JAVA WEB FRAMEWORKS: SPRING MVC

Advanced Java Programming

Introduction to Spring

- Spring provides in-depth concepts of Spring Framework with simplified examples. It was developed by **Rod Johnson in 2003.** Spring framework makes the easy development of JavaEE application.

- It is helpful for beginners and experienced persons.

Introduction to Spring

Spring enables developers to develop **enterprise-class** applications using **POJOs**. The benefit of using only POJOs is that you do not need an EJB container product such as an **application server** but you have the option of **using only a** robust servlet container such **as Tomcat** or some commercial product .

Spring is organized in a **modular fashion**. Even though the number of packages and classes are substantial, you have to worry only about ones you need and ignore the rest.

Spring's web framework is a **well-designed web MVC framework**, which provides a great alternative to web frameworks such as Struts or other over engineered or less popular web frameworks.

Spring Framework

- Spring is a lightweight framework. It can be thought of as **a framework of frameworks** because it provides support to various frameworks such as Struts, Hibernate, Tapestry, EJB, JSF etc. The framework, in broader sense, can be defined as a **structure where we find solution** of the various technical problems.

- The Spring framework comprises several modules such as IOC, AOP, DAO, Context, ORM, WEB MVC etc.

Spring Advantages

1) Predefined Templates

Spring framework provides templates for JDBC, Hibernate, JPA etc. technologies. So there is no need to write too much code. It hides the basic steps of these technologies.

Let's take the example of JdbcTemplate, you don't need to write the code for **exception handling, creating connection, creating statement, committing transaction, closing connection** etc. You need to write the code of executing query only. Thus, it save a lot of JDBC code.

Spring Advantages

2) Loose Coupling

The Spring applications are loosely coupled because of dependency injection.

3) Easy to test

The Dependency Injection makes easier to test the application. The EJB or Struts application require server to run the application but Spring framework doesn't require server.

4) Lightweight

Spring framework is lightweight because of its POJO implementation. The Spring Framework doesn't force the programmer to inherit any class or implement any interface. That is why it is said non-invasive.

Spring Advantages

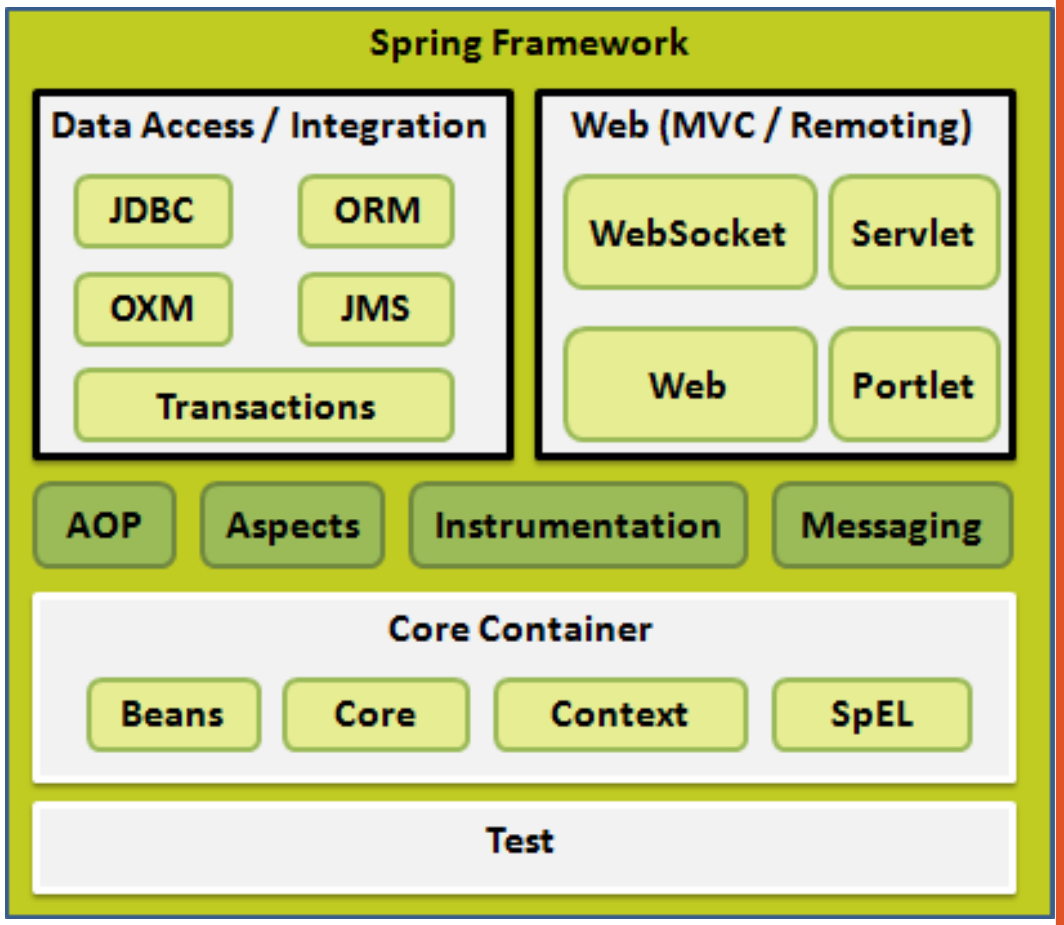
5) Fast Development
The Dependency Injection feature of Spring Framework and it support to various frameworks makes the easy development of JavaEE application.

6) Powerful abstraction
It provides powerful abstraction to JavaEE specifications such as JMS, JDBC, JPA and JTA.

7) Declarative support
It provides declarative support for caching, validation, transactions and formatting.

Spring Architecture

The Spring Framework provides about 20 modules which can be used based on an application requirement.



Spring Architecture

Core Container:

The Core Container consists of the Core, Beans, Context, and Expression Language modules whose detail is as follows:

The **Core** module provides the fundamental parts of the framework, including the IoC (Inversion of Control) and Dependency Injection features.

The **Bean** module provides BeanFactory.

The **Context** module builds on the solid base provided by the Core and Beans modules and it is a medium to access any objects defined and configured.

The **SpEL (Spring Expression Language)** module provides a powerful expression language for querying and manipulating an object graph at runtime.

Spring Architecture

Data Access/Integration:
The Data Access/Integration layer consists of the JDBC, ORM, OXM, JMS and Transaction modules whose detail is as follows:

The **JDBC** module provides a JDBC-abstraction layer that removes the need to do tedious JDBC related coding.

The **ORM** module provides integration layers for popular **object-relational mapping** APIs, including JPA, JDO (Java Data Object), Hibernate, and iBatis.

The **OXM** module provides an abstraction layer that supports **Object/XML mapping** implementations for JAXB (Java Architecture for XML Binding), Castor, XMLBeans, JiBX and XStream. The Java Messaging Service **JMS** module contains features for producing and consuming messages.

The **Transaction** module supports programmatic and declarative transaction management for classes that implement special interfaces and for all your POJOs.

Spring Architecture

Web:

- The Web layer consists of the Web, Web-MVC, Web-Socket, and Web-Portlet modules whose detail is as follows:
- The **Web** module provides basic web-oriented integration features such as multipart file-upload functionality and the initialization of the IoC container using servlet listeners and a web-oriented application context.
- The **Web-MVC** module contains Spring's model-view-controller (MVC) implementation for web applications.
- The **Web-Socket** module provides support for WebSocket-based, two-way communication between client and server in web applications.
- The **Web-Portlet** module provides the MVC implementation to be used in a **portlet environment** and **mirrors** the functionality of Web-Servlet module.

Spring Architecture

Miscellaneous:
There are few other important modules like AOP, Aspects, Instrumentation, Web and Test modules whose detail is as follows:

The **AOP** module provides **aspect-oriented programming** implementation allowing you to define **method-interceptors** and **pointcuts** to cleanly decouple code that implements functionality that should be separated.

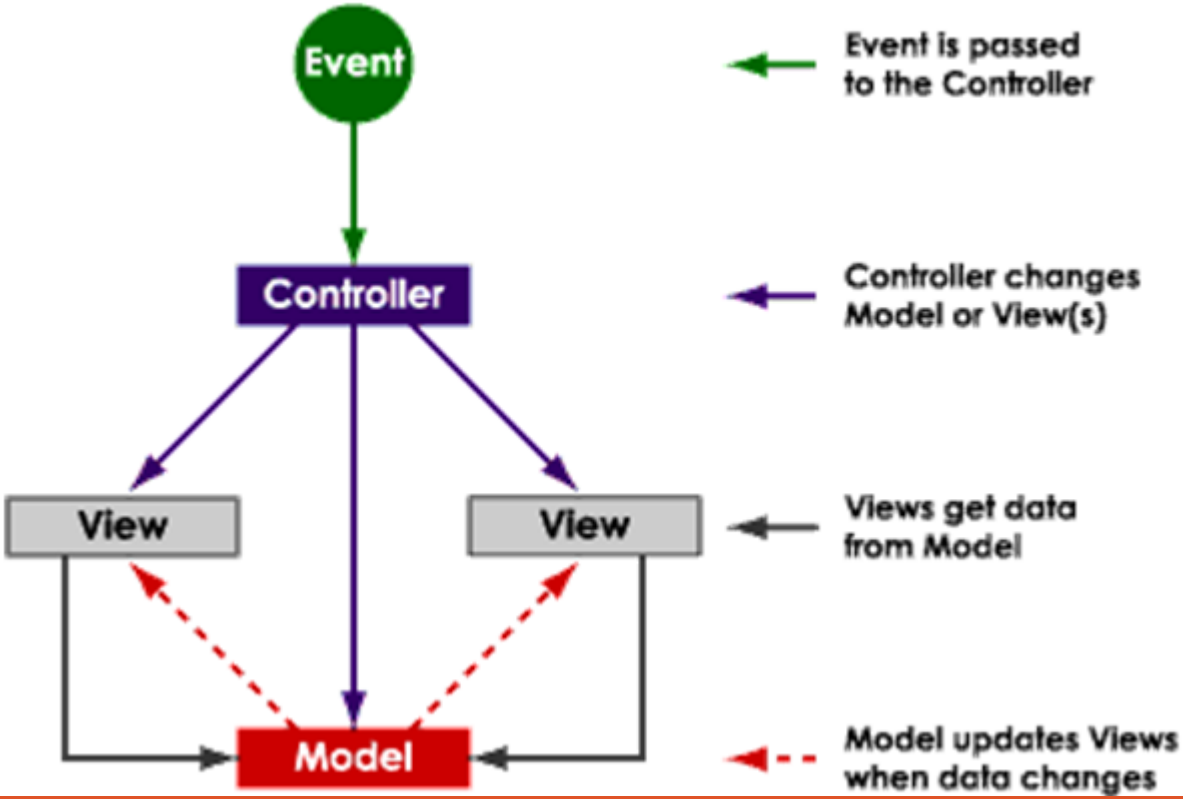
The **Aspects** module provides integration with AspectJ which is again a powerful and mature aspect oriented programming (AOP) framework.

The **Instrumentation** module provides class instrumentation support and class loader implementations to be used in certain application servers.

The **Messaging** module provides support for STOMP (**Streaming Text Oriented Messaging Protocol**) as the WebSocket sub-protocol to use in applications. It also supports an annotation programming model for routing and processing STOMP messages from WebSocket clients. The **Test** module supports the testing of Spring components with JUnit or TestNG frameworks.

Spring MVC

MVC: instances of the following:
M – **Model**: Eg. Java Bean,POJO etc
V – **View**: org.springframework.web.servlet.**View**
C – **Controller**: org.springframework.web.servlet.mvc.**Controller**



Spring MVC

MVC for Web

Event – HTTP request from client

Model –Eg Java Beans
View – Eg. JSP
Controller – Custom Spring Controller Class

Model is passed to the server-side View which is returned to the client

Spring MVC

MVC for Web

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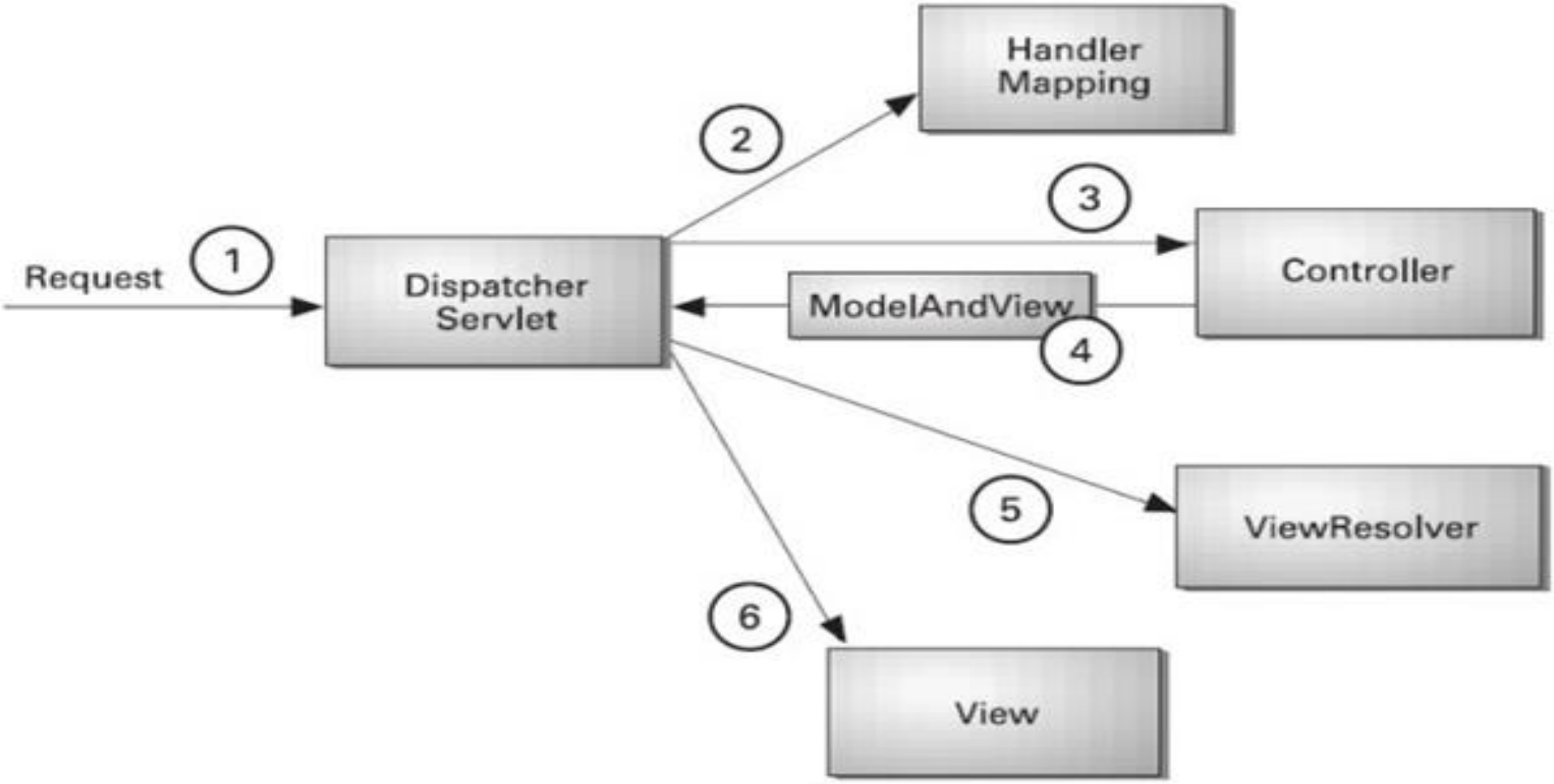
Spring MVC Lifecycle

Step 1: Incoming HTTP request is mapped to the Spring DispatcherServlet.
Step 2: The DispatcherServlet creates a container using the bean definitions found in the Servlet configuration file.
Step 3: The container finds an appropriate Controller to process the request.
Step 4: The Controller performs some custom logic and returns a ModelAndView to the container.
Step 5: The container renders the ModelAndView using the appropriate ViewResolver bean.
Step 6: An HTTP response is sent to the browser

Spring Web MVC Flow



Spring MVC Example..

link.html

```
<html>
<body>
<a href="Link.spring">GO TO SPRING HOME PAGE</a>
</body>
</html>
```

Spring MVC Example..

Spring MVC Step 1
Incoming HTTP request is mapped to the Spring DispatcherServlet.
This is configured like any other Servlet mapping. Pick a URI-Pattern and associate it with the DispatcherServlet
web.xml

```
<servlet>
 <servlet-name>Dispatcher</servlet-name>
 <servlet-class>
org.springframework.web.servlet.DispatcherServlet
</servlet-class>
 </servlet>

<servlet-mapping>
 <servlet-name>Dispatcher</servlet-name>
 <url-pattern>*.spring</url-pattern>
</servlet-mapping>
```

Spring MVC Example..

Spring MVC Step 2

- The DispatcherServlet creates a container using the bean definitions found in the Servlet configuration file.
- The DispatcherServlet locates the configuration file using the naming convention servletname-servlet.xml.

Dispatcher-servlet.xml

```
<?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:p="http://www.springframework.org/schema/p"
 xsi:schemaLocation="http://www.springframework
.org/schema/beans http://www.springframework
.org/schema/beans/spring-beans-2.5.xsd">

 <bean name="/Link.spring" class="mycontroller.LinkController"/>
  </beans>
```

Spring MVC Example..

Spring MVC Step 3
The container finds an appropriate Controller to process the request.
For example, a request for /Link.spring is mapped to the Controller defined by the **mycontroller.LinkController** class

Spring MVC Step 4
The Controller performs some custom logic and returns a ModelAndView to the container.The Controller is a Java class that extends the rg.springframework.web.servlet.mvc.Controller class.

The request is handled by the handleRequest method.

Spring MVC Example..

Spring MVC Step 4

- LinkController.java

```
package mycontroller;

import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;

import org.springframework.web.servlet.ModelAndView;
import org.springframework.web.servlet.mvc.Controller;

public class LinkController implements Controller {

  public ModelAndView handleRequest(HttpServletRequest argo,
     HttpServletResponse arg1) throws Exception {

    return new ModelAndView("Welcome.jsp");
  }
}
```

Spring MVC Example..

Spring MVC Step 5

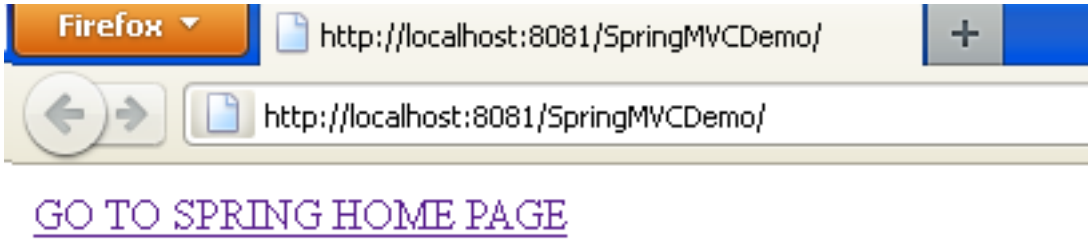
The container renders the ModelAndView using the appropriate View.

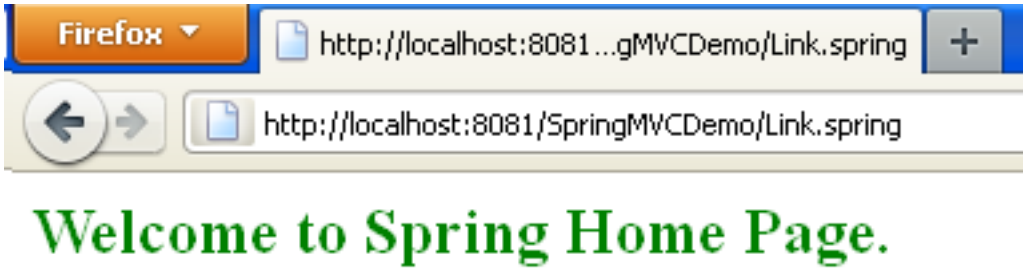
Welcome.jsp

```
<h2>
<font color="Green">
Welcome to Spring Home Page.
</font>
</h2>
```

Spring MVC Example..

Output:-

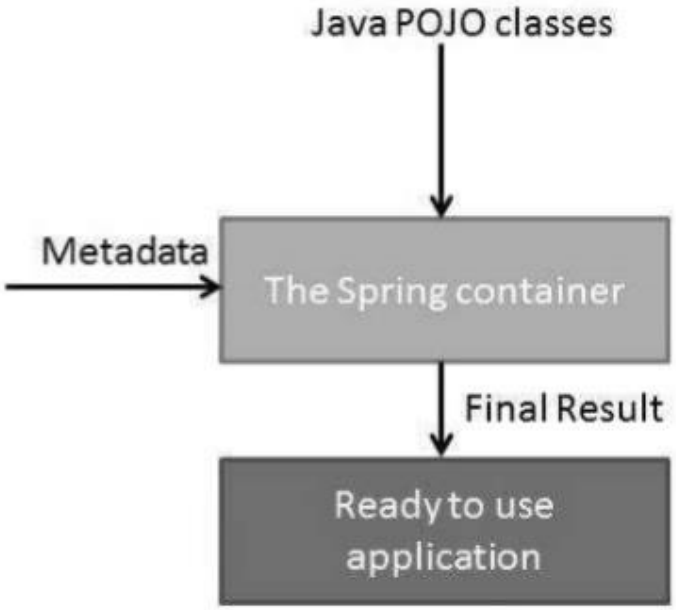




Spring - IoC Containers

The Spring container is at the core of the Spring Framework. The container will **create the objects**, **wire them together**, **configure them**, and **manage** their complete **life cycle** from creation till destruction.

The Spring container uses **DI** to manage the components that make up an application. These objects are **called Spring Beans.**



Inversion Of Control (IOC) and Dependency Injection

These are the **design patterns that** are used to **remove dependency** from the programming code. They make the **code easier to test** and **maintain**. Let's understand this with the following code:

```
class Employee{
Address address;
Employee(){
address=new Address();
}
}
```

In such case, there is dependency between the Employee and Address (**tight coupling).**

Inversion Of Control (IOC) and Dependency Injection

In the Inversion of Control scenario, we do this something like this:

```
class Employee{
Address address;
Employee(Address address){
this.address=address;
}
}
```

Thus, **IOC** makes the **code loosely coupled.** In such case, there is no need to modify the code if our logic is moved to new environment**.**

In Spring framework, IOC container is responsible to **inject the dependency**. We provide **metadata** to the IOC container **either by XML** file or **annotation.**

Advantages of Dependency Injection

- makes the code loosely coupled so easy to maintain
- makes the code easy to test

Constructor Injection

Consider you have an application which has a text editor component and you want to provide a spell check. Your standard code would look something like this –

```
public class TextEditor
{
  private SpellChecker spellChecker;
 public TextEditor()
    { spellChecker = new SpellChecker(); }
}
```

What we've done here is, create a dependency between the TextEditor and the SpellChecker.

```
public class TextEditor
{
  private SpellChecker spellChecker;
  public TextEditor(SpellChecker
spellChecker)
    { this.spellChecker = spellChecker; }
}
```

In an inversion of control scenario, the TextEditor should not worry about SpellChecker implementation. The SpellChecker will be implemented independently and will be provided to the TextEditor at the time of TextEditor instantiation. This entire procedure is controlled by the Spring Framework.

Dependency Injection

DI exists in two major variants:

1. Constructor-based dependency injection Constructor-based DI is accomplished when the container invokes a class constructor with a number of arguments, each representing a dependency on the other class.

2. Setter-based dependency injection Setter-based DI is accomplished by the container calling setter methods on your beans after invoking a no-argument constructor or no-argument static factory method to instantiate your bean.

You can mix both, Constructor-based and Setter-based DI but it is a good rule of thumb to use constructor arguments for mandatory dependencies and setters for optional dependencies. The code is cleaner with the DI principle and decoupling is more effective when objects are provided with their dependencies.

Spring provides the following two distinct types of containers.

1. **Spring BeanFactory Container**

   This is the simplest container providing the basic **support for DI** and is defined by the org.springframework.beans.factory.BeanFactory interface. The BeanFactory and related interfaces, such as BeanFactoryAware, InitializingBean, DisposableBean, are still present in Spring for the purpose of backward compatibility with a large number of third-party frameworks that integrate with Spring.

2. **Spring ApplicationContext Container**

   This container adds more enterprise-specific functionality such as the ability to resolve textual messages from a properties file and the ability to publish application events to interested **event listeners**. This container is defined by the *org.springframework.context.ApplicationContext* interface.

Spring – Bean Definition

The objects that form the backbone of your application and that are managed by the Spring IoC container are called **beans.**

A bean is an object that is instantiated, assembled, and managed by a Spring IoC container. These beans are created with the configuration metadata that you supply to the container. For example, in the form of **XML <bean/>** definitions.

Bean definition contains the information called **configuration metadata,** which is needed for the container to know the following –

- How to create a bean
- Bean's lifecycle details
- Bean's dependencies

Spring – Bean Life Cycle

The life cycle of a Spring bean is easy to understand. When a bean is instantiated, it may be required to perform some initialization to get it into a usable state. Similarly, when the bean is no longer required and is removed from the container, some cleanup may be required.

To define setup and teardown for a bean, we simply declare the <bean> with **init method** and/or **destroy-method** parameters.

```
public void init()
{
// do some initialization work
 }
```

```
public void destroy()
{
// do some destruction work
 }
```

Spring Example

1) create POJO class
2) create application class with main method
3) Bean Configuration

1) Create POJO Class HelloWorld.java

```
public class HelloWorld {

private String message;

public void setMessage(String message)
{ this.message = message; }

 public void getMessage()
{ System.out.println("Your Message : " + message);  }

public void init()
{ System.out.println("Bean is going through init."); }

public void destroy()
{ System.out.println("Bean will destroy now."); }

 }
```

2) Create application main method

```
import org.springframework.context.support.AbstractApplicationContext;
import org.springframework.context.support.ClassPathXmlApplicationContext;

public class MainApp
 {
public static void main(String[] args)
{
AbstractApplicationContext context = new
ClassPathXmlApplicationContext("Beans.xml");

HelloWorld obj = (HelloWorld) context.getBean("helloWorld");

obj.getMessage();

}
}
```

3) Create configuration file

Beans.xml

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

<bean id = "helloWorld" class = "com.HelloWorld" init-method = "init"
destroy-method = "destroy">

<property name = "message" value = "Hello World!"/> </bean>

</beans>
```

Output

Bean is going through init.
Your Message : Hello World!
Bean will destroy now.

Introduction to Spring AOP Module

Aspect-Oriented Programming **(AOP) complements** Object-Oriented Programming **(OOP)** by providing **another way of thinking** about program structure. The key unit of modularity in **OOP** is the **class**, whereas in **AOP** the unit of modularity is the ***aspect***.

Aspects enable the **modularization** of concerns such as **transaction management** that **cut across multiple types** and **objects**. (Such concerns are often termed ***crosscutting*** concerns in AOP literature.)

One of the **key components of Spring** is the ***AOP framework***. While the Spring **IoC container does not depend** on AOP, meaning you do not need to use AOP if you don't want to, AOP complements Spring IoC to provide a very capable middleware solution.

Introduction to Spring AOP Module

AOP is used in the Spring Framework to…

… provide **declarative enterprise services**, especially as a replacement for EJB declarative services. The most important such service is *declarative transaction management*.

… allow users to implement **custom aspects**, **complementing** their use of **OOP** with AOP.

AOP concepts

***Aspect*: a modularization of a concern that **cuts across multiple classes**.** Transaction management is a good example of a crosscutting concern in J2EE applications. In Spring AOP, aspects are implemented **using regular classes** (the schema-based approach) or regular classes annotated with the **@Aspect annotation** (the @AspectJ style).

***Join point*: a point during the execution of a program**, such as the **execution of a method** or **the handling of an exception**. In Spring AOP, a join point *always* represents a method execution.

Advice*: action taken by an aspect** at a particular join point. Different types of advice include "**around**," "**before**" and "**after**" advice. Many AOP frameworks, including Spring, model an advice as an ***interceptor, maintaining a chain of interceptors *around* **the join point.**

AOP concepts

***Pointcut*: a predicate that matches **join points**. Advice is associated with a pointcut expression and runs at any join point matched by the pointcut (for example, the execution of a method with a certain name). The concept of join points as matched by pointcut expressions is central to AOP, and Spring uses the AspectJ pointcut expression language by default.

Introduction: **declaring additional methods** or **fields** on behalf of a type. Spring AOP allows you to introduce new interfaces (and a corresponding implementation) to any advised object. For example, you could use an introduction to make a bean implement an IsModified interface, to simplify caching. (An introduction is known as an inter-type declaration in the AspectJ community.)

***Target object*: object being advised** by one or **more aspects**. Also referred to as the *advised* object. Since Spring AOP is implemented using runtime proxies, this object will always be a *proxied* object.

AOP Concepts

***AOP proxy*: an object** created by the AOP framework in order **to implement** the **aspect contracts** (advise method executions and so on).

***Weaving*: linking aspects** with **other application types** or objects to create an advised object. This can be done at compile time (using the AspectJ compiler, for example), load time, or at runtime. Spring AOP, like other pure Java AOP frameworks, performs weaving at runtime.

Types of Advice

***Before advice*:** Advice that executes before **a join point,** but which does **not have** the **ability to prevent execution flow** proceeding to the join point (unless it throws an exception).

After returning advice: Advice to be executed **after a join point** completes **normally**: for example, if a method returns without throwing an exception.

After throwing advice: Advice to be executed **if a method exits** by throwing an **exception**.

After (finally) advice: Advice to be executed regardless of the means by which a join **point exits** (normal or exceptional return).

***Around advice*:** Advice that **surrounds a join point** such as a method invocation. This is the most powerful kind of advice. Around advice can perform custom behavior before and after the method invocation.

AOP Examples

1. Simple AOP example… Tutorial 7 Program 2
2. https://www.journaldev.com/2583/spring-aop-example-tutorial-aspect-advice-pointcut-joinpoint-annotations

Database Transaction Management

Comprehensive transaction support is among the most compelling reasons to use the Spring Framework. The Spring Framework provides a **consistent abstraction for transaction management** that delivers the following benefits:

- Consistent programming model across **different transaction APIs** such as Java Transaction API (JTA), JDBC, Hibernate, Java Persistence API (JPA), and Java Data Objects (JDO).
- Support for **declarative transaction** management.
- Simpler API for **programmatic transaction management** than complex transaction APIs such as JTA.
- Excellent **integration** with Spring's data access abstractions.

Spring DAO

The **Data Access Object (DAO)** support in Spring is aimed at making it easy to work with data access technologies like JDBC, Hibernate, JPA or JDO in a consistent way.

This allows one to switch between the aforementioned persistence technologies fairly easily and it also allows one to code without worrying about catching exceptions that are specific to each technology.

Annotations used for configuring DAO or Repository classes

```
@Repository
public class JdbcMovieFinder implements MovieFinder {
private JdbcTemplate jdbcTemplate;

@Autowired

public void init(DataSource dataSource) {
this.jdbcTemplate = new JdbcTemplate(dataSource);
}
// ...
 }
```

CRUD Operation Using DAO and Spring API

1. Tutorial 7 Program 3
2. https://www.dineshonjava.com/spring-mvc-with-hibernate-crud-example/

Advanced Learning Resources

http://www.java2novice.com/spring/bean-scope-annotation/

http://mrbool.com/how-to-create-an-alias-for-a-bean-and-inner-bean-in-spring-framework/28549

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