

Basic Spring 4.0

Lesson 2:Introduction to Spring
Framework, IoC

Lesson Objectives

- Introduction to Spring Framework
 - Learn about the Spring Framework, its benefits and architecture
 - Learn about the IoC (Inversion of control) and how it allows wiring beans
 - Learns the types of bean factories and life-cycle of beans in these factories
 - Understand how to apply Annotations to Spring applications
- Injecting dependencies through setter and constructor injections
- Wiring Beans
- Bean containers
 - Life cycle of Beans in the factory container
 - BeanPostProcessors and BeanFactoryPostProcessors
- Annotation-based configuration



2.1 : Introduction to Spring Framework

Introduction

- December 1996 – JavaBeans makes its appearance.
 - Intended as a general-purpose means of defining reusable application components
 - Used more as a model for building user interface widgets
- Sophisticated applications often require services not directly provided by the JavaBeans specification
- March 1998 – EJB was published.
 - But EJBs are complicated in a different way, that is, they mandate deployment descriptors and plumbing code

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It all started with a bean. In 1996, the Java programming language was still a young, exciting, up-coming platform. Many developers flocked to the language because they had seen how to create rich and dynamic web applications using applets. But they soon learned that there is more to this strange new language than juggling animated cartoon characters. Unlike any language before it, Java made it possible to write complex applications made up of discrete parts. They came for the applets, but stayed for the components.

It was in December of that year that Sun Microsystems published the Java-Beans 1.00-A specification. JavaBeans defined a software component model for Java. This specification defined a set of coding policies that enabled simple Java objects to be reusable and easily composed into more complex applications. Although JavaBeans were intended as a general-purpose means of defining reusable application components, they have been primarily used as a model for building user interface widgets. They seemed too simple to be capable of any “real” work; enterprise developers wanted more.

Sophisticated applications often require services that are not directly provided by the JavaBeans specification such as transaction support, security, and distributed computing. Therefore in March 1998, Sun published the 1.0 version of the Enterprise JavaBeans (EJB) specification. This specification extended the notion of Java components to the server side, providing the much-needed enterprise services, but failed to continue the simplicity of the original JavaBeans specification. In fact, except in name, EJB bears very little resemblance to the original Javabean specification.

2.1 : Introduction to Spring Framework

Introduction

- Many successful applications were built based on EJB
 - But EJB never really achieved its intended purpose, which is to simplify enterprise application development
- Java development comes full circle
 - New programming techniques like including aspect-oriented programming (AOP) and inversion of control (IoC) are giving JavaBeans much of the power of EJB

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Despite the fact that many successful applications have been built based on EJB, it never really achieved its intended purpose: to simplify enterprise application development. It is true that EJB's declarative programming model simplifies many infrastructural aspects of development, such as transactions and security. But EJBs are complicated in a different way by mandating deployment descriptors and plumbing code (home and remote/local interfaces). As a result, its popularity has started to wane in recent years, leaving many developers looking for an easier way.

Now Java development is coming full circle. New programming techniques, including aspect-oriented programming (AOP) and inversion of control (IoC), are giving JavaBeans much of the power of EJB. These techniques furnish JavaBeans with a declarative programming model reminiscent of EJB, but without all of EJB's complexity. No longer must you resort to writing an unwieldy EJB component when a simple JavaBean will suffice.

And that's where Spring steps into the picture.

In all fairness, the latest EJB specification (EJB 3) has evolved to promote POJO-based programming model and is simpler than its predecessors.

Quick history :

Spring Framework project founded in Feb 2003
Release 1.0 in Mar 2004
Release 1.2 in May 2005
Release 2.0 in Oct 2006
Release 2.5 in Nov 2007
Release 3.0 in Dec 2009
Release 4.0 in Dec 2013

2.1 : Introduction to Spring Framework

What is Spring framework?

- Spring is an open source framework created by Rod Johnson, Juergen Hoeller et all
- Addresses the complexity of enterprise application development
- Any java application can benefit from Spring in terms of simplicity, testability and loose coupling



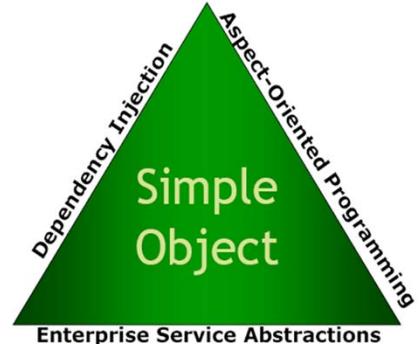
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Spring makes it easy to use POJO (Plain Old Java Objects) to achieve things that were previously only possible with EJBs. However, Spring's usefulness isn't restricted to server-side development. Any java application can benefit from Spring in terms of simplicity, testability and loose coupling.

2.1 : Introduction to Spring Framework

What is Spring framework?

- Spring is a lightweight inversion of control and aspect-oriented container framework
 - Lightweight: in terms of both size and overhead
 - Inversion of control: promotes loose coupling
 - Aspect-oriented: enables cohesive development by separating application business logic from system services
 - Container: contains and manages the life cycle and configuration of application objects
 - Framework: possible to configure and compose complex applications from simpler components



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Put simply, Spring is a lightweight inversion of control and aspect-oriented container framework. Breaking this description down makes it simpler:

Lightweight: Spring is Lightweight in terms of both size and overhead. The entire Spring framework can be distributed in a single jar file of 2.5 MB approximately. Processing overhead required by Spring is negligible. Moreover, Spring is non-intrusive; objects in a Spring-enabled application typically have no dependencies on Spring-specific classes.

Inversion of control: Spring promotes loose coupling through a technique known as inversion of control (IoC) or also known popularly as Dependency Injection (DI). When IoC is applied, objects are passively given their dependencies instead of creating or looking for dependent objects for themselves. IoC can be thought of as JNDI in reverse – instead of an object looking up dependencies from a container, the container gives the dependencies to the object at instantiation without waiting to be asked.

Aspect-oriented : Spring comes with rich support for aspect-oriented programming that enables cohesive development by separating application business logic from system services (such as auditing and transaction management). Application objects do what they are supposed to do – perform business logic – and nothing more. They are not responsible for other system concerns such as logging or transactional support.

Container: Spring is a container in the sense that it contains and manages the life cycle and configuration of application objects. You can configure how each of your beans should be created – either create one single instance of your bean or produce a new instance every time one is needed based on a configurable prototype – and how they should be associated with each other.

Framework: Spring makes it possible to configure and compose complex applications from simpler components. In Spring, application objects are composed declaratively, typically in an XML file. Spring also provides much infrastructure functionality (transaction management, persistence framework integration etc) leaving the development of application logic to user.

All these attributes of Spring enable you to write code that is cleaner, more manageable and easier to test.

2.1 : Introduction to Spring Framework

Why Spring?

- Spring simplifies Java development
- With Spring, complexity of application is proportional to the complexity of the problem being solved
- Essence of Spring is to provide enterprise services to POJO.
- Spring employs four key strategies:
 - Lightweight and minimally invasive development with plain old Java objects (POJOs)
 - Loose coupling through dependency injection and interface orientation
 - Declarative programming through aspects and common conventions
 - Boilerplate reduction through aspects and templates



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To put it simply, Spring makes developing enterprise applications easier. The complexity of your application is proportional to the complexity of the problem being solved.

Some key Spring values are:

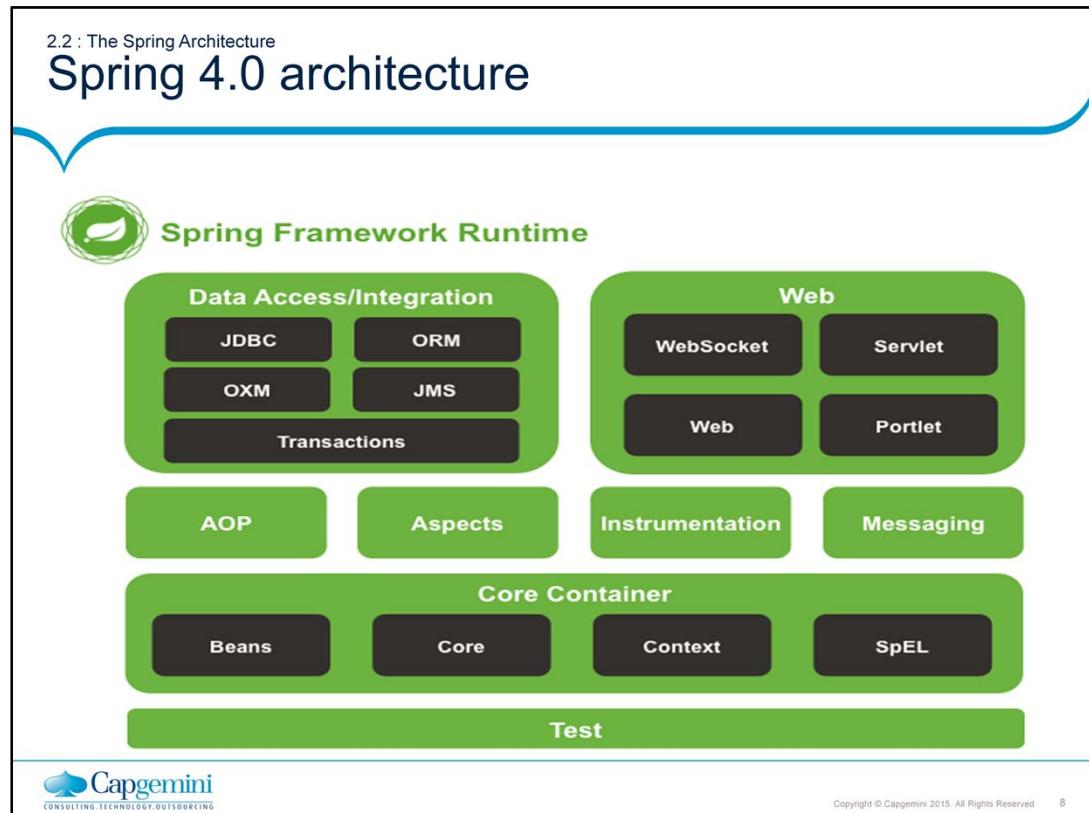
It's a non-invasive framework : Traditional frameworks force application code to be aware of the framework, implementing framework specific interfaces or extending framework-specific classes. Spring aims to minimize the dependence of application code on the framework.

Promotes pluggability : Spring encourages you to think of application objects as named services. Thus you can swap one service for another without affecting the rest of the application.

Aims to facilitate good programming practices, such as programming to interfaces: Using an IoC container like Spring reduces the complexity of coding to interfaces, rather than classes.

Spring applications are easy to test : Application objects will generally be POJOs and POJOs are easy to test; dependence on Spring APIs will normally be in the form of interfaces that are easy to stub or mock.

Does not reinvent the wheel : Spring does not introduce its own solution in areas such as O/R mapping where there are already good solutions. It also does not implement its own logging abstraction, connection pool, distributed transaction coordinator or other system services that are already well-served in other products or application servers. However Spring does make these existing solutions significantly easier to use.



The Spring Framework is composed of about 20 modules. These modules are grouped into Core Container, Data Access/Integration, Web, AOP (Aspect Oriented Programming),

Instrumentation, Messaging, and Test. When you download and unzip the Spring framework distribution, you'll find many different JAR files in the dist directory for every modules. When taken as a whole, these modules give you everything you need to develop enterprise-ready applications. But this modularity also gives you the freedom to choose the modules that suit your application.

Core Container : The Core Container consists of the spring-core, spring-beans, spring-context, spring-context-support, and spring-expression (Spring Expression Language) modules.

The spring-core and spring-beans modules are the most fundamental part of the framework. It defines how beans are created, configured and managed. The BeanFactory (a sophisticated implementation of the factory pattern and a primary component of this module) applies the Inversion of Control (IOC) pattern to separate an application's configuration and dependency specification from the actual application code

The spring-context module builds on the solid base provided by the Core and Beans modules. The core modules bean factory makes Spring a container, but the context modules makes it a framework. The Context module inherits its features from spring-beans module and adds support for internationalization, event-propagation, resource-loading etc.

The spring-expression module provides a powerful expression language for querying and manipulating an object graph at runtime.

Data Access/Integration : The *Data Access/Integration* layer consists of the spring-JDBC, spring-ORM, spring-OXM, spring-JMS and spring-tx modules.

- The *spring-jdbc* module provides a JDBC-abstraction layer that removes the need to do tedious JDBC coding and parsing of database-vendor specific error codes.
- The *spring-orm* module provides integration layers for popular object-relational mapping APIs, including JPA, JDO, Hibernate, and iBatis. Using the ORM package you can use all of these O/R-mapping frameworks in combination with all of the other features Spring offers.
- The *spring-oxm* module provides an abstraction layer that supports Object/XML mapping implementations for JAXB, Castor, XMLBeans, XStream etc.
- The *spring-jms*(Java Messaging Service) module contains features for producing and consuming messages.
- The *spring-tx*(Transaction) module supports programmatic and declarative transaction management for classes that implement special interfaces and for *all your POJOs (plain old Java objects)*.

Web : The *Web* layer consists of the *spring-web*, *spring-webmvc*, *spring-websocket* and *spring-webmvc-portlet* modules.

- The *spring-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 *spring-webmvc* module (also known as the *Web-Servlet* module) contains Spring's model-view-controller (*MVC*) implementation for web applications. Spring's MVC framework provides a clean separation between domain model code and web forms, and integrates with all the other features of the Spring Framework.
- The *spring-webmvc-portlet* module (also known as the *Web-Portlet* module) provides the MVC implementation to be used in a portlet environment and mirrors the functionality of Web-Servlet module.

AOP and Instrumentation : AOP (Aspect Oriented Programming) enables behavior that would otherwise be scattered through different methods to be modularized in a single place.

- The *spring-aop* module provides an AOP Alliance-compliant aspect-oriented programming implementation allowing you to define, for example, method interceptors and pointcut's to cleanly decouple code that implements functionality that should be separated.
- The separate *spring-aspects* module provides integration with AspectJ.
- The *spring-instrumentation* module provides class instrumentation support and classloader implementations to be used in certain application servers.

Messaging: Spring Framework 4 includes a *spring-messaging* module with key abstractions from the Spring Integration project such as Message, MessageChannel, MessageHandler, and others to serve as a foundation for messaging-based applications. The module also includes a set of annotations for mapping messages to methods, similar to the Spring MVC annotation based programming model.

Test : The *spring-test* module supports the testing of Spring components with JUnit or TestNG. It provides consistent loading of Spring ApplicationContexts and caching of those contexts. It also provides mock objects that you can use to test your code in isolation.

2.2.1 Dependency Injection

Dependency Injection

- Any enterprise application has objects that depend on each other
- Resolving the dependency is termed as 'Injecting Dependency' which facilitates loose coupling.
- Choosing the low level implementation to be injected into the reference of the interface in higher level layer, is termed as 'Inversion Of Control'



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Dependency Injection

Any enterprise application has objects that depend on each other

Resolving the dependency is termed as 'Injecting Dependency' which facilitates loose coupling.

Choosing the low level implementation to be injected into the reference of the interface in higher level layer, is termed as 'Inversion Of Control'

Thus the choice of low level dependency has control on the quality of the service that will be provided, this is configurable/changeable making the framework highly flexible and modular

For an example, if a person need to have a cup of coffee then either he can prepare by himself using ingredients such as coffeebean, milk, sugar,... Or he can raise request in vending machine, so that coffee will be prepared and automatically delivered to him.

Similarly, instead of creating object manually with the use of new operator, object creation will be taken care by container using DI.

2.2.1 Dependency Injection

Sample Code

```

package com.igate.di;
public class Person{
    private Address address;
    public Person() {this.address = new Address();}
    public Address getAddress() {return address;}
    public void setAddress(Address address) { this.address=address;}
}

```

- Tight coupling
- Rigid design

```

package com.igate.di;
public class Person{
    private Address address;
    public Person(Address address) {this.address = address;}
    public Address getAddress() {return address;}
    public void setAddress(Address address) { this.address=address;}
}

```

- Loose coupling
- Flexible Design
- Provisioning DI

```

package com.igate.di;
public class ResidenceAddress implements Address{.....}

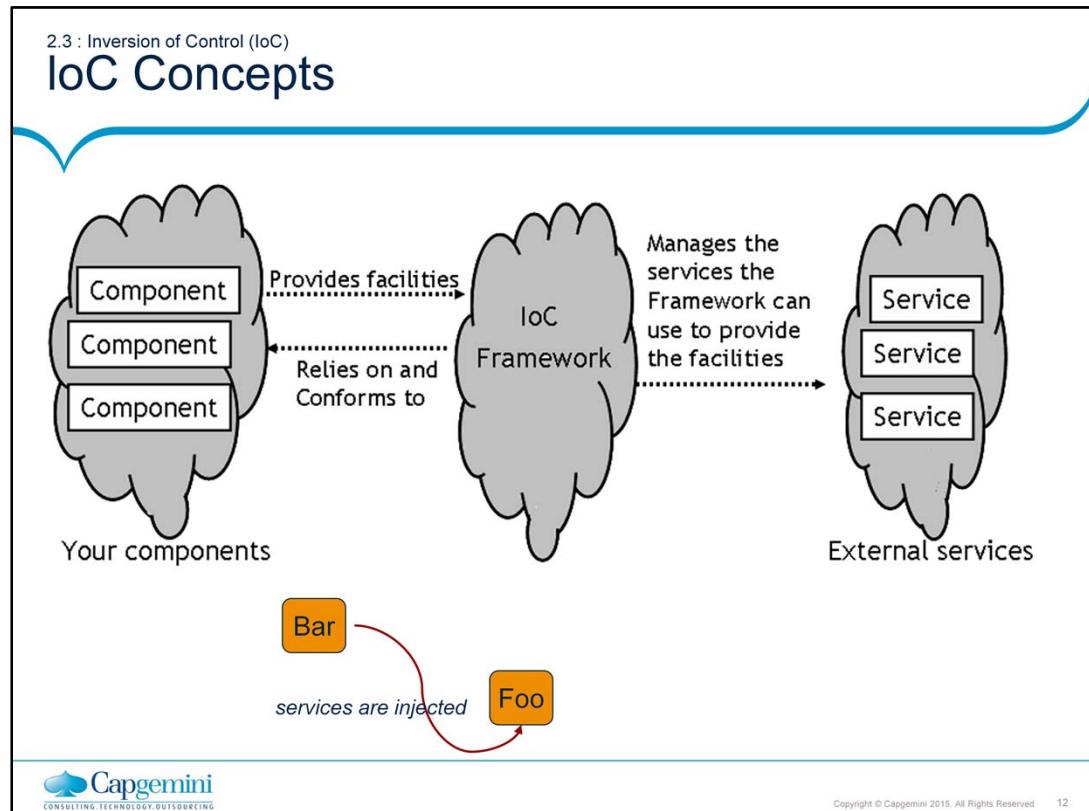
```

- Design to Interface
- Enabling Loose Coupling, Flexibility

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In DI or IOC process objects define their dependencies, only through constructor arguments, arguments to a factory method, or properties that are set on the object instance after it is constructed or returned from a factory method. The container (the environment provided to the Spring Beans, for wiring) then injects those dependencies when it creates the spring bean, this process is an inverse of traditional approach, hence the name Inversion of Control (IoC), of the bean itself controlling the instantiation or location of its dependencies by using direct construction of classes.



Understanding inversion of control: Inversion of control is at the heart of the Spring framework. As seen earlier, any non-trivial application is made up of two or more classes that collaborate with each other to perform some business logic. Traditionally, each object is responsible for obtaining its own references to the objects it collaborates with (its dependencies). This can lead to a highly coupled and hard-to-test code. Applying IoC, objects are given their dependencies at creation time by some external entity that coordinates each object in the system ie dependencies are injected into objects. So, IoC means an inversion of responsibility with regard to how an object obtains references to collaborating objects.

Dependency injection is kind of an Inversion of Control pattern. The term dependency injection describes the process of providing (or injecting) a component with the dependencies it needs, in an IoC fashion. Dependency Injection proposes separating the implementation of an object and the construction of objects that depend on them. Dependency injection is a form of PUSH configuration; the container pushes dependencies into application objects at runtime. This is opposite to the traditional PULL configuration in which the app object pulls dependencies from its environment. In the figure, we have application objects offering external services. The application components depend on these external services. The job of coordinating the implementation and construction is left to the assembler code, which in this case would be the spring IoC framework.

2.3 : Inversion of Control (IoC)

IoC, Beans and BeanFactories

- Used to achieve loose coupling between several interacting components in an application.
- The IoC framework separates facilities that your components are dependent upon and provides the “glue” for connecting the components.
- DI is specific type of IoC
- BeanFactory is the core of Spring’s DI container.
- In Spring, the term “bean” is used to refer to any component managed by the container.



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Loose coupling is one of the critical elements in object-oriented software development. It allows you to change the implementations of two related objects without affecting the other object. Strong coupling directly affects scalability of an application. Tightly coupled code is difficult to test, reuse and understand. On the other hand, completely uncoupled code doesn’t do anything. In order to do anything useful, classes need to know about each other somehow. Coupling is necessary but it must be managed very carefully. A common technique used to reduce coupling is to hide implementation details behind interfaces so that actual implementation class can be swapped out without impacting the client class.

That is what IoC is all about: the responsibility of coordinating collaboration between dependent objects is transferred away from the objects themselves. This is where lightweight framework containers like Spring come into play.

IoC introduces the concept of a framework of components that in turn has many similarities to a J2EE container. The IoC framework separates facilities that your components are dependent upon and provides the “glue” for connecting the components.

With Inversion of Control (IoC), you can achieve loose coupling between several interacting components in an application.

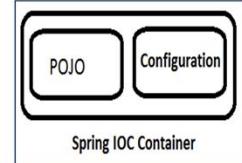
The core of Spring’s DI container is the BeanFactory. A bean factory is responsible for managing components and their dependencies. We shall see bean factories in detail later in this session. In Spring, the term “bean” is used to refer to any component managed by the container. Typically, beans adhere to Javabeans specification



2.3 : Inversion of Control (IoC)

Spring Beans and Configuration Metadata

- Spring Managed POJOs with business logic are termed as Spring Beans, **Spring IOC container manages one or more beans**
- Spring meta-data configuration can be ...
- **XML based**
- **Java based : Annotations**
- Java based configurations are recommended practice since inclusion of Spring JavaConfig project
- Spring Beans and Configuration Metadata is combined and the Spring Framework's IoC container is created & initialized
- Spring IoC container is decoupled from configuration metadata format

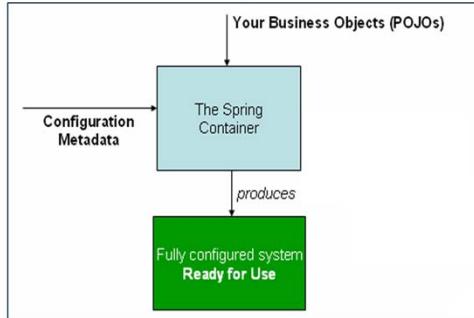


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2.3 : Inversion of Control (IoC)

Spring IOC Container

- The Spring IOC container instantiates, configures, and assembles the beans by reading configuration metadata
- It composes the application and interdependencies between the objects
- At this stage, the application is fully configured and ready to use
- The Spring IOC Container manages the **entire lifecycle** of the Spring Beans



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The Spring IOC container can manage any class you want it to manage; it is not limited to managing true JavaBeans

Spring container can also handle **non-bean-style classes**

Spring IoC container manages one or more beans

In the Spring IOC container, bean definitions are represented as BeanDefinition objects, with metadata:

- A package-qualified class name
- Bean behavioural configuration elements
- References to other beans, collaborators or dependencies
- Configuration settings to set in the newly created object, for example, the number of connections to use in a bean that manages a connection pool, or the size limit of the pool

2.3.1 : Spring Jumpstart

Spring Jumpstart with HelloWorld

```

package training.spring;
public class HelloWorld {
    public void sayHello(){
        System.out.println("Hello Spring 3.0");
    }
}

<?xml ....>
<beans ....>
<bean id="HWBean" class =
    "training.spring.HelloWorld" />
</beans>

public class HelloWorldClient {
    public static void main(String[] args) {
        XmlBeanFactory beanFactory = new XmlBeanFactory(
            new ClassPathResource("HelloWorld.xml"));
        HelloWorld bean = (HelloWorld) beanFactory.getBean("HWBean");
        bean.sayHello();
    }
}

```

The Spring configuration file

Output:
Hello Spring 3.0

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Dependency injection is the most basic thing that Spring does. We shall be covering this in detail later in the session. For now, let us see how Spring works with an example.

Spring-enabled applications are like any Java application. They are made up of several classes, each performing a specific purpose within the application. Difference lies in how these classes are configured and introduced to each other. Typically a Spring application has an XML file that describes how to configure the classes, known as Spring configuration file.

Pls. refer to Appendix-A for a detailed explanation of converting a traditional Java application into a Spring-based application.

Look in slide above for a typical Hello World application using Spring Framework. Detailed explanation for this code is given in subsequent demos.

2.3 : Inversion of Control (IoC)

Inversion of Control Approaches

- IoC pattern uses three different approaches to achieve decoupling of control of services from components:
 - Type 1: Setter Injection
 - Type 2: Constructor injection
 - Type 3: Interface injection



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The IoC pattern uses three different approaches to achieve decoupling of control of services from your components:

Type 1 : Interface injection: This is how most J2EE worked. Components are explicitly conformed to a set of interfaces with associated configuration metadata, in order to allow framework to manage them correctly.

Type 2 : Setter Injection: External metadata is used to configure how components can interact. Our first example used this approach, by using a Springconfig.xml file.

Type 3 : Constructor injection: Components are registered with the framework, including the parameters to be used when the components are constructed, and the framework provides instances of the component with all the specified facilities applied. Our last example used this approach.

There is a fourth approach called “Lookup-method injection”. This has been covered in detail in Appendix-B.

2.3.1 : Spring Jumpstart

Injecting dependencies via setter methods

```
public interface CurrencyConverter {  
    public double dollarsToRupees(double dollars);  
}
```

```
public class CurrencyConverterImpl implements CurrencyConverter {  
    private double exchangeRate;  
    public double getExchangeRate() { return exchangeRate; }  
    public void setExchangeRate(double exchangeRate) {  
        this.exchangeRate = exchangeRate;    }  
    public double dollarsToRupees(double dollars) {  
        return dollars * exchangeRate;  
    }  
}
```



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The example shows a service class whose purpose is to print the value of dollars converted to rupees. The listing above shows `CurrencyConverter.java`, an interface that defines the contract for the service class.

`CurrencyConverterImpl.java` implements the `CurrencyConverter` interface. Although it is not necessary to hide the implementation behind an interface, its highly recommended as a way to separate the implementation from its contract.

The `CurrencyConverterImpl` class has a single property `exchangeRate`. This property is simply a double variable that will hold the exchange rate passed by its setter method. We can also pass value through the constructor (We shall see this in the next example)

2.3.1 : Spring Jumpstart

Injecting dependencies via setter methods

```
<?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:aop="http://www.springframework.org/schema/aop"
       xsi:schemaLocation="http://www.springframework.org/schema/beans
                           http://www.springframework.org/schema/beans/spring-beans-4.0.xsd">

    <bean id="currencyConverter"
          class="training.Spring.CurrencyConverterImpl">
        <property name="exchangeRate" value="44.50" />
    </bean>
</beans>
```

The configuration file
(CurrencyConverter.xml)

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Question now is who will make a call to either the constructor or the `setExchangeRate()` method to set the `exchangeRate` property? The Spring configuration file in the above listing tells how to configure the `CurrencyConverter` service. This XML file declares an instance of a `CurrencyConverterImpl` in the Spring container and configures its `exchangeRate` property with a value of 44.50. Notice the `<beans>` element at the root of the XML file. This is the root element of any Spring configuration file. The `<bean>` element is used to tell the Spring container about a class and how it should be configured. The `id` attribute is used to name the bean `currencyConverter` and the `class` attribute specifies the bean's fully qualified class name. Within the `<bean>` element, the `<property>` element is used to set a property, in this case `exchangeRate` property. By using `<property>`, we are telling the Spring container to call `setExchangeRate()` when setting the property. This is called setter injection and is a straightforward way to configure and wire bean properties. The value of the exchange rate is defined using the `value` attribute. The following snippet of code illustrates roughly what the container does when instantiating the `currencyConverter` service based on the XML definition seen above.

```
CurrencyConverterImpl currencyConverter = new CurrencyConverterImpl();
currencyConverter.setExchangeRate(44.50);
```

Notice the configuration metadata is represented in XML. But it can also be done using Java annotations, or Java code.



2.3.1 : Spring Jumpstart

Injecting dependencies via setter methods

The diagram illustrates the interaction between the client application and the Spring container. A starburst labeled "The client application" points to a code block in a rounded rectangle. An arrow from the container points to a callout box labeled "Output".

```

public class CurrencyConverterClient {
    public static void main(String args[]) throws Exception {
        Resource res = new ClassPathResource("currencyconverter.xml");
        BeanFactory factory = new XmlBeanFactory(res);
        CurrencyConverter curr = (CurrencyConverter)
            factory.getBean("currencyConverter");
        double rupees = curr.dollarsToRupees(50.0);
        System.out.println("50 $ is "+rupees+" Rs.");
    }
}

```

Output:
CurrencyConverterImpl()
setExchangeRate()
dollarsToRupees()
50 \$ is 2225.0 Rs.

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Finally look at the class above. This class loads the Spring container and uses it to retrieve the currencyConverter service. The BeanFactory class used here is the Spring container. After loading the currencyconverter.xml file into the container, the main() method calls the **getBean() method** on the BeanFactory to retrieve a reference to the CurrencyConverter service. With this reference in hand, it finally calls the dollarsToRupees() method. When we run the above application (CurrencyConverterClient.java), output is as seen above.

This example illustrates the basics of configuring and using a class in Spring. It is simple because it only illustrates how to configure a bean by injecting a double value into a property. The real power of Spring lies in how beans can be injected into other beans using IoC (Inversion of Control – which shall be discussed in the next topic).

2.3.1 : Spring Jumpstart

DemoSpring_1

- This demo illustrates how the container will instantiate the CurrencyConverter service using setter injection.



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Please refer to demo, DemoSpring_1.

2.3.1 : Spring Jumpstart

Injecting dependencies via constructor

- Bean classes can be programmed with constructors that take enough arguments to fully define the bean at instantiation

```
<bean id="currencyConverter" class="training.Spring.CurrencyConverterImpl">
    <constructor-arg>
        <value> 44.50 </value>
    </constructor-arg>
</bean>
```

```
public CurrencyConverterImpl(double er) {
    exchangeRate = er;
}
```



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Injecting dependencies via constructor:

Setter injection assumes that all mutable properties are available via a setter method. For one thing, when this type of bean is instantiated, none of its properties have been set and it could possibly be in an invalid state.

Second, you may want all properties to be set just once, when the bean is created and become immutable after that point. This is impossible when all properties are exposed via setter methods.

In Java, a class can have multiple constructors and thus you can program your bean classes with constructors that take enough arguments to fully define the bean at instantiation. This is called **constructor injection**. In the above example, this is done by having Spring set the exchangeRate property through currencyConverterImpl's single argument constructor.

2.3.1 : Spring Jumpstart

Injecting dependencies via constructor

- If a constructor has multiple arguments, then ambiguities among constructor arguments can be dealt with in two ways :
 - by index
 - by type

```
<beans>
<bean id="currencyConverter"
      class="training.Spring.CurrencyConverterImpl3">
<constructor-arg><value>44.25</value></constructor-arg>
<!--<constructor-arg index="0"><value>44.25</value></constructor-arg>-->
<!--<constructor-arg type="double"><value>44.25</value></constructor-arg>-->
</bean>
</beans>
```



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The `<constructor-arg>` element has an optional `index` attribute that specifies the ordering of the constructor arguments.

```
<constructor-arg index="1">
  <value> some-value </value>
<constructor-arg>
```

The `type` attribute lets you specify exactly what type each argument is supposed to be.

```
<constructor-arg type="java.lang.String">
  <value> some-value </value>
<constructor-arg>
```

The code above illustrates how the container will instantiate the `CurrencyConverter` service when using the `<constructor-arg>` element using the same classes seen earlier.

2.3.1 : Spring Jumpstart

DemoSpring_2

- This demo illustrates how the container will instantiate the CurrencyConverter service when using the <constructor-arg> element.



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Please refer to demo, DemoSpring_2.

Sometimes the only way to instantiate an object is through a static factory method. Spring is ready-made to wire factory-created beans through the <bean> element's factory-method attribute. DemoSpring_2 demonstrates this. Pls. refer to demos.

2.3 : Inversion of Control (IoC)

Using collections for injection

- Often, beans need access to collections of objects, rather than just individual beans or values.
- Spring allows you to inject a collection of objects into your beans.
- You can choose either <list>, <map>, <set> or <props> to represent a List, Map, Set or Properties instance.
- You will pass in the individual items just as you would with any other injection.



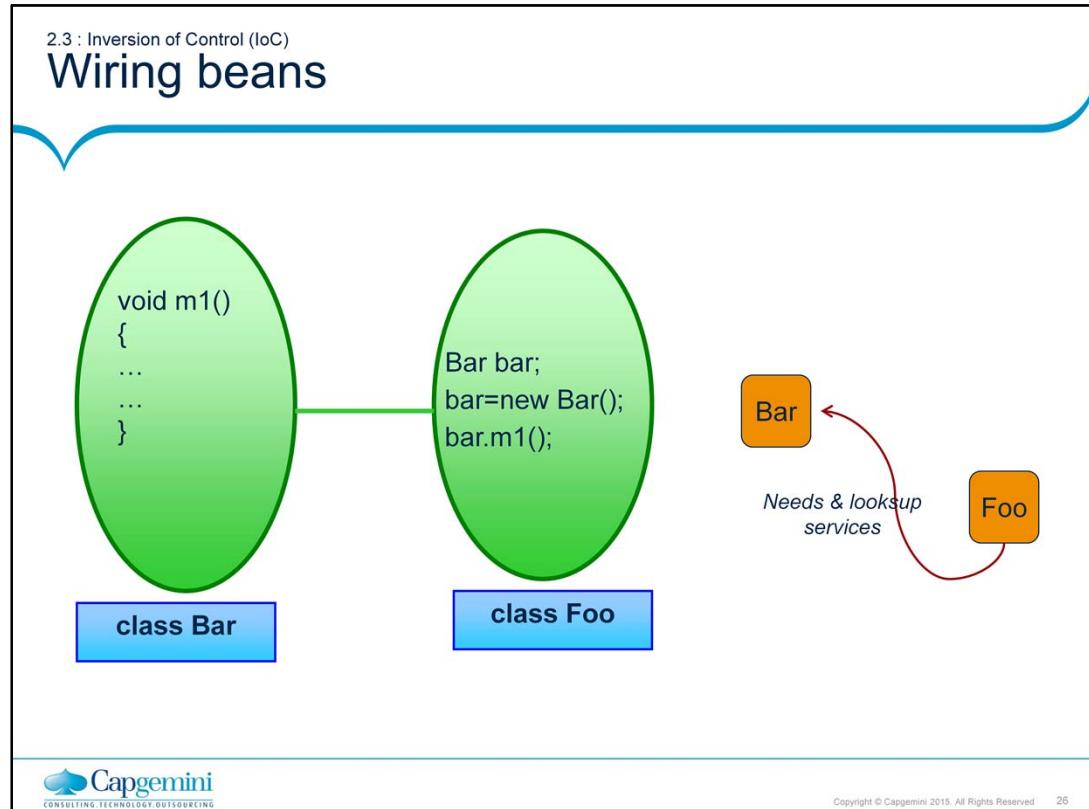
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Example:

```
<bean id="complexObject" class="example.ComplexObject">
    <property name="people">
        <props>
            <prop key="HarryPotter">The magic property</prop>
            <prop key="JerrySeinfeld">The funny property</prop>
        </props>
    </property>
    <property name="someList">
        <list>
            <value>red</value>
            <value>blue</value>
        </list>
    </property>
    <property name="someMap">
        <map>
            <entry key="an entry" value="just some string"/>
            <entry key="a ref" value-ref="myDataSource"/>
        </map>
    </property>
</bean>
```

One example is also available. Refer to demo, DemoSpring_5





Software code is normally broken down into logical components or services that interact with one another. In java, these components are usually instances of Java classes or objects. Each object must use or work with other objects in order to do its job.

To understand this better, let us see a situation in which two java classes need to communicate. In the above figure, class Foo depends on an instance of class Bar for some functionality. Traditionally, Foo creates instance of Bar using new operator or obtains one from a factory class.

In IoC however, an instance of Bar is provided to Foo at runtime by some external processes ie the container will handle the “injection” of an appropriate implementation.

Inversion of Control is best understood through the term the “Hollywood Principle,” which basically means “Don’t call me, I’ll call you.”

We don't directly connect our components and services together in code but describe which services are needed by which components in a configuration file. A container is responsible for hooking it up. This concept is similar to 'Declarative Management'.

Spring-enabled applications are like any Java application. They are made up of several classes, each performing a specific purpose within the application. Difference lies in how these classes are configured and introduced to each other. Typically a Spring application has an XML (the Spring configuration) file that describes how to configure these classes.

2.3 : Inversion of Control (IoC)

Wiring Beans - Inner Beans

- Another way of wiring bean references is to embed a <bean> element directly in the <property> element

```
<bean id="currencyConverter" class="CurrencyConverterImpl">
    <property name="exchangeService">
        <bean class="ExchangeServiceImpl" />
    </property>
</bean>
```

- The drawback here is that the instance of inner class cannot be used anywhere else; it is an instance created specifically for use by the outer bean.



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The drawback of the above method is that you cannot reuse the instance of ExchangeServiceImpl anywhere else – it is an instance created specifically for use by the currencyConverter bean.

Inner beans aren't limited to setter injection. You may also wire inner beans into constructor arguments. E.g.:

```
<bean id="currencyConverter"
      class="com.Spring.CurrencyConverterImpl4">
    <constructor-arg>
        <bean class="com.Spring.ExchangeServiceImpl" />
    </constructor-arg>
</bean>
```

2.3 : Inversion of Control (IoC)

IoC in action: Wiring Beans

- The act of creating associations between application components is known as wiring.
- In Spring, there are many ways of wiring components together, but most commonly used is XML. An example:

```
<bean id="exchangeService" class="ExchangeServiceImpl" />
<bean id="currencyConverter" class="CurrencyConverterImpl">
    <property name="exchangeService">
        <ref bean="exchangeService" />
    </property>
    <!--<property name="exchangeService">
        <ref local="exchangeService" /> </property> -->
    <!--<property name="exchangeService">
        <idref local="exchangeService" /> </property> -->
</bean>
```



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The act of creating associations between application components is known as wiring. In Spring there are many ways of wiring components together, but most commonly used is XML. A BeanFactory will load the bean definition and wire the beans together. In the above example, the `<ref>` subelement of the `<property>` tag is used to set the value or constructor argument to be a reference to another bean from the factory. The `bean` attribute is the ID of the other bean. Specifying the target bean by using the `bean` attribute of the `ref` tag is the most general form, and will allow creating a reference to any bean in the same BeanFactory or parent BeanFactory. Specifying the target bean by using the `local` attribute leverages the ability of the XML parser to validate XML id references within the same file. The value of the `local` attribute must be the same as the `id` attribute of the target bean. The XML parser will issue an error if no matching element is found in the same file. As such, using the `local` variant is the best choice (in order to know about errors early as possible) if the target bean is in the same XML file. Specifying the `idref` tag will allow Spring to validate at deployment time whether the other bean actually exists.

2.3 : Inversion of Control (IoC)

DemoSpring_3

- This demo illustrates how the BeanFactory loads the bean definition and wires the beans together



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Please refer to demo, DemoSpring_3. CurrencyConverterClient.java uses an XmlBeanFactory (a BeanFactory implementation) to load currencyconverter.xml and to get a reference to the CurrencyConverter object. It then invokes the dollarsToRupees() method.

There are two application objects. The instance of ExchangeRateImpl is responsible for retrieving the exchange rate, using which, the currency converter instance would convert currency. When the CurrencyConverterImpl is instantiated, it in turn first instantiates the ExchangeService bean. The ExchangeService instance in the CurrencyConverterImpl class then exposes its getExchangeRate() method to return the exchange rate.

Summarizing how the container initializes and resolves bean dependencies:
The container first initializes the bean definition, without initializing the bean itself, typically at the time of the container startup. The bean dependencies may be explicitly expressed in the form of constructor arguments or arguments to a factory method and/or bean properties.

Each property or constructor argument in a bean definition is either an actual value to set, or a reference to another bean in the bean factory.

Constructor arguments or bean properties that refer to another bean will force the container to create or obtain that other bean first. Effectively, the referred bean is a dependent of the calling bean. This can trigger a chain of bean creation.

Every Constructor argument or bean property must be able to be converted from String format to the actual format expected. Spring is able to convert from String to built-in scalar types like int, float etc. Spring uses JavaBeans PropertyEditors to convert all other types.

2.3 : Inversion of Control (IoC)

Autowiring

- Autowiring allows Spring to wire all bean's properties automatically by setting the autowire property on each <bean> that you want autowired

```
<bean id="foo" class="com.igate.Foo" autowire="autowire type" />
```

- Four types of autowiring:
 - byName
 - byType
 - constructor
 - Autodetect



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So far, you have seen how to wire all your bean's properties explicitly. You can also have Spring wire them automatically by setting the autowire property on each bean that you want autowired.

There are four types of autowiring:

byName: Attempts to find a bean in the container whose name (or id) is same as the name of the property being wired. If matching bean is not found, then property will remain unwired.

byType: Attempts to match all properties of the autowired bean with beans whose types are assignable to the properties. Properties for which there's no matching bean will remain unwired.

constructor : Tries to match a constructor of the autowired bean with beans whose types are assignable to the constructor arguments. In the event of ambiguous beans or ambiguous constructors, an

`org.springframework.beans.factory.UnsatisfiedDependencyException` will be thrown.

autodetect : Attempts constructor autowiring first. If that fails, attempts autowiring byType.

2.3 : Inversion of Control (IoC)

DemoSpring_4

- This demo illustrates automatically wiring your beans



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Refer to demo, DemoSpring_4 . This uses the same exchange service and currency converter service seen in earlier examples. However, by using the autowire attribute in the currencyconverter.xml we can execute the client program even without specifying the exchange service.

```
<bean id="exchangeService" class="com.igate.intro.ExchangeService">
<constructor-arg><value>44.25</value></constructor-arg>
</bean>
```

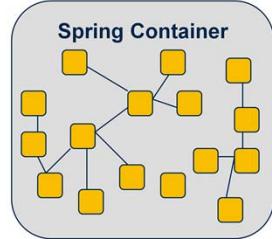
```
<bean id="currencyConverter"
class="com.igate.intro.CurrencyConverter" autowire="byName"/>
```

```
public class CurrencyConverter
{
private ExchangeService exchangeService;
..... }
```

2.4 : Bean containers

Bean containers: concept

- The container or bean factory is at the core of the Spring framework and uses IoC to manage components.
- Bean factory is responsible to create and dispense beans.
- It takes part in the life cycle of a bean, making calls to custom initialization and destruction methods, if those methods are defined.
- Spring has two types of containers:
 - Bean factories that are the simplest, providing basic support for dependency injection
 - Application contexts that build on bean factory by providing application framework services



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The container is at the core of the Spring framework and uses IoC to manage components. The basic IoC container in Spring is called the bean factory. Any bean factory allows the configuration and wiring of objects using dependency injection, in a consistent and workable fashion. A bean factory also provides some management of these objects, with respect to their lifecycles. Thus,

Bean factory is a class whose responsibility is to create and dispense beans.

A bean factory knows about many objects within an application.

Able to create associations between collaborating objects as they are instantiated.

This removes the burden of configuration from the bean itself and the bean's client. As a result, when a bean factory hands out objects, those objects are fully configured, aware of their collaborating objects and ready to use.

A bean factory also takes part in the life cycle of a bean, making calls to custom initialization and destruction methods, if those methods are defined.

Spring actually comes with two different types of containers:

Beanfactory interface: provides an advanced configuration mechanism capable of managing any type of object.

ApplicationContext interface : is a sub-interface of BeanFactory. It allows easier integration with Spring's AOP features, message resource handling, event publication, and application-layer specific contexts such as the WebApplicationContext for use in web applications.

We shall look at the Application context in detail later.

2.4 : Bean containers

Bean containers: The BeanFactory

- BeanFactory interface is responsible for managing beans and their dependencies
- Its `getBean()` method allows you to get a bean from the container by name
- It has a number of implementing classes:
 - `DefaultListableBeanFactory`
 - `SimpleJndiBeanFactory`
 - `StaticListableBeanFactory`
 - `XmlBeanFactory`



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Lets start our exploration of Spring containers with the most basic of Spring containers : the BeanFactory.

Bean factory is responsible for managing beans and their dependencies. Your application interacts with Spring DI container via the BeanFactory interface. It has a `getBean()` method that allows you to get a bean from the container by name. Additional methods allow you to query the bean factory to see if bean exists, to find the type of bean and to find if a bean is configured as a singleton.

Different bean factory implementations exist to support varying levels of functionality with `XmlBeanFactory` being the most common representation. A partial listing of the implementing classes follows:

`DefaultListableBeanFactory`
`SimpleJndiBeanFactory`
`StaticListableBeanFactory`
`XmlBeanFactory`

Please refer to the Spring documentation for more information on these classes



2.4 : Bean containers

The XmlBeanFactory

- One of the most useful implementations of the bean factory is instantiated via explicit user code as:

```
Resource res = new FileSystemResource("beans.xml");
XmlBeanFactory factory = new XmlBeanFactory(res);
```

or

```
Resource res = new ClassPathResource("beans.xml");
XmlBeanFactory factory = new XmlBeanFactory(res);
```



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One of the most useful implementations of the bean factory is the `org.springframework.beans.factory.xml.XmlBeanFactory`. The BeanFactory is instantiated via explicit user code such as shown above.

This simple line of code tells the bean factory to read the bean definitions from the XML file (beans.xml in this case). But the bean factory doesn't instantiate the beans just yet. Beans are "lazily" instantiated into bean factories, meaning that while the bean factory will immediately load the bean definitions, beans themselves will not be instantiated until they are needed.

The Spring IoC container consumes some form of configuration metadata; which is nothing more than how you inform the Spring container as to how to instantiate, configure, and assemble the objects in your application. This configuration metadata is typically supplied in a simple and intuitive XML format. When using XML-based configuration metadata, you write bean definitions for those beans that you want the Spring IoC container to manage, and then let the container do its stuff.

Note

XML-based metadata is by far the most commonly used form of configuration metadata. It is not however the only form of configuration metadata that is allowed. The Spring IoC container itself is totally decoupled from the format in which this configuration metadata is actually written. The XML-based configuration metadata format really is simple though, and so the majority of this material will use the XML format to convey key concepts and features of the Spring IoC container.

2.4 : Bean containers

The Resource interface

- The Resource interface is a unified mechanism for accessing resources in a protocol-independent manner.
- Some methods:
 - `getInputStream()`: locates and opens the resource, returning an `InputStream` for reading from the resource
 - `exists()`: indicates whether this resource actually exists
 - `isOpen()`: indicates whether this resource represents a handle with an open stream
 - `getDescription()`: returns a description for this resource, to be used for error output



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The Resource interface: Often, an application needs to access a variety of resources in different forms. You may need to access some configuration data stored in a file in the filesystem, some image data stored in a JAR file on the classpath, or maybe some data on a server elsewhere. Spring provides a unified mechanism for accessing resources in a protocol-independent manner. This means that your application can access a file resource in the same way, whether it is stored in the file system, the classpath or on a remote server.

At the core of the Spring's support is the Resource interface. This defines self-explanatory methods mentioned above. There are a number of implementations that come supplied straight out of the box in Spring:

UrlResource : The UrlResource wraps a `java.net.URL`, and may be used to access any object that is normally accessible via a URL, such as files, an HTTP target, an FTP target, etc.

ClassPathResource : This class represents a resource which should be obtained from the classpath. This uses either the thread context class loader, a given class loader, or a given class for loading resources.

FileSystemResource : This is a Resource implementation for `java.io.File` handles. It obviously supports resolution as a File, and as a URL.

ServletContextResource : This is a Resource implementation for `ServletContext` resources, interpreting relative paths within the relevant web application's root directory.

Two of the implemented classes examples for this interface ie. **ClassPathResource** and **FileSystemResource**, are shown in previous slide. Please refer to the Spring documentation for more details.

2.4 : Bean containers

The XmlBeanFactory (Cont...)

- In an XmlBeanFactory, bean definitions are configured as one or more bean elements inside a top-level beans element

```
<?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.xsd">
    <bean id="..." class="...">
        ...
    </bean>
    ...
</beans>
```



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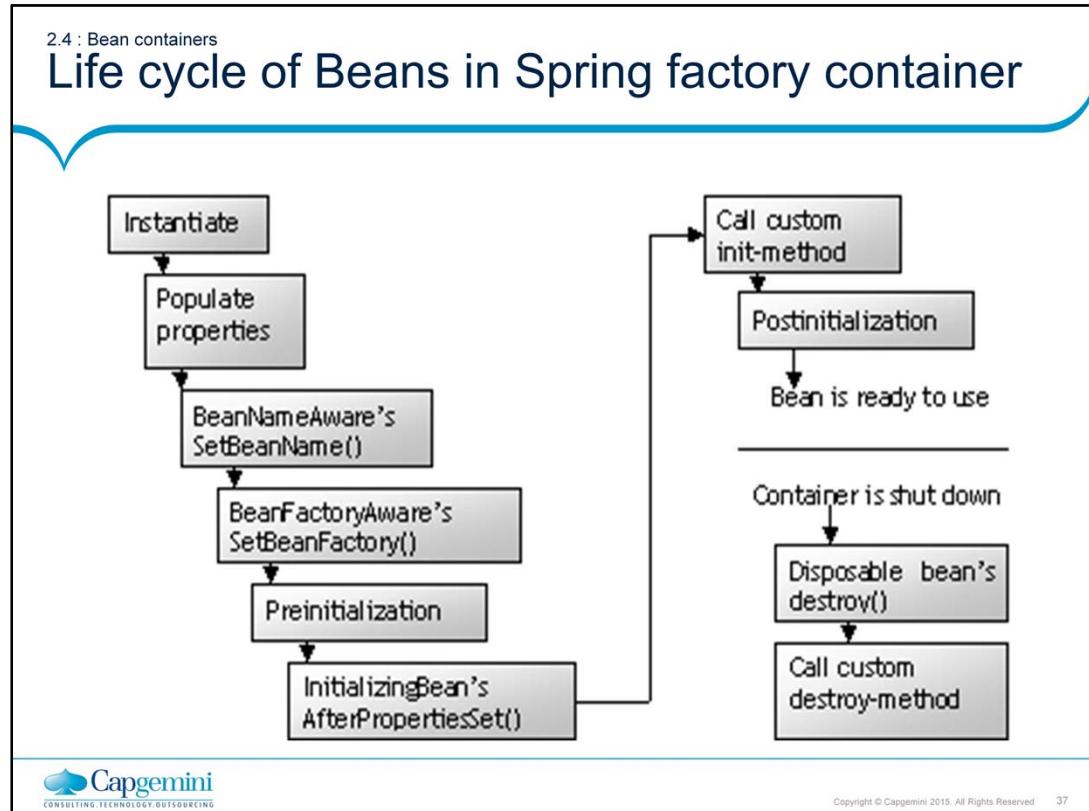
A BeanFactory configuration consists of, at its most basic level, definitions of one or more beans that the BeanFactory must manage. In an XmlBeanFactory, these are configured as one or more bean elements inside a top-level beans element.

The first versions of Spring used a DTD. But Spring 2.0 onwards uses schema for the xml configuration file.

To retrieve a bean from a bean factory, simply call the getBean() method, passing it the name of the bean you want to retrieve.

```
MyBean myBean = (MyBean) factory.getBean("myBean");
```

When getBean() is called, the factory will instantiate the bean and begin setting the bean's properties using dependency injection. Thus begins the bean's life cycle within the container (explained further on).



In a traditional Java application, the life cycle of a bean is fairly simple. Java's new keyword is used to instantiate the bean and it is ready to use. In contrast, the life cycle of a bean within a Spring container is a bit more elaborate.

A bean factory performs several setup steps before a bean is ready to use.

The container finds the bean's definition and instantiates the bean.

Using dependency injection, Spring populates all the properties as specified in the bean definition.

If the bean implements the `BeanNameAware` interface, the factory calls `setBeanName()` passing the bean's ID.

If the bean implements the `BeanFactoryAware` interface, the factory calls `setBeanFactory()` passing an instance of itself.

If there are any `BeanPostProcessors` associated with the bean, their `PostProcessBeforeInitialization()` methods will be called.

If an init-method is specified for the bean, it will be called.

Finally, if there are any `BeanPostProcessors` associated with the bean, their `PostProcessAfterInitialization()` methods will be called.

The bean is now ready to be used and will remain in the bean factory until it is no longer needed. It is removed from the factory in two ways:

If the bean implements the `DisposableBean` interface, the `destroy()` method is called.

If a custom destroy-method is specified, it will be called.

2.4 : Bean containers

Initialization and Destruction

- When a bean is instantiated, some initialization can be performed to get it to a usable state
- When the bean is removed from the container, some cleanup may be required
- Spring can use two life-cycle methods of each bean to perform this setup and teardown.
- Example:

```
<bean id="foo" class="com.spring.Foo"  
      init-method="setup"  
      destroy-method="teardown" />
```



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Declaring a custom init-method in your bean's definition specifies a method that is to be called on the bean immediately upon instantiation. Similarly, a custom destroy-method specifies a method that is called just before a bean is removed from the container.

E.g., the init-method="setup" in the above example calls setup() method in the bean class when bean is loaded into container and teardown() when bean is removed from container.

Defaulting init-method and destroy-method:

If many of the beans in a context definition file will have initialization or destroy methods with same name, you don't have to declare init-method or destroy-method on each individual bean. Instead, you can take advantage of the default-init-method and default-destroy-method attributes on the <beans> element.

```
<beans.....  
default-init-method="tuneApplication"  
default-destroy-method="cleanApplication" >  
.....  
</beans>
```

2.4 : Bean containers

InitializingBean and DisposableBean

▪ InitializingBean interface

- provides afterPropertiesSet() method which is called once all specified properties for the bean have been set.

▪ DisposableBean interface

- provides destroy() method which is called when the bean is disposed by the container
- The advantage is that Spring container is able to automatically detect beans without any external configuration.
- The drawback is that the applications' beans are coupled to Spring API.



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As an option to init-method and destroy-method, we can also rewrite the bean class to implement two special Spring interfaces: InitializingBean and DisposableBean. The Spring container treats beans that implement these interfaces in a special way, by allowing them to hook into the bean lifecycle.

The InitializingBean interface provides a method afterPropertiesSet(). This is called once all specified properties for the bean have been set. This makes it possible for the bean to perform initialization that cannot be performed until all properties have been completely set.

DisposableBean provides a destroy() method which will be called on the other end of a bean-lifecycle., when the bean is disposed by the container.

The benefit of using these interfaces is that Spring container is able to automatically detect beans that implement them without any external configuration. However, the disadvantage of implementing these interfaces is that you couple your application's beans to Spring API.

```
import org.springframework.beans.factory.InitializingBean;
import org.springframework.beans.factory.DisposableBean;
public class SampleBean implements InitializingBean, DisposableBean{
    ...
    public void afterPropertiesSet(){...}
    public void destroy(){...}
}
```

2.4 : Bean containers

Bean containers:Application context

- Provides application framework services such as :
 - Resolving text messages, including support for internationalization of these messages
 - Load file resources, such as images
 - Publish events to beans that are registered as listeners

- Many implementations of application context exist:
 - AnnotationConfigApplicationContext
 - AnnotationConfigWebApplicationContext
 - ClassPathXmlApplicationContext
 - FileSystemApplicationContext
 - XmlWebApplicationContext



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Application contexts build on bean factory by providing application framework services. A bean factory is fine for simple applications, but to take advantage of the full power of Spring framework, we need to use the application context container, which offers services mentioned in slide above. Many implementations of application context exist:

AnnotationConfigApplicationContext : Loads a Spring application context from one or more Java-based configuration classes

AnnotationConfigWebApplicationContext : Loads a Spring web application context from one or more Java-based configuration classes

ClassPathXmlApplicationContext : Loads context definition from a XML file located in the class path.

FileSystemApplicationContext: Loads context definition from an XML file in the file system.

XmlWebApplicationContext : Loads context definition from an XML file contained within a web application

Loading the ApplicationContext: Some examples :

```
ApplicationContext ctx = new ClassPathXmlApplicationContext("app.xml");
```

```
ApplicationContext ctx = new
```

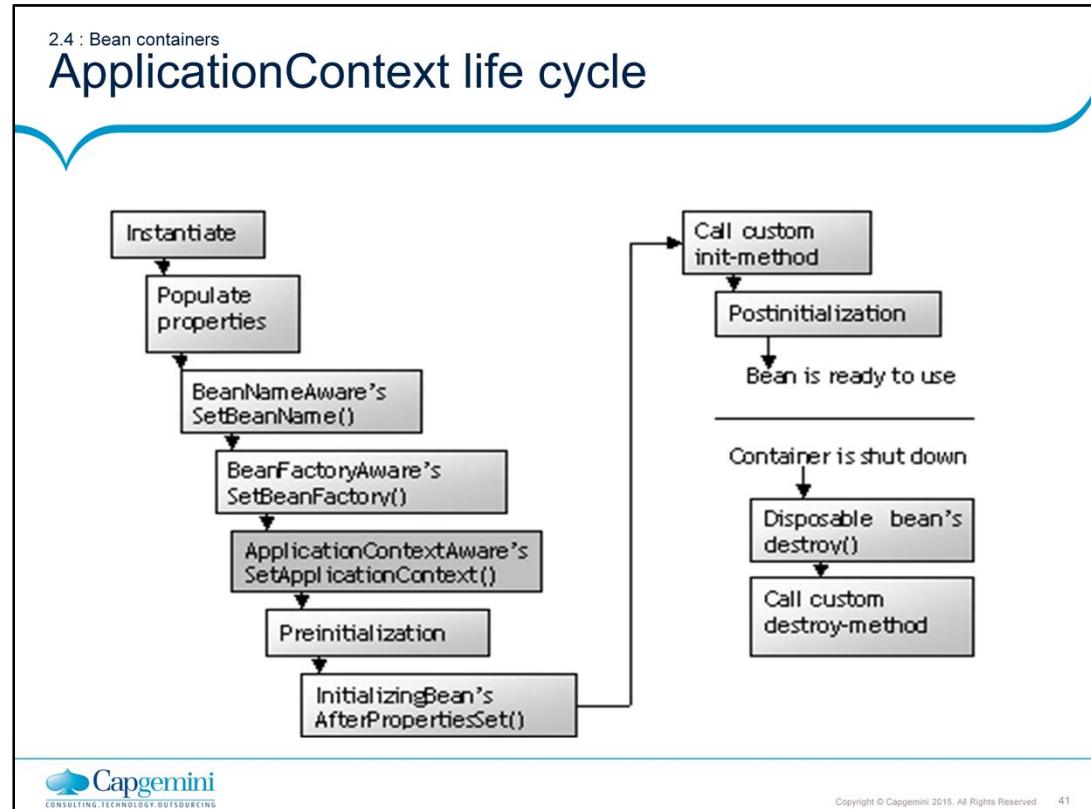
```
FileSystemXmlApplicationContext("/some/file/path/app.xml");
```

```
ApplicationContext ctx = new ClassPathXmlApplicationContext( new
```

```
String[]{"app1.xml","app2.xml"}); // combines multiple xml file fragments
```

Spring support Wildcards in application context constructor resource paths.

The resource paths in application context constructor values may be a simple path which has a one-to-one mapping to a target Resource, or alternately may contain the special "classpath*:" prefix and/or internal Ant-style regular expressions (matched using Spring's PathMatcher utility). Both of the latter are effectively wildcards.
(Continued on next page....)



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Eg.

```

/WEB-INF/*-context.xml
com/mycompany/**/applicationContext.xml
file:C:/some/path/*-context.xml
classpath:com/mycompany/**/applicationContext.xml
classpath:com/mycompany/**/service-context.xml
ApplicationContext ctx = new
ClassPathXmlApplicationContext("classpath*:conf/appContext*.xml");
  
```

ApplicationContext life cycle:

The life cycle of a bean within a Spring ApplicationContext differs only slightly from that of a bean within a bean factory as shown in above figure.

The only difference is that if a bean implements the **ApplicationContextAware** interface, the `setApplicationContext()` method is invoked.

2.4 : Bean containers

Prototyping Vs Singleton

- By default, all Spring beans are singletons.
- But each time a bean is asked for, prototyping lets the container return a new instance.
- This is achieved through the scope attribute of <bean>
- Example:

```
<bean id="foo" class="com.igate.Foo" scope="prototype" />
```

- Additional Bean scopes:
 - request
 - session
 - global-session



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Singleton beans, the default, are created only once by the container and all calls to BeanFactory.getBean() return the same instance. The container will then hold and use the same instance of the bean whenever it is referenced again. This can be significantly less expensive in terms of resource usage than creating a new instance of the bean on each request.

A non-singleton, or prototype bean, may be specified by setting the scope attribute to prototype (see example above). The lifecycle of a prototype bean will often be different than a singleton. When a container is asked to supply a prototype bean, it's initialized and then used, but the container does not hold on to it past that point.

Prototyped beans are useful when you want the container to give a unique instance of a bean each time it is asked for, but you still want to configure one or more properties of the bean through Spring. Thus a new instance is created when getBean() is invoked with the bean's name.

Previous versions of Spring had IoC container level support for exactly two distinct bean scopes (singleton and prototype). Spring 2.0 onwards provides a number of additional scopes depending on the environment in which Spring is being deployed (for example, request and session scoped beans in a web environment).

It also provides integration points so that Spring users can create their own scopes. Beans can be defined to be deployed in one of a number of scopes. See the table in the next page for the different scopes.

2.4 : Bean containers

Additional Bean scopes



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An example:

```
<bean id="accountService" class="com.foo.DefaultAccountService"  
scope="singleton"/>
```

2.4 : Bean containers

Customizing beans with BeanPostProcessor

- Post processing involves cutting into a bean's life cycle and reviewing or altering its configuration.
- Occurs after some event has occurred.
- Spring provides two interfaces :
 - BeanPostProcessor interface
 - BeanFactoryPostProcessor interface
- ApplicationContext automatically detects Bean Post-Processor, but these have to manually be explicitly registered for bean factory.



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The lifecycle of the BeanFactory and ApplicationContext provide many opportunities to cut into the bean's life cycle to review or alter its configuration. This is called post processing and occurs after some event has occurred. A bean post-processor is a java class which implements the BeanPostProcessor interface, which consists of two callback methods:

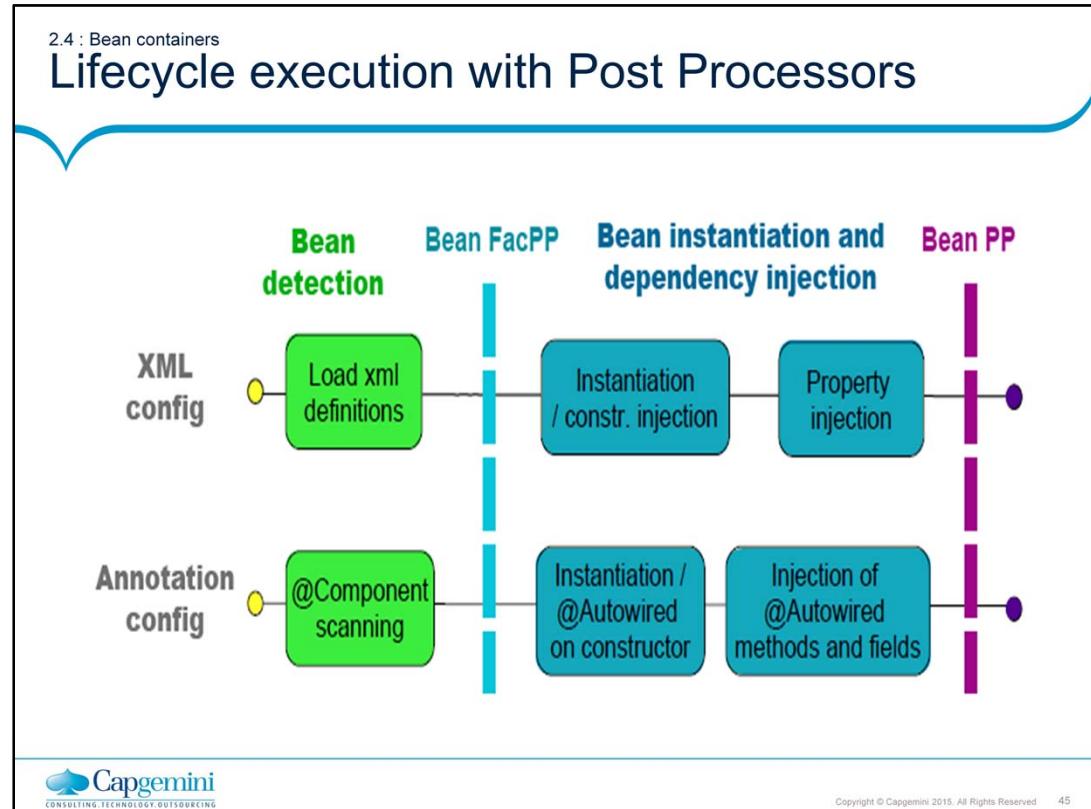
`postProcessBeforeInitialization`: called immediately before bean initialization.
`postProcessAfterInitialization`: called immediately after bean Initialization.

BeanPostProcessors operate on bean (or object) instances; ie the Spring IoC container instantiates a bean instance and then BeanPostProcessor interfaces do their work.

An ApplicationContext will automatically detect any beans which are deployed into it which implement the BeanPostProcessor interface, and register them as post-processors, to be then called appropriately by the factory on bean creation. Simply deploy the post-processor in a similar fashion to any other bean! However, for BeanFactory, bean post-processors have to manually be explicitly registered, with a code sequence as shown below.

Since this manual registration step is not convenient, and ApplicationContexts are functionally supersets of BeanFactories, it is generally recommended that ApplicationContext variants are used when bean post-processors are needed.

```
ConfigurableBeanFactory bf = new ....; // create BeanFactory
// now register some beans and any needed BeanPostProcessors
MyBeanPostProcessor pp = new MyBeanPostProcessor();
bf.addBeanPostProcessor(pp); // now start using the factory ...
```



Discuss about annotation config later.

```

ConfigurableBeanFactory bf = new .....; // create BeanFactory
// now register some beans and any needed BeanPostProcessors
MyBeanPostProcessor pp = new MyBeanPostProcessor();
bf.addBeanPostProcessor(pp); // now start using the factory ...

```

2.5 : Customizing beans

Customizing beans with Bean Factory Post Processor

- BeanFactoryPostProcessor performs post processing on the entire Spring container.
- It has a single method, which is `postProcessBeanFactory()`.
- Spring offers a number of pre-existing bean factory post-processors:
 - AspectJWeaving
 - CustomAutowireConfigurer
 - CustomEditorConfigurer
 - CustomScopeConfigurer
 - PropertyPlaceholderConfigurer
 - PreferencesPlaceholderConfigurer
 - PropertyOverrideConfigurer



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BeanFactoryPostProcessors operate on the bean configuration metadata; that is, the Spring IoC container allows BeanFactoryPostProcessors to read the configuration metadata and potentially change it before the container instantiates any beans other than BeanFactoryPostProcessors.!

Has a single method – `postProcessBeanFactory()`. This is called by Spring container after all bean definitions have been loaded but before any beans are instantiated (including BeanPostProcessor beans).

Spring offers a number of pre-existing bean factory post-processors. Two very useful implementations are:

`PropertyPlaceholderConfigurer` : Loads properties from one or more external property files and uses these properties to fill in place holder variables in the bean wiring XML file.

`CustomEditorConfigurer` : Lets you register custom implementation of `java.beans.PropertyEditor` to translate property wired values to other property types.

Let's take a look at how you can use these implementations of BeanFactoryPostProcessor.

2.5 : Customizing beans

Property Place holder Configurer

- It is possible to configure entire application in a single bean wiring file.

```
<bean id="datasource" class="com.spring.ConnectionDataSource" >
    <property name="url">
        <value> jdbc:hsqldb:training </value>
    </property>
    <property name="driverclassname">
        <value> org.hsqldb.jdbcDriver </value>
    </property>
    ....
</bean>
```

- But, sometimes it is beneficial to extract certain pieces of that configuration into a separate property file.



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For the most part, it is possible to configure entire application in a single bean wiring file. But sometimes it is beneficial to extract certain pieces of that configuration into a separate property file. E.g. , a configuration concern common to many applications is configuring a data source. Traditionally, in Spring, you do this with the following XML in the bean wiring file (see above)

Configuring the data source directly in the bean wiring file may not be appropriate. The database specifics are a deployment detail and must be separated.

2.5 : Customizing beans

Property Place holder Configurer

- Externalizing properties using PropertyPlaceholderConfigurer indicates Spring to load certain configuration from an external property file.

```
<bean id="placeHolderConfig" class="org.springframework.beans.  
factory.config.PropertyPlaceholderConfigurer">  
    <property name="location" value="data.properties"/>  
</bean>  
<bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource">  
    <property name="driverClassName" value="${jdbc.driverClassName}"/>  
    <property name="url" value="${jdbc.url}"/>  
    <property name="username" value="${jdbc.username}"/>  
    <property name="password" value="${jdbc.password}"/>  
</bean>
```

```
jdbc.driverClassName=oracle.jdbc.driver.OracleDriver  
jdbc.url=jdbc:oracle:thin:@192.168.224.26:1521:trgdb  
.....
```



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Fortunately, externalizing properties in Spring is easy if you are using ApplicationContext as your Spring container. You can use PropertyPlaceholderConfigurer to tell Spring to load certain configuration from an external property file as shown in the code snippet above. The location property tells Spring where to find the property file data.properties. When Spring creates the bean, the PropertyPlaceholderConfigurer will step in and replace the place holder variables with the values from the property file. It pulls values from a properties file into bean definitions.

2.5 : Customizing beans

Demo: DemoSpring_6

- This demo shows how to use the PropertyPlaceholderConfigurer BeanFactoryPostProcessor



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Please refer to demo, DemoSpring_6. In this case user.java is a POJO with two properties – username and password. We shall set the properties of this bean during its instantiation using external properties file. user.properties is a properties file. user.xml has two place holder variables \${username} and \${password}

```
<bean id="user" class="training.spring.User">
<property name="username"><value>${username}</value></property>
<property name="password"><value>${password}</value></property>
</bean>
```

Whenever setter is called, the listener (PropertyPlaceholderConfigurer) is invoked and it will look into the properties file, retrieve values, place them in the place holders and initialize.

If instead of application context, bean factory is used, then the listener would have to be explicitly registered as shown below (also in the commented out code in userClient.java file).

```
XmlBeanFactory factory = new XmlBeanFactory(new
FileSystemResource("user.xml"));
PropertyPlaceholderConfigurer cfg = new PropertyPlaceholderConfigurer();
cfg.setLocation(new FileSystemResource("user.properties"));
cfg.postProcessBeanFactory(factory);
```

2.5 : Customizing beans

Custom Editor Configurer

- **CustomEditorConfigurer** is a bean factory post-processor which allows to convert values in String form to final property values.
- It allows you to register custom implementation of **PropertyEditor** to translate property wired values to other property types.
- **Java.beans.PropertyEditorSupport** is a convenience implementation **java.beans.PropertyEditor** interface that allows setting a non-string property to a string value.
- It has two methods: `getAsText()` and `setAsText(String s)`



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CustomEditorConfigurer : Lets you register custom implementation of **java.beans.PropertyEditor** to translate property wired values to other property types. This is a bean factory post-processor which allows to convert values in String form to final property values.

So far, we have seen several examples in which a complex property is set with a simple String value. When setting bean properties as a string value, a BeanFactory ultimately uses standard **java.beans.PropertyEditor** interface to convert these strings to the complex type of the property. There is a convenience implementation of the above interface called **java.beans.PropertyEditorSupport**, that has two methods of interest to us:

`getAsText()` : returns the String representation of a property's value.

`setAsText(String value)` : sets a bean property value from the string value passed in.

If an attempt is made to set a non-string property to a string value, the `setAsText()` method is called to perform the conversion. Likewise, the `getAsText()` is called to return a textual representation of the property's value.

Spring comes with several custom editors based on **PropertyEditorSupport**. You can also write your own custom editor by extending the **PropertyEditorSupport** class.

2.5 : Customizing beans

Custom Editor Configurer

```
<bean id="customEditorConfigurer" class="org.springframework.  
beans.factory.config.CustomEditorConfigurer">  
<property name="customEditors">  
<map>  
<entry key="java.util.Date" value="MyCustomDateEditor"/>  
</map>  
</property>  
</bean>
```

```
CustomEditorConfigurer configurer = (CustomEditorConfigurer)  
factory.getBean("customEditorConfigurer ");  
Configurer.postProcessBeanFactory(factory);  
BeanClass bean = (BeanClass) factory.getBean("exampleBean");
```



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Declarative registration process:

The custom PropertyEditors (MyCustomDateEditor in this case) is injected into the CustomEditorConfigurer class using the Map-typed customEditors property. A map can have multiple entries and each entry in the Map represents a single PropertyEditor with the key of the entry being the name of the class for which the PropertyEditors is used.

In the above first example, the key for the MyCustomDateEditor is java.util.Date, which signifies that this is the class for which the editor should be used.

Programmatic Registration Process:

The second code snippet shows a call to Configurer.postProcessBeanFactory(), which passes in the BeanFactory instance. This is another method of registering custom editors in Spring. You should call this before you attempt to access any beans that need to use the custom PropertyEditors.

However, adding a new PropertyEditor means changing the application code, whereas with the declarative mechanism, you can define your editors as beans, which means you can configure them using DI. Besides, using ApplicationContext means no java code to use the declarative mechanism, which strengthens the argument against programmatic mechanism.

2.5 : Customizing beans

Demo: DemoSpring_7

- This demo shows how to use the CustomEditorConfigurer BeanFactoryPostProcessor



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Please refer to DemoSpring_7. The Employee.java is a POJO that holds the date property. Using basic wiring techniques learnt so far, you could set a value into Employee beans' date property. But we have created SQLDateEditor.java extending PropertyEditorSupport class.

Spring must recognize this custom property editor when wiring bean properties using Spring's CustomEditorConfigurer. This BeanFactory PostProcesser internally loads custom editors into the BeanFactory by calling the registerCustomEditor() method. By adding the following bit of XML into the bean configuration file, you will tell Spring to register the SQLDateEditor as a custom editor.

```
<bean id="customEditorConfigurer" class="org.springframework.beans.factory.config.CustomEditorConfigurer">
    <property name="customEditors">
        <map> <entry key="java.sql.Date">
            <bean class="training.spring.SQLDateEditor" />
        </map>
    </property>
</bean>
```

You will now be able to configure the Employee objects date property using a simple string value:

```
<bean id="employee" class="training.spring.Employee">
    <property name="date"><value>2006-01-01</value></property>
</bean>
```

2.5 : Customizing beans

Internationalization: Resolving text messages

- ApplicationContext interface provides messaging functionality by extending MessageSource interface.
- getMessage() is a basic method used to retrieve a message from the MessageSource.
- On loading, ApplicationContext automatically searches for a MessageSource bean defined in the context.
- ResourceBundleMessageSource is a ready-to-use implementation of MessageSource.



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Many times you may not want to hard-code certain text that will be displayed to the user. This may be because text is subject to change or perhaps your application will be internationalized and you will display text in the user's native language.

Java's support for parameterization and internationalization of messages enables you to define one or more properties files that contain the text that is to be displayed in your application. There should always be a default message file along with optional language-specific message files. For ex: if name of the application's message bundle is "MsgText", you may have the following set of message property files:

MsgText.properties: Default messages when a locale cannot be determined or locale-specific properties file is not available.

MsgText_en_US.properties: text for English speaking users in US.

Spring's ApplicationContext supports parameterized messages by making them available to the container through the MessageSource interface that has a single method – getMessage(). Spring comes with a ready-to-use implementation of MessageSource – the ResourceBundleMessageSource. This simply uses Java's own java.util.ResourceBundle to resolve messages. A ResourceBundleMessageSource works on a set of properties files that are identified by base names. When looking for a message for a particular Locale, the ResourceBundle looks for a file that is named as a combination of base name and the Locale name. For e.g. : applicationResources_fr will match a French locale.

2.5 : Customizing beans

Internationalization: Resolving text messages

```
<bean id="messageSource" class="org.springframework.context.  
support.ResourceBundleMessageSource">  
    <property name="basename">  
        <value>applicationResources</value>  
    </property>  
</bean>
```

```
MessageSource messageSource = (MessageSource) factory.getBean  
("messageSource");  
Locale locale = new Locale("en", "US");  
String msg = messageSource.getMessage("welcome.message", null, locale);
```



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To use ResourceBundleMessageSource, add the above xml entry (the first code snippet) to the bean wiring file.

It is very important that this bean be named messageSource because the ApplicationContext will look for a bean specifically by that name when setting up its internal message source.

The basename property specifies the base name of the bundle. The bundle will normally look for messages in properties files with names that are variations of base name depending on locale.

You will never need to inject the messageSource bean into your application beans but will instead access messages via ApplicationContext's own getMessage() methods. For e.g. to retrieve the message whose name is "welcome.message", please refer to the second code snippet above.

You will likely be using parameterized messages in the context of a web application, displaying the text on a web page. In that case, you can use Spring's <spring:message> jsp tag to retrieve messages and need not need directly access the ApplicationContext.

```
< spring:message code="welcome.message" />
```

Alternatively, you can use the second argument of the getMessage() to pass in an array of arguments that will be filled in for params within the message

2.5 : Customizing beans

Demo SpringI 18N

- This demo shows how to provide messaging functionality in the application context.



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Please refer to DemoSpringI18N. There are two resource bundles defined :

applicationResources_en_GB.properties

applicationResources_en_US.properties

Message source has been defined in message.xml

MessageClient.java creates a new locale object and uses the getMessage() to access messages from the appropriate resource bundle based on locale. Notice that the message is parameterized :

welcome.message = Welcome {0}, in UK

Hence we need to send value for {0} parameter in this manner:

```
String msg = messageSource.getMessage("welcome.message", new  
Object[]{"Majrul"},locale);
```

This will set the value of the {0} parameter to "Majrul". We can pass in many parameters for a single message, by using this object array in the getMessage() method.

Annotation-based configuration

- Spring has a number of custom annotations:
 - @Required
 - @Autowired
 - @Resource
 - @PostConstruct
 - @PreDestroy
- Annotations to configure beans:
 - @Component
 - @Controller
 - @Repository
 - @Service



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So far, we have configured our beans in the XML configuration files. Starting with Spring 2.0, we can use annotations to configure our beans. By annotating your classes, you state their typical usage or stereotype. Spring has a number of custom (Java5+) annotations.

@Required : The @Required annotation is used to specify that the value of a bean property is required to be dependency injected. That means, an error is caused if a value is not specified for that property

@Autowired: Prior to Spring 2.5, autowiring could be configured for a number of different approaches: constructor, setters by type, setters by name, or autodetect – which offer a large degree of flexibility, but not very fine-grained control. For eg, it has not been possible to autowire a specific subset of an object's setter methods or to autowire some of its properties by type and others by name.

By using @Autowired, you can eliminate the additional XML in your configuration file that specifies the relationship between two objects. Also, you no longer need methods to set the property in the owning class. Just include a private or protected variable and Spring will do the rest.

@Resource : Declares a reference to a resource such as a data source, Java Messaging Service (JMS) destination, or environment entry. This annotation is equivalent to declaring a resource-ref, message-destination-ref, env-ref, or resource-env-ref element in the deployment descriptor.

Annotation-based configuration

- Annotations to configure Application:
 - @Configuration
 - @Bean
 - @EnableAutoConfiguration
 - @ComponentScan
 - Some other transactions:
 - @Transactional
 - @AspectJ



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By using @Autowired, you can eliminate the additional XML in your configuration file that specifies the relationship between two objects. Also, you no longer need methods to set the property in the owning class. Just include a private or protected variable and Spring will do the rest.

@Resource : Declares a reference to a resource such as a data source, Java Messaging Service (JMS) destination, or environment entry. This annotation is equivalent to declaring a resource-ref, message-destination-ref, env-ref, or resource-env-ref element in the deployment descriptor.

- **@PostConstruct** : Specifies a method that the container will invoke after resource injection is complete but before any of the component's life-cycle methods are called.
- **@PreDestroy** : Specifies a method that the container will invoke before removing the component from service.

When Spring discovers one of these annotations, it creates the appropriate bean by matching the stereotype.

Annotations to configure beans:

@Component: Is the basic stereotype. Classes annotated with this will become spring beans.

@Controller: Classes annotated with this annotation will be considered as a Controller in Spring MVC support.

@Repository: Classes with @Repository annotation represent a repository (eg a data access object)

@Service: This annotation marks classes that implement a part of the business logic of the application.

Annotations to configure application

@Configuration indicates that the class can be used by the Spring IoC container as a source of bean definitions.

@Bean annotation tells Spring that a method annotated with @Bean will return an object that should be registered as a bean in the Spring application context.

@EnableAutoConfiguration annotation will trigger automatic loading of all the beans the application requires

@ComponentScan : An equivalent for Spring XML's <context:component-scan/> is provided with the **@ComponentScan** annotation.

Some other annotations:

@Transactional: is an alternative to the XML-based declarative approach to transaction configuration. All methods of a Spring bean instantiated from a class with the @Transactional annotation will be transactional (thus indirectly, all methods will execute in a transaction). The functionality offered by the @Transactional annotation and the support classes is only available to you if you are using at least Java 5

@Aspect : This annotation on a class marks it as an aspect along with @Pointcut definitions and advice (@Before, @After, @Around)

We shall be covering each of these as we move forwards into AOP, database programming and web applications.

Notice that in all the XML configurations so far, we have used the beans namespace only. But the core Spring Framework comes with ten configuration namespaces as shown in next slide.



XML namespaces through which you can configure the Spring container

Name	Purpose
aop	Provides elements for declaring aspects and for automatically proxying @AspectJ annotated classes as Spring aspects.
beans	The core primitive Spring namespace, enabling declaration of beans and how they should be wired.
context	Comes with elements for configuring the Spring application context, including the ability to autodetect and autowire beans and injection of objects not directly managed by Spring.
jee	Offers integration with Java EE APIs such as JNDI and EJB.
jms	Provides configuration elements for declaring message-driven POJOs.
lang	Enables declaration of beans that are implemented as Groovy, JRuby, or BeanShell scripts.
mvc	Enables Spring MVC capabilities such as annotation-oriented controllers, view controllers, and interceptors.
oxm	Supports configuration of Spring's object-to-XML mapping facilities.
tx	Provides for declarative transaction configuration.
util	A miscellaneous selection of utility elements. Includes the ability to declare collections as beans and support for property placeholder elements.

2.6: Spring Annotations

@Autowired annotation

```
<?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.xsd
                           http://www.springframework.org/schema/context
                           http://www.springframework.org/schema/context/spring-context-4.0.xsd">
    <context:annotation-config />

    <context:component-scan base-package="training.spring" />

    <!-- bean declarations go here -->
</beans>
```

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We can use annotations to automatically wire bean properties. It is similar to autowire attribute in configuration file, but allows more fine-grained autowiring, where you can selectively annotate certain properties for autowiring.

However, simply annotating your classes is not enough to get an annotation's behavior. You need to enable a component that is aware of the annotation and that can process it appropriately. This component (a special BeanPostProcessor implementation) will be different for all annotations. For eg, the RequiredAnnotationBeanPostProcessor class is necessary for @Required annotation. Annotation wiring isn't turned on in the Spring container by default. So, before we can use annotation-based autowiring, we'll need to enable it in our Spring configuration. The simplest way to do that is with the `<context:annotation-config>` element from Spring's context configuration namespace.

`<context:annotation-config>` tells Spring that you intend to use annotation-based wiring in Spring. Once it's in place you can start annotating your code to indicate that Spring should automatically wire values into properties, methods, and constructors. The implicitly registered post-processors include AutowiredAnnotationBeanPostProcessor, CommonAnnotationBeanPostProcessor, PersistenceAnnotationBeanPostProcessor, as well as the RequiredAnnotationBeanPostProcessor.

So far, we have seen how `<context:annotation-config>` eliminates most uses of `<property>` and `<constructor-arg>` elements from your Spring configuration. But we still need to explicitly declare beans using `<bean>`.

The `<context:component-scan>` element is similar to `<context:annotation-config>`. But it also configures Spring to automatically discover beans and declare them, that is, most of the beans in your Spring application can be declared and wired without using `<bean>`.

The `<context:component-scan>` element scans a package and all of its subpackages, looking for classes that could be automatically registered as beans in the Spring container. The `base-package` attribute tells `<context:component-scan>` package to start its scan.

How does this work? By default, `<context:component-scan>` looks for classes that are annotated with one of the following: `@Component`, `@Controller`, `@Repository`, `@Service`.

For example, suppose that our application context only has the `currencyConverter` and `exchangeService` beans in it. We can eliminate the explicit `<bean>` declarations from the XML configuration by using `<context:component-scan>` and annotating the `CurrencyConverterImpl` and `ExchangeServiceImpl` classes with `@Component`.

2.6: Spring Annotations

Execution with Spring Boot

```
@Component("hello")
public class HelloWorld {
    public String sayHello(){
        return "Hello";
    }
}
```

```
@Configuration
@EnableAutoConfiguration
@ComponentScan("com.igate")
public class Client {
    public static void main(String[] args) {
        ApplicationContext context = SpringApplication.run(Client.class, args);
        HelloWorld bean = (HelloWorld) context.getBean(HelloWorld.class);
        String s=bean.sayHello();
        System.out.println(s);
    }
}
```



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We can use annotations to automatically wire bean properties. It is similar to autowire attribute in configuration file, but allows more fine-grained autowiring, where you can selectively annotate certain properties for autowiring.

However, simply annotating your classes is not enough to get an annotation's behavior. You need to enable a component that is aware of the annotation and that can process it appropriately. This component (a special BeanPostProcessor implementation) will be different for all annotations. For eg, the RequiredAnnotationBeanPostProcessor class is necessary for @Required annotation. Annotation wiring isn't turned on in the Spring container by default. So, before we can use annotation-based autowiring, we'll need to enable it in our Spring configuration. The simplest way to do that is with the <context:annotation-config> element from Spring's context configuration namespace.

<context:annotation-config> tells Spring that you intend to use annotation-based wiring in Spring. Once it's in place you can start annotating your code to indicate that Spring should automatically wire values into properties, methods, and constructors. The implicitly registered post-processors include AutowiredAnnotationBeanPostProcessor, CommonAnnotationBeanPostProcessor, PersistenceAnnotationBeanPostProcessor, as well as the RequiredAnnotationBeanPostProcessor.

2.6: Spring Annotations

DemoSpring_Aanno

- This demo illustrates autowired annotation



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Please refer to demo, DemoSpring_Aanno, This example uses the anno.xml for configuring the beans.

Notice how the CurrencyConverterImpl.java depends on the com.igate.anno.ExchangeServiceImpl.java class for services. Notice how the exchangeService property has been annotated with @Autowired. The configuration file now just contains beans declaration and no instructions on wiring!

2.6: Spring Annotations

Annotating beans for autodiscovery

- Refer to demos, DemoSpring_Ann



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Refer to demo, DemoSpring_Ann , Notice the anno.xml configuration file. It contains no beans! Notice the bean classes themselves are annotated with @Component, @PostConstruct, @Autowired etc.

Lab

- From the lab guide
 - Lab-1 problem-statement-1 2 and 3



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Lesson Summary

- We have so far seen:
 - What is Spring and why spring?
 - The Spring architecture
 - Inversion of control
 - Bean containers
 - Lifecycle of beans in containers.
 - Some popular implementations of BeanFactoryPostProcessors



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Thus we have seen that Spring is the most popular and comprehensive of the lightweight J2EE frameworks that have gained popularity since 2003.

We saw how Spring is designed to promote architectural good practice. A typical Spring architecture will be based on programming to interfaces rather than classes.

We have seen what is Inversion of control and dependency injection.

We also saw Bean containers and lifecycle of beans in containers. We saw how to hook into the lifecycle of a bean and make it aware of the Spring environment.

Review Questions

- Question 1: The <constructor-arg> element has an optional _____ attribute that specifies the ordering of the constructor arguments.
 - Option 1: By index
 - Option 2: By type
 - Option 3: By order

- Question 2: A _____ bean lets the container return a new instance each time a bean is asked for in a non-web application
 - Option 1: Singleton
 - Option 2: Prototype
 - Option 3: Request
 - Option 4: session



Review Questions

- Question 3: Specifying the _____ tag will allow Spring to validate at deployment time that the other bean actually exists.
 - Option 1: idref
 - Option 2: ref
 - Option 3: local

- Question 4: The BeanPostProcessor performs post processing on the entire Spring container.
 - Option 1: True
 - Option 2: false

