\tcpmon***, and run ***tcpmon.bat***
  - You can double click on it - this starts up the tcpmon program
  - It opens in the **Sender** tab
  - Select the **Admin** tab, which we can use to intercept all the traffic between our REST client and the RESTful service
  - Continue as described on the next slide

[Optional] Use tcpmon

Lab

Tasks to Perform

- In the admin tab, fill in the values as follows:
  - Listen Port # **8081**
  - Target Port # **8080**
  - Click the [**Add**] button
- **Click the 8081 tab**, that appears (it shows request/response traffic)
- In your client, modify BASE_URI to use port 8081, instead of 8080
- Run your client
  - tcpmon should show the request/response traffic
  - See next slide for an example



[Optional] The TCPMon dialogue

Lab

State	Time	Request H...	Target Host	Request...
---	Most Recent	---	---	---
Done	2012-11-02 09:57:44	localhost	127.0.0.1	GET /javatunes/rest/items/1 HTTP/1.1

Remove Selected Remove All

```
GET /javatunes/rest/items/1 HTTP/1.1
Accept: application/xml, text/xml, application/*+xml, application/json
User-Agent: Java/1.6.0_35
Host: 127.0.0.1:8081
Connection: keep-alive
```

REQUEST

```
HTTP/1.1 200 OK
Server: Apache-Coyote/1.1
Content-Type: application/xml
Transfer-Encoding: chunked
Date: Fri, 02 Nov 2012 13:57:44 GMT

fc
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<musicItem><artist>Annie Lennox</artist><id>1</id><listPrice>17.97</listPrice><
0
```

RESPONSE

STOP

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[Optional] The TCPMon dialogue

Lab

RestTemplate.getForEntity()

- ***getForEntity()*** performs a GET request for an HTTP entity
  - Returns a ***ResponseEntity***, which extends ***HttpEntity***, and represents a request or response entity
  - *HttpEntity/ResponseEntity* allows access to the HTTP specific data of a response
- *getForEntity()* signature (1 of 3 variations):

```
<T> ResponseEntity<T> getForEntity(
    String  url,                    // The request URL
    Class<T>  responseType,         // Response type
    Object... urlVariables)         // URI Template values
  throws RestClientException
```

  - The arguments are as we've seen before
  - Details on the next page

HttpEntity and HttpHeaders

- *org.springframework.http.HttpEntity* / *ResponseEntity* represent a request or response entity
- Contains headers (in an *HttpHeaders* object) and a body
  - Access the headers and body via the methods below

```
public HttpHeaders getHeaders()
public T getBody()
```

- *ResponseEntity* adds the method *getStatusCode()*
  - Below is a simple example

```
String URI = "http://foo.com/crm/rest/customers/{id}";
RestTemplate rt = new RestTemplate();
ResponseEnity<Customer> foundEntity =
    rt.getForEntity(URI, Customer.class, "123");
System.out.println(foundEntity.getStatusCode());
```

Accessing Headers

- ***HttpHeaders*** has methods to access the headers
  - **Common headers** have specific methods, e.g.

long ***getContentLength()***: Content-length header value

MediaType ***getContentType()***: Content-type header value

  - **Generic access** useable for any header

String ***getFirst(String headerName)***: First value for header

  - Many others - see the documentation
  - Below is a simple example of accessing headers

```
    // Assume same URI and RestTemplate object as before ...

ResponseEnity<Customer> foundEntity =
    rt.getForEntity(URI, Customer.class, "123");
System.out.println("getForEntity has content type: " +
                        foundEntity.getHeaders().getContentType());
```

RestTemplate.exchange()

- *RestTemplate.exchange()* takes an *HttpEntity* object
  - Can be used to set headers for the request
  - The signature is below

```
<T> ResponseEntity<T> exchange(
    String url,                    // The request URL
    HttpMethod method,             // HTTP method e.g. GET
    HttpEntity<?> requestEntity,   // Request entity
    Class<T> responseType, Object...urlVariables)
  throws RestClientException
```

- *url*, *responseType*, *urlVariables* as seen earlier
- ***method*** is the HTTP method to use - GET, POST, etc.
- ***requestEntity*** is the entity to write to the request
  - May include headers

Setting Headers on a Request

- Below, *exchange()* is used to set an accept header specifying JSON
  - Using the enum *org.springframework.http.**MediaType***
  - Also shows some of the API for the types used (see notes)
  - It's somewhat lengthy, but fairly straightforward

```
// Assume same URI and RestTemplate object as before ...

List<MediaType> accepts = new ArrayList<MediaType>();
accepts.add(MediaType.APPLICATION_JSON);
HttpHeaders headers =new HttpHeaders();
headers.setAccept(accepts);
HttpEntity<customer>requestEntity =
        new HttpEntity<Customer>(headers);
ResponseEntity<Customer> exchangeEnt = rt.exchange(ID_URI,
        HttpMethod.GET, requestEntity, Customer.class,"123");
System.out.println(exchangeEnt.getHeaders().getContentType());
```

Error Handling

- A number of choices in handling errors on the server side
- For example, if lookup of an item by id finds no item you can:
  - Throw an exception in controller (e.g. IllegalArgumentException)
  - Return null
    - Both of these will **result in a (runtime) exception** on the client side
  - Provide a way to test ahead of time if a call will fail
    - e.g. make sure that the id is found by the REST service below
- You must decide how to deal with these in the client
  - e.g. handling exceptions, or calling a test method

```
// Based on REST controller used before

@RequestMapping(value="/exists/{id}", method=RequestMethod.GET)
@ResponseBody
public Boolean checkForCustomer(@PathVariable("id") Long id)
{ /* Check for customer with given id */ }
```

Summary of RestTemplate Usage

- We've looked at some core functionality of *RestTemplate*
  - Focusing on using get to make requests
- We've seen there are many variants of each capability
  - Multiple versions of each method like *getForObject()*
  - Multiple methods to accomplish a particular task
    - e.g. *getForObject()*, *getForEntity()*, *exchange()*
- There is broad HTTP method support
  - Methods to do POST, PUT, DELETE, etc.
  - Multiple variants of each method
  - Other ways to execute requests (e.g. the *execute()* method)
- We'll cover some more of this later
  - There are many details beyond the scope of the course
  - Look at the documentation !!

LEARNINGPATTERNS

Lab 8.4 – [Optional] Accessing Headers

Lab – Accessing Headers

Lab

- **Overview**: In this lab, we'll use additional *RestTemplate* functionality to access the HTTP headers
  - We'll examine the headers from a *getForEntity()* request
  - We'll use *exchange()* to set accept headers
- **Objectives**: Use *RestTemplate* to get and set headers when accessing a RESTful service
- **Builds on previous labs**: 8.3
  - You will continue to work in your Lab08.3 project
- **Approximate Time**: 25-45 minutes (depending on optional parts done)

Use getForEntity()

Lab

Tasks to Perform

- Open *TestRest.java* for editing
  - Comment out all the *getForObject()* invocation and output code
- Add code to do the following
  - Use *RestTemplate.getForEntity()* to get a *MusicItem*
    - Use *ID_URI* as the URI, *MusicItem.class* as the response type, and a single id value (a string) for the url variables
    - The return type of the call will be *ResponseEntity<MusicItem>*
    - Access and output the content type and status code from the return value
    - Access and output the body from the return value
- **Run** the *TestRest* program and view the results
  - The returned item should be the same
  - You should also be able to see the content type and status codes of the call

[Optional] Set Headers

Lab

Tasks to Perform

- Time permitting, do the following
- Create an *HttpHeaders* object
- Create an *ArraryList<MediaType>*
  - Add in *MediaType.APPLICATION_XML* to the list
  - Set the accepts list of the headers to be your list of *MediaType*
- Create an *HttpEntity<MusicItem>*- passing in your headers object to the constructor
- Call *RestTemplate.exchange()*, to GET an item by id
  - Pass in your *HttpEntity* as the request entity in the call
  - The *HttpMethod* should be *HttpMethod.GET*
  - The response type should be *MusicItem.class*, and other parameters as in previous calls
  - Access and output the content type and body from the return value
- **Run** the program - look at the results

[Optional] Change Media Type

Lab

Tasks to Perform

- Change the media type in your list of media type to MediaType.APPLICATION_JSON
  - Comment out the code that adds the XML type, and add in the JSON
  - **Run** your program again - notice that the content type of the exchange call is now application/json
- If you want to see the json that was returned, do the following
  - Create an *HttpEntity<String>* passing in your same headers object to the constructor
  - Call *exchange()* as before, except use your new request entity, and use *String.class* for the response type
  - Get the body from the return value of *exchange()* and output it
  - **Run** the program, and view the output
- That's it - you've used some of the entity capabilities
  - We'll explore more *RestTemplate* capabilities later

STOP

LEARNINGPATTERNS

Common REST Patterns

REST Overview

REST and Spring MVC

Client-Side Access to RESTful Service

Common REST Patterns

The REST Methods

- We'll now review some standard REST methods (or verbs)
  - We'll look at the following details for each:
  - The **REST method** and its effect
    - For GET, POST, PUT and DELETE
  - The **CRUD equivalent operation** (assuming a standard Create-Read-Update-Delete) system
  - The **kind of entity** it operates on (the noun)
    - Either a single entity or a collection of entities
  - Other characteristics, such as is it **idempotent** or **cacheable**
    - An idempotent operation can be applied multiple times without changing the result
  - A **Controller implementation** example (the server side)
    - We won't show the business logic for the examples
  - A ***RestTemplate* client** implementation example (a client)

GET: Retrieve Information

- **REST Verb**: GET (We've seen many examples of this already)
- **CRUD Equivalent**: Read
- **Noun**: Collection URI (multiple) or Entity URI (single)
- **Idempotent**: So it should not initiate state change
- **Cacheable**
- Examples (only pertinent parts of URL shown in all examples)
  - Multiple: GET /**customers**
  - Single: GET /**customers/123**

```
// Controller - Assumes @RequestMapping("/customers") on class

@RequestMapping // Multiple: Match URI like /customers
@ResponseBody
public Object getAll() {...} // See notes about return value

@RequestMapping("/{id}") // Single: Match URI like /customers/123
@ResponseBody
public Customer getCustomer(@PathVariable Long id) { ... }
```

POST: Add New Information

- **REST Verb**: POST
- **CRUD Equivalent**: Create
- **Noun**: Collection URI (Since entity URI only available after creation)
- Example: POST /**customers**
- **Server**: To implement this specify HTTP POST on the handler
  - Done via *@RequestMapping*'s ***method*** element (See next slide also)

```
// Controller - Assumes @RequestMapping("/customers") on class
// Must specify GET now (see notes)
@RequestMapping(method=RequestMethod.GET)
@ResponseBody
public Object getAll() {...}

@RequestMapping(method=RequestMethod.POST) // Matches on POST only
   @ResponseStatus(HttpStatus.CREATED)
   @ResponseBody
   public void createCustomer(@RequestBody Customer cust) {
      // Create a Customer from the passed in parameters
   }
```

Server: POST Controller - Details

- *@RequestMapping* specifies the HTTP method as POST
  - Via ***method=RequestMethod.POST***
  - Note that *getAll()* must now specify that it handles GET
    - Otherwise, it would also be available to handle a POST
- *createCustomer()* receives a Customer object *
  - Created from the request body by an Http message converter
  - ***@RequestBody*** binds the *cust* method parameter to the request body
- Note the setting of the CREATED status code
  - We would also return the created object in this example

```
@RequestMapping(method=RequestMethod.POST) // Matches on POST only
@ResponseStatus(HttpStatus.CREATED)
@ResponseBody
public Customer createCustomer(@RequestBody Customer cust)
{ /* … */ }
```

Server: Setting Location Header for POST

- Common practice for a controller to **set the location header**
  - So the client can request just a **location URI** instead of an object
    - Which it may use for later access to the new object
- Below, we show this in a handler
  - The handler method has an *HttpServletResponse* parameter
    - Which is initialized with the current response object (see notes)
  - This is used to set the location header

```
@RequestMapping(method=RequestMethod.POST) // Matches on POST only
@ResponseStatus(HttpStatus.CREATED)
@ResponseBody
public Customer createCustomer(@RequestBody Customer cust,
                               HttpServletResponse response) {
  Customer created = // Create customer - detail not shown
  response.setHeader("Location", "/customers/" + created.getId());
  return created;
}
```

Client: RestTemplate for POST

- *RestTemplate.**postXXX()*** can be used to send a POST
  - Creates a new object using data sent in the call
- *postForObject()* signature (1 of 3 variations):
  - POSTs to the specified URI with the given object

```
<T> T postForObject (
    String url,                    // The request URL
    Object request,                // Object to create
    Class<T> responseType)         // Type of return value
  throws RestClientException
```

- Below is an example usage

```
String URI = "http://foo.com/crm/rest/customers";
RestTemplate rt = new RestTemplate();
Customer custData = new Customer("Jane", "Doe");
Customer created = rt.post(URI, custData, Customer.class);
```

PUT: Update Information

- **REST Verb**: PUT
- **CRUD Equivalent**: Update
- **Noun**: Entity URI (URI of entity that is updated)
- Example: PUT /**customers/123**
  - URI includes the id - remaining data is in the request body
- **Server**: Specify HTTP PUT on the handler - Similar to POST
  - *updateCustomer()*, below, updates the passed in customer
  - We return nothing - can also return the updated object if you want

```
// Implementation - Assumes @RequestMapping("/customers") on class

  // Matches URI like /customers/123 with method of PUT (only)
  @RequestMapping(value="/{id}",  method=RequestMethod.PUT)
  @ResponseBody
  public void updateCustomer(@PathVariable("id") Long id,
                             @RequestBody Customer cust) {
    // Update Customer with given id using values in Customer object
  }
```

Client: RestTemplate for PUT

- *RestTemplate.**put()*** can be used to send a PUT
  - Must send the object to update in the call
- PUT method signature (1 of 3 variations):
  - PUT to the specified URI with the given object

```
<T> T put (
    String url,                    // The request URL
    Object request,                // Object to update
    Object... urlVariables)        //      URI Template
            values
  throws RestClientException
```

- Below, we update the customer retrieved for id = 123

```
String URI = "http://foo.com/crm/rest/customers/{id}";
RestTemplate rt = new RestTemplate();
Customer found = rt.getForObject(URI, Customer.class, "123");
found.setFirstName("NewName");
```

Client: RestTemplate for PUT

```
rt.put(URI, found, "123");
```

DELETE: Remove an Entity

- **REST Verb**: DELETE
- **CRUD Equivalent**: Delete
- **Noun**: Entity URI (URI of entity that is deleted)
- Example: DELETE /**customers/123**
- **Server**: Below we show a controller annotated for DELETE

```
// Implementation - Assumes @RequestMapping("/customers") on class

  // Matches URI like /customers/123 with method of DELETE (only)
  @RequestMapping(value="/{id}", method=RequestMethod.DELETE)
  @ResponseStatus(HttpStatus.NO_CONTENT)
  @ResponseBody
  public void deleteCustomer(@PathVariable("id") Long id){
    // Delete customer with given id
  }
```

Client: RestTemplate for DELETE

- *RestTemplate.**delete()*** can be used to send a DELETE
- *delete()* signature (1 of 3 variations):
  - Deletes the resource at the specified URI

```
public void delete (
    String url,                          // The request URL
    Object... urlVariables)              // URI Template values
  throws RestClientException
```

- Below, we delete the customer with id = 123

```
String URI = "http://foo.com/crm/rest/customers/{id}";
RestTemplate rt = new RestTemplate();
rt.delete(URI, "123");
```

LEARNINGPATTERNS

[Optional] Lab 8.5: More REST Operations

Lab 8.5 – More REST Operations

Lab

- **Overview**: In this (optional) lab, we will implement additional REST operations on the server side
  - PUT, DELETE, and POST
    - Most of the code will be given to you - you'll just need to add the code to turn them into RESTful services
  - We'll also write clients for these using *RestTemplate*
- **Objectives**:
  - Use additional REST capabilities
- **Builds on previous labs**: none
- **Approximate Time**: 45-60 minutes

Lab Preparation

Lab

- There are two new directories where you will do your work:

  Server: C:\StudentWork\Spring\workspace**\Lab08.5**

  Client: C:\StudentWork\Spring\workspace**\Lab08.5-Client**

Tasks to Perform: Server Project

- Remove any projects from the server, close all open files\projects
- Create a new Dynamic Web project called Lab08.5
  - See Lab 6.1 instructions if you need more detail on this
  - Remember to set the context root to javatunes
  - Remember to add the Spring user library to the build path and also via the **Deployment Assembly** (see notes)
- **Create a Java project** called **Lab08.5-Client** in the workspace *
  - See Lab 1.1 instructions on how to do this if you need to
  - Remember to **add the Spring User Library**
  - **Do not** switch to a Java Perspective if prompted

Finish Controller for DELETE

Lab

Tasks to Perform

- In the **Lab08.5** project (the server) open *ItemsController.java* for editing, find the *deleteItem()* method, and add the following to it
  - *@RequestMapping* that specifies the correct URI and HTTP method
    - The URI will be something like *<webapp>/items/**2***
    - The "2" part will be represented by an URI Template variable, and your controller method will extract this as the id of the item to delete
    - The method is HTTP DELETE
  - *@ResponseBody* to specify the return value is used to create response
  - *@PathVariable* to bind the URI Template variable to the id parameter
  - Add *@ResponseStatus* to specify NO_CONTENT status
- **Add** the project to the server (see earlier labs if you need details)
  - **Restart** the server

Finish Client for DELETE

Lab

Tasks to Perform

- In the **Lab08.5-Client** project open *TestRest.java* for editing
  - Look for the TODO comments in *main()* that include DELETE
- Add a call to the RESTful DELETE service using *RestTemplate*
  - Use one of the *RestTemplate.delete()* variants
  - Use the simplest method that you can here and in the rest of the lab
    - This is generally the one that takes an Object… argument if you need to pass in URI Template variable values
  - Use a URI with a URI Template variable for the id
- **Run** the client / view the results - the item you deleted shouldn't be present in the collection of all items fetched after the delete
  - **Note**: See notes about running the client more than once

Finish and Test PUT

Lab

Tasks to Perform

- In *ItemsController.java*, find the *updateItem()* method, and add:
  - *@RequestMapping* that specifies the correct URI and HTTP method
    - The URI will be something like *<webapp>/items/2* (with a URI Template var)
    - The method should be an HTTP PUT
  - *@ResponseBody* to specify the return value is used to create response
  - *@PathVariable* to bind the URI Template variable to the *id* parameter
  - *@RequestBody* to bind the request body to the *item* parameter
  - **Restart** the server
- In *TestRest.java*, add the following (Look for TODO comment with PUT)
  - Add a call to the RESTful PUT service using *RestTemplate*
  - The URI should include a URI Template var for the id
  - Use the *putId* variable as your id value, and the found (and changed) object we already include in the code as the request object
  - **Run** the client / view the results - the 2nd GET should show new values

Finish Controller for POST

Lab

Tasks to Perform

- In *ItemsController.java*, find the *createItem()* method, and add:
  - *@RequestMapping* that specifies the correct URI and HTTP method
    - The URI will be something like <webapp>/items
    - There is NO URI Template variable in the URI
    - The method should be an HTTP POST
  - *@ResponseBody* to specify the return value is used to create response
  - *@ResponseStatus* to specify CREATED status
  - *@RequestBody* to bind the request body to the *item* parameter
    - This will be in the method parameter list
  - Within the *createItem()* method, set the ***Location*** header via the *HttpResponse* parameter passed into the method
    - The value will be of the form */items/idValue*
- **Restart** the server

Finish Client for POST

Lab

Tasks to Perform

- In *TestRest.java*, add the following (Look for TODO comment w/POST)
  - Add a call to the RESTful POST service using *RestTemplate*
  - The URI should include a URI Template var for the id
  - Use the already created item (*newItem*) supplied in the code as the request object
  - First use *postForObject()* to create and get the object back
  - Next, use *postForLocation()* to create and get just the location back
    - This second call creates a new object (with a different id) using the same data as in the *postForObject()* call - that's fine for our testing
- **Run** the client / view the results
  - You should see the newly created item output, and then a location URI(with a different id)
- That's it - you've written and used 3 new REST services

STOP

Review Questions

- What is REST? What are RESTful services?
- What representations does REST support for data?
- How do you implement RESTful services using Spring?
- How do you create RESTful clients with Spring?

Lesson Summary

- **REST** (**Re**presentational **S**tate **T**ransfer) is a set of principles on defining and accessing resources on a network
  - REST services are stateless, and systems communicate by transferring representations of resources
  - RESTful resources are uniquely identified by URI, and can include URI Templates
  - REST uses only a few methods based on HTTP
    - GET, POST, PUT, DELETE

- REST can support many data representations
  - Including text, XML, JSON, and others

Lesson Summary

- Spring's REST support builds on top of Spring MVC, including:
  - *@RequestMapping* maps RESTful URIs to standard controllers
  - *@PathVariable* supports URI templates
  - *@RequestBody* binds incoming HTTP data to Java objects
  - *@ResponseBody* binds return values to the response body
  - HTTP Message converters support different data representations

- Spring's RestTemplate takes care of much of the boilerplate code for REST clients, including:
  - Handling connectivity requirements
  - Supporting creation of URIs, including URI Templates
  - Converting to/from Java objects to other representations e.g. XML or JSON
  - Supporting all HTTP methods (GET, POST, PUT …)

LEARNINGPATTERNS

[Optional] Module 9: Aspect Oriented Programming

Overview

Spring AOP Introduction

Pointcut Expressions and Advice

XML Based AOP Support

Other Considerations

Lesson Objectives

- Understand what Aspect Oriented Programming (AOP) is and the kinds of issues that it addresses
- Define Spring AOP using @AspectJ annotations
- Define aspects, pointcuts, and advice
- Learn about the Spring AOP architecture
- Understand and use Pointcut expressions and the different kinds of advice in Spring AOP
- Learn how to define Spring AOP using its XML schema support
- Be aware of the strengths and weaknesses of AOP

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Overview

Overview

Spring AOP Introduction

Pointcut Expressions and Advice

XML Based AOP Support

Other Considerations

The Issue with Crosscutting Concerns

- **Crosscutting concerns**: Concerns (functionality) extending across multiple modules
  - For example, logging and transaction control
  - Generally present in any complex system
- Easy to conceptualize directly
  - Can include the required code where needed
  - For example, using logging statements or transactional control statements in the normal code flow
- Direct inclusion of crosscutting code can increase complexity
  - Making systems difficult to understand and maintain
  - Core functionality is interweaved with and complicated by crosscutting code
- **AOP** is designed to address this issue

Crosscutting Illustrated

- Below, are two code segments
  - The 1st without crosscutting concerns, the 2nd with
  - Note the added complexity of the 2nd sample

```
void transfer(Account fromAccount, Account toAccount, int amount) {
   fromAccount.withdraw(amount);
   toAccount.deposit(amount);
}
```

```
void transfer(Account fromAccount, Account toAccount, int amount) {
   Transaction tx = database.newTransaction();
   try {
       fromAccount.withdraw(amount);
       toAccount.deposit(amount);
       tx.commit();
       systemLog.log("Transfer",   ...   );
   }
   catch(Exception e) {
       tx.rollback();
       throw e;
   }
}
```

Aspect Oriented Programming (AOP) Defined

- AOP **encapsulates crosscutting concerns** in one place called **aspects**
  - **Separates** aspects from other system components
  - Aspects are **composed** with other components to produce the needed functionality
- Key AOP concepts:
  - **Aspect**: A module holding cross-cutting concerns (a class in Spring)
  - **Advice**: The action taken by an aspect (its functionality)
  - **Joinpoint**: A point during the execution of a program, such as a method call, where advice may run
  - **Pointcut**: A specification that matches joinpoints. Advice runs at any joinpoint that matches an associated pointcut
  - **Advised (target) object**: An object being advised by an aspect
  - **Weaving**: The process of combining the aspects with the rest of your application to create advised objects

Spring AOP Introduction

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Spring AOP With AspectJ Annotations

- Spring AOP can be defined with annotations and/or XML
  - We'll cover the annotation based usage first
- Spring uses **@AspectJ annotations** to program AOP
  - AspectJ is an open source AOP framework for Java AOP
  - Uses Java classes annotated with special annotations
- This section provides a simple example of Spring AOP using @AspectJ notations
  - It leaves out a lot of detail, and focuses on the basic concepts and syntax
  - We will cover some more of the detail later

Defining an Aspect with @AspectJ

- We'll use our *JavaInstructor* class as an example
  - Focusing on its *teach()* method
  - Assume we want to "set up a display projector" before any call to *teach()*
  - We'll implement this as AOP advice
- We'll code this using the *TeachingSupport* aspect below
  - **@Aspect** indicates that the class is an aspect
  - It doesn't do anything yet - that comes next

```
package com.javatunes.teach;

import org.aspectj.lang.annotation.Aspect;

@Aspect
public class TeachingSupport {  // Doesn't really do anything yet
}
```

Defining a Pointcut

- A **joinpoint** is a location in your program
  - This is where your advice can run
  - In Spring AOP, this is basically a method
- A **pointcut** is a specification that matches joinpoints
  - Pointcuts are used to select the joinpoints where advice will run
- ***@Pointcut*** and an expression to specify the joinpoint are used to define a pointcut
  - ***@Pointcut*** applies to methods (only) in Spring
    - Having signature *public void*
    - The method name becomes the name of the pointcut
  - An **AspectJ expression** specifies the joinpoints affected

Defining a Pointcut

- Below we specify a pointcut that matches "**any execution of a method called teach**"
  - The pointcut is called ***anyTeach()***, the same as the method
  - The AspectJ expression is ***execution(* teach(..))***
  - We'll go into more detail on the expression later
  - Note that there is no code nor return value for the method

```
package com.javatunes.teach;

import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.Pointcut;

@Aspect
public class TeachingSupport {
  @Pointcut("execution(* teach(..))")
  public void anyTeach() {} // Shouldn't be any body in this method
}
```

Defining Advice

- **Advice** is associated with a pointcut expression
  - It runs when the pointcut expression is matched
  - Advice is specified by an **annotation** (there are several) on a method
    - It includes a **pointcut** name specifying when the advice is run
    - The annotated method defines the action of the advice
- Below, ***@Before*** declares advice in ***setupDisplayProjector()***
  - It will run **before** any method execution matching the ***anyTeach()*** pointcut

```
@Aspect // note - package statement, imports omitted
public class TeachingSupport {
   @Pointcut("execution(* teach(..))") // syntax covered later
   public void anyTeach() {}

   @Before("anyTeach()")
   public void setupDisplayProjector() {
      System.out.println("Turning On Display Projector");
   }
}
```

Configuring Spring

- To use @AspectJ aspects, you must enable support for it
  - Done in the Spring configuration via the following element:

```
<aop:aspectj-autoproxy/>
```

  - This enables **autoproxying** - where Spring generates a proxy for beans that use AOP when the bean is looked up

- Aspect classes and beans using AOP must be declared in the Spring configuration, as shown below
  - They must be managed by the Spring container to enable AOP

```
<beans> <!-- xmlns and schema locations omitted - see notes -->

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

  <aop:aspectj-autoproxy/>
</beans>
```

Triggering Advice

- When the code at bottom is run – guess what happens?
  - **The advice is executed** and the following output results:

```
Turning On Display Projector
Spring is cool
```

  - The *teacher.teach()* call matches the *anyTeach()* pointcut
    - Which is defined in the *TeachingSupport* aspect
  - The before advice (the *setupDisplayProjector()* method) therefore runs before the method executes

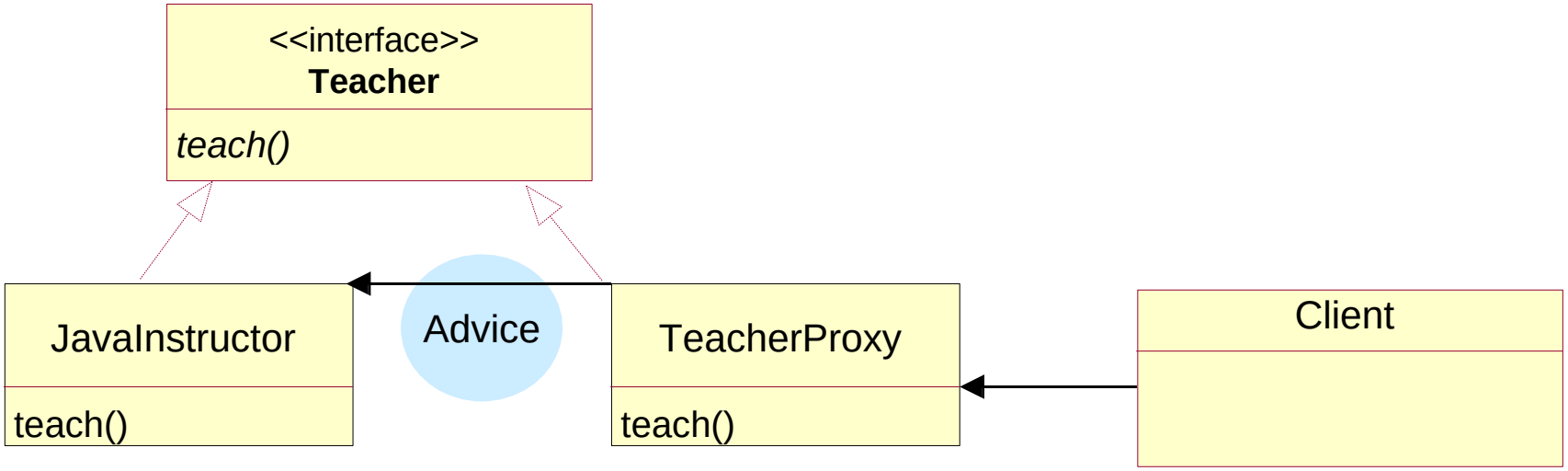
- Spring automatically generated any needed AOP code
  - *JavaInstructor* and *Teacher* **didn't need to change** !

```
ClassPathXmlApplicationContext ctx =
 new ClassPathXmlApplicationContext("applicationContext.xml");
Teacher teacher = (Teacher)ctx.getBean("springGuru");
teacher.teach();
```

More on How Spring AOP Works

- Spring uses proxies (by default) to implement the AOP functionality
  - When you look up an advised bean, you receive a proxy instead
  - When you invoke on the proxy, it adds advice applicable to the target

- **Spring AOP only supports method joinpoints**
  - Since it is proxy based, it can't support joinpoints on things like field access and constructors



LEARNINGPATTERNS

Lab 9.1 – Hello AOP World

Lab 9.1 – Using Spring AOP

Lab

- **Overview**: In this lab, we will work with Spring AOP
  - We'll use the @AspectJ annotations, and create a very simple system that shows the basics of AOP
  - Notice that this lab builds on the types used in our very early Spring labs – *JavaInstructor* and its associated types
- **Objectives**:
  - Become familiar with Spring AOP using @AspectJ annotations, and use it in a program
- **Builds on previous labs**: None
- **Approximate Time**: 25-45 minutes (depending on optional parts)

Lab Preparation

- New lab folder: **C:\StudentWork\Spring\workspace\Lab09.1**

Tasks to Perform

- Close all open files
- Create a new Java project called Lab09.1 in the workspace *
  - See Lab 1.1 instructions on how to do this
  - **Do not** switch to a Java Perspective if prompted
- Remember to **add the Spring user library** while creating the project as follows
  - **Click** *Next*, and in the Java Settings dialog, **click** the *Libraries* tab *
  - **Click** the *Add Library* button, and in the dialog that comes up, **select** *User Library* then **click** *Next*
  - **Check off** *Spring*, then **click** *Finish* in all open dialogs

Defining the Aspect (Pointcut/Advice)

Lab

Tasks to Perform

- Open up the file **TeachingSupport.java**
  - Declare this class to be an aspect using @Aspect
- Define a pointcut in *TeachingSupport*, using ***@Pointcut***
  - Use the following pointcut expression to specify any execution of the teach method (See the manual slides for sample code):

    execution(* teach(..))
  - Name the pointcut ***anyTeach()*** (by associating *@Pointcut* with a method of this name)
- Define advice in *TeachingSupport* using ***@Before***
  - Associate it with the *anyTeach()* pointcut
  - Define it on the method ***setupDisplayProjector()***
  - The method can print something using *System.out.println()*
  - That's all we need in our aspect right now

Configuring the Aspect

Lab

Tasks to Perform

- Open up the file *src/applicationContext.xml*
  - Notice the *aop* namespace declarations in the <*beans*> element
  - Add in the following element: **<aop:aspectj-autoproxy/>**
  - Add in a new bean element for *TeachingSupport*
    - The id does not matter
  - These are both **required** for Spring to recognize the aspect
- **Open** up the file ***TeachMeSpring.java*** and review it
  - All it does is look up a *JavaInstructor* and call *teach()*
- **Run** the program in ***TeachMeSpring.java***
  - You should see the output from your advice
  - If your advice isn't run, make sure the joinpoint expression in the Pointcut is exactly as in the manual – make sure all parenthesis and quotes are balanced

[Optional] Additional Pointcut & Advice

Lab

[Optional] Tasks to Perform

- Review the *JavaInstructor*, *InfoSource*, and *SpringCourseBook* classes to refresh your memory
  - We'll define advice to check the data in an *InfoSource*
- In the *TeachingSupport* class, declare an additional pointcut
  - Use the following pointcut expression to specify an execution of any method in the *InfoSource* interface *

    execution(* com.javatunes.teach.InfoSource.*(..))
  - Associate the pointcut with a method called *inInfoSource()*
- Define additional advice in *TeachingSupport* using *@Before*
  - Associate it with the *inInfoSource()* pointcut
  - Define it on the method ***checkData()***
  - The method can print something using *System.out.println()*
- Build/run your program
  - You should see the output from your additional advice

[Optional] Additional Things to Try

Lab

[Optional] Tasks to Perform

- In *TeachMeSpring.java* try adding code that creates a JavaInstructor, rather than getting it from the Spring container
  - See example code below
- Run your program
  - What happens? Is advice called when the teach() method is called on this instance?
  - Why or why not?

```
JavaInstructor ji = new JavaInstructor();
ji.setInfo(new SpringCourseBook());
System.out.println("*** Teaching with new-ed instructor ***");
ji.teach();
```

STOP

LEARNINGPATTERNS

Pointcut Expressions and Advice

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Pointcut Expressions

- Pointcuts are defined using AspectJ expressions
  - The expressions include **designators** that specify the joinpoint
  - We'll cover these enough so the concepts are clear
  - We won't cover the many details - they are in the AspectJ docs
- The ***execution*** designator has the general form shown at bottom
  - The **return type**, **name**, and **parameter** patterns are required
  - All others are optional
  - Wildcards (e.g. *) are allowed in the patterns
  - We'll review several examples to show how it works

```
execution(modifiers-pattern? ret-type-pattern
          declaring-type-pattern? name-pattern(param-pattern)
          throws-pattern?)
```

Sample execution Designator Patterns

- ***execution(public * *(..))***: Matches any public method
  - *public* = the modifier pattern
  - The 1st * = the return type, and matches any type
  - The 2nd * = the method name and matches any name
  - *(..)* matches "any number of parameters" (zero or more)
- ***execution(* teach(..))***: Matches any invocation of *teach()*
  - * = the return type (any type)
  - *teach* = the method name, and matches teach only
  - *(..)* Matches "any number of parameters" (zero or more)
- ***execution(* com.javatunes.teach.InfoSource.*(..))***: Matches invocation of method defined in the *InfoSource* interface
  - * = the return type (any type)
  - *com.javatunes.teach.InfoSource.** = the method name, and matches any method in the *InfoSource* interface in the given package
  - *(..)* Matches "any number of parameters" (zero or more)

Sample execution Designator Patterns

- ***execution(* com.javatunes.teach.*.*(..))***: Matches any method invocation from types in package *com.javatunes.teach*
  - *com.javatunes.teach.*.** = the method name – the ***.*** means any method in any class
- ***execution(* teach())***: Matches any invocation of *teach()* (from any class) that is invoked with no arguments
  - *()* Matches "zero parameters"
- ***execution(* teach(String))***: Matches any invocation of *teach()* that takes a String argument
  - *(String)* Matches "a single String argument"
- ***execution(* teach(*, String))***: Matches any invocation of *teach()* invoked with two arguments, with the 2nd being a *String*
  - *(*, String)* Matches "any param, followed by a *String* param"
- ***execution(* Teacher.teach(..))***: Matches any invocation of *Teacher.teach()* that is invoked with any number of arguments

Other Designators Available in Spring AOP

- ***within***: Limits matching to joinpoints within certain types
- ***this***: Limits matching to joinpoints where the bean reference (Spring AOP proxy) is an instance of the given type
- ***target***: Limits matching to joinpoints where the target object (application object being proxied) is an instance of the given type
- ***args***: Limits matching to joinpoints where the arguments are instances of the given types
- ***@target***: Limits matching to joinpoints where the class of the executing object has an annotation of the given type
- ***@args***: Limits matching to joinpoints where the runtime type of the actual arguments passed have annotations of the given type(s)
- ***@within***: Limits matching to joinpoints within types that have the given annotation
- ***@annotation***: Limits matching to joinpoints where the subject of the joinpoint has the given annotation

Sample Designator Patterns

- ***within(com.javatunes.teach.Teacher+)***: Matches invocation on any object of type Teacher or its subclasses
  - + means include subclasses – needed as *Teacher* is an interface *
- ***within(com.javatunes.teach.*)***: Matches invocation on any type in the single package *com.javatunes.teach*
- ***within(com.javatunes.teach..*)***: Matches invocation on any type in the package *com.javatunes.teach* or its subpackages
  - .. mean include subpackages
- ***target(com.javatunes.teach.Teacher)***: Match invocation where the target object (not the proxy) is a *Teacher* instance
- ***args(String)***: Match invocation on any method with a String arg
- ***args(*)***: Match on method with a single arg of any type
- ***args(*, String)***: Match on method with two args – the first of any type, the second of type String

Combining Pointcut Expressions

- Combine pointcut expressions using **&&** (and), **||** (or) and **!** (not)
  - You can use explicit pointcut expressions, or named pointcuts
- Assume the pointcut *anyTeach()* is defined in the aspect *School*
  - The *@Before* in *TeachingSupport* "ands" it with *targetTeacher()*
  - The advice will **only** run on a teach method executed on a *Teacher*

```
@Aspect
public class School {
    @Pointcut("execution(*  teach(..))")
    public void anyTeach() {}
}
```

```
@Aspect
public class TeachingSupport {
   @Pointcut("target(com.javatunes.teach.Teacher)")
   public void targetTeacher() {}

   @Before("targetTeacher() && School.anyTeach()")
   public void setupDisplayProjector() {
      System.out.println("Turning On Display Projector");
   }
}
```

Kinds of Advice

- Spring AOP supports several different advice types
  - They differ in when the advice is executed
  - We describe them below (labeled with their @AspectJ names)

- ***@Before***: Runs before each joinpoint
- ***@AfterReturning***: Runs after each joinpoint returning normally
- ***@AfterThrowing***: Runs after each joinpoint that throws a Throwable
- ***@After***: Runs after each joinpoint regardless of how it completes
- ***@Around***: Runs in place of each joinpoint
  - You can execute the joinpoint by calling *proceed()*

- The kind of advice you use controls when the advice is executed
  - For example, *@After* advice will execute code no matter how the joinpoint completes - i.e. completes normally or throws an exception

Advice Examples

- In the example below, the *bringTeacherADrink()* advice will run after any invocation of *teach()*
  - Even if *teach()* threw an exception
  - The *getEvals()* advice only runs if *teach()* completes normally

```
@Aspect
public class TeachingSupport {
   @Pointcut("execution(* teach(..))")
   public void anyTeach() {}

  @AfterReturning("anyTeach()")
   public void getEvals() {
      System.out.println("Hmm - How did the teach go?");
   }

   @After("anyTeach()")
   public void bringTeacherADrink() {
      System.out.println("Ahhh, Bringing teacher a drink");
   }
}
```

Around Example

- **Around** advice actually **replaces the running of the joinpoint**
  - You can execute advice before the joinpoint, proceed with the joinpoint (or not) and execute advice after the joinpoint
  - The advice method must take a ***ProceedingJoinPoint*** parameter
  - The joinpoint is intercepted by the advice – allowing full control of execution before and after, and whether to execute the joinpoint
    - Calling ***proceed()*** on the *ProceedingJoinPoint* executes the joinpoint

```
import org.aspectj.lang.annotation.Around;
import org.aspectj.lang.ProceedingJoinPoint;
// Much detail omitted ...

  @Around("anyTeach()")
  public void helpTeach(ProceedingJoinPoint joinPoint)
                                                  throws Throwable {
    System.out.println("before: Turning Display Projector On");
    joinPoint.proceed(); // Execute the joinpoint
    System.out.println("after: Ahhh, Bringing teacher a drink");
  }
```

Around Example

- Calling *teach()* on a *JavaInstructor* instance will output:

  before: Turning Display Projector On

  Spring is Cool

  after: Ahhh, Bringing teacher a drink

- We don't necessarily have to call *proceed()*
  - For example, if we have logic in *helpTeach()* to check if the display projector is broken, we might not call *proceed()*

```
@Around("anyTeach()")
public void helpTeach(ProceedingJoinPoint joinPoint)
                                        throws Throwable {
  if (turnOnDisplayProjector()) {
    joinPoint.proceed();
    System.out.println("after: Ahhh, Bringing teacher a drink");
  } else {
    System.out.println("Class cancelled - broken projector");
  }
}
```

LEARNINGPATTERNS

Lab 9.2 – More Spring AOP

Lab 9.2 – More Spring AOP

Lab

- **Overview**: In this lab, we will work with some more Spring AOP capabilities
  - We'll use additional kinds of advice and additional designators
  - We will still keep it fairly simple – it's easy to lose the concepts in a sea of advice and pointcuts
- **Objectives**:
  - Use more of the Spring AOP capabilities
- **Builds on previous labs**: 9.1
- **Approximate Time**: 20-40 minutes

Using Around Advice

Lab

Tasks to Perform

- Continue to work in the **Lab09.1** project
- Open up the file *TeachingSupport.java*
  - Create an ***@Around*** advice on the *anyTeach()* pointcut you defined in the previous lab
  - Define it on the method *helpTeach()*
  - The advice should output something before the joinpoint, proceed with the joinpoint, and output something after the joinpoint
- Run the program - you should see output from both your advice and from the call to *teach()*
- Try commenting out the call to *proceed()* in the advice
  - Run your program – what do you see? Why?
  - Remove the comment so everything runs normally

[Optional] AfterReturning Advice

Lab

[Optional] Tasks to Perform - Depends on previous labs optional

- Continue to work in *TeachingSupport.java*
  - Modify the *inInfoSource()* pointcut expression to use the following to specify the execution of *getData()* only

```
execution(* com.javatunes.teach.InfoSource.getData(..))
```

- Modify the *@Before* advice that uses the *inInfoSource()* pointcut to be *@AfterReturning* advice instead
  - Modify the pointcut expression to access the return value of the joinpoint (see the notes page of the *@AfterReturning* example code)
  - Print out the return value in your advice method
- You can't modify the return value using *@AfterReturning*
  - If you wanted to do this, you'd have to use Around advice
  - With Around advice, you have a chance to get the return value from *proceed()*, and do something with it, or return a different value it you want

[Optional] Additional Things to Try

Lab

[Optional] Tasks to Perform

- Try using additional designators, and designator expressions
  - You may need to define new pointcuts for this – make up your own
- Try accessing arguments in your advice
  - You'll need to define a new method on *Teacher* that takes an argument, implement it in *JavaInstructor*, and call it in *TeachMeSpring*
  - You'll then need to write your advice to access the arguments (see the notes on Around advice in the earlier Module slides)

STOP

XML Based AOP Support

Overview

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XML Based AOP Support

Other Considerations

Defining Aspects Using XML

- Spring AOP supports defining aspects with XML in the Spring configuration files, which has some advantages
  - You don't need the source code of the Aspect class
  - Centrally organizes AOP configuration
- XML configuration uses tags in the Spring ***aop*** namespace
  - It supports the same capabilities as the @AspectJ style aspects
  - We'll cover the syntax of using the XML configuration here
- When you use the XML configuration, the aspects are completely normal Java classes
  - The pointcut and advice information is captured in the XML
  - There is no evidence of it in the Java class

AOP XML Configuration Example

- The fragment below shows an example aop XML configuration
  - **<aop:config>** is the top level element for almost all AOP configuration
  - *<aop:pointcut>* defines the *anyTeach* pointcut seen before
  - *<aop:aspect>* defines an aspect and specifies the aspect class as *TeachingSupport* (through the *teachSupport* ref)
  - *<aop:before>* defines *setupDisplayProjector* as before advice using the *anyTeach* pointcut
  - This aspect acts exactly like the one we defined with @AspectJ

```
<beans ... >
<bean id="teachSupport" class="com.javatunes.teach.TeachingSupport"/>

<aop:config>
   <aop:pointcut id="anyTeach" expression="execution(* teach(..))"/>
   <aop:aspect id="teachAspect" ref="teachSupport">
     <aop:before pointcut-ref="anyTeach"
                 method="setupDisplayProjector"/>
   </aop:aspect>
</aop:config>
</beans>
```

Specifying Advice With XML

- The same advice types we've seen earlier are supported
  - *aop:before, aop:after, aop:after-returning, aop:after-throwing, aop:around*
  - They act the same as the @AspectJ counterparts we've seen
  - For example, for *aop:around*, the first parameter of the advice method has to be of type *ProceedingJoinPoint*
  - e.g., if *TeachingSupport* defined the following method

```
public void helpTeach(ProceedingJoinPoint joinPoint)
                                    throws Throwable {
```

  - We could specify *helpTeach()* as *around* advice as shown below:

```
<aop:config>
  <aop:pointcut id="anyTeach" expression="execution(* teach(..))"/>
  <aop:aspect id="teachAspect" ref="teachSupport">
    <aop:around pointcut-ref="anyTeach" method="helpTeach"/>
  </aop:aspect>
</aop:config>
```

LEARNINGPATTERNS

Lab 9.3 – Using AOP XML Configuration [Optional]

[Optional] Lab 9.3 – XML Configuration

Lab

- **Overview**: In this (optional) lab, we will use the XML configuration to define our aspects
  - We'll define the same aspects and advice as in the previous lab
- **Objectives**:
  - Understand and use the Spring AOP XML configuration
- **Builds on previous labs**: 9.2
- **Approximate Time**: 20-30 minutes

Using Before Advice

Lab

Tasks to Perform

- Continue to work in the **Lab09.1** project
- Copy the Lab09.1 project to another project if you want to save a copy of the annotation based lab
- **Open TeachingSupport.java** for editing
  - **Comment out or remove all the pointcuts and annotations**
  - You can comment out the imports if you want, but you'll need the import of *ProceedingJoinPoint*
- **Open *applicationContext.xml*** for editing
  - Add in configuration elements to define the *anyTeach* pointcut, an aspect using a *TeachingSupport* bean, and *before* advice with *setupDisplayProjector* as the advice method
  - See the Module slides, and your @AspectJ version for help
- **Run the program**, and you should still see output from your before advice, and from the call to *teach()*

Using Other Kinds of Advice

Lab

Tasks to Perform

- Continue to work in *applicationContext.xml*
  - Add the configuration to define *around* advice in your aspect with *helpTeach* as the advice method
  - The configuration follows the same structure as before advice
- **Run the program**, and you should see output from your before advice, your around advice, and from the call to *teach()*
- **Optional**: Add the configuration to define after-returning advice in your aspect, with *checkData* as the advice method
  - You'll need to include a returning attribute in the advice, as well as the *pointcut-ref* and *method* attributes

  returning="retVal"
  - **Run the program** and see that the output is what you expect
- You can see that the XML configuration isn't hard to use
  - It's different syntax, but the exact same structure

STOP

Other Considerations

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Other Considerations

Spring Proxies and Direct Invocation

- Spring AOP works by using proxies that intercept a method invocation and then add in the AOP functionality
  - We've seen this with Spring's transaction support also
  - It has similar results here
- You must access an object through the container for Spring AOP to work
- If you are in a class, and call another method on the same class, **the invocation won't be advised**
  - The invocation is via the *this* reference, not through a proxy
- As with transactions, you can configure load time weaving

```
<context:load-time-weaver aspectj-weaving="on"/>
```

  - See the transaction Module for more details

More on Spring Proxies

- In general, your Spring managed beans should be referenced through interface types, not through concrete types
  - This is the standard and recommended practice
  - When you do this, the AOP proxies are created via Java dynamic proxies

- If your class doesn't implement any interfaces (bad practice), you can still use AOP
  - Spring will proxy the class using CGLIB – which creates subclasses for the proxy type, but this has some ramifications
  - You can't advise final methods
  - You'll need the cglib jars in your classpath
  - Your constructor will be called twice (once for the bean instance, once for the proxy subclass instance)

Issues with AOP

- We've seen some of the capabilities of AOP
  - How it complements OO programming by providing a way to inject cross-cutting concerns into your code
- Let's now look at some of AOP's issues
- **You can't see what's going on** just by looking at your business code
  - An aspect might be injected that you don't know anything about
  - This makes the code harder to understand and maintain
  - Tools also don't have much support for visualizing the crosscutting concerns
- AOP is powerful – a **mistake** may have large consequences
  - For example, if a programmer makes a mistake in defining a pointcut, advice may be applied unintentionally

Issues with AOP

- It's easy to **unintentionally and unknowingly** change the way AOP applies to your code
  - e.g., if a programmer simply renames a method or module, it can affect the way AOP applies to that method or module
- It's **hard to debug** or find out the cause of failures
  - If something goes wrong in a system, it may be difficult to pinpoint if it's happening in core business code, in advice code, if a complex pointcut expression is not exactly right, if somebody changed a name so advice is being improperly applied, and etc.
  - This also means it's hard to assign responsibility (and even legal liability) for a bug or failure
- There are **security issues**
  - What happens if someone maliciously injects around advice into your security verification code so it allows them in?

Is AOP Worth It ?

- Like with any powerful capability, it needs to be used appropriately
  - It should only be used where it is a true cross-cutting concern AND it makes your life easier
  - Overuse or overly complex use can be problematic as it can make your code harder to write, understand, and maintain
  - Instead of making your life easier – which was the whole reason we would even consider it
- Spring transactions are a nice use of AOP
  - It makes TX behavior much easier to understand and control
- When used appropriately, it can be a very useful technique
  - But it is powerful, and should be used with care – even caution

Other AOP Capabilities and Functionality

- There is an enormous amount of capability in Spring AOP
  - We've given you enough to understand the mechanisms and the structure - but there is much more detail

- Spring AOP also gives you the capability to use more extensive capabilities
  - The Spring implementation is designed for ease of use, and usability in most common circumstances
  - For requirements that require more, you can use more capabilities, such as load-time-weaving

  - The Spring and AspectJ docs have a large amount of information for you to use to dig in deeper

Review Questions

- What is AOP, and what kinds of issues does AOP address?
- What is an aspect, a pointcut, advice?
- What are @AspectJ annotations, and how do they relate to Spring AOP
- How does Spring weave AOP advice into your program?
- What is a pointcut expression, and how do you define one with @AspectJ and Spring AOP
- How do you define advice with @AspectJ and Spring AOP
- How do you use AOP with Spring 2.x schema support?
- What are some of the issues surrounding AOP

Lesson Summary

- Dealing with crosscutting concerns (functionality) that extends across multiple modules is difficult in large software systems.
  - AOP allows you to encapsulate crosscutting concerns in one place called aspects
- **Aspects** can define the following (among other things)
  - **Advice**: The action taken by an aspect
  - **Joinpoint**: Point in a program where advice may run
  - **Pointcut**: A specification that matches joinpoints
- Spring uses **@AspectJ**'s annotations and compiler to define AOP types - while keeping its own proxy-based runtime
  - Annotations like *@Aspect*, *@Pointcut* and *@Before*, let you fully define the aspect in a Java class
  - Aspect code runs via Spring's proxy mechanism

Lesson Summary

- **Pointcuts** use pointcut expressions in the AspectJ language to specify what joinpoints are of interest
- **Advice** is associated with a method via one of the advice annotations, such as ***@Before***
  - The method body implements the advice
  - All the AOP capabilities can be also be configured with Spring XML elements from the ***aop*** namespace
- While very powerful, AOP raises some significant issues
  - These arise from the same characteristic that makes it powerful
  - You are invisibly injecting advice into your existing code base
  - There are many usability, maintenance, and security issues that can arise from this

LEARNINGPATTERNS

Recap

Recap of what we've done

- We've covered a large part of the Spring Framework
  - The **core Spring container** with bean configuration, Dependency Injection, resource access, bean lifecycle management, events, etc.
  - **Database access** with Spring, including the use of templates such as *JdbcTemplate* and Spring's support for building DAOs based on JDBC, Hibernate, and JPA
  - **Controlling transactions** declaratively with Spring declaratively using Spring annotations and XML configuration
  - Integrating Spring with **Web apps** using *ContextLoaderListener*
  - How to use **Spring security** to add access protection to your apps
  - Creating **RESTful services** using Spring MVC
  - The powerful **AOP** features of Spring, and Spring's @AspectJ and XML configuration

What Else is There

- Spring is a very large framework
  - We covered the structure and core ideas of all the areas we touched on
  - There is lots of opportunity for you to learn as you get more familiar with Spring
  - Read the documentation, read the books, use the Web
  - There is a lot of information out there to help you

- There are also additional capabilities that Spring provides
  - Look at the Spring reference manual - it has a lot of information on what the Spring capabilities are
  - There is much to explore in the wide Spring world

Resources

- The **Spring documentation**
  - The reference manual, API docs, and samples
  - They're all available in the full Spring download
- **http://www.springsource.org**
  - The home of the Spring Framework
- **Spring in Action** – Third Edition by Craig Walls
  - An excellent book, full of useful examples and explanations
  - It's big - 700 pages +
- There are many more - these are a great place to start