SPRING IOC CONTAINER

NEELAM AGARWAL

OUTLINE

- Inversion of Control explained
- Spring IOC Container
- Spring Bean
- Container Overview
- Spring Bean Configuration
  - XML Based Spring Bean Configuration
  - Annotation Based Spring Bean Configuration
  - Java Based Spring Bean Configuration

INVERSION OF CONTROL

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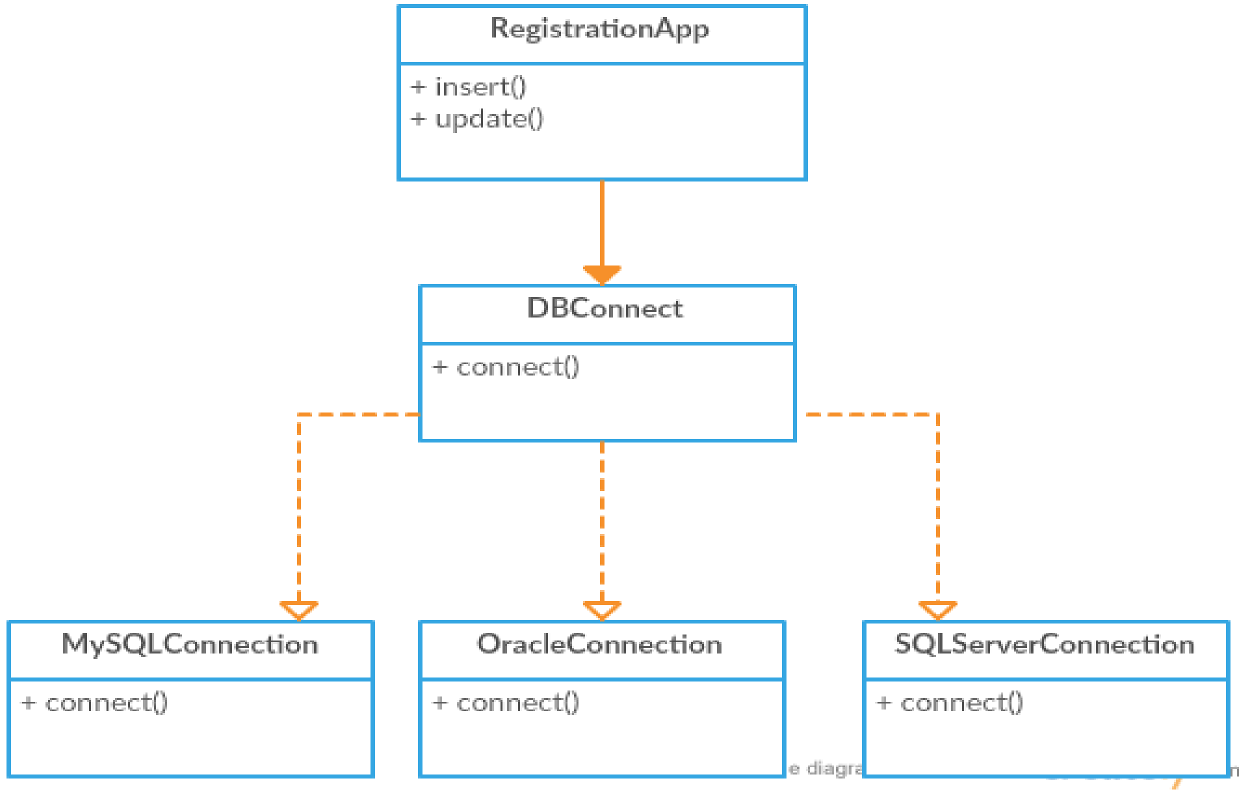
INVERSION OF CONTROL

- Object management inverted from Application Code to the Container
- A Design Pattern that says you do not create your objects but describe how they should be created.
  - You don't directly connect your components and services together in code but describe which services are needed by which components in a configuration file.
  - Help achieve loose coupling between Object Dependencies
- Dependency Injection is a specialized form of Inversion of Control.
- Object Dependencies are injected by other assembler objects.
- Example of IOC is explained in the upcoming slides

INVERSION OF CONTROL

Class Diagram for a Registration Application, which may need to connect to different Databases.



INVERSION OF CONTROL (IOC)

```
package com.training.spring;

public class RegistrationApp {
        public static void main(String[] args) {
                DBConnect dbcon = new MySQLConnection();
                dbcon.connect();
        }
}
```

Creating object of corresponding DB class

```
package com.training.spring;

public class RegistrationApp {
        public static void main(String[] args) {
                DBConnect dbcon = new OracleConnection();
                dbcon.connect();
        }
}
```

INVERSION OF CONTROL (IOC)

IOC reverse the process of Object creation. Container is going to provide us with the required class object

```
package com.training.spring;

public class RegistrationApp {
        public static void main(String[] args) {
        DBConnect dbcon = (DBConnect)Container.getComponent(args[0]);
        if(dbcon !=null)
                dbcon.connect();
        }
}
```

INVERSION OF CONTROL (IOC)

Container class Implementation

```java
package com.training.spring;

public class Container {
            private static Map<String, object> container;

            public synchronized static Object getComponent(final String componentName) {
                        if (container == null) {
                                    container = new HashMap<String, Object>();
                        }
                        Object result = container.get(componentName);
                        if (result == null) {
                                    if ("mysql".equals(componentName)) {
                                                result = new MySQLConnection();
                                    } else if ("oracle".equals(componentName)) {
                                                result = new OracleConnection();
                                    } else if ("sqlserver".equals(componentName)) {
                                                result = new SQLServerConnection();
                                    }
                                    if (result != null) {
                                                container.put(componentName, result);
                                    }
                        }
                        return result;
            }
}
```

SUMMEDUP

- DI is a process whereby objects define their dependencies through constructor arguments, setters or arguments to a factory method. The container then injects those dependencies when it creates the bean

- This process is fundamentally the inverse, 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, or a mechanism such as the *Service Locator* pattern.

WHAT DOES IOC DO?

- Create new objects
- Configure/solve dependency among objects and assemble them
- Allow objects to be retrieved by id/name
- Manage object’s lifecycle
- Allow external configuration

WHY DO WE USE IOC?

- Achieve Loose coupling among Object Dependencies
- Reduce the amount of code in your application
- Does the plumbing work for you
- Application is more testable
- No more creating and hooking of objects together
- No more lookup

SPRING IOC CONTAINER

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SPRING IOC CONTAINER

- Spring IOC Container is the program that injects dependencies into an object and make it ready for use.

- Packages for Spring IOC container
  - org.springframework.beans
  - org.springframework.context

- 2 types of IoC container implementation
  - BeanFactory
  - ApplicationContext

BEAN FACTORY

- BeanFactory interface provides an advanced configuration mechanism capable of managing any type of objects
- Provides the underlying basis for Spring’s IOC functionality.
- It is the root container that loads all the beans and provide dependency injection to enterprise applications
- Now largely historical in nature for most users of Spring.

APPLICATIONCONTEXT

- ApplicationContext is a subinterface of BeanFactory
- It adds easier integration with Spring AOP features, i18n, event publication, and application-layer specific context

USEFUL APPLICATIONCONTEXT IMPLEMENTATIONS

- **AnnotationConfigApplicationContext**: If we are using Spring in standalone java applications and using annotations for Configuration, then we can use this to initialize the container and get the bean objects.

- **ClassPathXmlApplicationContext**: If we have spring bean configuration xml file in standalone application, then we can use this class to load the file and get the container object.

- **FileSystemXmlApplicationContext**: This is similar to ClassPathXmlApplicationContext except that the xml configuration file can be loaded from anywhere in the file system.

- **AnnotationConfigWebApplicationContext** and **XmlWebApplicationContext** for web applications.

BEANFACTORY OR APPLICATIONCONTEXT?

Use an ApplicationContext unless you have a good reason for not doing so.

Feature	BeanFactory	ApplicationContext
Bean instantiation/wiring	Yes	Yes
Automatic BeanPostProcessor registration	No	Yes
Automatic BeanFactoryPostProcessor regist ration	No	Yes
Convenient MessageSource access (for i18n)	No	Yes
ApplicationEvent publication	No	Yes

SPRING BEANS

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SPRING BEANS

- The objects that form the backbone of the application and that are managed by Spring IOC Container are called beans.
- A bean is an object that is instantiated, assembled and otherwise managed by a Spring IOC Container.

BEAN SCOPES

- Singleton
  - Default Scope
  - Only one instance of the bean will be created for each container
- Prototype
  - A new instance will be created every time the bean is requested
- Request
  - Same as prototype scope, but is used in Web Applications.
  - A new instance will be created for each HTTP request
- Session
  - A new bean will be created for each HTTP Session by the container
- Global-session
  - To create global session beans for Portlet applications

SPRING BEAN CONFIGURATION

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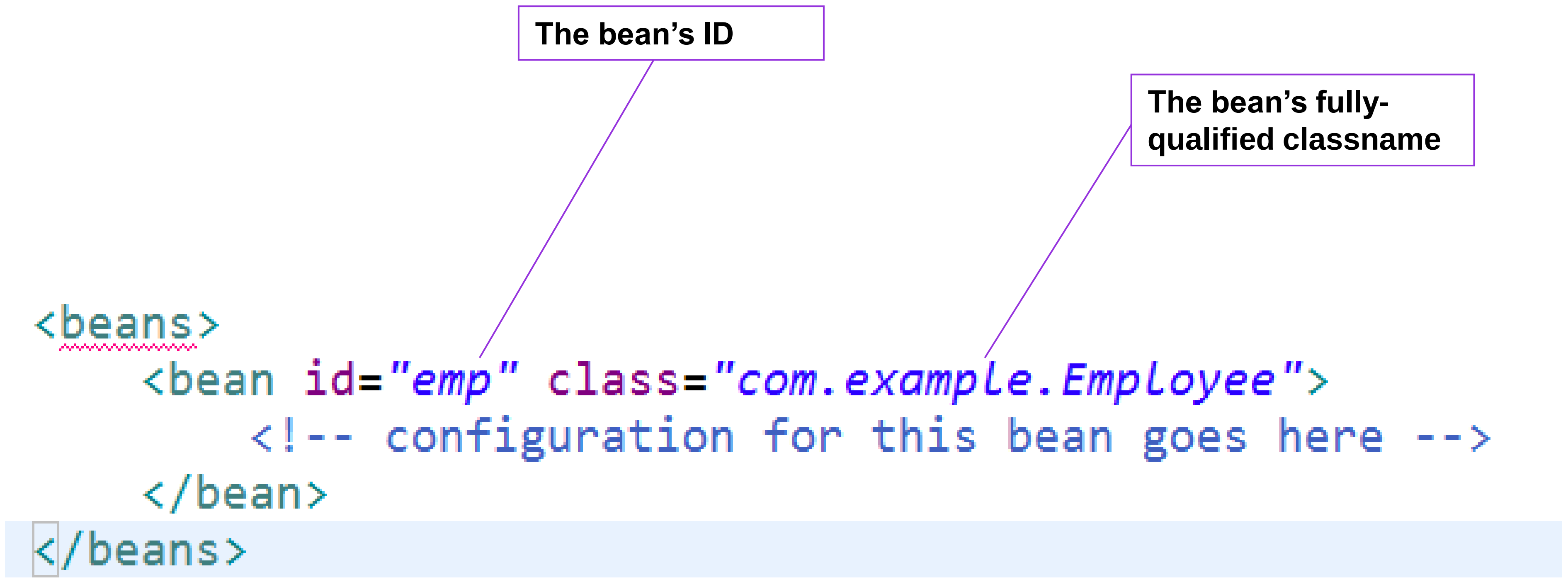
SPRING BEAN CONFIGURATION

- Spring provides three ways to configure beans to be used in applications
  - XML Based Configuration
    - By creating Spring Configuration XML file to configure the beans.
  - Annotation Based Configuration
    - Spring 2.5 introduced support for annotation-based configuration metadata. Base Container is still XML.
  - Java Based Configuration
    - Starting from Spring 3.0, we can configure Spring beans using java programs. Pure Java-based configuration. No need for having XML file for configuration Metadata

XML-BASED CONFIGURATION METADATA

- Root element: <beans>
- The XML contains one or more <bean> elements
  - id (or name) attribute to identify the bean
  - class attribute to specify the fully qualified class
- By default, beans are treated as singletons
- Can also be prototypes (non singletons)

XML-BASED CONFIGURATION METADATA

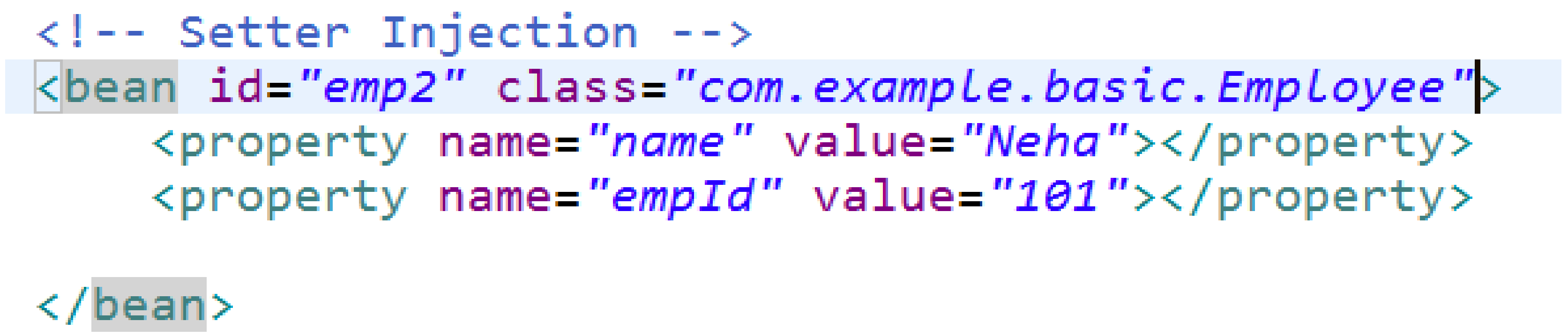


```xml
<beans>
    <bean id="emp" class="com.example.Employee">
        <!-- configuration for this bean goes here -->
    </bean>
</beans>
```

DEPENDENCY INJECTION

- Setter-Based
  - Dependencies are assigned through **JavaBeans** properties (for example, setter methods)
- Constructor-Based
  - Dependencies are provided as **constructor parameters** and are not exposed as JavaBeans properties
- Method-Based
  - The container is responsible for **implementing methods** at **runtime**

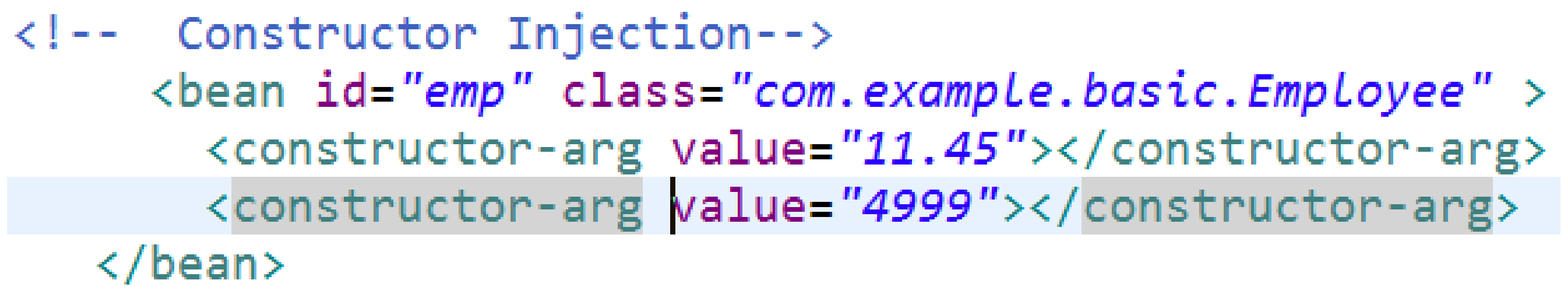
SETTER INJECTION



```
<!-- Setter Injection -->
<bean id="emp2" class="com.example.basic.Employee">
    <property name="name" value="Neha"></property>
    <property name="empId" value="101"></property>

</bean>
```

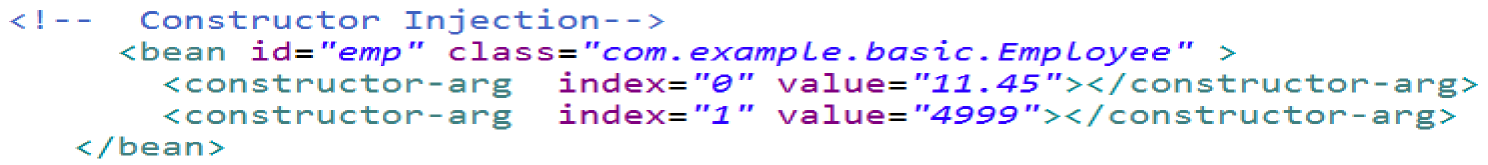
CONSTRUCTOR INJECTION



```
<!--  Constructor Injection-->
     <bean id="emp" class="com.example.basic.Employee" >
       <constructor-arg value="11.45"></constructor-arg>
       <constructor-arg value="4999"></constructor-arg>
   </bean>
```

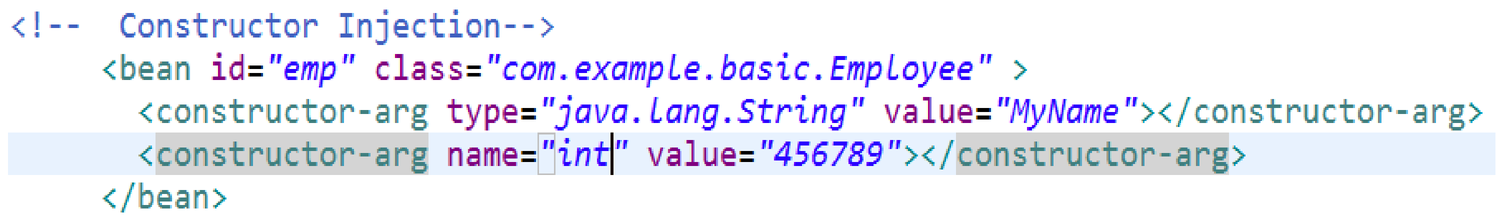
CONSTRUCTOR ARGUMENT RESOLUTION

- Index



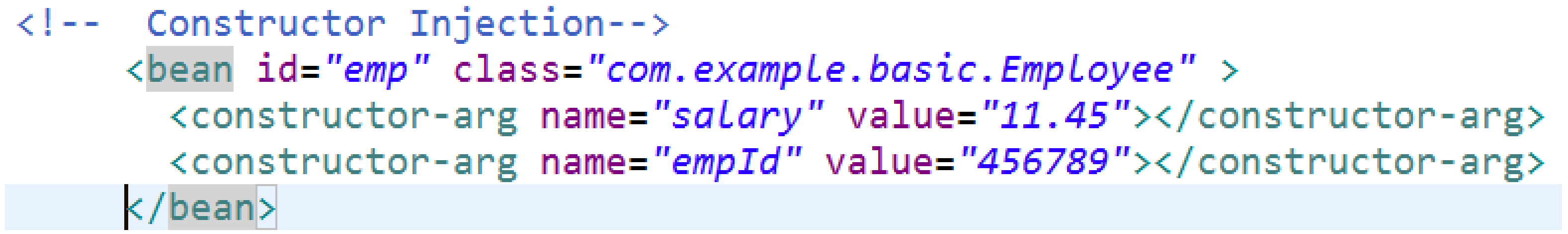
```
<!--  Constructor Injection-->
     <bean id="emp" class="com.example.basic.Employee" >
       <constructor-arg  index="0" value="11.45"></constructor-arg>
       <constructor-arg  index="1" value="4999"></constructor-arg>
   </bean>
```

- Type



```
<!--  Constructor Injection-->
     <bean id="emp" class="com.example.basic.Employee" >
       <constructor-arg type="java.lang.String" value="MyName"></constructor-arg>
       <constructor-arg name="int" value="456789"></constructor-arg>
     </bean>
```

- Name



```
<!--  Constructor Injection-->
     <bean id="emp" class="com.example.basic.Employee" >
       <constructor-arg name="salary" value="11.45"></constructor-arg>
       <constructor-arg name="empId" value="456789"></constructor-arg>
     </bean>
```

WHICH ONE TO CHOOSE?

POINTS IN FAVOR OF CONSTRUCTOR

- Constructor injection enforces a strong dependency contract. In short, a bean cannot be instantiated without being given all of its dependencies. It is perfectly valid and ready to use upon instantiation.
- Because all of the bean's dependencies are set through its constructor, there's no need for superfluous setter methods. This helps keep the lines of code at a minimum.
- By only allowing properties to be set through the constructor, you are, in effect, making those properties immutable.

POINTS IN FAVOR OF SETTER

- If a bean has several dependencies, the constructor's parameter list can be quite lengthy.
- If there are several ways to construct a valid object, it can be hard to come up with unique constructors since constructor signatures vary only by the number and type of parameters.
- If a constructor takes two or more parameters of the same type, it may be difficult to determine what each parameter's purpose is.
- Constructor injection does not lend itself readily to inheritance. A bean's constructor will have to pass parameters to super() in order to set private properties in the parent object.

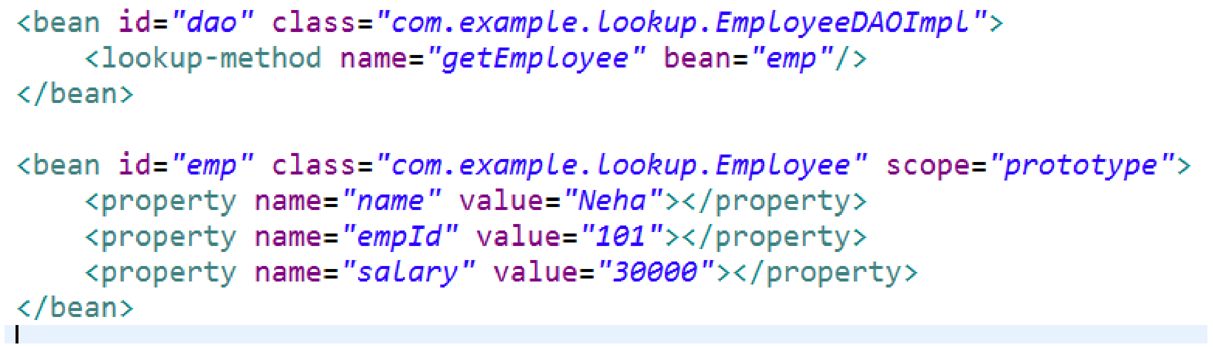
CONSTRUCTOR-BASED VS SETTER-BASED DI

- Tips : Use constructor arguments for mandatory dependencies and setters for optional dependencies
- More properties, more arguments to constructor
- Hence the Spring team generally advocates setter injection

METHOD-BASED INJECTION

- Useful when a singleton bean needs to use a non-singleton bean

- Using CGLIB library, Spring generates dynamically a subclass and overrides the look up method



```xml
<bean id="dao" class="com.example.lookup.EmployeeDAOImpl">
    <lookup-method name="getEmployee" bean="emp"/>
</bean>

<bean id="emp" class="com.example.lookup.Employee" scope="prototype">
    <property name="name" value="Neha"></property>
    <property name="empId" value="101"></property>
    <property name="salary" value="30000"></property>
</bean>
```

- Spring overrides the getEmployee() using lookup-method injection to provide a new instance of a Employee every time that method is called

METHOD BASED INJECTION

- Look-up method must be as follows
  - <public|protected> [abstract] <return-type> theMethodName(no-arguments)

- We need an abstract method which will be configured as a lookup-method in the configuration file.

- Spring will generate a proxy around which will implement the abstract method and return the object of the target bean. Again used only if scopes of both the beans are different

- Also you must have the CGLIB jar(s) in your classpath

AUTOWIRING COLLABORATORS

- Spring can resolve collaborators (other beans) automatically for your bean by inspecting the contents of the ApplicationContext
- Advantages:
  - Reduces the need to specify properties or constructor arguments
  - New dependencies can be added to a class without changing the configuration

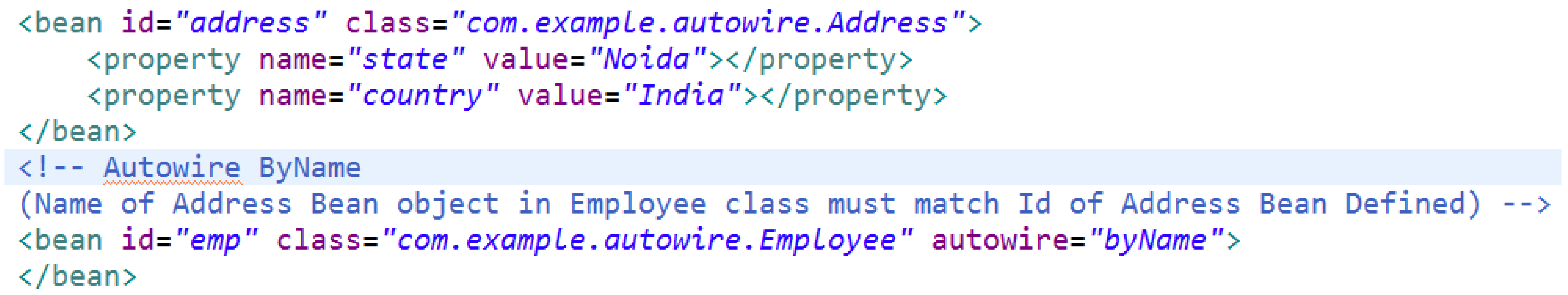
AUTOWIRING MODES

Mode	Explanation
No (Default)	No autowiring
byName	Autowiring by property name. Spring looks for a bean with the same name as the property that needs to be autowired
byType	Allows a property to be autowired if exactly one bean of the property type exists in the container. If more than one exists, a fatal exception is thrown.
constructor	Analogous to byType, but applies to constructor arguments.
autodetect	If a default constructor with no argument is found, the dependencies will be auto-wired by type. Otherwise, they will be auto-wired by constructor

- Note :Autowiring works best when it is used consistently across a project

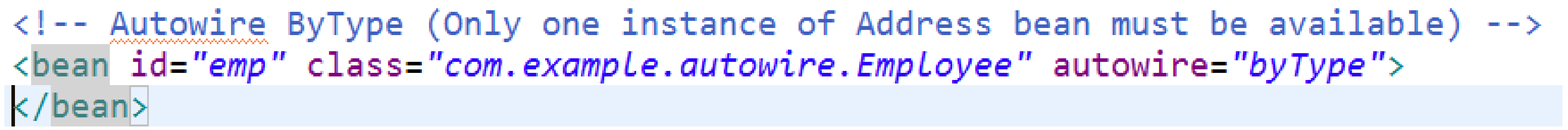
AUTOWIRING EXAMPLE

Autowire by Name



```xml
<bean id="address" class="com.example.autowire.Address">
    <property name="state" value="Noida"></property>
    <property name="country" value="India"></property>
</bean>
<!-- Autowire ByName
(Name of Address Bean object in Employee class must match Id of Address Bean Defined) -->
<bean id="emp" class="com.example.autowire.Employee" autowire="byName">
</bean>
```

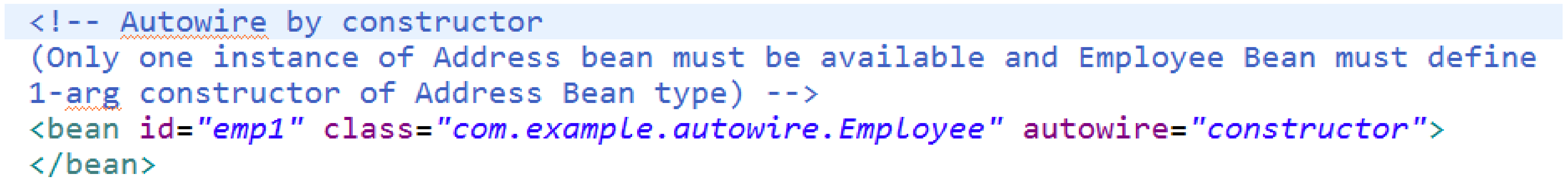
Autowire by Type



```xml
<!-- Autowire ByType (Only one instance of Address bean must be available) -->
<bean id="emp" class="com.example.autowire.Employee" autowire="byType">
</bean>
```

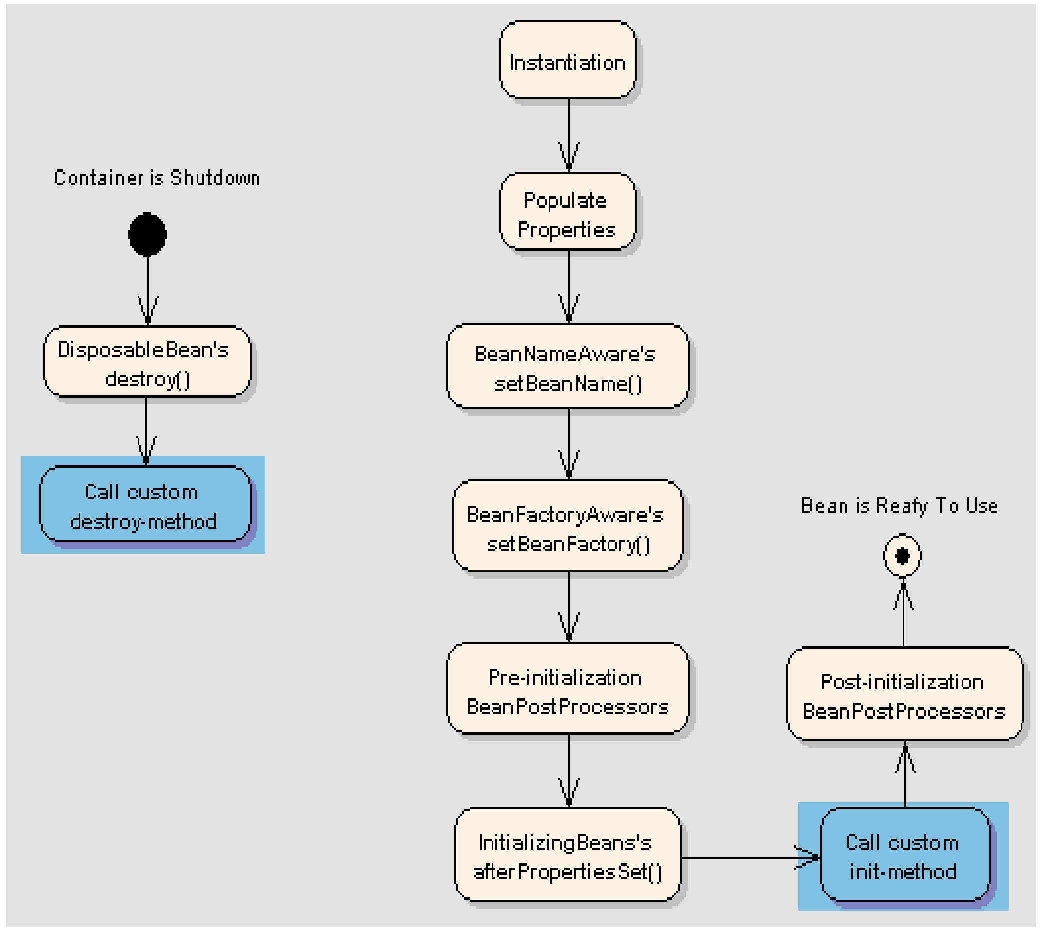
AUTOWIRING EXAMPLE

Autowire Constructor



```xml
<!-- Autowire by constructor
(Only one instance of Address bean must be available and Employee Bean must define
1-arg constructor of Address Bean type) -->
<bean id="emp1" class="com.example.autowire.Employee" autowire="constructor">
</bean>
```

LIFECYCLE OF BEANS


Instantiation
Populate Properties
BeanNameAware's setBeanName()
BeanFactoryAware's setBeanFactory()
Pre-initialization BeanPostProcessors
InitializingBeans's afterPropertiesSet()
Call custom init-method
Post-initialization BeanPostProcessors
Bean is Reafy To Use
Container is Shutdown
DisposableBean's destroy()
Call custom destroy-method

LIFECYCLE CALLBACKS

- Three ways to interact with the container’s bean lifecycle management

  - By implementing the InitializingBean and DisposableBean interfaces

  - Using init-method and destroy-method attributes in the bean definition

    (if you don’t want your classes coupled to Spring interfaces)

  - @PostConstruct and @PreDestroy annotations (More on this later)

INITIALIZATION CALLBACKS

- Implement the InitializingBean interface and override afterPropertiesSet() method
- Container calls this method upon initialization of your beans

```
        public class Employee implements InitializingBean {
                public void afterPropertiesSet() {
                                // do some initialization work
                }}
```

- Alternatively specify a POJO initialization using the init-method attribute

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

```
<bean id=“emp”  class=“com.example.lifecycle.Employee“ init-method="init"/>
```

DESTRUCTION CALLBACKS

- Implement the DisposableBean interface and override destroy() method
- Container calls this method upon destruction of your beans

```
public class Employee implements DisposableBean{
        public void destroy() {
//do some destruction work (like releasing pooled connections)   }
}
```

- Alternatively specify a POJO initialization using destroy-method attribute

```
public class Employee {
        public void cleanup() {
                        // do some destruction work
        }
}
```

```
<bean id="emp" class="com.example.lifecycle.Employee" destroy-method="cleanup"/>
```

ANNOTATION BASED CONTAINER CONFIGURATION

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TO CONFIGURE SPRING - ANNOTATION VS XML

- Annotations

  + More concise configuration

  + Wiring is more close to the source

  - Configuration becomes decentralized and harder to control

- XML

  + Wiring done without touching source code or recompiling

  + A centralized location for configuration

  - Can become verbose

- It is up to the developer to decide the strategy that suits better

CAN WE USE BOTH?

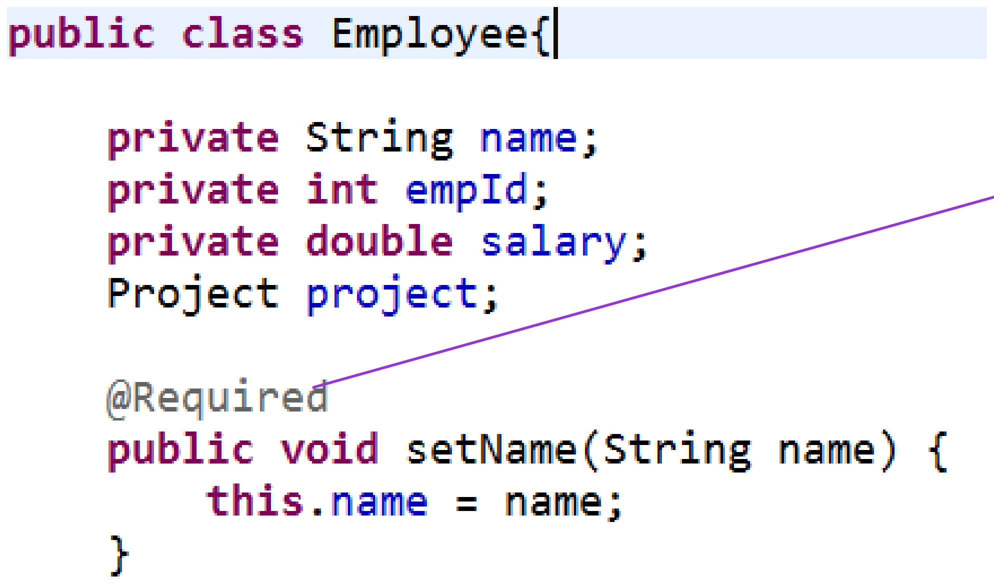
- Spring supports mix of both
- But Annotation injection is performed *before* XML injection
- Hence XML-based injection will override Annotation-based injection for properties wired through both approaches

ANNOTATIONS INTRODUCED IN SPRING

- Spring 2.0
  - *@Required*
- Spring 2.5
  - *@Autowired*
  - *@Resource, @PostConstruct, @PreDestroy*
- Spring 3.0
  - *@Inject, @Qualifier, @Named, and @Provider*

@REQUIRED

- Applies to bean property setter methods
- Indicates that the affected bean property must be populated at configuration time
- Throws an exception if it has not been set



```
public class Employee{

    private String name;
    private int empId;
    private double salary;
    Project project;

    @Required
    public void setName(String name) {
        this.name = name;
    }
```

@Required use. Must use setter injection to set the value

@AUTOWIRED

- Can be used in the Java source code for specifying DI requirement

- Places where @Autowired can be used
  - Fields
  - Setter methods
  - Constructor methods
  - Arbitrary methods

- Need to include the below element in the bean configuration file to use this
  - <context:annotation-config>

- Because autowiring by type may lead to multiple candidates, it is necessary to have more control over the selection process
- One way to accomplish this is with Spring's *@Qualifier annotation.*

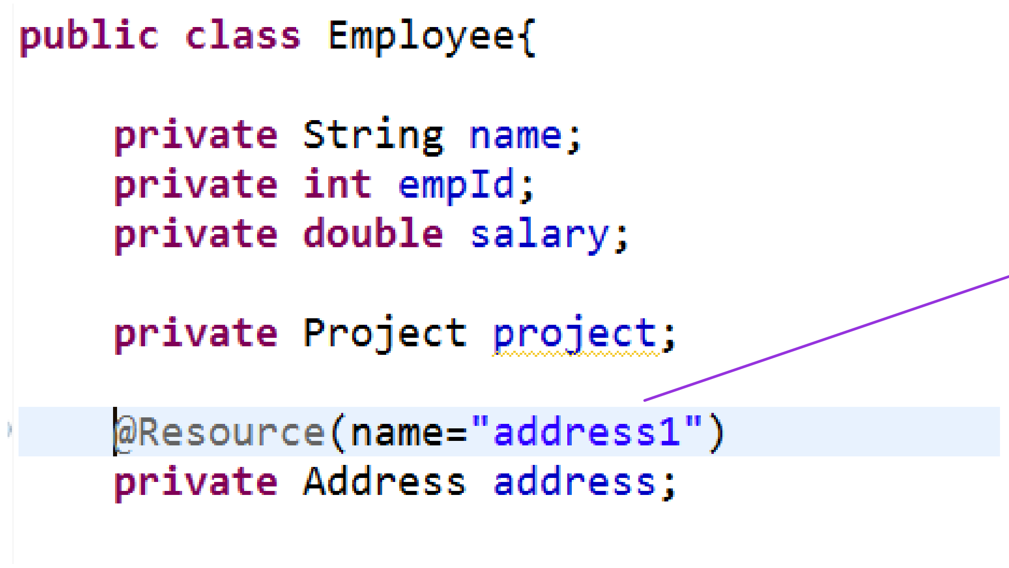
```
@Autowired
@Qualifier("address1")
public void setAddress( Address address) {
    this.address = address;
}

@Autowired
public void assignValues
(@Qualifier("address1") Address address,Project project) {
    this.address = address;
    this.project = project;
}
```

Of all the beans of Address class, it uses one matching the address1 id.

@Qualifier can be used with parameter names as well.

@RESOURCE

- Spring also supports injection using the @Resource on fields or bean property setter methods
- It takes a 'name' attribute, and by default Spring will interpret that value as the bean name to be injected i.e., it follows by-name semantics

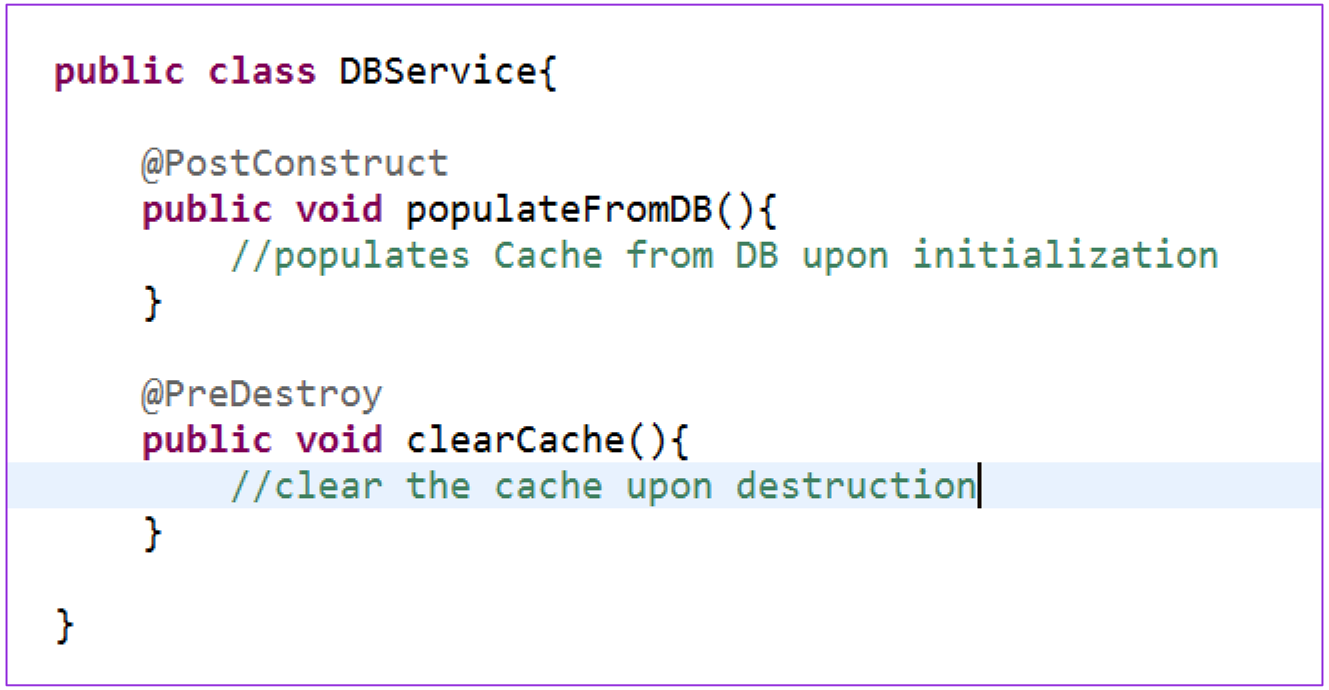


```
public class Employee{

    private String name;
    private int empId;
    private double salary;

    private Project project;

    @Resource(name="address1")
    private Address address;
```

Must have a bean with id – address1 of type Address defined in config file.

@POSTCONSTRUCT AND @PREDESTROY

- An alternative to initialization callbacks and destruction callbacks



```java
public class DBService{

    @PostConstruct
    public void populateFromDB(){
        //populates Cache from DB upon initialization
    }

    @PreDestroy
    public void clearCache(){
        //clear the cache upon destruction
    }

}
```

JAVA BASED CONTAINER CONFIGURATION

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@CONFIGURATION AND @BEAN

- Class with *@Configuration* indicates that the class can be used as a source of bean definitions
- @Bean-annotated methods define instantiation, configuration, and initialization logic for objects to be managed by the Spring IoC container

```
@Configuration
public class AppConfig {
@Bean
public MyService myService() {
        return new MyServiceImpl();
} }
```

- This is equivalent to

```
<beans>
<bean id="myService" class="MyServiceImpl"/>
</beans>
```

ANNOTATIONCONFIGAPPLICATIONCONTEXT

- An ApplicationContext implementation
- Uses @Configuration classes as input

```
public static void main(String[] args) {

ApplicationContext ctx = new
AnnotationConfigApplicationContext(AppConfig.class);

MyService myService = ctx.getBean(MyService.class);

myService.doStuff();
}
```

@CONFIGURATION AND @BEAN

```
@Configuration
public class AppConfig {
@Bean
public TransferService transferService() {
return new TransferServiceImpl(accountRepository());
}
@Bean
public AccountRepository accountRepository() {
return new InMemoryAccountRepository();
} }
```

This is same as:

```
<bean id = "accountRepository"
class = “InMemoryAccountRepository”></bean>
<bean id = "transferService“ class = “TransferServiceImpl">
<property name="accountRepository" ref="accountRepository"/>
</bean>
```

SCANNING COMPONENTS FROM CLASSPATH

SCANNING COMPONENTS FROM THE CLASSPATH

- So far the “base" bean definitions are explicitly defined in the XML file, while the annotations only drive the dependency injection
- But *Component Scanning avoids* manual configuration
- It can automatically scan, detect, and instantiate your components with particular stereotype annotations from the classpath
- The basic annotation denoting a Spring-managed component is @Component
- Other stereotypes include @Repository, @Service, and @Controller denoting components in the persistence, service, and presentation layers, respectively

AUTOMATICALLY DETECTING CLASSES AND REGISTERING BEAN DEFINITIONS

```java
@Service
public class EmployeeServiceImpl implements EmployeeService {

    @Autowired
    private DBImpl dao;
}
```

```java
@Repository
public class DBImpl implements DBInterface {

    @Autowired
    DataSource datasource;

}
```

To Add in Configuration XML File other than DataSource Configuartion

common parent package for the two classes

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