Mastering the Spring Framework

Chapter 1:
Introducing the Spring Framework

Chapter Objectives

In this chapter, we will:

- Provide a basic introduction to XML
- Introduce the Spring Tool Suite
- Introduce the Spring Framework and its core areas of functionality

What This Course Covers

- We will begin by discussing several technologies and tools that will be used in our software development:
  - XML which will be used for several configuration files
  - Maven which will control the project dependencies and build process
  - Spring Tool Suite which provides Eclipse plugins that are Spring aware
- We will then introduce the Spring object factory and its role in development
  - Spring will create objects (beans) for us and inject their dependencies on other objects

Chapter Concepts

What Is XML?

The Spring Tool Suite

The Spring Object Factory

Annotation-Based Factory Configuration

Chapter Summary

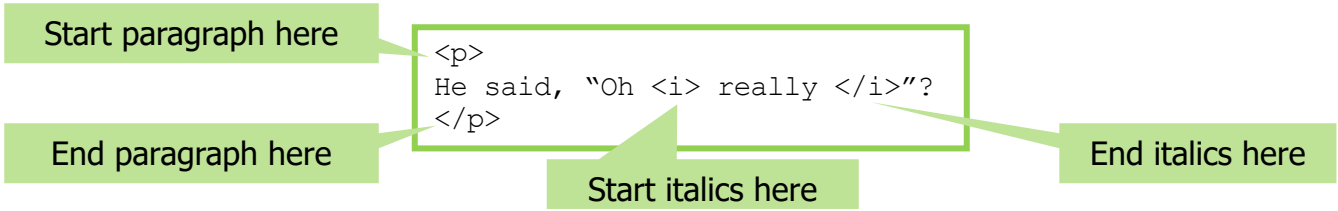
What Is XML?

- XML is an acronym for Extensible Markup Language
  - A standard from the World Wide Web Consortium (w3c)
- XML documents are in plain text
  - White space usually doesn't matter
  - Indentation is a way of improving readability

```
<!-- This is a comment -->
<project basedir="." default="build" name="ex1">
   <target name="clean">
        <delete dir="build"/>
   </target>
   <target name="build">
        <mkdir dir="build"/>
        <javac destdir="build">
            <src path="src"/>
            <classpath refid="project.classpath"/>
        </javac>
   </target>
</project>
```

What Is a Markup Language?

- Markup means that different parts of the document itself are annotated
  - For example, consider the Hyper-Text Markup Language (HTML):
    - Makes it easy for a computer program to decode content and display it
    - No need to consult separate file that says "characters 32-41" are italics



- Many markup languages are textual
  - Makes it easy for humans to view/edit documents
  - Documents are portable across platforms

What Is Extensibility?

- HTML is not an extensible language
  - The tags allowed (`p`, `b`, `it`, `br`, etc.) are part of a standard
- What happens if you insert a made-up tag into your HTML document?

```
<p>
He said, "Oh <irony> really </irony>"?
</p>
```

  - The HTML standard specifies that a browser should ignore such tags
    - So that older browsers can continue to operate on documents that are written to newer versions of the HTML standard
- To add a tag to HTML, the W3C has to approve it
  - Cannot simply create new tags to mark up proprietary content
- Why is being able to define your own tags important?

XML Is Extensible

- By allowing producers to define their own tags:
  - It is possible for the producers to describe the data they are producing
  - Possible to transmit "self-describing" data
- XML is a standard, but it is extensible
  - Only the markup syntax is fixed
  - The tags allowed (the "grammar") are not fixed
- Because tags are not fixed:
  - Producers and consumers of XML documents have to agree on what each tag means
  - Any data can be represented using XML
    - Not always concisely
    - JPEG, GIF, PNG, etc. may be better suited for large amounts of numerical or image data

XML Is Hierarchical

- In XML, "element" and "tag" are often used interchangeably
  - In this XML document, the project element contains a target element
  - XML is hierarchical
    - Every XML document has only one "root" element

```
<project basedir="." default="build" name="ex1">
   <target name="clean">
        <delete dir="build"/>
   </target>
</project>
```

- Because XML is hierarchical, easy to map XML documents to Java classes
  - Classes: `Project`, `Target`, `Delete`
  - Aggregation (has-a) relationships:
    - `Project` has a field of type `Target`
    - `Target` has a field of type `Delete`
  - If `Project` can have many `Target` fields, use `List<Target>`

Elements, Attributes, Character Data

- The data in an XML document is held mostly in elements
  - One top-level element called the root element
  - The root element of this document is the project element
- An element:
  - Has a tag name; e.g., the element with a tag name "quote"
  - May have attributes within its start tag; e.g., the `asof` attribute of quote
  - May have child elements; e.g., the symbol element is a child of target
  - May have textual content; e.g., "IBM" is the text content of symbol
  - Maybe empty; e.g., the exchange element is empty

```
<quote asof="20070321081423UTC">
   <symbol>IBM</symbol>
   <price>35.23</price>
   <exchange name="NYSE"/>
</quote>
```

XML vs. HTML

- Easy for automated algorithm to find necessary piece of data in XML
  - If document consumer knows the structure of the XML document

```
<quote>
   <symbol>IBM</symbol>
   <price>35.23</price>
</quote>
```

Find the quote element whose symbol element's content is "IBM" and get the content of its price element

- HTML is only a presentation format
  - The consumer is a web browser which knows the HTML standard
  - XHTML is HTML written in strict XML syntax
  - Hard to find necessary piece of data, even if it is displayed on screen

```
<table>
   <tr><td>IBM</td><td><i>35.23</i></td></tr>
   <tr><td>Sun Micro</td><td><b>3.12</b></td></tr>
</table>
```

  - Logic breaks every time page format changes

Find the "tr" whose first "td" has inside it a string named "IBM" or "International Business Machines" and then find the content of next "td", disregarding any "i" or "b" elements but use their text

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Spring Tool Suite

- The Spring Tool Suite (STS) is an Eclipse-based development environment that is customized to provide assistance to developers building a Spring-based application
- The STS understands the meaning of the various files in a Spring application
  - It can parse a Spring configuration file and understand the bean definitions
  - It will display detailed information about the Spring managed beans and their dependencies
  - It will validate your Spring project, which will allow it to catch configuration errors at design time instead of at runtime
- The STS provides some Spring-specific refactorings, such as renaming of a Spring managed bean
- Plus many more features
  - See the STS website for more info: https://spring.io/tools/sts

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What Is Spring?

The Spring Framework is an open-source application framework and inversion of control container for the Java platform*

- The major focus of Spring is on simplifying application development
- At the core is an object factory—known as the container
- Supplemented by extensive support for application development
  - Data access
  - Web application development—MVC framework
  - Aspect-oriented programming
  - Transaction control
  - Security
  - Batch processing
  - Much more

*Source: Wikipedia

The Spring Object Factory

- Spring provides an object factory
  - Creates and manages lifecycle of application objects
  - Principle is known as *Inversion of Control* (IoC)
    - You hand-over control of object creation to Spring
- Object factory can also perform *Dependency Injection* (DI)
  - Establish links between objects it creates when dependencies exist
- Object factory needs to be configured
  - With which objects to create
  - Which dependencies to establish
- Configuration can be performed with:
  - Annotations or
  - XML

Using Spring's Object Factory

- Consider the following simple plain Java code
  - The `PopupGreeter` class has a dependency on the Visitor interface
    - An interface is used to maintain loose coupling between greeter and visitor

```
public class PopupGreeter implements Greeter {
  private Visitor visitor;

  public Visitor getVisitor() {  return visitor;  }
  public void setVisitor(Visitor visitor) { this.visitor = visitor;  }
  public void greet() {
    JOptionPane.showMessageDialog(null, visitor.getGreeting() + "," +
                                  visitor.getFullName());
  }
}
```

Has dependency on Visitor

```
public interface Greeter {
 void greet();
 void setVisitor(Visitor v);
}
```

```
public interface Visitor {
  String getFullName();
  public String getGreeting();
}
```

Using Spring's Object Factory (continued)

```
public class AmarilloVisitor implements Visitor {
  private String fullName;
  private String greeting;

  public AmarilloVisitor(){ this.greeting = "Howdy"; }

  public String getGreeting() {return greeting;  }

  public String getFullName() { return fullName; }

  public void setFullName(String name) { this.fullName = name;
}
}
```

- To use the `PopupGreeter` class with the `AmarilloVisitor` above, we need to:
  - Create an instance of `PopupGreeter`
  - Create an instance of the `AmarilloVisitor`
    - Call `setVisitor` on `PopupGreeter` passing the instance of `AmarilloVisitor`

Using Spring's Object Factory for the `PopupGreeter`

- Spring's object factory will create the two objects for us – IoC
  - And pass the `AmarilloVisitor` to `setVisitor()` of the `PopupGreeter` – DI
  - Pass a name configured to `setFullName()` of the `AmarilloVisitor` – DI
- To use Spring, we need to:
  - Configure the factory
  - Instantiate the factory and ask it for the `PopupGreeter`
- Springs factory creates objects referred to as Beans
  - JavaBeans are:
    - Plain Java classes
    - Normally have a default constructor (although not necessary for Spring)
    - Provide access to data values via properties
      - Properties are get/set methods

JavaBean Example

- `AmarilloVisitor` is a JavaBean providing the following properties
  - A read and write property called *fullName*
  - A read-only property named greeting
- Property names are defined by the name of the get/set methods
  - Not the data member they access

```
public class AmarilloVisitor implements Visitor {
  private String fullName;
  private String greeting;

  public AmarilloVisitor(){ this.greeting = "Howdy"; }
  public String getGreeting() {return greeting;  }
  public String getFullName() { return fullName; }
  public void setFullName(String name) { this.fullName = name;
}
}
```

Spring Factories: `ApplicationContext`

- Spring provides several factories that may be used by an application
  - All of them implement the `ApplicationContext` interface
  - `org.springframework.context.ApplicationContext`
  - Configuration is provided in XML file(s) or by annotations or both
- Any `ApplicationContext` implementation is capable of:
  - Instantiating a bean (IoC)
  - Injecting its dependencies (DI)
  - Providing access to bean to any code that requires it
- Each factory is its own "container"
  - Manages the lifecycle of the beans that it creates
  - The factory constructs beans as needed
    - Can also dispose of beans that are no longer needed
- Objects created by factory are known as *Spring-managed beans*

ClassPathXmlApplicationContext

- This factory expects the configuration in XML file(s)
  - File(s) should be present somewhere in the classpath:

Should be on the classpath

```
AbstractApplicationContext factory
      = new ClassPathXmlApplicationContext("greeter-beans.xml");

// Use factory

factory.close();
```

- The `close()` method is not available in the `ApplicationContext` interface
  - So we declare the factory as `AbstractApplicationContext`

Using Beans from Factory

- Beans are provided by the `getBean` method on `factory`
  - An id/name is provided for each bean when configured
    - Id is used when asking for the bean from the factory

```
AbstractApplicationContext factory =
     new ClassPathXmlApplicationContext("greeter-beans.xml");

Greeter greeter = factory.getBean("greeter", Greeter.class);

greeter.greet();

factory.close();
```

Use bean

Id of bean requested

Interface bean should implement

XML Configuration File

- XML configuration file has `<beans>` root element
- Every bean to be created is configured using `<bean>` element
  - Id is provided to enable access by clients requesting bean from factory
  - Fully qualified class name so Spring knows which type of object to create

```
<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.xsd">

   <bean id="vis" class="com.masteringspring.greeter.AmarilloVisitor”/>

   <bean id="greeter” class="com.masteringspring.greeter.PopupGreeter”/>

</beans>
```

Id of bean when requested from factory

Configuring Dependency Injection in XML

- Spring will automatically call setter methods on properties if configured
- Values passed to properties can be:
  - Other Spring created objects(beans)
  - Absolute values configured in XML

```
<beans …>
  <bean id="vis" class="com.masteringspring.greeter.AmarilloVisitor">
    <property name="fullName" value="Joe Bob Springstein"/>
  </bean>
  <bean id="greeter" class="com.masteringspring.greeter.PopupGreeter">
    <property name="visitor" ref="vis"/>
  </bean>
</beans>
```

Call setFullName on AmarilloVisitor with value as parameter

Call setVisitor on PopupGreeter with bean whose id is vis as parameter

How Many Beans Will Be Created?

- The `getBean` method may:
  - Keep returning the same object each time
    - "singleton"
    - One bean per Spring container (`ApplicationContext` instance)
  - Return a freshly instantiated object each time
    - Uses the XML configuration as a "prototype"
    - Return a fresh object for every new request from the factory
- The number of beans created is controlled by the *scope* configuration of the bean
  - Five scopes are available
    - Singleton and prototype
    - Request and session for web applications
    - Global session for Portlets

Bean Scope Example

- The scope attribute of the <bean> element is used to define the scope
  - If omitted, singleton is the default

```
<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.xsd">

   <bean id="vis" class="com.masteringspring.greeter.AmarilloVisitor"
                 scope="singleton"/>

   <bean id="greeter" class="com.masteringspring.greeter.PopupGreeter"
                 scope="prototype"/>

</beans>
```

New bean per request from factory

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Configuration Using Annotations

- Possible to use annotations for configuration rather than XML
- To use annotation-based configuration requires:
  1. Annotating any class(es) that are to be Spring-managed beans
  2. Enable annotation-based configuration in XML configuration file
- `@Component` is used to mark a class as a Spring-managed bean
  - `@Autowired` or `@Inject` is used to indicate dependency injection
  - Both work the same way
- `@Autowired` is Spring-specific
  - `@Inject` is a Java JEE standard annotation
    - Needs JEE jar file in classpath to use this

Annotation Example

- Can use annotations, instead of XML configuration for every class:

Bean Id is value passed to annotation

```
@Component ("greeter")
public class PopupGreeter implements Greeter {
  private Visitor visitor;

  public Visitor getVisitor() { return visitor; }

  @Autowired
  public void setVisitor(Visitor visitor) {  this.visitor = visitor; }

  public void greet() {
    JOptionPane.showMessageDialog(null, visitor.getGreeting() + "," +
                          visitor.getFullName());
  }
}
```

Annotation Configuration in XML

- In the XML configuration file, need to tell Spring to scan the package(s) that contains the bean

```
<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.xsd
             http://www.springframework.org/schema/context
                http://www.springframework.org/schema/context/spring-context.xsd">

    <context:annotation-config/>

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

</beans>
```

Scan XML defined classes for annotations

Package to scan for annotated classes

Annotation Stereotypes

- When configuring a class using annotations the following annotations can be used:
  - `@Component`
  - `@Controller`
  - `@Service`
  - `@Repository`
- A Component is a catch-all
  - Controllers are associated with the presentation tier
  - Services are associated with the business tier
  - Repositories are associated with the integration tier

Complete Configuration Using Annotations

- XML can be completely removed from a Spring application
- Spring allows for a class to be annotated with `@Configuration`
  - Creation of objects is completed in code

```
@Configuration
public class AppConfig {
          @Bean
          public Visitor createVisitor(){
                    return new AmarilloVisitor();
          }
          @Bean(name="greeter")
          public Greeter createGreeter(){
                    return new PopupGreeter();
          }
}
```

Annotation-Based Factory Creation

- The Configuration class can be used to create an `ApplicationContext`
  - Use `AnnotationConfigApplicationContext`

```
AbstractApplicationContext factory =
        new AnnotationConfigApplicationContext(AppConfig.class);

Greeter g = factory.getBean("greeter", Greeter.class);

g.greet();

factory.close();
```

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- Spring provides a general-purpose object factory
  - Factory performs dependency injection when configured to do so
- To use the Spring factory:
  1. Configure the factory using XML or annotations(or both)
  2. Create a `ApplicationContext`
  3. Get beans from the `ApplicationContext`
     - Using the id of the bean and its interface type