5. The IoC container

5.1 Introduction to the Spring IoC container and beans

This chapter covers the Spring Framework implementation of the Inversion of Control (IoC) [1]principle. IoC is also known as *dependency injection* (DI). It is a process whereby objects define their dependencies, that is, the other objects they work with, 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 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.

The `org.springframework.beans` and `org.springframework.context` packages are the basis for Spring Framework's IoC container. The `BeanFactory` interface provides an advanced configuration mechanism capable of managing any type of object. `ApplicationContext` is a sub-interface of `BeanFactory.` It adds easier integration with Spring's AOP features; message resource handling (for use in internationalization), event publication; and application-layer specific contexts such as the `WebApplicationContext` for use in web applications.

In short, the `BeanFactory` provides the configuration framework and basic functionality, and the `ApplicationContext` adds more enterprise-specific functionality. The `ApplicationContext` is a complete superset of the `BeanFactory`, and is used exclusively in this chapter in descriptions of Spring's IoC container. For more information on using the `BeanFactory` instead of the `ApplicationContext,` refer to Section 5.15, “The BeanFactory”.

In Spring, the objects that form the backbone of your application and that are managed by the Spring IoC *container* are called *beans*. A bean is an object that is instantiated, assembled, and otherwise managed by a Spring IoC container. Otherwise, a bean is simply one of many objects in your application. Beans, and the *dependencies* among them, are reflected in the *configuration metadata* used by a container.

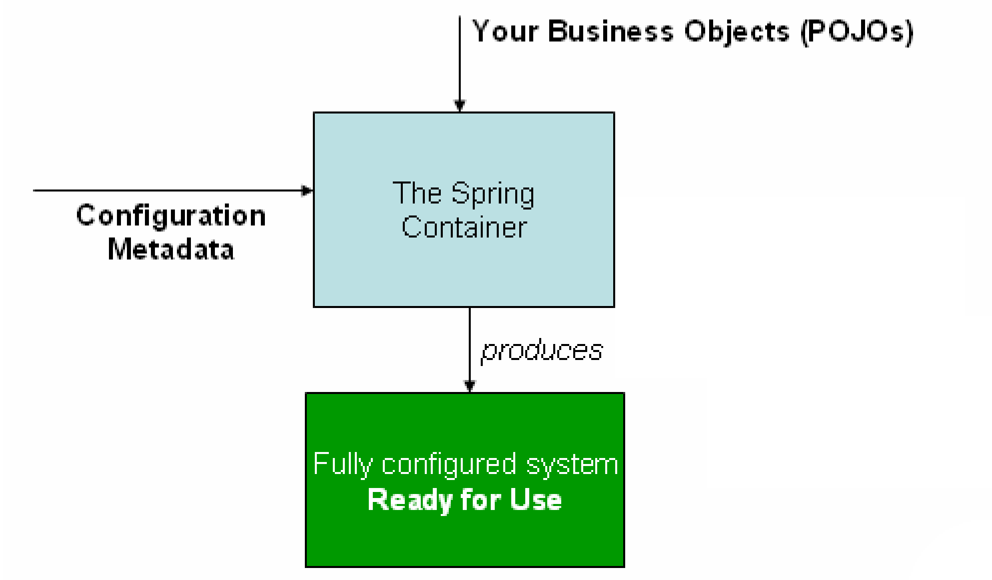
5.2 Container overview

The interface `org.springframework.context.ApplicationContext` represents the Spring IoC container and is responsible for instantiating, configuring, and assembling the aforementioned beans. The container gets its instructions on what objects to instantiate, configure, and assemble by reading configuration metadata. The configuration metadata is represented in XML, Java annotations, or Java code. It allows you to express the objects that compose your application and the rich interdependencies between such objects.

Several implementations of the `ApplicationContext` interface are supplied out-of-the-box with Spring. In standalone applications it is common to create an instance of `ClassPathXmlApplicationContext` or `FileSystemXmlApplicationContext`. While XML has been the traditional format for defining configuration metadata you can instruct the container to use Java annotations or code as the metadata format by providing a small amount of XML configuration to declaratively enable support for these additional metadata formats.

In most application scenarios, explicit user code is not required to instantiate one or more instances of a Spring IoC container. For example, in a web application scenario, a simple eight (or so) lines of boilerplate J2EE web descriptor XML in the `web.xml` file of the application will typically suffice (see Section 5.14.4, “Convenient `ApplicationContext` instantiation for web applications”). If you are using the SpringSource Tool Suite Eclipse-powered development environment or Spring Roo this boilerplate configuration can be easily created with few mouse clicks or keystrokes.

The following diagram is a high-level view of how Spring works. Your application classes are combined with configuration metadata so that after the `ApplicationContext` is created and initialized, you have a fully configured and executable system or application.



The Spring IoC container

5.2.1 Configuration metadata

As the preceding diagram shows, the Spring IoC container consumes a form of *configuration metadata*; this configuration metadata represents how you as an application developer tell the Spring container to instantiate, configure, and assemble the objects in your application.

Configuration metadata is traditionally supplied in a simple and intuitive XML format, which is what most of this chapter uses to convey key concepts and features of the Spring IoC container.

> XML-based metadata is *not* the only allowed form of configuration metadata. The Spring IoC container itself is *totally* decoupled from the format in which this configuration metadata is actually written.

For information about using other forms of metadata with the Spring container, see:

- Annotation-based configuration: Spring 2.5 introduced support for annotation-based configuration metadata.
- Java-based configuration: Starting with Spring 3.0, many features provided by the Spring JavaConfig project became part of the core Spring Framework. Thus you can define beans external to your application classes by using Java rather than XML files. To use these new features, see the `@Configuration`, `@Bean, @Import` and `@DependsOn` annotations.

Spring configuration consists of at least one and typically more than one bean definition that the container must manage. XML-based configuration metadata shows these beans configured as `<bean/>` elements inside a top-level `<beans/>` element.

These bean definitions correspond to the actual objects that make up your application. Typically you define service layer objects, data access objects (DAOs), presentation objects such as Struts `Action` instances, infrastructure objects such as Hibernate `SessionFactories`, JMS `Queues`, and so forth. Typically one does not configure fine-grained domain objects in the container, because it is usually the responsibility of DAOs and business logic to create and load domain objects. However, you can use Spring's integration with AspectJ to configure objects that have been created outside the control of an IoC container. See Using AspectJ to dependency-inject domain objects with Spring.

The following example shows the basic structure of XML-based configuration metadata:

```
<?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="...">
    <!-- collaborators and configuration for this bean go here -->
  </bean>

  <bean id="..." class="...">
    <!-- collaborators and configuration for this bean go here -->
  </bean>

  <!-- more bean definitions go here -->

```

```
</beans>
```

The `id` attribute is a string that you use to identify the individual bean definition. The `class` attribute defines the type of the bean and uses the fully qualified classname. The value of the id attribute refers to collaborating objects. The XML for referring to collaborating objects is not shown in this example; see Dependencies for more information.

5.2.2 Instantiating a container

Instantiating a Spring IoC container is straightforward. The location path or paths supplied to an `ApplicationContext` constructor are actually resource strings that allow the container to load configuration metadata from a variety of external resources such as the local file system, from the Java `CLASSPATH`, and so on.

```
ApplicationContext context =
    new ClassPathXmlApplicationContext(new String[] {"services.xml", "daos.xml"});
```

After you learn about Spring's IoC container, you may want to know more about Spring's `Resource` abstraction, as described in Chapter 6, *Resources*, which provides a convenient mechanism for reading an InputStream from locations defined in a URI syntax. In particular, `Resource` paths are used to construct applications contexts as described in Section 6.7, “Application contexts and `Resource` paths”.

The following example shows the service layer objects `(services.xml)` configuration file:

```
<?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">

  <!-- services -->
```

```
  <bean id="petStore"
        class="org.springframework.samples.jpetstore.services.PetStoreServiceImpl">
    <property name="accountDao" ref="accountDao"/>
    <property name="itemDao" ref="itemDao"/>
    <!-- additional collaborators and configuration for this bean go here -->
  </bean>

  <!-- more bean definitions for services go here -->

</beans>
```

The following example shows the data access objects `daos.xml` file:

```
<?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="accountDao"
      class="org.springframework.samples.jpetstore.dao.ibatis.SqlMapAccountDao">
    <!-- additional collaborators and configuration for this bean go here -->
  </bean>

  <bean id="itemDao" class="org.springframework.samples.jpetstore.dao.ibatis.SqlMapItemDao">
    <!-- additional collaborators and configuration for this bean go here -->
  </bean>

  <!-- more bean definitions for data access objects go here -->

</beans>
```

In the preceding example, the service layer consists of the class `PetStoreServiceImpl`, and two data access objects of the type `SqlMapAccountDao` and SqlMapItemDao are based on the iBatis Object/Relational mapping framework. The `property name` element refers to the name of the JavaBean property, and the `ref` element refers to the name of another bean definition. This linkage between id and ref elements expresses the dependency between collaborating objects. For details of configuring an object's dependencies, see Dependencies.

Composing XML-based configuration metadata

It can be useful to have bean definitions span multiple XML files. Often each individual XML configuration file represents a logical layer or module in your architecture.

You can use the application context constructor to load bean definitions from all these XML fragments. This constructor takes multiple `Resource` locations, as was shown in the previous section. Alternatively, use one or more occurrences of the `<import/>` element to load bean definitions from another file or files. For example:

```
<beans>

    <import resource="services.xml"/>
    <import resource="resources/messageSource.xml"/>
    <import resource="/resources/themeSource.xml"/>

    <bean id="bean1" class="..."/>
    <bean id="bean2" class="..."/>

</beans>
```

In the preceding example, external bean definitions are loaded from three files, `services.xml`, `messageSource.xml`, and `themeSource.xml`. All location paths are relative to the definition file doing the importing, so `services.xml` must be in the same directory or classpath location as the file doing the importing, while `messageSource.xml` and `themeSource.xml` must be in a `resources` location below the location of the importing file. As you can see, a leading slash is ignored, but given that these paths are relative, it is better form not to use the slash at all. The contents of the files being imported, including the top level `<beans/>` element, must be valid XML bean definitions according to the Spring Schema or DTD.

It is possible, but not recommended, to reference files in parent directories using a relative "../" path. Doing so creates a dependency on a file that is outside the current application. In particular, this reference is not recommended for "classpath:" URLs (for example, "classpath:../services.xml"), where the runtime resolution process chooses the "nearest" classpath root and then looks into its parent directory. Classpath configuration changes may lead to the choice of a different, incorrect directory.
You can always use fully qualified resource locations instead of relative paths: for example, "file:C:/config/services.xml" or "classpath:/config/services.xml". However, be aware that you are coupling your application's configuration to specific absolute locations. It is generally preferable to keep an indirection for such absolute locations, for example, through "${...}" placeholders that are resolved against JVM system properties at runtime.

5.2.3 Using the container

The `ApplicationContext` is the interface for an advanced factory capable of maintaining a registry of different beans and their dependencies. Using the method `T getBean(String name, Class<T> requiredType)` you can retrieve instances of your beans.

The `ApplicationContext` enables you to read bean definitions and access them as follows:

```
// create and configure beans
ApplicationContext context =
    new ClassPathXmlApplicationContext(new String[] {"services.xml", "daos.xml"});

// retrieve configured instance
PetStoreServiceImpl service = context.getBean("petStore", PetStoreServiceImpl.class);

// use configured instance
List userList = service.getUsernameList();
```

You use `getBean()` to retrieve instances of your beans. The `ApplicationContext` interface has a few other methods for retrieving beans, but ideally your application code should never use them. Indeed, your application code should have no calls to the `getBean()` method at all, and thus no dependency on Spring APIs at all. For example, Spring's integration with web frameworks provides for dependency injection for various web framework classes such as controllers and JSF-managed beans.

5.3 Bean overview

A Spring IoC container manages one or more *beans*. These beans are created with the configuration metadata that you supply to the container, for example, in the form of XML `<bean/>` definitions.

Within the container itself, these bean definitions are represented as `BeanDefinition` objects, which contain (among other information) the following metadata:

- *A package-qualified class name:* typically the actual implementation class of the bean being defined.
- Bean behavioral configuration elements, which state how the bean should behave in the container (scope, lifecycle callbacks, and so forth).
- References to other beans that are needed for the bean to do its work; these references are also called *collaborators* or *dependencies*.
- Other 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.

This metadata translates to a set of properties that make up each bean definition.

Table 5.1. The bean definition

Property	Explained in...
class	Section 5.3.2, “Instantiating beans”
name	Section 5.3.1, “Naming beans”

Property	Explained in...
scope	Section 5.5, “Bean scopes”
constructor arguments	Section 5.4.1, “Dependency injection”
properties	Section 5.4.1, “Dependency injection”
autowiring mode	Section 5.4.5, “Autowiring collaborators”
lazy-initialization mode	Section 5.4.4, “Lazy-initialized beans”
initialization method	the section called “Initialization callbacks”
destruction method	the section called “Destruction callbacks”

In addition to bean definitions that contain information on how to create a specific bean, the `ApplicationContext` implementations also permit the registration of existing objects that are created outside the container, by users. This is done by accessing the ApplicationContext's BeanFactory via the method `getBeanFactory()` which returns the BeanFactory implementation `DefaultListableBeanFactory`. `DefaultListableBeanFactory` supports this registration through the methods `registerSingleton(..)` and `registerBeanDefinition(..)`. However, typical applications work solely with beans defined through metadata bean definitions.

5.3.1 Naming beans

Every bean has one or more identifiers. These identifiers must be unique within the container that hosts the bean. A bean usually has only one identifier, but if it requires more than one, the extra ones can be considered aliases.

In XML-based configuration metadata, you use the `id` and/or `name` attributes to specify the bean identifier(s). The `id` attribute allows you to specify exactly one id. Conventionally these names are alphanumeric ('myBean', 'fooService', etc), but may special characters as well. If you want to introduce other aliases to the bean, you can also specify them in the `name` attribute, separated by a comma (`,`), semicolon (`;`), or white space. As a historical note, in versions prior to Spring 3.1, the `id` attribute was typed as an `xsd:ID`, which constrained possible characters. As of 3.1, it is now `xsd:string`. Note that bean id uniqueness is still enforced by the container, though no longer by XML parsers.

You are not required to supply a name or id for a bean. If no name or id is supplied explicitly, the container generates a unique name for that bean. However, if you want to refer to that bean by name, through the use of the `ref` element or Service Locator style lookup, you must provide a name. Motivations for not supplying a name are related to using inner beans and autowiring collaborators.

Bean naming conventions

The convention is to use the standard Java convention for instance field names when naming beans. That is, bean names start with a lowercase letter, and are camel-cased from then on. Examples of such names would be (without quotes) `'accountManager'`, `'accountService'`, `'userDao'`, `'loginController'`, and so forth.

Naming beans consistently makes your configuration easier to read and understand, and if you are using Spring AOP it helps a lot when applying advice to a set of beans related by name.

Aliasing a bean outside the bean definition

In a bean definition itself, you can supply more than one name for the bean, by using a combination of up to one name specified by the `id` attribute, and any number of other names in the `name` attribute. These names can be equivalent aliases to the same bean, and are useful for some situations, such as allowing each component in an application to refer to a common dependency by using a bean name that is specific to that component itself.

Specifying all aliases where the bean is actually defined is not always adequate, however. It is sometimes desirable to introduce an alias for a bean that is defined elsewhere. This is commonly the case in large systems where configuration is split amongst each subsystem, each subsystem having its own set of object definitions. In XML-based configuration metadata, you can use the `<alias/>` element to accomplish this.

```
<alias name="fromName" alias="toName"/>
```

In this case, a bean in the same container which is named `fromName`, may also after the use of this alias definition, be referred to as `toName`.

For example, the configuration metadata for subsystem A may refer to a DataSource via the name 'subsystemA-dataSource. The configuration metadata for subsystem B may refer to a DataSource via the name 'subsystemB-dataSource'. When composing the main application that uses both these subsystems the main application refers to the DataSource via the name 'myApp-dataSource'. To have all three names refer to the same object you add to the MyApp configuration metadata the following aliases definitions:

```
<alias name="subsystemA-dataSource" alias="subsystemB-dataSource"/>
<alias name="subsystemA-dataSource" alias="myApp-dataSource" />
```

Now each component and the main application can refer to the dataSource through a name that is unique and guaranteed not to clash with any other definition (effectively creating a namespace), yet they refer to the same bean.

5.3.2 Instantiating beans

A bean definition essentially is a recipe for creating one or more objects. The container looks at the recipe for a named bean when asked, and uses the configuration metadata encapsulated by that bean definition to create (or acquire) an actual object.

If you use XML-based configuration metadata, you specify the type (or class) of object that is to be instantiated in the `class` attribute of the `<bean/>` element. This `class` attribute, which internally is a `Class` property on a `BeanDefinition` instance, is usually mandatory. (For exceptions, see the section called “Instantiation using an instance factory method” and Section 5.7, “Bean definition inheritance”.) You use the `Class` property in one of two ways:

- Typically, to specify the bean class to be constructed in the case where the container itself directly creates the bean by calling its constructor reflectively, somewhat equivalent to Java code using the `new` operator.
- To specify the actual class containing the `static` factory method that will be invoked to create the object, in the less common case where the container invokes a `static`, *factory* method on a class to create the bean. The object type returned from the invocation of the `static` factory method may be the same class or another class entirely.

Inner class names

If you want to configure a bean definition for a `static` nested class, you have to use the *binary* name of the inner class.

For example, if you have a class called `Foo` in the `com.example` package, and this `Foo` class has a `static` inner class called `Bar`, the value of the `'class'` attribute on a bean definition would be...

`com.example.Foo$Bar`

Notice the use of the `$` character in the name to separate the inner class name from the outer class name.

Instantiation with a constructor

When you create a bean by the constructor approach, all normal classes are usable by and compatible with Spring. That is, the class being developed does not need to implement any specific interfaces or to be coded in a specific fashion. Simply specifying the bean class should suffice. However, depending on what type of IoC you use for that specific bean, you may need a default (empty) constructor.

The Spring IoC container can manage virtually *any* class you want it to manage; it is not limited to managing true JavaBeans. Most Spring users prefer actual JavaBeans with only a default (no-argument) constructor and appropriate setters and getters modeled after the properties in the container. You can also have more exotic non-bean-style classes in your container. If, for example, you need to use a legacy connection pool that absolutely does not adhere to the JavaBean specification, Spring can manage it as well.

With XML-based configuration metadata you can specify your bean class as follows:

```
<bean id="exampleBean" class="examples.ExampleBean"/>

<bean name="anotherExample" class="examples.ExampleBeanTwo"/>
```

For details about the mechanism for supplying arguments to the constructor (if required) and setting object instance properties after the object is constructed, see Injecting Dependencies.

Instantiation with a static factory method

When defining a bean that you create with a static factory method, you use the `class` attribute to specify the class containing the `static` factory method and an attribute named `factory-method` to specify the name of the factory method itself. You should be able to call this method (with optional arguments as described later) and return a live object, which subsequently is treated as if it had been created through a constructor. One use for such a bean definition is to call `static` factories in legacy code.

The following bean definition specifies that the bean will be created by calling a factory-method. The definition does not specify the type (class) of the returned object, only the class containing the factory method. In this example, the `createInstance()` method must be a *static* method.

```
<bean id="clientService"
      class="examples.ClientService"
      factory-method="createInstance"/>
```

```
public class ClientService {
  private static ClientService clientService = new ClientService();
  private ClientService() {}

  public static ClientService createInstance() {
    return clientService;
  }
}
```

For details about the mechanism for supplying (optional) arguments to the factory method and setting object instance properties after the object is returned from the factory, see Dependencies and configuration in detail.

Instantiation using an instance factory method

Similar to instantiation through a static factory method, instantiation with an instance factory method invokes a non-static method of an existing bean from the container to create a new bean. To use this mechanism, leave the `class` attribute empty, and in the `factory-bean` attribute, specify the name of a bean in the current (or parent/ancestor) container that contains the instance method that is to be invoked to create the object. Set the name of the factory method itself with the `factory-method` attribute.

```
<!-- the factory bean, which contains a method called createInstance() -->
<bean id="serviceLocator" class="examples.DefaultServiceLocator">
  <!-- inject any dependencies required by this locator bean -->
</bean>

<!-- the bean to be created via the factory bean -->
<bean id="clientService"
      factory-bean="serviceLocator"
      factory-method="createClientServiceInstance"/>
```

```
public class DefaultServiceLocator {
  private static ClientService clientService = new ClientServiceImpl();
  private DefaultServiceLocator() {}

  public ClientService createClientServiceInstance() {
    return clientService;
  }
}
```

One factory class can also hold more than one factory method as shown here:

```
<bean id="serviceLocator" class="examples.DefaultServiceLocator">
  <!-- inject any dependencies required by this locator bean -->
</bean>
<bean id="clientService"
      factory-bean="serviceLocator"
      factory-method="createClientServiceInstance"/>

<bean id="accountService"
      factory-bean="serviceLocator"
      factory-method="createAccountServiceInstance"/>
```

```
public class DefaultServiceLocator {
  private static ClientService clientService = new ClientServiceImpl();
  private static AccountService accountService = new AccountServiceImpl();

  private DefaultServiceLocator() {}

  public ClientService createClientServiceInstance() {
    return clientService;
  }

  public AccountService createAccountServiceInstance() {
    return accountService;
  }
}
```

This approach shows that the factory bean itself can be managed and configured through dependency injection (DI). See Dependencies and configuration in detail.

In Spring documentation, *factory bean* refers to a bean that is configured in the Spring container that will create objects through an instance or static factory method. By contrast, `FactoryBean` (notice the capitalization) refers to a Spring-specific `FactoryBean` .

5.4 Dependencies

A typical enterprise application does not consist of a single object (or bean in the Spring parlance). Even the simplest application has a few objects that work together to present what the end-user sees as a coherent application. This next section explains how you go from defining a number of bean definitions that stand alone to a fully realized application where objects collaborate to achieve a goal.

5.4.1 Dependency injection

Dependency injection (DI) is a process whereby objects define their dependencies, that is, the other objects they work with, 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 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 on its own by using direct construction of classes, or the *Service Locator* pattern.

Code is cleaner with the DI principle and decoupling is more effective when objects are provided with their dependencies. The object does not look up its dependencies, and does not know the location or class of the dependencies. As such, your classes become easier to test, in particular when the dependencies are on interfaces or abstract base classes, which allow for stub or mock implementations to be used in unit tests.

DI exists in two major variants, Constructor-based dependency injection and Setter-based dependency injection.

Constructor-based dependency injection

Constructor-based DI is accomplished by the container invoking a constructor with a number of arguments, each representing a dependency. Calling a `static` factory method with specific arguments to construct the bean is nearly equivalent, and this discussion treats arguments to a constructor and to a `static` factory method similarly. The following example shows a class that can only be dependency-injected with constructor injection. Notice that there is nothing *special* about this class, it is a POJO that has no dependencies on container specific interfaces, base classes or annotations.

```
public class SimpleMovieLister {

  // the SimpleMovieLister has a dependency on a MovieFinder
  private MovieFinder movieFinder;

  // a constructor so that the Spring container can 'inject' a MovieFinder
  public SimpleMovieLister(MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
```

```
  }

  // business logic that actually 'uses' the injected MovieFinder is omitted...
}
```

Constructor argument resolution

Constructor argument resolution matching occurs using the argument's type. If no potential ambiguity exists in the constructor arguments of a bean definition, then the order in which the constructor arguments are defined in a bean definition is the order in which those arguments are supplied to the appropriate constructor when the bean is being instantiated. Consider the following class:

```
package x.y;

public class Foo {

  public Foo(Bar bar, Baz baz) {
      // ...
  }
}
```

No potential ambiguity exists, assuming that `Bar` and `Baz` classes are not related by inheritance. Thus the following configuration works fine, and you do not need to specify the constructor argument indexes and/or types explicitly in the `<constructor-arg/>` element.

```
<beans>
  <bean id="foo" class="x.y.Foo">
      <constructor-arg ref="bar"/>
      <constructor-arg ref="baz"/>
  </bean>

  <bean id="bar" class="x.y.Bar"/>
  <bean id="baz" class="x.y.Baz"/>
```

```
</beans>
```

When another bean is referenced, the type is known, and matching can occur (as was the case with the preceding example). When a simple type is used, such as `<value>true<value>`, Spring cannot determine the type of the value, and so cannot match by type without help. Consider the following class:

```
package examples;

public class ExampleBean {

  // No. of years to the calculate the Ultimate Answer
  private int years;

  // The Answer to Life, the Universe, and Everything
  private String ultimateAnswer;

  public ExampleBean(int years, String ultimateAnswer) {
      this.years = years;
      this.ultimateAnswer = ultimateAnswer;
  }
}
```

Constructor argument type matching

In the preceding scenario, the container *can* use type matching with simple types if you explicitly specify the type of the constructor argument using the `type` attribute. For example:

```
<bean id="exampleBean" class="examples.ExampleBean">
<constructor-arg type="int" value="7500000"/>
<constructor-arg type="java.lang.String" value="42"/>
</bean>
```

Constructor argument index

Use the `index` attribute to specify explicitly the index of constructor arguments. For example:

```
<bean id="exampleBean" class="examples.ExampleBean">
<constructor-arg index="0" value="7500000"/>
<constructor-arg index="1" value="42"/>
</bean>
```

In addition to resolving the ambiguity of multiple simple values, specifying an index resolves ambiguity where a constructor has two arguments of the same type. Note that the *index is 0 based*.

Constructor argument name

As of Spring 3.0 you can also use the constructor parameter name for value disambiguation:

```
<bean id="exampleBean" class="examples.ExampleBean">
<constructor-arg name="years" value="7500000"/>
<constructor-arg name="ultimateanswer" value="42"/>
</bean>
```

Keep in mind that to make this work out of the box your code must be compiled with the debug flag enabled so that Spring can look up the parameter name from the constructor. If you can't compile your code with debug flag (or don't want to) you can use `@ConstructorProperties` JDK annotation to explicitly name your constructor arguments. The sample class would then have to look as follows:

```
package examples;

public class ExampleBean {

  // Fields omitted

  @ConstructorProperties({"years", "ultimateAnswer"})
```

```
    public ExampleBean(int years, String ultimateAnswer) {
        this.years = years;
        this.ultimateAnswer = ultimateAnswer;
    }
}
```

Setter-based dependency injection

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

The following example shows a class that can only be dependency-injected using pure setter injection. This class is conventional Java. It is a POJO that has no dependencies on container specific interfaces, base classes or annotations.

```
public class SimpleMovieLister {

    // the SimpleMovieLister has a dependency on the MovieFinder
    private MovieFinder movieFinder;

    // a setter method so that the Spring container can 'inject' a MovieFinder
    public void setMovieFinder(MovieFinder movieFinder) {
        this.movieFinder = movieFinder;
    }

    // business logic that actually 'uses' the injected MovieFinder is omitted...
}
```

The `ApplicationContext` supports constructor- and setter-based DI for the beans it manages. It also supports setter-based DI after some dependencies are already injected through the constructor approach. You configure the dependencies in the form of a `BeanDefinition`, which you use with `PropertyEditor` instances to convert properties from one format to another. However, most Spring users do not work with these classes directly (programmatically), but rather with an XML definition file that is then converted internally into instances of these classes, and used to load an entire Spring IoC container instance.

Constructor-based or setter-based DI?

Since you can mix both, Constructor- and Setter-based DI, it is a good rule of thumb to use constructor arguments for mandatory dependencies and setters for optional dependencies. Note that the use of a @Required annotation on a setter can be used to make setters required dependencies.

The Spring team generally advocates setter injection, because large numbers of constructor arguments can get unwieldy, especially when properties are optional. Setter methods also make objects of that class amenable to reconfiguration or re-injection later. Management through JMX MBeans is a compelling use case.

Some purists favor constructor-based injection. Supplying all object dependencies means that the object is always returned to client (calling) code in a totally initialized state. The disadvantage is that the object becomes less amenable to reconfiguration and re-injection.

Use the DI that makes the most sense for a particular class. Sometimes, when dealing with third-party classes to which you do not have the source, the choice is made for you. A legacy class may not expose any setter methods, and so constructor injection is the only available DI.

Dependency resolution process

The container performs bean dependency resolution as follows:

1. The `ApplicationContext` is created and initialized with configuration metadata that describes all the beans. Configuration metadata can be specified via XML, Java code or annotations.
2. For each bean, its dependencies are expressed in the form of properties, constructor arguments, or arguments to the static-factory method if you are using that instead of a normal constructor. These dependencies are provided to the bean, *when the bean is actually created*.
3. Each property or constructor argument is an actual definition of the value to set, or a reference to another bean in the container.
4. Each property or constructor argument which is a value is converted from its specified format to the actual type of that property or constructor argument. By default Spring can convert a value supplied in string format to all built-in types, such as `int`, `long`, `String`, `boolean`, etc.

The Spring container validates the configuration of each bean as the container is created, including the validation of whether bean reference properties refer to valid beans. However, the bean properties themselves are not set until the bean *is actually created*. Beans that are singleton-scoped and set to be pre-instantiated (the default) are created when the container is created. Scopes are defined in Section 5.5, “Bean scopes” Otherwise, the bean is created only when it is requested. Creation of a bean potentially causes a graph of beans to be created, as the bean's dependencies and its dependencies' dependencies (and so on) are created and assigned.

Circular dependencies

If you use predominantly constructor injection, it is possible to create an unresolvable circular dependency scenario.

For example: Class A requires an instance of class B through constructor injection, and class B requires an instance of class A through constructor injection. If you configure beans for classes A and B to be injected into each other, the Spring IoC container detects this circular reference at runtime, and throws a `BeanCurrentlyInCreationException`.

One possible solution is to edit the source code of some classes to be configured by setters rather than constructors. Alternatively, avoid constructor injection and use setter injection only. In other words, although it is not recommended, you can configure circular dependencies with setter injection.

Unlike the *typical* case (with no circular dependencies), a circular dependency between bean A and bean B forces one of the beans to be injected into the other prior to being fully initialized itself (a classic chicken/egg scenario).

You can generally trust Spring to do the right thing. It detects configuration problems, such as references to non-existent beans and circular dependencies, at container load-time. Spring sets properties and resolves dependencies as late as possible, when the bean is actually created. This means that a Spring container which has loaded correctly can later generate an exception when you request an object if there is a problem creating that object or one of its dependencies. For example, the bean throws an exception as a result of a missing or invalid property. This potentially delayed visibility of some configuration issues is why `ApplicationContext` implementations by default pre-instantiate singleton beans. At the cost of some upfront time and memory to create these beans before they are actually needed, you discover configuration issues when the `ApplicationContext` is created, not later. You can still override this default behavior so that singleton beans will lazy-initialize, rather than be pre-instantiated.

If no circular dependencies exist, when one or more collaborating beans are being injected into a dependent bean, each collaborating bean is *totally* configured prior to being injected into the dependent bean. This means that if bean A has a dependency on bean B, the Spring IoC container completely configures bean B prior to invoking the setter method on bean A. In other words, the bean is instantiated (if not a pre-instantiated singleton), its dependencies are set, and the relevant lifecycle methods (such as a configured init method or the InitializingBean callback method) are invoked.

Examples of dependency injection

The following example uses XML-based configuration metadata for setter-based DI. A small part of a Spring XML configuration file specifies some bean definitions:

```
<bean id="exampleBean" class="examples.ExampleBean">

<!-- setter injection using the nested <ref/> element -->
<property name="beanOne"><ref bean="anotherExampleBean"/></property>

<!-- setter injection using the neater 'ref' attribute -->
<property name="beanTwo" ref="yetAnotherBean"/>
<property name="integerProperty" value="1"/>
</bean>

<bean id="anotherExampleBean" class="examples.AnotherBean"/>
<bean id="yetAnotherBean" class="examples.YetAnotherBean"/>
```

```
public class ExampleBean {

  private AnotherBean beanOne;
  private YetAnotherBean beanTwo;
  private int i;

  public void setBeanOne(AnotherBean beanOne) {
      this.beanOne = beanOne;
  }
```

```
  public void setBeanTwo(YetAnotherBean beanTwo) {
      this.beanTwo = beanTwo;
  }

  public void setIntegerProperty(int i) {
      this.i = i;
  }
}
```

In the preceding example, setters are declared to match against the properties specified in the XML file. The following example uses constructor-based DI:

```
<bean id="exampleBean" class="examples.ExampleBean">

<!-- constructor injection using the nested <ref/> element -->
<constructor-arg>
  <ref bean="anotherExampleBean"/>
</constructor-arg>

<!-- constructor injection using the neater 'ref' attribute -->
<constructor-arg ref="yetAnotherBean"/>

<constructor-arg type="int" value="1"/>
</bean>

<bean id="anotherExampleBean" class="examples.AnotherBean"/>
<bean id="yetAnotherBean" class="examples.YetAnotherBean"/>
```

```
public class ExampleBean {

  private AnotherBean beanOne;
  private YetAnotherBean beanTwo;
  private int i;
```

```
  public ExampleBean(
      AnotherBean anotherBean, YetAnotherBean yetAnotherBean, int i) {
      this.beanOne = anotherBean;
      this.beanTwo = yetAnotherBean;
      this.i = i;
  }
}
```

The constructor arguments specified in the bean definition will be used as arguments to the constructor of the `ExampleBean`.

Now consider a variant of this example, where instead of using a constructor, Spring is told to call a `static` factory method to return an instance of the object:

```
<bean id="exampleBean" class="examples.ExampleBean"
    factory-method="createInstance">
<constructor-arg ref="anotherExampleBean"/>
<constructor-arg ref="yetAnotherBean"/>
<constructor-arg value="1"/>
</bean>

<bean id="anotherExampleBean" class="examples.AnotherBean"/>
<bean id="yetAnotherBean" class="examples.YetAnotherBean"/>
```

```
public class ExampleBean {

  // a private constructor
  private ExampleBean(...) {
    ...
  }

  // a static factory method; the arguments to this method can be
  // considered the dependencies of the bean that is returned,
  // regardless of how those arguments are actually used.
```

```
    public static ExampleBean createInstance (
            AnotherBean anotherBean, YetAnotherBean yetAnotherBean, int i) {

        ExampleBean eb = new ExampleBean (...);
        // some other operations...
        return eb;
    }
}
```

Arguments to the `static` factory method are supplied via `<constructor-arg/>` elements, exactly the same as if a constructor had actually been used. The type of the class being returned by the factory method does not have to be of the same type as the class that contains the `static` factory method, although in this example it is. An instance (non-static) factory method would be used in an essentially identical fashion (aside from the use of the `factory-bean` attribute instead of the `class` attribute), so details will not be discussed here.

5.4.2 Dependencies and configuration in detail

As mentioned in the previous section, you can define bean properties and constructor arguments as references to other managed beans (collaborators), or as values defined inline. Spring's XML-based configuration metadata supports sub-element types within its `<property/>` and `<constructor-arg/>` elements for this purpose.

Straight values (primitives, `Strings`, and so on)

The `value` attribute of the `<property/>` element specifies a property or constructor argument as a human-readable string representation. As mentioned previously, JavaBeans `PropertyEditors` are used to convert these string values from a `String` to the actual type of the property or argument.

```
<bean id="myDataSource" class="org.apache.commons.dbcp.BasicDataSource" destroy-method="close">

<!-- results in a setDriverClassName(String) call -->
<property name="driverClassName" value="com.mysql.jdbc.Driver"/>
<property name="url" value="jdbc:mysql://localhost:3306/mydb"/>
```

```
<property name="username" value="root"/>
<property name="password" value="masterkaoli"/>
</bean>
```

The following example uses the p-namespace for even more succinct XML configuration.

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

<bean id="myDataSource" class="org.apache.commons.dbcp.BasicDataSource"
      destroy-method="close"
      p:driverClassName="com.mysql.jdbc.Driver"
      p:url="jdbc:mysql://localhost:3306/mydb"
      p:username="root"
      p:password="masterkaoli"/>

</beans>
```

The preceding XML is more succinct; however, typos are discovered at runtime rather than design time, unless you use an IDE such as IntelliJ IDEA or the SpringSource Tool Suite (STS) that support automatic property completion when you create bean definitions. Such IDE assistance is highly recommended.

You can also configure a `java.util.Properties` instance as:

```
<bean id="mappings"
    class="org.springframework.beans.factory.config.PropertyPlaceholderConfigurer">

 <!-- typed as a java.util.Properties -->
```

```
  <property name="properties">
     <value>
        jdbc.driver.className=com.mysql.jdbc.Driver
        jdbc.url=jdbc:mysql://localhost:3306/mydb
     </value>
  </property>
</bean>
```

The Spring container converts the text inside the `<value/>` element into a `java.util.Properties` instance by using the JavaBeans `PropertyEditor` mechanism. This is a nice shortcut, and is one of a few places where the Spring team do favor the use of the nested `<value/>` element over the `value` attribute style.

The `idref` element

The `idref` element is simply an error-proof way to pass the *id* (string value - not a reference) of another bean in the container to a `<constructor-arg/>` or `<property/>` element.

```
<bean id="theTargetBean" class="..."/>

<bean id="theClientBean" class="...">
  <property name="targetName">
      <idref bean="theTargetBean" />
  </property>
</bean>
```

The above bean definition snippet is *exactly* equivalent (at runtime) to the following snippet:

```
<bean id="theTargetBean" class="..." />

<bean id="client" class="...">
  <property name="targetName" value="theTargetBean" />
</bean>
```

The first form is preferable to the second, because using the `idref` tag allows the container to validate *at deployment time* that the referenced, named bean actually exists. In the second variation, no validation is performed on the value that is passed to the `targetName` property of the `client` bean. Typos are only discovered (with most likely fatal results) when the `client` bean is actually instantiated. If the `client` bean is a prototype bean, this typo and the resulting exception may only be discovered long after the container is deployed.

Additionally, if the referenced bean is in the same XML unit, and the bean name is the bean *id*, you can use the `local` attribute, which allows the XML parser itself to validate the bean id earlier, at XML document parse time.

```
<property name="targetName">
 <!-- a bean with id 'theTargetBean' must exist; otherwise an exception will be thrown -->
 <idref local="theTargetBean"/>
</property>
```

A common place (at least in versions earlier than Spring 2.0) where the <idref/> element brings value is in the configuration of AOP interceptors in a `ProxyFactoryBean` bean definition. Using <idref/> elements when you specify the interceptor names prevents you from misspelling an interceptor id.

References to other beans (collaborators)

The `ref` element is the final element inside a `<constructor-arg/>` or `<property/>` definition element. Here you set the value of the specified property of a bean to be a reference to another bean (a collaborator) managed by the container. The referenced bean is a dependency of the bean whose property will be set, and it is initialized on demand as needed before the property is set. (If the collaborator is a singleton bean, it may be initialized already by the container.) All references are ultimately a reference to another object. Scoping and validation depend on whether you specify the id/name of the other object through the `bean`,`local,` or `parent` attributes.

Specifying the target bean through the `bean` attribute of the `<ref/>` tag is the most general form, and allows creation of a reference to any bean in the same container or parent container, regardless of whether it is in the same XML file. The value of the `bean` attribute may be the same as the `id` attribute of the target bean, or as one of the values in the `name` attribute of the target bean.

```
<ref bean="someBean"/>
```

Specifying the target bean through 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 issues 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 as early as possible) if the target bean is in the same XML file.

```
<ref local="someBean"/>
```

Specifying the target bean through the `parent` attribute creates a reference to a bean that is in a parent container of the current container. The value of the `parent` attribute may be the same as either the `id` attribute of the target bean, or one of the values in the `name` attribute of the target bean, and the target bean must be in a parent container of the current one. You use this bean reference variant mainly when you have a hierarchy of containers and you want to wrap an existing bean in a parent container with a proxy that will have the same name as the parent bean.

```
<!-- in the parent context -->
<bean id="accountService" class="com.foo.SimpleAccountService">
  <!-- insert dependencies as required as here -->
</bean>
```

```
<!-- in the child (descendant) context -->
<bean id="accountService"  <-- bean name is the same as the parent bean -->
    class="org.springframework.aop.framework.ProxyFactoryBean">
    <property name="target">
        <ref parent="accountService"/>  <!-- notice how we refer to the parent bean -->
    </property>
  <!-- insert other configuration and dependencies as required here -->
</bean>
```

Inner beans

A `<bean/>` element inside the `<property/>` or `<constructor-arg/>` elements defines a so-called *inner bean*.

```
<bean id="outer" class="...">
<!-- instead of using a reference to a target bean, simply define the target bean inline -->
<property name="target">
  <bean class="com.example.Person"> <!-- this is the inner bean -->
    <property name="name" value="Fiona Apple"/>
    <property name="age" value="25"/>
  </bean>
</property>
</bean>
```

An inner bean definition does not require a defined id or name; the container ignores these values. It also ignores the `scope` flag. Inner beans are *always* anonymous and they are *always* created with the outer bean. It is *not* possible to inject inner beans into collaborating beans other than into the enclosing bean.

Collections

In the `<list/>`, `<set/>`, `<map/>`, and `<props/>` elements, you set the properties and arguments of the Java `Collection` types `List`, `Set`, `Map`, and `Properties`, respectively.

```
<bean id="moreComplexObject" class="example.ComplexObject">
<!-- results in a setAdminEmails(java.util.Properties) call -->
<property name="adminEmails">
  <props>
      <prop key="administrator">administrator@example.org</prop>
      <prop key="support">support@example.org</prop>
      <prop key="development">development@example.org</prop>
  </props>
</property>
<!-- results in a setSomeList(java.util.List) call -->
<property name="someList">
  <list>
```

```
        <value>a list element followed by a reference</value>
        <ref bean="myDataSource" />
    </list>
  </property>
  <!-- results in a setSomeMap(java.util.Map) call -->
  <property name="someMap">
    <map>
        <entry key="an entry" value="just some string"/>
        <entry key ="a ref" value-ref="myDataSource"/>
    </map>
  </property>
  <!-- results in a setSomeSet(java.util.Set) call -->
  <property name="someSet">
    <set>
        <value>just some string</value>
        <ref bean="myDataSource" />
    </set>
  </property>
</bean>
```

The value of a map key or value, or a set value, can also again be any of the following elements:

```
bean | ref | idref | list | set | map | props | value | null
```

Collection merging

As of Spring 2.0, the container supports the *merging* of collections. An application developer can define a parent-style `<list/>`, `<map/>`, `<set/>` or `<props/>` element, and have child-style `<list/>`, `<map/>`, `<set/>` or `<props/>` elements inherit and override values from the parent collection. That is, the child collection's values are the result of merging the elements of the parent and child collections, with the child's collection elements overriding values specified in the parent collection.

This section on merging discusses the parent-child bean mechanism. Readers unfamiliar with parent and child bean definitions may wish to read the relevant section before continuing.

The following example demonstrates collection merging:

```
<beans>
<bean id="parent" abstract="true" class="example.ComplexObject">
  <property name="adminEmails">
      <props>
          <prop key="administrator">administrator@example.com</prop>
          <prop key="support">support@example.com</prop>
      </props>
  </property>
</bean>
<bean id="child" parent="parent">
  <property name="adminEmails">
      <!-- the merge is specified on the *child* collection definition -->
      <props merge="true">
          <prop key="sales">sales@example.com</prop>
          <prop key="support">support@example.co.uk</prop>
      </props>
  </property>
</bean>
<beans>
```

Notice the use of the `merge=true` attribute on the `<props/>` element of the `adminEmails` property of the `child` bean definition. When the `child` bean is resolved and instantiated by the container, the resulting instance has an `adminEmails` `Properties` collection that contains the result of the merging of the child's `adminEmails` collection with the parent's `adminEmails` collection.

```
administrator=administrator@example.com
sales=sales@example.com
support=support@example.co.uk
```

The child `Properties` collection's value set inherits all property elements from the parent `<props/>`, and the child's value for the `support` value overrides the value in the parent collection.

This merging behavior applies similarly to the `<list/>`, `<map/>`, and `<set/>` collection types. In the specific case of the `<list/>` element, the semantics associated with the `List` collection type, that is, the notion of an `ordered` collection of values, is maintained; the parent's values precede all of the child list's values. In the case of the `Map`, `Set`, and `Properties` collection types, no ordering exists. Hence no ordering semantics are in effect for the collection types that underlie the associated `Map`, `Set`, and `Properties` implementation types that the container uses internally.

Limitations of collection merging

You cannot merge different collection types (such as a `Map` and a `List`), and if you do attempt to do so an appropriate `Exception` is thrown. The `merge` attribute must be specified on the lower, inherited, child definition; specifying the `merge` attribute on a parent collection definition is redundant and will not result in the desired merging. The merging feature is available only in Spring 2.0 and later.

Strongly-typed collection (Java 5+ only)

In Java 5 and later, you can use strongly typed collections (using generic types). That is, it is possible to declare a `Collection` type such that it can only contain `String` elements (for example). If you are using Spring to dependency-inject a strongly-typed `Collection` into a bean, you can take advantage of Spring's type-conversion support such that the elements of your strongly-typed `Collection` instances are converted to the appropriate type prior to being added to the `Collection`.

```
public class Foo {

  private Map<String, Float> accounts;

  public void setAccounts(Map<String, Float> accounts) {
      this.accounts = accounts;
  }
}
```

```
<beans>
  <bean id="foo" class="x.y.Foo">
```

```
        <property name="accounts">
            <map>
                <entry key="one" value="9.99"/>
                <entry key="two" value="2.75"/>
                <entry key="six" value="3.99"/>
            </map>
        </property>
    </bean>
</beans>
```

When the `accounts` property of the `foo` bean is prepared for injection, the generics information about the element type of the strongly-typed `Map<String, Float>` is available by reflection. Thus Spring's type conversion infrastructure recognizes the various value elements as being of type `Float`, and the string values `9.99, 2.75`, and `3.99` are converted into an actual `Float` type.

Null and empty string values

Spring treats empty arguments for properties and the like as empty `Strings`. The following XML-based configuration metadata snippet sets the email property to the empty `String` value ("")

```
<bean class="ExampleBean">
<property name="email" value=""/>
</bean>
```

The preceding example is equivalent to the following Java code: `exampleBean.setEmail("")`. The `<null/>` element handles `null` values. For example:

```
<bean class="ExampleBean">
<property name="email"><null/></property>
</bean>
```

The above configuration is equivalent to the following Java code: `exampleBean.setEmail(null)`.

XML shortcut with the p-namespace

The p-namespace enables you to use the `bean` element's attributes, instead of nested `<property/>` elements, to describe your property values and/or collaborating beans.

Spring 2.0 and later supports extensible configuration formats with namespaces, which are based on an XML Schema definition. The `beans` configuration format discussed in this chapter is defined in an XML Schema document. However, the p-namespace is not defined in an XSD file and exists only in the core of Spring.

The following example shows two XML snippets that resolve to the same result: The first uses standard XML format and the second uses the p-namespace.

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

  <bean name="classic" class="com.example.ExampleBean">
      <property name="email" value="foo@bar.com"/>
  </bean>

  <bean name="p-namespace" class="com.example.ExampleBean"
        p:email="foo@bar.com"/>
</beans>
```

The example shows an attribute in the p-namespace called email in the bean definition. This tells Spring to include a property declaration. As previously mentioned, the p-namespace does not have a schema definition, so you can set the name of the attribute to the property name.

This next example includes two more bean definitions that both have a reference to another bean:

```
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
```

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

    <bean name="john-classic" class="com.example.Person">
        <property name="name" value="John Doe"/>
        <property name="spouse" ref="jane"/>
    </bean>

    <bean name="john-modern"
        class="com.example.Person"
        p:name="John Doe"
        p:spouse-ref="jane"/>

    <bean name="jane" class="com.example.Person">
        <property name="name" value="Jane Doe"/>
    </bean>
</beans>
```

As you can see, this example includes not only a property value using the p-namespace, but also uses a special format to declare property references. Whereas the first bean definition uses `<property name="spouse" ref="jane"/>` to create a reference from bean `john` to bean `jane`, the second bean definition uses `p:spouse-ref="jane"` as an attribute to do the exact same thing. In this case `spouse` is the property name, whereas the `-ref` part indicates that this is not a straight value but rather a reference to another bean.

> The p-namespace is not as flexible as the standard XML format. For example, the format for declaring property references clashes with properties that end in `Ref`, whereas the standard XML format does not. We recommend that you choose your approach carefully and communicate this to your team members, to avoid producing XML documents that use all three approaches at the same time.

XML shortcut with the c-namespace

Similar to the the section called “XML shortcut with the p-namespace”, the *c-namespace*, newly introduced in Spring 3.1, allows usage of inlined attributes for configuring the constructor arguments rather then nested `constructor-arg` elements.

Let's review the examples from the section called “Constructor-based dependency injection” with the `c` namespace:

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

  <bean id="bar" class="x.y.Bar"/>
  <bean id="baz" class="x.y.Baz"/>

  <-- 'traditional' declaration -->
  <bean id="foo" class="x.y.Foo">
      <constructor-arg ref="bar"/>
      <constructor-arg ref="baz"/>
      <constructor-arg value="foo@bar.com"/>
  </bean>

  <-- 'c-namespace' declaration -->
  <bean id="foo" class="x.y.Foo" c:bar-ref="bar" c:baz-ref="baz" c:email="foo@bar.com">

</beans>
```

The `c:` namespace uses the same conventions as the `p:` one (trailing `-ref` for bean references) for setting the constructor arguments by their names. And just as well, it needs to be declared even though it is not defined in an XSD schema (but it exists inside the Spring core).

For the rare cases where the constructor argument names are not available (usually if the bytecode was compiled without debugging information), one can use fallback to the argument indexes:

```
<-- 'c-namespace' index declaration -->
<bean id="foo" class="x.y.Foo" c:_0-ref="bar" c:_1-ref="baz">
```

Due to the XML grammar, the index notation requires the presence of the leading _ as XML attribute names cannot start with a number (even though some IDE allow it).

In practice, the constructor resolution mechanism is quite efficient in matching arguments so unless one really needs to, we recommend using the name notation through-out your configuration.

Compound property names

You can use compound or nested property names when you set bean properties, as long as all components of the path except the final property name are not `null`. Consider the following bean definition.

```
<bean id="foo" class="foo.Bar">
<property name="fred.bob.sammy" value="123" />
</bean>
```

The `foo` bean has a `fred` property, which has a `bob` property, which has a `sammy` property, and that final `sammy` property is being set to the value `123`. In order for this to work, the `fred` property of `foo`, and the `bob` property of `fred` must not be `null` after the bean is constructed, or a `NullPointerException` is thrown.

5.4.3 Using `depends-on`

If a bean is a dependency of another that usually means that one bean is set as a property of another. Typically you accomplish this with the `<ref/>` element in XML-based configuration metadata. However, sometimes dependencies between beans are less direct; for example, a static initializer in a class needs to be triggered, such as database driver registration. The `depends-on` attribute can explicitly force one or more beans to be initialized before the bean using this element is initialized. The following example uses the `depends-on` attribute to express a dependency on a single bean:

```
<bean id="beanOne" class="ExampleBean" depends-on="manager"/>

<bean id="manager" class="ManagerBean" />
```

To express a dependency on multiple beans, supply a list of bean names as the value of the `depends-on` attribute, with commas, whitespace and semicolons, used as valid delimiters:

```
<bean id="beanOne" class="ExampleBean" depends-on="manager,accountDao">
<property name="manager" ref="manager" />
</bean>

<bean id="manager" class="ManagerBean" />
<bean id="accountDao" class="x.y.jdbc.JdbcAccountDao" />
```

> The `depends-on` attribute in the bean definition can specify both an initialization time dependency and, in the case of singleton beans only, a corresponding destroy time dependency. Dependent beans that define a `depends-on` relationship with a given bean are destroyed first, prior to the given bean itself being destroyed. Thus `depends-on` can also control shutdown order.

5.4.4 Lazy-initialized beans

By default, `ApplicationContext` implementations eagerly create and configure all singleton beans as part of the initialization process. Generally, this pre-instantiation is desirable, because errors in the configuration or surrounding environment are discovered immediately, as opposed to hours or even days later. When this behavior is *not* desirable, you can prevent pre-instantiation of a singleton bean by marking the bean definition as lazy-initialized. A lazy-initialized bean tells the IoC container to create a bean instance when it is first requested, rather than at startup.

In XML, this behavior is controlled by the `lazy-init` attribute on the `<bean/>` element; for example:

```
<bean id="lazy" class="com.foo.ExpensiveToCreateBean" lazy-init="true"/>

<bean name="not.lazy" class="com.foo.AnotherBean"/>
```

When the preceding configuration is consumed by an `ApplicationContext`, the bean named `lazy` is not eagerly pre-instantiated when the `ApplicationContext` is starting up, whereas the `not.lazy` bean is eagerly pre-instantiated.

However, when a lazy-initialized bean is a dependency of a singleton bean that is *not* lazy-initialized, the `ApplicationContext` creates the lazy-initialized bean at startup, because it must satisfy the singleton's dependencies. The lazy-initialized bean is injected into a singleton bean elsewhere that is not lazy-initialized.

You can also control lazy-initialization at the container level by using the `default-lazy-init` attribute on the `<beans/>` element; for example:

```
<beans default-lazy-init="true">
  <!-- no beans will be pre-instantiated... -->
</beans>
```

5.4.5 Autowiring collaborators

The Spring container can *autowire* relationships between collaborating beans. You can allow Spring to resolve collaborators (other beans) automatically for your bean by inspecting the contents of the `ApplicationContext`. Autowiring has the following advantages:

- Autowiring can significantly reduce the need to specify properties or constructor arguments. (Other mechanisms such as a bean template discussed elsewhere in this chapter are also valuable in this regard.)
- Autowiring can update a configuration as your objects evolve. For example, if you need to add a dependency to a class, that dependency can be satisfied automatically without you needing to modify the configuration. Thus autowiring can be especially useful during development, without negating the option of switching to explicit wiring when the code base becomes more stable.

When using XML-based configuration metadata[2], you specify autowire mode for a bean definition with the `autowire` attribute of the `<bean/>` element. The autowiring functionality has five modes. You specify autowiring *per* bean and thus can choose which ones to autowire.

Table 5.2. Autowiring modes

Mode	Explanation
no	(Default) No autowiring. Bean references must be defined via a `ref` element. Changing the default setting is not recommended for larger deployments, because specifying collaborators explicitly gives greater control and clarity. To some extent, it documents the structure of a system.
byName	Autowiring by property name. Spring looks for a bean with the same name as the property that needs to be autowired. For example, if a bean definition is set to autowire by name, and it contains a *master* property (that is, it has a *setMaster(..)* method), Spring looks for a bean definition named `master`, and uses it to set the property.
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, which indicates that you may not use *byType* autowiring for that bean. If there are no matching beans, nothing happens; the property is not set.
constructor	Analogous to *byType*, but applies to constructor arguments. If there is not exactly one bean of the constructor argument type in the container, a fatal error is raised.

With *byType* or *constructor* autowiring mode, you can wire arrays and typed-collections. In such cases *all* autowire candidates within the container that match the expected type are provided to satisfy the dependency. You can autowire strongly-typed Maps if the expected key type is `String`. An autowired Maps values will consist of all bean instances that match the expected type, and the Maps keys will contain the corresponding bean names.

You can combine autowire behavior with dependency checking, which is performed after autowiring completes.

Limitations and disadvantages of autowiring

Autowiring works best when it is used consistently across a project. If autowiring is not used in general, it might be confusing to developers to use it to wire only one or two bean definitions.

Consider the limitations and disadvantages of autowiring:

- Explicit dependencies in `property` and `constructor-arg` settings always override autowiring. You cannot autowire so-called *simple* properties such as primitives, `Strings`, and `Classes` (and arrays of such simple properties). This limitation is by-design.
- Autowiring is less exact than explicit wiring. Although, as noted in the above table, Spring is careful to avoid guessing in case of ambiguity that might have unexpected results, the relationships between your Spring-managed objects are no longer documented explicitly.
- Wiring information may not be available to tools that may generate documentation from a Spring container.
- Multiple bean definitions within the container may match the type specified by the setter method or constructor argument to be autowired. For arrays, collections, or Maps, this is not necessarily a problem. However for dependencies that expect a single value, this ambiguity is not arbitrarily resolved. If no unique bean definition is available, an exception is thrown.

In the latter scenario, you have several options:

- Abandon autowiring in favor of explicit wiring.
- Avoid autowiring for a bean definition by setting its `autowire-candidate` attributes to `false` as described in the next section.
- Designate a single bean definition as the *primary* candidate by setting the `primary` attribute of its `<bean/>` element to `true`.
- If you are using Java 5 or later, implement the more fine-grained control available with annotation-based configuration, as described in Section 5.9, “Annotation-based container configuration”.

Excluding a bean from autowiring

On a per-bean basis, you can exclude a bean from autowiring. In Spring's XML format, set the `autowire-candidate` attribute of the `<bean/>` element to `false`; the container makes that specific bean definition unavailable to the autowiring infrastructure (including annotation style configurations such as `@Autowired`).

You can also limit autowire candidates based on pattern-matching against bean names. The top-level `<beans/>` element accepts one or more patterns within its `default-autowire-candidates` attribute. For example, to limit autowire candidate status to any bean whose name ends with *Repository,* provide a value of *Repository. To provide multiple patterns, define them in a comma-separated list. An explicit value of `true` or `false` for a bean definitions `autowire-candidate` attribute always takes precedence, and for such beans, the pattern matching rules do not apply.

These techniques are useful for beans that you never want to be injected into other beans by autowiring. It does not mean that an excluded bean cannot itself be configured using autowiring. Rather, the bean itself is not a candidate for autowiring other beans.

5.4.6 Method injection

In most application scenarios, most beans in the container are singletons. When a singleton bean needs to collaborate with another singleton bean, or a non-singleton bean needs to collaborate with another non-singleton bean, you typically handle the dependency by defining one bean as a property of the other. A problem arises when the bean lifecycles are different. Suppose singleton bean A needs to use non-singleton (prototype) bean B, perhaps on each method invocation on A. The container only creates the singleton bean A once, and thus only gets one opportunity to set the properties. The container cannot provide bean A with a new instance of bean B every time one is needed.

A solution is to forego some inversion of control. You can make bean A aware of the container by implementing the `ApplicationContextAware` interface, and by making a getBean("B") call to the container ask for (a typically new) bean B instance every time bean A needs it. The following is an example of this approach:

```
// a class that uses a stateful Command-style class to perform some processing
package fiona.apple;

// Spring-API imports
```

```
import org.springframework.beans.BeansException;
import org.springframework.context.ApplicationContext;
import org.springframework.context.ApplicationContextAware;

public class CommandManager implements ApplicationContextAware {

 private ApplicationContext applicationContext;

 public Object process(Map commandState) {
    // grab a new instance of the appropriate Command
    Command command = createCommand();
    // set the state on the (hopefully brand new) Command instance
    command.setState(commandState);
    return command.execute();
 }

 protected Command createCommand() {
    // notice the Spring API dependency!
    return this.applicationContext.getBean("command", Command.class);
 }


 public void setApplicationContext(ApplicationContext applicationContext)
                                                                  throws BeansException {
    this.applicationContext = applicationContext;
 }
}
```

The preceding is not desirable, because the business code is aware of and coupled to the Spring Framework. Method Injection, a somewhat advanced feature of the Spring IoC container, allows this use case to be handled in a clean fashion.

> You can read more about the motivation for Method Injection in this blog entry.

Lookup method injection

Lookup method injection is the ability of the container to override methods on *container managed beans*, to return the lookup result for another named bean in the container. The lookup typically involves a prototype bean as in the scenario described in the preceding section. The Spring Framework implements this method injection by using bytecode generation from the CGLIB library to generate dynamically a subclass that overrides the method.

> For this dynamic subclassing to work, the class that the Spring container will subclass cannot be `final`, and the method to be overridden cannot be `final` either. Also, testing a class that has an `abstract` method requires you to subclass the class yourself and to supply a stub implementation of the `abstract` method. Finally, objects that have been the target of method injection cannot be serialized. As of Spring 3.2 it is no longer necessary to add CGLIB to your classpath, because CGLIB classes are repackaged under org.springframework and distributed within the spring-core JAR. This is done both for convenience as well as to avoid potential conflicts with other projects that use differing versions of CGLIB.

Looking at the `CommandManager` class in the previous code snippet, you see that the Spring container will dynamically override the implementation of the `createCommand()` method. Your `CommandManager` class will not have any Spring dependencies, as can be seen in the reworked example:

```
package fiona.apple;

// no more Spring imports!

public abstract class CommandManager {

 public Object process(Object commandState) {
    // grab a new instance of the appropriate Command interface
    Command command = createCommand();
    // set the state on the (hopefully brand new) Command instance
    command.setState(commandState);
    return command.execute();
```

```
    }

    // okay... but where is the implementation of this method?
    protected abstract Command createCommand();
}
```

In the client class containing the method to be injected (the `CommandManager` in this case), the method to be injected requires a signature of the following form:

```
<public|protected> [abstract] <return-type> theMethodName(no-arguments);
```

If the method is `abstract`, the dynamically-generated subclass implements the method. Otherwise, the dynamically-generated subclass overrides the concrete method defined in the original class. For example:

```
<!-- a stateful bean deployed as a prototype (non-singleton) -->
<bean id="command" class="fiona.apple.AsyncCommand" scope="prototype">
  <!-- inject dependencies here as required -->
</bean>

<!-- commandProcessor uses statefulCommandHelper -->
<bean id="commandManager" class="fiona.apple.CommandManager">
  <lookup-method name="createCommand" bean="command"/>
</bean>
```

The bean identified as *commandManager* calls its own method `createCommand()` whenever it needs a new instance of the *command* bean. You must be careful to deploy the `command` bean as a prototype, if that is actually what is needed. If it is deployed as a singleton, the same instance of the `command` bean is returned each time.

The interested reader may also find the `ServiceLocatorFactoryBean` (in the `org.springframework.beans.factory.config` package) to be of use. The approach used in ServiceLocatorFactoryBean is similar to that of another utility class, `ObjectFactoryCreatingFactoryBean`, but it allows you to specify your own lookup interface as opposed to a Spring-specific lookup interface. Consult the JavaDocs for these classes as well as this blog entry for additional information ServiceLocatorFactoryBean.

Arbitrary method replacement

A less useful form of method injection than lookup method Injection is the ability to replace arbitrary methods in a managed bean with another method implementation. Users may safely skip the rest of this section until the functionality is actually needed.

With XML-based configuration metadata, you can use the `replaced-method` element to replace an existing method implementation with another, for a deployed bean. Consider the following class, with a method computeValue, which we want to override:

```
public class MyValueCalculator {

public String computeValue(String input) {
  // some real code...
}

// some other methods...

}
```

A class implementing the `org.springframework.beans.factory.support.MethodReplacer` interface provides the new method definition.

```
/** meant to be used to override the existing computeValue(String)
  implementation in MyValueCalculator
*/
public class ReplacementComputeValue implements MethodReplacer {

  public Object reimplement(Object o, Method m, Object[] args) throws Throwable {
      // get the input value, work with it, and return a computed result
      String input = (String) args[0];
```

```
        String input = (String) args[0];
        ...
        return ...;
    }
}
```

The bean definition to deploy the original class and specify the method override would look like this:

```
<bean id="myValueCalculator" class="x.y.z.MyValueCalculator">

<!-- arbitrary method replacement -->
<replaced-method name="computeValue" replacer="replacementComputeValue">
  <arg-type>String</arg-type>
</replaced-method>
</bean>

<bean id="replacementComputeValue" class="a.b.c.ReplacementComputeValue"/>
```

You can use one or more contained `<arg-type/>` elements within the `<replaced-method/>` element to indicate the method signature of the method being overridden. The signature for the arguments is necessary only if the method is overloaded and multiple variants exist within the class. For convenience, the type string for an argument may be a substring of the fully qualified type name. For example, the following all match `java.lang.String`:

```
  java.lang.String
String
Str
```

Because the number of arguments is often enough to distinguish between each possible choice, this shortcut can save a lot of typing, by allowing you to type only the shortest string that will match an argument type.

5.5 Bean scopes

When you create a bean definition, you create a *recipe* for creating actual instances of the class defined by that bean definition. The idea that a bean definition is a recipe is important, because it means that, as with a class, you can create many object instances from a single recipe.

You can control not only the various dependencies and configuration values that are to be plugged into an object that is created from a particular bean definition, but also the *scope* of the objects created from a particular bean definition. This approach is powerful and flexible in that you can *choose* the scope of the objects you create through configuration instead of having to bake in the scope of an object at the Java class level. Beans can be defined to be deployed in one of a number of scopes: out of the box, the Spring Framework supports five scopes, three of which are available only if you use a web-aware `ApplicationContext`.

The following scopes are supported out of the box. You can also create a custom scope.

Table 5.3. Bean scopes

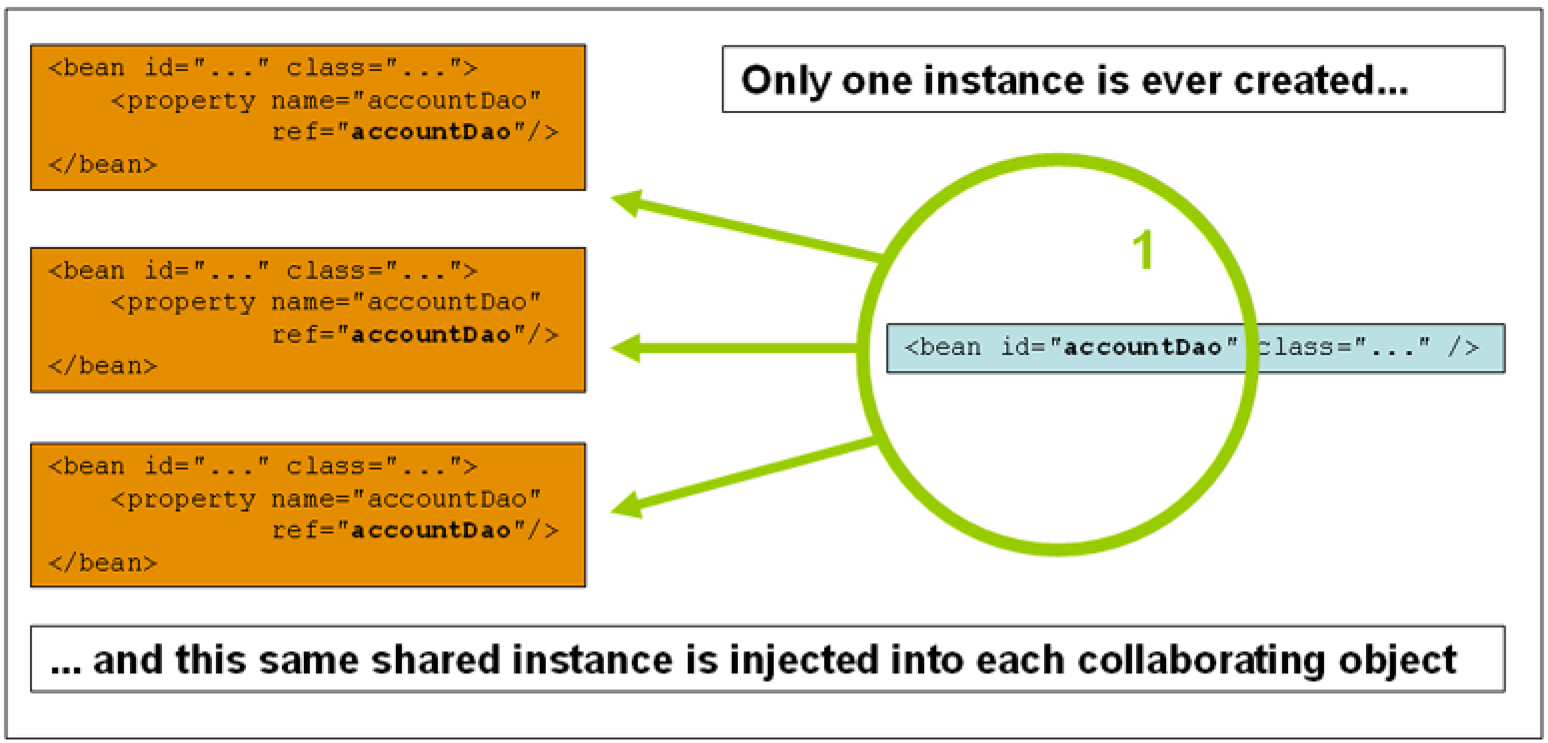
Scope	Description
singleton	(Default) Scopes a single bean definition to a single object instance per Spring IoC container.
prototype	Scopes a single bean definition to any number of object instances.
request	Scopes a single bean definition to the lifecycle of a single HTTP request; that is, each HTTP request has its own instance of a bean created off the back of a single bean definition. Only valid in the context of a web-aware Spring `ApplicationContext`.
session	Scopes a single bean definition to the lifecycle of an HTTP `Session`. Only valid in the context of a web-aware Spring `ApplicationContext`.
global session	Scopes a single bean definition to the lifecycle of a global HTTP `Session`. Typically only valid when used in a portlet context. Only valid in the context of a web-aware Spring `ApplicationContext`.

As of Spring 3.0, a *thread scope* is available, but is not registered by default. For more information, see the documentation for SimpleThreadScope. For instructions on how to register this or any other custom scope, see the section called “Using a custom scope”.

5.5.1 The singleton scope

Only one *shared* instance of a singleton bean is managed, and all requests for beans with an id or ids matching that bean definition result in that one specific bean instance being returned by the Spring container.

To put it another way, when you define a bean definition and it is scoped as a singleton, the Spring IoC container creates *exactly one* instance of the object defined by that bean definition. This single instance is stored in a cache of such singleton beans, and *all subsequent requests and references* for that named bean return the cached object.



Spring's concept of a singleton bean differs from the Singleton pattern as defined in the Gang of Four (GoF) patterns book. The GoF Singleton hard-codes the scope of an object such that one *and only one* instance of a particular class is created *per `ClassLoader`*. The scope of the Spring singleton is best described as *per container and per bean*. This means that if you define one bean for a particular class in a single Spring container, then the Spring container creates one *and only one* instance of the class defined by that bean definition. *The singleton scope is the default scope in Spring*. To define a bean as a singleton in XML, you would write, for example:

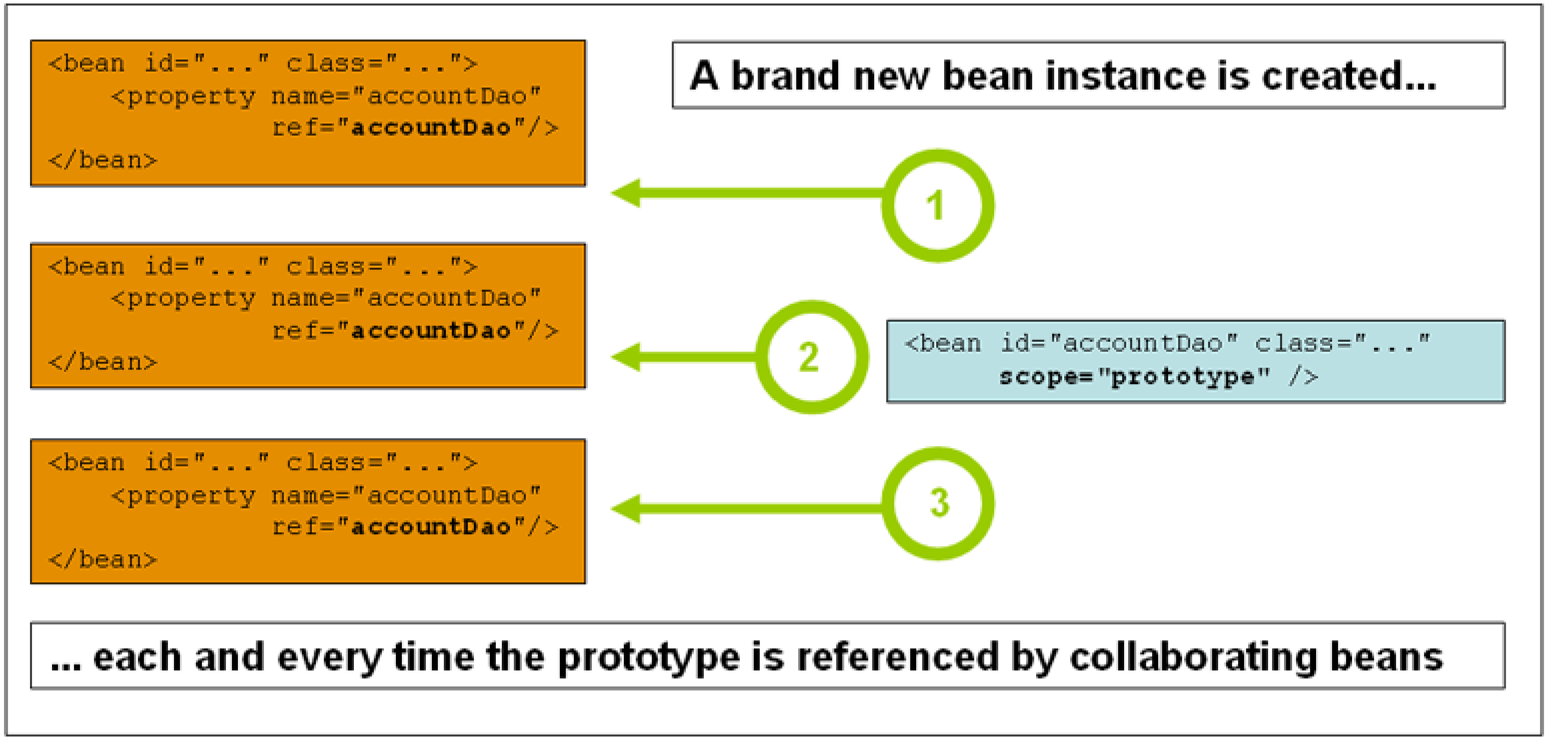
```
<bean id="accountService" class="com.foo.DefaultAccountService"/>

<!-- the following is equivalent, though redundant (singleton scope is the default) -->
<bean id="accountService" class="com.foo.DefaultAccountService" scope="singleton"/>
```

5.5.2 The prototype scope

The non-singleton, prototype scope of bean deployment results in the *creation of a new bean instance* every time a request for that specific bean is made. That is, the bean is injected into another bean or you request it through a `getBean()` method call on the container. As a rule, use the prototype scope for all stateful beans and the singleton scope for stateless beans.

The following diagram illustrates the Spring prototype scope. *A data access object (DAO) is not typically configured as a prototype, because a typical DAO does not hold any conversational state; it was just easier for this author to reuse the core of the singleton diagram.*



The following example defines a bean as a prototype in XML:

```
<!-- using spring-beans-2.0.dtd -->
<bean id="accountService" class="com.foo.DefaultAccountService" scope="prototype"/>
```

In contrast to the other scopes, Spring does not manage the complete lifecycle of a prototype bean: the container instantiates, configures, and otherwise assembles a prototype object, and hands it to the client, with no further record of that prototype instance. Thus, although *initialization* lifecycle callback methods are called on all objects regardless of scope, in the case of prototypes, configured *destruction* lifecycle callbacks are *not* called. The client code must clean up prototype-scoped objects and release expensive resources that the prototype bean(s) are holding. To get the Spring container to release resources held by prototype-scoped beans, try using a custom bean post-processor, which holds a reference to beans that need to be cleaned up.

In some respects, the Spring container's role in regard to a prototype-scoped bean is a replacement for the Java `new` operator. All lifecycle management past that point must be handled by the client. (For details on the lifecycle of a bean in the Spring container, see Section 5.6.1, “Lifecycle callbacks”.)

5.5.3 Singleton beans with prototype-bean dependencies

When you use singleton-scoped beans with dependencies on prototype beans, be aware that *dependencies are resolved at instantiation time*. Thus if you dependency-inject a prototype-scoped bean into a singleton-scoped bean, a new prototype bean is instantiated and then dependency-injected into the singleton bean. The prototype instance is the sole instance that is ever supplied to the singleton-scoped bean.

However, suppose you want the singleton-scoped bean to acquire a new instance of the prototype-scoped bean repeatedly at runtime. You cannot dependency-inject a prototype-scoped bean into your singleton bean, because that injection occurs only *once*, when the Spring container is instantiating the singleton bean and resolving and injecting its dependencies. If you need a new instance of a prototype bean at runtime more than once, see Section 5.4.6, “Method injection”

5.5.4 Request, session, and global session scopes

The `request`, `session`, and `global session` scopes are *only* available if you use a web-aware Spring `ApplicationContext` implementation (such as `XmlWebApplicationContext`). If you use these scopes with regular Spring IoC containers such as the `ClassPathXmlApplicationContext`, you get an `IllegalStateException` complaining about an unknown bean scope.

Initial web configuration

To support the scoping of beans at the `request`, `session`, and `global session` levels (web-scoped beans), some minor initial configuration is required before you define your beans. (This initial setup is *not* required for the standard scopes, singleton and prototype.)

How you accomplish this initial setup depends on your particular Servlet environment..

If you access scoped beans within Spring Web MVC, in effect, within a request that is processed by the Spring `DispatcherServlet`, or `DispatcherPortlet`, then no special setup is necessary: `DispatcherServlet` and `DispatcherPortlet` already expose all relevant state.

If you use a Servlet 2.4+ web container, with requests processed outside of Spring's DispatcherServlet (for example, when using JSF or Struts), you need to add the following `javax.servlet.ServletRequestListener` to the declarations in your web applications `web.xml` file:

```
<web-app>
...
<listener>
  <listener-class>
      org.springframework.web.context.request.RequestContextListener
  </listener-class>
</listener>
...
</web-app>
```

If you use an older web container (Servlet 2.3), use the provided `javax.servlet.Filter` implementation. The following snippet of XML configuration must be included in the `web.xml` file of your web application if you want to access web-scoped beans in requests outside of Spring's DispatcherServlet on a Servlet 2.3 container. (The filter mapping depends on the surrounding web application configuration, so you must change it as appropriate.)

```
<web-app>
..
<filter>
  <filter-name>requestContextFilter</filter-name>
  <filter-class>org.springframework.web.filter.RequestContextFilter</filter-class>
</filter>
<filter-mapping>
  <filter-name>requestContextFilter</filter-name>
  <url-pattern>/*</url-pattern>
</filter-mapping>
```

```
...
</web-app>
```

`DispatcherServlet`, `RequestContextListener` and `RequestContextFilter` all do exactly the same thing, namely bind the HTTP request object to the `Thread` that is servicing that request. This makes beans that are request- and session-scoped available further down the call chain.

Request scope

Consider the following bean definition:

```
<bean id="loginAction" class="com.foo.LoginAction" scope="request"/>
```

The Spring container creates a new instance of the `LoginAction` bean by using the `loginAction` bean definition for each and every HTTP request. That is, the `loginAction` bean is scoped at the HTTP request level. You can change the internal state of the instance that is created as much as you want, because other instances created from the same `loginAction` bean definition will not see these changes in state; they are particular to an individual request. When the request completes processing, the bean that is scoped to the request is discarded.

Session scope

Consider the following bean definition:

```
<bean id="userPreferences" class="com.foo.UserPreferences" scope="session"/>
```

The Spring container creates a new instance of the `UserPreferences` bean by using the `userPreferences` bean definition for the lifetime of a single HTTP `Session`. In other words, the `userPreferences` bean is effectively scoped at the HTTP `Session` level. As with `request-scoped` beans, you can change the internal state of the instance that is created as much as you want, knowing that other HTTP `Session` instances that are also using instances created from the same `userPreferences` bean definition do not see these changes in state, because they are particular to an individual HTTP `Session`. When the HTTP `Session` is eventually discarded, the bean that is scoped to that particular HTTP `Session` is also discarded.

Global session scope

Consider the following bean definition:

```
<bean id="userPreferences" class="com.foo.UserPreferences" scope="globalSession"/>
```

The `global session` scope is similar to the standard HTTP `Session` scope (described above), and applies only in the context of portlet-based web applications. The portlet specification defines the notion of a global `Session` that is shared among all portlets that make up a single portlet web application. Beans defined at the `global session` scope are scoped (or bound) to the lifetime of the global portlet `Session`.

If you write a standard Servlet-based web application and you define one or more beans as having `global session` scope, the standard HTTP `Session` scope is used, and no error is raised.

Scoped beans as dependencies

The Spring IoC container manages not only the instantiation of your objects (beans), but also the wiring up of collaborators (or dependencies). If you want to inject (for example) an HTTP request scoped bean into another bean, you must inject an AOP proxy in place of the scoped bean. That is, you need to inject a proxy object that exposes the same public interface as the scoped object but that can also retrieve the real, target object from the relevant scope (for example, an HTTP request) and delegate method calls onto the real object.

> You *do not* need to use the `<aop:scoped-proxy/>` in conjunction with beans that are scoped as `singletons` or `prototypes`.

The configuration in the following example is only one line, but it is important to understand the "why" as well as the "how" behind it.

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

  <!-- an HTTP Session-scoped bean exposed as a proxy -->
  <bean id="userPreferences" class="com.foo.UserPreferences" scope="session">

        <!-- instructs the container to proxy the surrounding bean -->
        <aop:scoped-proxy/>
  </bean>

  <!-- a singleton-scoped bean injected with a proxy to the above bean -->
  <bean id="userService" class="com.foo.SimpleUserService">

      <!-- a reference to the proxied userPreferences bean -->
      <property name="userPreferences" ref="userPreferences"/>

  </bean>
</beans>
```

To create such a proxy, you insert a child `<aop:scoped-proxy/>` element into a scoped bean definition. See the section called “Choosing the type of proxy to create” and Appendix E, *XML Schema-based configuration*.) Why do definitions of beans scoped at the `request`, `session`, `globalSession` and custom-scope levels require the `<aop:scoped-proxy/>` element ? Let's examine the following singleton bean definition and contrast it with what you need to define for the aforementioned scopes. (The following `userPreferences` bean definition as it stands is *incomplete.)*

```
<bean id="userPreferences" class="com.foo.UserPreferences" scope="session"/>
```

```
<bean id="userManager" class="com.foo.UserManager">
  <property name="userPreferences" ref="userPreferences"/>
</bean>
```

In the preceding example, the singleton bean `userManager` is injected with a reference to the HTTP `Session`-scoped bean `userPreferences`. The salient point here is that the `userManager` bean is a singleton: it will be instantiated *exactly once* per container, and its dependencies (in this case only one, the `userPreferences` bean) are also injected only once. This means that the `userManager` bean will only operate on the exact same `userPreferences` object, that is, the one that it was originally injected with.

This is *not* the behavior you want when injecting a shorter-lived scoped bean into a longer-lived scoped bean, for example injecting an HTTP `Session`-scoped collaborating bean as a dependency into singleton bean. Rather, you need a single `userManager` object, and for the lifetime of an HTTP `Session`, you need a `userPreferences` object that is specific to said HTTP `Session`. Thus the container creates an object that exposes the exact same public interface as the `UserPreferences` class (ideally an object that *is a* `UserPreferences` instance) which can fetch the real `UserPreferences` object from the scoping mechanism (HTTP request, `Session`, etc.). The container injects this proxy object into the `userManager` bean, which is unaware that this `UserPreferences` reference is a proxy. In this example, when a `UserManager` instance invokes a method on the dependency-injected `UserPreferences` object, it actually is invoking a method on the proxy. The proxy then fetches the real `UserPreferences` object from (in this case) the HTTP `Session`, and delegates the method invocation onto the retrieved real `UserPreferences` object.

Thus you need the following, correct and complete, configuration when injecting `request-`, `session-`, and `globalSession-scoped` beans into collaborating objects:

```
<bean id="userPreferences" class="com.foo.UserPreferences" scope="session">
  <aop:scoped-proxy/>
</bean>

<bean id="userManager" class="com.foo.UserManager">
  <property name="userPreferences" ref="userPreferences"/>
</bean>
```

Choosing the type of proxy to create

By default, when the Spring container creates a proxy for a bean that is marked up with the `<aop:scoped-proxy/>` element, *a CGLIB-based class proxy is created*.

Note: CGLIB proxies only intercept public method calls! Do not call non-public methods on such a proxy; they will not be delegated to the scoped target object.

Alternatively, you can configure the Spring container to create standard JDK interface-based proxies for such scoped beans, by specifying `false` for the value of the `proxy-target-class` attribute of the `<aop:scoped-proxy/>` element. Using JDK interface-based proxies means that you do not need additional libraries in your application classpath to effect such proxying. However, it also means that the class of the scoped bean must implement at least one interface, and *that all* collaborators into which the scoped bean is injected must reference the bean through one of its interfaces.

```
<!-- DefaultUserPreferences implements the UserPreferences interface -->
<bean id="userPreferences" class="com.foo.DefaultUserPreferences" scope="session">
  <aop:scoped-proxy proxy-target-class="false"/>
</bean>


<bean id="userManager" class="com.foo.UserManager">
  <property name="userPreferences" ref="userPreferences"/>
</bean>
```

For more detailed information about choosing class-based or interface-based proxying, see Section 9.6, “Proxying mechanisms”.

5.5.5 Custom scopes

As of Spring 2.0, the bean scoping mechanism is extensible. You can define your own scopes, or even redefine existing scopes, although the latter is considered bad practice and you *cannot* override the built-in `singleton` and `prototype` scopes.

Creating a custom scope

To integrate your custom scope(s) into the Spring container, you need to implement the `org.springframework.beans.factory.config.Scope` interface, which is described in this section. For an idea of how to implement your own scopes, see the `Scope` implementations that are supplied with the Spring Framework itself and the Scope Javadoc, which explains the methods you need to implement in more detail.

The `Scope` interface has four methods to get objects from the scope, remove them from the scope, and allow them to be destroyed.

The following method returns the object from the underlying scope. The session scope implementation, for example, returns the session-scoped bean (and if it does not exist, the method returns a new instance of the bean, after having bound it to the session for future reference).

```
Object get(String name, ObjectFactory objectFactory)
```

The following method removes the object from the underlying scope. The session scope implementation for example, removes the session-scoped bean from the underlying session. The object should be returned, but you can return null if the object with the specified name is not found.

```
Object remove(String name)
```

The following method registers the callbacks the scope should execute when it is destroyed or when the specified object in the scope is destroyed. Refer to the Javadoc or a Spring scope implementation for more information on destruction callbacks.

```
void registerDestructionCallback(String name, Runnable destructionCallback)
```

The following method obtains the conversation identifier for the underlying scope. This identifier is different for each scope. For a session scoped implementation, this identifier can be the session identifier.

```
String getConversationId()
```

Using a custom scope

After you write and test one or more custom `Scope` implementations, you need to make the Spring container aware of your new scope(s). The following method is the central method to register a new `Scope` with the Spring container:

```
void registerScope(String scopeName, Scope scope);
```

This method is declared on the `ConfigurableBeanFactory` interface, which is available on most of the concrete `ApplicationContext` implementations that ship with Spring via the BeanFactory property.

The first argument to the `registerScope(..)` method is the unique name associated with a scope; examples of such names in the Spring container itself are `singleton` and `prototype`. The second argument to the `registerScope(..)` method is an actual instance of the custom `Scope` implementation that you wish to register and use.

Suppose that you write your custom `Scope` implementation, and then register it as below.

> The example below uses `SimpleThreadScope` which is included with Spring, but not registered by default. The instructions would be the same for your own custom `Scope` implementations.

```
Scope threadScope = new SimpleThreadScope();
beanFactory.registerScope("thread", threadScope);
```

You then create bean definitions that adhere to the scoping rules of your custom `Scope`:

```
<bean id="..." class="..." scope="thread">
```

With a custom `Scope` implementation, you are not limited to programmatic registration of the scope. You can also do the `Scope` registration declaratively, using the `CustomScopeConfigurer` class:

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

  <bean class="org.springframework.beans.factory.config.CustomScopeConfigurer">
      <property name="scopes">
          <map>
              <entry key="thread">
                  <bean class="org.springframework.context.support.SimpleThreadScope"/>
              </entry>
          </map>
      </property>
  </bean>

  <bean id="bar" class="x.y.Bar" scope="thread">
      <property name="name" value="Rick"/>
      <aop:scoped-proxy/>
  </bean>

  <bean id="foo" class="x.y.Foo">
      <property name="bar" ref="bar"/>
  </bean>

</beans>
```

When you place <aop:scoped-proxy/> in a `FactoryBean` implementation, it is the factory bean itself that is scoped, not the object returned from `getObject()`.

5.6 Customizing the nature of a bean

5.6.1 Lifecycle callbacks

To interact with the container's management of the bean lifecycle, you can implement the Spring `InitializingBean` and `DisposableBean` interfaces. The container calls `afterPropertiesSet()` for the former and `destroy()` for the latter to allow the bean to perform certain actions upon initialization and destruction of your beans.

> The JSR-250 `@PostConstruct` and `@PreDestroy` annotations are generally considered best practice for receiving lifecycle callbacks in a modern Spring application. Using these annotations means that your beans are not coupled to Spring specific interfaces. For details see Section 5.9.6, "`@PostConstruct` and `@PreDestroy`".
> If you don't want to use the JSR-250 annotations but you are still looking to remove coupling consider the use of init-method and destroy-method object definition metadata.

Internally, the Spring Framework uses `BeanPostProcessor` implementations to process any callback interfaces it can find and call the appropriate methods. If you need custom features or other lifecycle behavior Spring does not offer out-of-the-box, you can implement a `BeanPostProcessor` yourself. For more information, see Section 5.8, "Container Extension Points".

In addition to the initialization and destruction callbacks, Spring-managed objects may also implement the `Lifecycle` interface so that those objects can participate in the startup and shutdown process as driven by the container's own lifecycle.

The lifecycle callback interfaces are described in this section.

Initialization callbacks

The `org.springframework.beans.factory.InitializingBean` interface allows a bean to perform initialization work after all necessary properties on the bean have been set by the container. The `InitializingBean` interface specifies a single method:

```
void afterPropertiesSet() throws Exception;
```

It is recommended that you do not use the `InitializingBean` interface because it unnecessarily couples the code to Spring. Alternatively, use the `@PostConstruct` annotation or specify a POJO initialization method. In the case of XML-based configuration metadata, you use the `init-method` attribute to specify the name of the method that has a void no-argument signature. For example, the following definition:

```
<bean id="exampleInitBean" class="examples.ExampleBean" init-method="init"/>
```

```
public class ExampleBean {

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

...is exactly the same as...

```
<bean id="exampleInitBean" class="examples.AnotherExampleBean"/>
```

```
public class AnotherExampleBean implements InitializingBean {

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

... but does not couple the code to Spring.

Destruction callbacks

Implementing the `org.springframework.beans.factory.DisposableBean` interface allows a bean to get a callback when the container containing it is destroyed. The `DisposableBean` interface specifies a single method:

```
void destroy() throws Exception;
```

It is recommended that you do not use the `DisposableBean` callback interface because it unnecessarily couples the code to Spring. Alternatively, use the `@PreDestroy` annotation or specify a generic method that is supported by bean definitions. With XML-based configuration metadata, you use the `destroy-method` attribute on the `<bean/>`. For example, the following definition:

```
<bean id="exampleInitBean" class="examples.ExampleBean" destroy-method="cleanup"/>
```

```
public class ExampleBean {

  public void cleanup() {
      // do some destruction work (like releasing pooled connections)
  }
}
```

...is exactly the same as...

```
<bean id="exampleInitBean" class="examples.AnotherExampleBean"/>
```

```
public class AnotherExampleBean implements DisposableBean {

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

... but does not couple the code to Spring.

Default initialization and destroy methods

When you write initialization and destroy method callbacks that do not use the Spring-specific `InitializingBean` and `DisposableBean` callback interfaces, you typically write methods with names such as `init()`, `initialize()`, `dispose()`, and so on. Ideally, the names of such lifecycle callback methods are standardized across a project so that all developers use the same method names and ensure consistency.

You can configure the Spring container to `look` for named initialization and destroy callback method names on *every* bean. This means that you, as an application developer, can write your application classes and use an initialization callback called `init()`, without having to configure an `init-method="init"` attribute with each bean definition. The Spring IoC container calls that method when the bean is created (and in accordance with the standard lifecycle callback contract described previously). This feature also enforces a consistent naming convention for initialization and destroy method callbacks.

Suppose that your initialization callback methods are named `init()` and destroy callback methods are named `destroy()`. Your class will resemble the class in the following example.

```
public class DefaultBlogService implements BlogService {

  private BlogDao blogDao;


  public void setBlogDao(BlogDao blogDao) {
      this.blogDao = blogDao;
  }

  // this is (unsurprisingly) the initialization callback method
  public void init() {
      if (this.blogDao == null) {
          throw new IllegalStateException("The [blogDao] property must be set.");
      }
  }
}
```

```
<beans default-init-method="init">

  <bean id="blogService" class="com.foo.DefaultBlogService">
      <property name="blogDao" ref="blogDao" />
  </bean>
```

```
</beans>
```

The presence of the `default-init-method` attribute on the top-level `<beans/>` element attribute causes the Spring IoC container to recognize a method called `init` on beans as the initialization method callback. When a bean is created and assembled, if the bean class has such a method, it is invoked at the appropriate time.

You configure destroy method callbacks similarly (in XML, that is) by using the `default-destroy-method` attribute on the top-level `<beans/>` element.

Where existing bean classes already have callback methods that are named at variance with the convention, you can override the default by specifying (in XML, that is) the method name using the `init-method` and `destroy-method` attributes of the <bean/> itself.

The Spring container guarantees that a configured initialization callback is called immediately after a bean is supplied with all dependencies. Thus the initialization callback is called on the raw bean reference, which means that AOP interceptors and so forth are not yet applied to the bean. A target bean is fully created *first*, *then* an AOP proxy (for example) with its interceptor chain is applied. If the target bean and the proxy are defined separately, your code can even interact with the raw target bean, bypassing the proxy. Hence, it would be inconsistent to apply the interceptors to the init method, because doing so would couple the lifecycle of the target bean with its proxy/interceptors and leave strange semantics when your code interacts directly to the raw target bean.

Combining lifecycle mechanisms

As of Spring 2.5, you have three options for controlling bean lifecycle behavior: the `InitializingBean` and `DisposableBean` callback interfaces; custom `init()` and `destroy()` methods; and the `@PostConstruct` and `@PreDestroy` annotations. You can combine these mechanisms to control a given bean.

If multiple lifecycle mechanisms are configured for a bean, and each mechanism is configured with a different method name, then each configured method is executed in the order listed below. However, if the same method

> name is configured - for example, `init()` for an initialization method - for more than one of these lifecycle mechanisms, that method is executed once, as explained in the preceding section.

Multiple lifecycle mechanisms configured for the same bean, with different initialization methods, are called as follows:

- Methods annotated with `@PostConstruct`
- `afterPropertiesSet()` as defined by the `InitializingBean` callback interface
- A custom configured `init()` method

Destroy methods are called in the same order:

- Methods annotated with `@PreDestroy`
- `destroy()` as defined by the `DisposableBean` callback interface
- A custom configured `destroy()` method

Startup and shutdown callbacks

The `Lifecycle` interface defines the essential methods for any object that has its own lifecycle requirements (e.g. starts and stops some background process):

```
public interface Lifecycle {

  void start();

  void stop();

  boolean isRunning();

}
```

Any Spring-managed object may implement that interface. Then, when the ApplicationContext itself starts and stops, it will cascade those calls to all Lifecycle implementations defined within that context. It does this by delegating to a

`LifecycleProcessor`:

```
public interface LifecycleProcessor extends Lifecycle {

  void onRefresh();

  void onClose();

}
```

Notice that the `LifecycleProcessor` is itself an extension of the `Lifecycle` interface. It also adds two other methods for reacting to the context being refreshed and closed.

The order of startup and shutdown invocations can be important. If a "depends-on" relationship exists between any two objects, the dependent side will start *after* its dependency, and it will stop *before* its dependency. However, at times the direct dependencies are unknown. You may only know that objects of a certain type should start prior to objects of another type. In those cases, the `SmartLifecycle` interface defines another option, namely the `getPhase()` method as defined on its super-interface, `Phased`.

```
public interface Phased {

  int getPhase();

}


public interface SmartLifecycle extends Lifecycle, Phased {

  boolean isAutoStartup();

  void stop(Runnable callback);

}
```

When starting, the objects with the lowest phase start first, and when stopping, the reverse order is followed. Therefore, an object that implements `SmartLifecycle` and whose getPhase() method returns `Integer.MIN_VALUE` would be among the first to start and the last to stop. At the other end of the spectrum, a phase value of `Integer.MAX_VALUE` would indicate that the object should be started last and stopped first (likely because it depends on other processes to be running). When considering the phase value, it's also important to know that the default phase for any "normal" `Lifecycle` object that does not implement `SmartLifecycle` would be 0. Therefore, any negative phase value would indicate that an object should start before those standard components (and stop after them), and vice versa for any positive phase value.

As you can see the stop method defined by `SmartLifecycle` accepts a callback. Any implementation *must* invoke that callback's run() method after that implementation's shutdown process is complete. That enables asynchronous shutdown where necessary since the default implementation of the `LifecycleProcessor` interface, `DefaultLifecycleProcessor`, will wait up to its timeout value for the group of objects within each phase to invoke that callback. The default per-phase timeout is 30 seconds. You can override the default lifecycle processor instance by defining a bean named "lifecycleProcessor" within the context. If you only want to modify the timeout, then defining the following would be sufficient:

```
<bean id="lifecycleProcessor" class="org.springframework.context.support.DefaultLifecycleProcessor">
  <!-- timeout value in milliseconds -->
  <property name="timeoutPerShutdownPhase" value="10000"/>
</bean>
```

As mentioned, the `LifecycleProcessor` interface defines callback methods for the refreshing and closing of the context as well. The latter will simply drive the shutdown process as if stop() had been called explicitly, but it will happen when the context is closing. The 'refresh' callback on the other hand enables another feature of `SmartLifecycle` beans. When the context is refreshed (after all objects have been instantiated and initialized), that callback will be invoked, and at that point the default lifecycle processor will check the boolean value returned by each `SmartLifecycle` object's `isAutoStartup()` method. If "true", then that object will be started at that point rather than waiting for an explicit invocation of the context's or its own start() method (unlike the context refresh, the context start does not happen automatically for a standard context implementation). The "phase" value as well as any "depends-on" relationships will determine the startup order in the same way as described above.

Shutting down the Spring IoC container gracefully in non-web applications

> This section applies only to non-web applications. Spring's web-based `ApplicationContext` implementations already have code in place to shut down the Spring IoC container gracefully when the relevant web application is shut down.

If you are using Spring's IoC container in a non-web application environment; for example, in a rich client desktop environment; you register a shutdown hook with the JVM. Doing so ensures a graceful shutdown and calls the relevant destroy methods on your singleton beans so that all resources are released. Of course, you must still configure and implement these destroy callbacks correctly.

To register a shutdown hook, you call the `registerShutdownHook()` method that is declared on the `AbstractApplicationContext` class:

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

public final class Boot {

  public static void main(final String[] args) throws Exception {
      AbstractApplicationContext ctx
          = new ClassPathXmlApplicationContext(new String []{"beans.xml"});

      // add a shutdown hook for the above context...
      ctx.registerShutdownHook();

      // app runs here...

      // main method exits, hook is called prior to the app shutting down...
  }
}
```

5.6.2 `ApplicationContextAware` and `BeanNameAware`

When an `ApplicationContext` creates a class that implements the `org.springframework.context.ApplicationContextAware` interface, the class is provided with a reference to that `ApplicationContext`.

```
public interface ApplicationContextAware {

  void setApplicationContext(ApplicationContext applicationContext) throws BeansException;
}
```

Thus beans can manipulate programmatically the `ApplicationContext` that created them, through the `ApplicationContext` interface, or by casting the reference to a known subclass of this interface, such as `ConfigurableApplicationContext`, which exposes additional functionality. One use would be the programmatic retrieval of other beans. Sometimes this capability is useful; however, in general you should avoid it, because it couples the code to Spring and does not follow the Inversion of Control style, where collaborators are provided to beans as properties. Other methods of the ApplicationContext provide access to file resources, publishing application events, and accessing a MessageSource. These additional features are described in Section 5.14, “Additional Capabilities of the `ApplicationContext`”

As of Spring 2.5, autowiring is another alternative to obtain reference to the `ApplicationContext`. The "traditional" `constructor` and `byType` autowiring modes (as described in Section 5.4.5, “Autowiring collaborators”) can provide a dependency of type `ApplicationContext` for a constructor argument or setter method parameter, respectively. For more flexibility, including the ability to autowire fields and multiple parameter methods, use the new annotation-based autowiring features. If you do, the `ApplicationContext` is autowired into a field, constructor argument, or method parameter that is expecting the `ApplicationContext` type if the field, constructor, or method in question carries the `@Autowired` annotation. For more information, see Section 5.9.2, “`@Autowired`”.

When an ApplicationContext creates a class that implements the `org.springframework.beans.factory.BeanNameAware` interface, the class is provided with a reference to the name defined in its associated object definition.

```
public interface BeanNameAware {
```

```
    void setBeanName(string name) throws BeansException;
}
```

The callback is invoked after population of normal bean properties but before an initialization callback such as `InitializingBean`s *afterPropertiesSet* or a custom init-method.

5.6.3 Other `Aware` interfaces

Besides `ApplicationContextAware` and `BeanNameAware` discussed above, Spring offers a range of *`Aware`* interfaces that allow beans to indicate to the container that they require a certain *infrastructure* dependency. The most important `Aware` interfaces are summarized below - as a general rule, the name is a good indication of the dependency type:

Table 5.4. `Aware` interfaces

Name	Injected Dependency	Explained in...
`ApplicationContextAware`	Declaring `ApplicationContext`	Section 5.6.2, “`ApplicationContextAware` and `BeanNameAware`”
`ApplicationEventPublisherAware`	Event publisher of the enclosing `ApplicationContext`	Section 5.14, “Additional Capabilities of the `ApplicationContext`”
`BeanClassLoaderAware`	Class loader used to load the bean classes.	Section 5.3.2, “Instantiating beans”
`BeanFactoryAware`	Declaring `BeanFactory`	Section 5.6.2, “`ApplicationContextAware` and `BeanNameAware`”

Name	Injected Dependency	Explained in...
`BeanNameAware`	Name of the declaring bean	Section 5.6.2, “`ApplicationContextAware` and `BeanNameAware`”
`BootstrapContextAware`	Resource adapter `BootstrapContext` the container runs in. Typically available only in JCA aware `ApplicationContext`s	Chapter 25, *JCA CCI*
`LoadTimeWeaverAware`	Defined *weaver* for processing class definition at load time	Section 9.8.4, “Load-time weaving with AspectJ in the Spring Framework”
`MessageSourceAware`	Configured strategy for resolving messages (with support for parametrization and internationalization)	Section 5.14, “Additional Capabilities of the `ApplicationContext`”
`NotificationPublisherAware`	Spring JMX notification publisher	Section 24.7, “Notifications”
`PortletConfigAware`	Current `PortletConfig` the container runs in. Valid only in a web-aware Spring `ApplicationContext`	Chapter 20, *Portlet MVC Framework*
`PortletContextAware`	Current `PortletContext` the container runs in. Valid only in a web-aware Spring `ApplicationContext`	Chapter 20, *Portlet MVC Framework*
`ResourceLoaderAware`	Configured loader for low-level access to resources	Chapter 6, *Resources*

Name	Injected Dependency	Explained in...
`ServletConfigAware`	Current `ServletConfig` the container runs in. Valid only in a web-aware Spring `ApplicationContext`	Chapter 17, *Web MVC framework*
`ServletContextAware`	Current `ServletContext` the container runs in. Valid only in a web-aware Spring `ApplicationContext`	Chapter 17, *Web MVC framework*

Note again that usage of these interfaces ties your code to the Spring API and does not follow the Inversion of Control style. As such, they are recommended for infrastructure beans that require programmatic access to the container.

5.7 Bean definition inheritance

A bean definition can contain a lot of configuration information, including constructor arguments, property values, and container-specific information such as initialization method, static factory method name, and so on. A child bean definition inherits configuration data from a parent definition. The child definition can override some values, or add others, as needed. Using parent and child bean definitions can save a lot of typing. Effectively, this is a form of templating.

If you work with an `ApplicationContext` interface programmatically, child bean definitions are represented by the `ChildBeanDefinition` class. Most users do not work with them on this level, instead configuring bean definitions declaratively in something like the `ClassPathXmlApplicationContext`. When you use XML-based configuration metadata, you indicate a child bean definition by using the `parent` attribute, specifying the parent bean as the value of this attribute.

```
<bean id="inheritedTestBean" abstract="true"
    class="org.springframework.beans.TestBean">
  <property name="name" value="parent"/>
  <property name="age" value="1"/>
```

```
</bean>

<bean id="inheritsWithDifferentClass"
      class="org.springframework.beans.DerivedTestBean"
      parent="inheritedTestBean" init-method="initialize">

  <property name="name" value="override"/>
  <!-- the age property value of 1 will be inherited from  parent -->

</bean>
```

A child bean definition uses the bean class from the parent definition if none is specified, but can also override it. In the latter case, the child bean class must be compatible with the parent, that is, it must accept the parent's property values.

A child bean definition inherits scope, constructor argument values, property values, and method overrides from the parent, with the option to add new values. Any scope, initialization method, destroy method, and/or `static` factory method settings that you specify will override the corresponding parent settings.

The remaining settings are *always* taken from the child definition: *depends on*, *autowire mode*, *dependency check*, *singleton*, *lazy init*.

The preceding example explicitly marks the parent bean definition as abstract by using the `abstract` attribute. If the parent definition does not specify a class, explicitly marking the parent bean definition as `abstract` is required, as follows:

```
<bean id="inheritedTestBeanWithoutClass" abstract="true">
    <property name="name" value="parent"/>
    <property name="age" value="1"/>
</bean>

<bean id="inheritsWithClass" class="org.springframework.beans.DerivedTestBean"
    parent="inheritedTestBeanWithoutClass" init-method="initialize">
  <property name="name" value="override"/>
  <!-- age will inherit the value of 1 from the parent bean definition-->
</bean>
```

The parent bean cannot be instantiated on its own because it is incomplete, and it is also explicitly marked as `abstract`. When a definition is `abstract` like this, it is usable only as a pure template bean definition that serves as a parent definition for child definitions. Trying to use such an `abstract` parent bean on its own, by referring to it as a ref property of another bean or doing an explicit `getBean()` call with the parent bean id, returns an error. Similarly, the container's internal `preInstantiateSingletons()` method ignores bean definitions that are defined as abstract.

> `ApplicationContext` pre-instantiates all singletons by default. Therefore, it is important (at least for singleton beans) that if you have a (parent) bean definition which you intend to use only as a template, and this definition specifies a class, you must make sure to set the *abstract* attribute to *true*, otherwise the application context will actually (attempt to) pre-instantiate the `abstract` bean.

5.8 Container Extension Points

Typically, an application developer does not need to subclass `ApplicationContext` implementation classes. Instead, the Spring IoC container can be extended by plugging in implementations of special integration interfaces. The next few sections describe these integration interfaces.

5.8.1 Customizing beans using a `BeanPostProcessor`

The `BeanPostProcessor` interface defines *callback methods* that you can implement to provide your own (or override the container's default) instantiation logic, dependency-resolution logic, and so forth. If you want to implement some custom logic after the Spring container finishes instantiating, configuring, and initializing a bean, you can plug in one or more `BeanPostProcessor` implementations.

You can configure multiple `BeanPostProcessor` instances, and you can control the order in which these `BeanPostProcessor`s execute by setting the `order` property. You can set this property only if the `BeanPostProcessor` implements the `Ordered` interface; if you write your own `BeanPostProcessor` you should consider implementing the `Ordered` interface too. For further details, consult the Javadoc for the `BeanPostProcessor` and `Ordered` interfaces. See also the note below on programmatic registration of `BeanPostProcessors`

> `BeanPostProcessor`s operate on bean (or object) *instances*; that is to say, the Spring IoC container instantiates a bean instance and *then* `BeanPostProcessor`s do their work.
> `BeanPostProcessor`s are scoped *per-container*. This is only relevant if you are using container hierarchies. If you define a `BeanPostProcessor` in one container, it will *only* post-process the beans in that container. In other words, beans that are defined in one container are not post-processed by a `BeanPostProcessor` defined in another container, even if both containers are part of the same hierarchy.
> To change the actual bean definition (i.e., the *blueprint* that defines the bean), you instead need to use a `BeanFactoryPostProcessor` as described in Section 5.8.2, "Customizing configuration metadata with a `BeanFactoryPostProcessor`".

The `org.springframework.beans.factory.config.BeanPostProcessor` interface consists of exactly two callback methods. When such a class is registered as a post-processor with the container, for each bean instance that is created by the container, the post-processor gets a callback from the container both *before* container initialization methods (such as InitializingBean's *afterPropertiesSet()* and any declared init method) are called as well as *after* any bean initialization callbacks. The post-processor can take any action with the bean instance, including ignoring the callback completely. A bean post-processor typically checks for callback interfaces or may wrap a bean with a proxy. Some Spring AOP infrastructure classes are implemented as bean post-processors in order to provide proxy-wrapping logic.

An `ApplicationContext` *automatically detects* any beans that are defined in the configuration metadata which implement the `BeanPostProcessor` interface. The `ApplicationContext` registers these beans as post-processors so that they can be called later upon bean creation. Bean post-processors can be deployed in the container just like any other beans.

> While the recommended approach for `BeanPostProcessor` registration is through `ApplicationContext` auto-detection (as described above), it is also possible to register them *programmatically* against a `ConfigurableBeanFactory` using the `addBeanPostProcessor` method. This can be useful when needing to

evaluate conditional logic before registration, or even for copying bean post processors across contexts in a hierarchy. Note however that `BeanPostProcessors` added programmatically *do not respect the* `Ordered` *interface*. Here it is the *order of registration* that dictates the order of execution. Note also that `BeanPostProcessors` registered programmatically are always processed before those registered through auto-detection, regardless of any explicit ordering.

Classes that implement the `BeanPostProcessor` interface are *special* and are treated differently by the container. All `BeanPostProcessors` *and beans that they reference directly* are instantiated on startup, as part of the special startup phase of the `ApplicationContext`. Next, all `BeanPostProcessors` are registered in a sorted fashion and applied to all further beans in the container. Because AOP auto-proxying is implemented as a `BeanPostProcessor` itself, neither `BeanPostProcessors` nor the beans they reference directly are eligible for auto-proxying, and thus do not have aspects woven into them.
For any such bean, you should see an informational log message: "*Bean foo is not eligible for getting processed by all BeanPostProcessor interfaces (for example: not eligible for auto-proxying)*".
Note that if you have beans wired into your `BeanPostProcessor` using autowiring or `@Resource` (which may fall back to autowiring), Spring might access unexpected beans when searching for type-matching dependency candidates, and therefore make them ineligible for auto-proxying or other kinds of bean post-processing. For example, if you have a dependency annotated with `@Resource` where the field/setter name does not directly correspond to the declared name of a bean and no name attribute is used, then Spring will access other beans for matching them by type.

The following examples show how to write, register, and use `BeanPostProcessors` in an `ApplicationContext`.

Example: Hello World, `BeanPostProcessor`-style

This first example illustrates basic usage. The example shows a custom `BeanPostProcessor` implementation that invokes the `toString()` method of each bean as it is created by the container and prints the resulting string to the system console.

Find below the custom `BeanPostProcessor` implementation class definition:

```java
package scripting;

import org.springframework.beans.factory.config.BeanPostProcessor;
import org.springframework.beans.BeansException;

public class InstantiationTracingBeanPostProcessor implements BeanPostProcessor {

  // simply return the instantiated bean as-is
  public Object postProcessBeforeInitialization(Object bean, String beanName)
                                                                      throws BeansException {
      return bean; // we could potentially return any object reference here...
  }

  public Object postProcessAfterInitialization(Object bean, String beanName)
                                                                      throws BeansException {
      System.out.println("Bean '" + beanName + "' created : " + bean.toString());
      return bean;
  }
}
```

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

  <lang:groovy id="messenger"
        script-source="classpath:org/springframework/scripting/groovy/Messenger.groovy">
      <lang:property name="message" value="Fiona Apple Is Just So Dreamy."/>
  </lang:groovy>
```

```
  </lang:groovy>

  <!--
      when the above bean (messenger) is instantiated, this custom
      BeanPostProcessor implementation will output the fact to the system console
   -->
  <bean class="scripting.InstantiationTracingBeanPostProcessor"/>


</beans>
```

Notice how the `InstantiationTracingBeanPostProcessor` is simply defined. It does not even have a name, and because it is a bean it can be dependency-injected just like any other bean. (The preceding configuration also defines a bean that is backed by a Groovy script. The Spring 2.0 dynamic language support is detailed in the chapter entitled Chapter 28, *Dynamic language support*.)

The following simple Java application executes the preceding code and configuration:

```
import org.springframework.context.ApplicationContext;
import org.springframework.context.support.ClassPathXmlApplicationContext;
import org.springframework.scripting.Messenger;

public final class Boot {

  public static void main(final String[] args) throws Exception {
      ApplicationContext ctx = new ClassPathXmlApplicationContext("scripting/beans.xml");
      Messenger messenger = (Messenger) ctx.getBean("messenger");
      System.out.println(messenger);
  }
}
```

The output of the preceding application resembles the following:

```
Bean 'messenger' created : org.springframework.scripting.groovy.GroovyMessenger@272961
org.springframework.scripting.groovy.GroovyMessenger@272961
```

Example: The `RequiredAnnotationBeanPostProcessor`

Using callback interfaces or annotations in conjunction with a custom `BeanPostProcessor` implementation is a common means of extending the Spring IoC container. An example is Spring's `RequiredAnnotationBeanPostProcessor` — a `BeanPostProcessor` implementation that ships with the Spring distribution which ensures that JavaBean properties on beans that are marked with an (arbitrary) annotation are actually (configured to be) dependency-injected with a value.

5.8.2 Customizing configuration metadata with a `BeanFactoryPostProcessor`

The next extension point that we will look at is the `org.springframework.beans.factory.config.BeanFactoryPostProcessor`. The semantics of this interface are similar to those of the `BeanPostProcessor`, with one major difference: `BeanFactoryPostProcessor`s 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`.

You can configure multiple `BeanFactoryPostProcessors`, and you can control the order in which these `BeanFactoryPostProcessors` execute by setting the `order` property. However, you can only set this property if the `BeanFactoryPostProcessor` implements the `Ordered` interface. If you write your own `BeanFactoryPostProcessor`, you should consider implementing the `Ordered` interface too. Consult the Javadoc for the `BeanFactoryPostProcessor` and `Ordered` interfaces for more details.

> If you want to change the actual bean *instances* (i.e., the objects that are created from the configuration metadata), then you instead need to use a `BeanPostProcessor` (described above in Section 5.8.1, “Customizing beans using a `BeanPostProcessor`”). While it is technically possible to work with bean instances within a `BeanFactoryPostProcessor` (e.g., using `BeanFactory.getBean()`), doing so causes premature bean instantiation, violating the standard container lifecycle. This may cause negative side effects such as bypassing bean post processing.

> Also, `BeanFactoryPostProcessors` are scoped *per-container*. This is only relevant if you are using container hierarchies. If you define a `BeanFactoryPostProcessor` in one container, it will *only* be applied to the bean definitions in that container. Bean definitions in one container will not be post-processed by `BeanFactoryPostProcessors` in another container, even if both containers are part of the same hierarchy.

A bean factory post-processor is executed automatically when it is declared inside an `ApplicationContext`, in order to apply changes to the configuration metadata that define the container. Spring includes a number of predefined bean factory post-processors, such as `PropertyOverrideConfigurer` and `PropertyPlaceholderConfigurer`. A custom `BeanFactoryPostProcessor` can also be used, for example, to register custom property editors.

An `ApplicationContext` automatically detects any beans that are deployed into it that implement the `BeanFactoryPostProcessor` interface. It uses these beans as bean factory post-processors, at the appropriate time. You can deploy these post-processor beans as you would any other bean.

> As with `BeanPostProcessor`s, you typically do not want to configure `BeanFactoryPostProcessor`s for lazy initialization. If no other bean references a `Bean(Factory)PostProcessor`, that post-processor will not get instantiated at all. Thus, marking it for lazy initialization will be ignored, and the `Bean(Factory)PostProcessor` will be instantiated eagerly even if you set the `default-lazy-init` attribute to `true` on the declaration of your `<beans />` element.

Example: the `PropertyPlaceholderConfigurer`

You use the `PropertyPlaceholderConfigurer` to externalize property values from a bean definition in a separate file using the standard Java `Properties` format. Doing so enables the person deploying an application to customize environment-specific properties such as database URLs and passwords, without the complexity or risk of modifying the main XML definition file or files for the container.

Consider the following XML-based configuration metadata fragment, where a `DataSource` with placeholder values is defined. The example shows properties configured from an external `Properties` file. At runtime, a `PropertyPlaceholderConfigurer` is applied to the metadata that will replace some properties of the DataSource. The values to replace are specified as *placeholders* of the form ${property-name} which follows the Ant / log4j / JSP EL style.

```
<bean class="org.springframework.beans.factory.config.PropertyPlaceholderConfigurer">
  <property name="locations" value="classpath:com/foo/jdbc.properties"/>
</bean>

<bean id="dataSource" destroy-method="close"
    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>
```

The actual values come from another file in the standard Java `Properties` format:

```
jdbc.driverClassName=org.hsqldb.jdbcDriver
jdbc.url=jdbc:hsqldb:hsql://production:9002
jdbc.username=sa
jdbc.password=root
```

Therefore, the string `${jdbc.username}` is replaced at runtime with the value 'sa', and the same applies for other placeholder values that match keys in the properties file. The `PropertyPlaceholderConfigurer` checks for placeholders in most properties and attributes of a bean definition. Furthermore, the placeholder prefix and suffix can be customized.

With the `context` namespace introduced in Spring 2.5, it is possible to configure property placeholders with a dedicated configuration element. One or more locations can be provided as a comma-separated list in the `location` attribute.

```
<context:property-placeholder location="classpath:com/foo/jdbc.properties"/>
```

The `PropertyPlaceholderConfigurer` not only looks for properties in the `Properties` file you specify. By default it also checks against the Java `System` properties if it cannot find a property in the specified properties files. You can customize this behavior by setting the `systemPropertiesMode` property of the configurer with one of the following three supported integer values:

- *never* (0): Never check system properties
- *fallback* (1): Check system properties if not resolvable in the specified properties files. This is the default.
- *override* (2): Check system properties first, before trying the specified properties files. This allows system properties to override any other property source.

Consult the Javadoc for the `PropertyPlaceholderConfigurer` for more information.

> You can use the `PropertyPlaceholderConfigurer` to substitute class names, which is sometimes useful when you have to pick a particular implementation class at runtime. For example:

```
<bean class="org.springframework.beans.factory.config.PropertyPlaceholderConfigurer">
  <property name="locations">
      <value>classpath:com/foo/strategy.properties</value>
  </property>
  <property name="properties">
      <value>custom.strategy.class=com.foo.DefaultStrategy</value>
  </property>
</bean>

<bean id="serviceStrategy" class="${custom.strategy.class}"/>
```

> If the class cannot be resolved at runtime to a valid class, resolution of the bean fails when it is about to be created, which is during the `preInstantiateSingletons()` phase of an `ApplicationContext` for a non-lazy-init bean.

Example: the `PropertyOverrideConfigurer`

The `PropertyOverrideConfigurer`, another bean factory post-processor, resembles the `PropertyPlaceholderConfigurer`, but unlike the latter, the original definitions can have default values or no values at all for bean properties. If an overriding `Properties` file does not have an entry for a certain bean property, the default context definition is used.

Note that the bean definition is *not* aware of being overridden, so it is not immediately obvious from the XML definition file that the override configurer is being used. In case of multiple `PropertyOverrideConfigurer` instances that define different values for the same bean property, the last one wins, due to the overriding mechanism.

Properties file configuration lines take this format:

```
beanName.property=value
```

For example:

```
dataSource.driverClassName=com.mysql.jdbc.Driver
dataSource.url=jdbc:mysql:mydb
```

This example file can be used with a container definition that contains a bean called *dataSource*, which has *driver* and *url* properties.

Compound property names are also supported, as long as every component of the path except the final property being overridden is already non-null (presumably initialized by the constructors). In this example...

```
foo.fred.bob.sammy=123
```

... the `sammy` property of the `bob` property of the `fred` property of the `foo` bean is set to the scalar value `123`.

> Specified override values are always *literal* values; they are not translated into bean references. This convention also applies when the original value in the XML bean definition specifies a bean reference.

With the `context` namespace introduced in Spring 2.5, it is possible to configure property overriding with a dedicated configuration element:

```
<context:property-override location="classpath:override.properties"/>
```

5.8.3 Customizing instantiation logic with a `FactoryBean`

Implement the `org.springframework.beans.factory.FactoryBean` interface for objects that *are themselves factories*.

The `FactoryBean` interface is a point of pluggability into the Spring IoC container's instantiation logic. If you have complex initialization code that is better expressed in Java as opposed to a (potentially) verbose amount of XML, you can create your own `FactoryBean`, write the complex initialization inside that class, and then plug your custom `FactoryBean` into the container.

The `FactoryBean` interface provides three methods:

- `Object getObject()`: returns an instance of the object this factory creates. The instance can possibly be shared, depending on whether this factory returns singletons or prototypes.
- `boolean isSingleton()`: returns `true` if this `FactoryBean` returns singletons, `false` otherwise.
- `Class getObjectType()`: returns the object type returned by the `getObject()` method or `null` if the type is not known in advance.

The `FactoryBean` concept and interface is used in a number of places within the Spring Framework; more than 50 implementations of the `FactoryBean` interface ship with Spring itself.

When you need to ask a container for an actual `FactoryBean` instance itself instead of the bean it produces, preface the bean's id with the ampersand symbol (`&`) when calling the `getBean()` method of the `ApplicationContext`. So for a given `FactoryBean` with an id of `myBean`, invoking `getBean("myBean")` on the container returns the product of the `FactoryBean`; whereas, invoking `getBean("&myBean")` returns the `FactoryBean` instance itself.

5.9 Annotation-based container configuration

Are annotations better than XML for configuring Spring?

The introduction of annotation-based configurations raised the question of whether this approach is 'better' than XML. The short answer is *it depends*. The long answer is that each approach has its pros and cons, and usually it is up to the developer to decide which strategy suits her better. Due to the way they are defined, annotations provide a lot of context in their declaration, leading to shorter and more concise configuration. However, XML excels at wiring up components without touching their source code or recompiling them. Some developers prefer having the wiring close to the source while others argue that annotated classes are no longer POJOs and, furthermore, that the configuration becomes decentralized and harder to control.

No matter the choice, Spring can accommodate both styles and even mix them together. It's worth pointing out that through its JavaConfig option, Spring allows annotations to be used in a non-invasive way, without touching the target components source code and that in terms of tooling, all configuration styles are supported by the SpringSource Tool Suite.

An alternative to XML setups is provided by annotation-based configuration which rely on the bytecode metadata for wiring up components instead of angle-bracket declarations. Instead of using XML to describe a bean wiring, the developer moves the configuration into the component class itself by using annotations on the relevant class, method, or field declaration. As mentioned in the section called “Example: The `RequiredAnnotationBeanPostProcessor`”, using a `BeanPostProcessor` in conjunction with annotations is a common means of extending the Spring IoC container. For example, Spring 2.0 introduced the possibility of enforcing required properties with the @Required annotation. Spring 2.5 made it possible to follow that same general approach to drive Spring's dependency injection. Essentially, the `@Autowired` annotation provides the same capabilities as described in Section 5.4.5, “Autowiring collaborators” but with more fine-grained control and wider applicability. Spring 2.5 also added support for JSR-250 annotations such as `@PostConstruct`, and `@PreDestroy`. Spring 3.0 added support for JSR-330 (Dependency Injection for Java) annotations contained in the javax.inject package such as `@Inject` and `@Named`. Details about those annotations can be found in the relevant section.

> Annotation injection is performed *before* XML injection, thus the latter configuration will override the former for properties wired through both approaches.

As always, you can register them as individual bean definitions, but they can also be implicitly registered by including the following tag in an XML-based Spring configuration (notice the inclusion of the `context` namespace):

```
<?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.xsd">

  <context:annotation-config/>

</beans>
```

(The implicitly registered post-processors include `AutowiredAnnotationBeanPostProcessor`, `CommonAnnotationBeanPostProcessor`, `PersistenceAnnotationBeanPostProcessor`, as well as the aforementioned `RequiredAnnotationBeanPostProcessor`.)

> `<context:annotation-config/>` only looks for annotations on beans in the same application context in which it is defined. This means that, if you put `<context:annotation-config/>` in a `WebApplicationContext` for a `DispatcherServlet`, it only checks for `@Autowired` beans in your controllers, and not your services. See Section 17.2, "The `DispatcherServlet`" for more information.

5.9.1 `@Required`

The `@Required` annotation applies to bean property setter methods, as in the following example:

```
public class SimpleMovieLister {

  private MovieFinder movieFinder;

  @Required
  public void setMovieFinder(MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
  }
```

```
    // ...
}
```

This annotation simply indicates that the affected bean property must be populated at configuration time, through an explicit property value in a bean definition or through autowiring. The container throws an exception if the affected bean property has not been populated; this allows for eager and explicit failure, avoiding `NullPointerException`s or the like later on. It is still recommended that you put assertions into the bean class itself, for example, into an init method. Doing so enforces those required references and values even when you use the class outside of a container.

5.9.2 `@Autowired`

As expected, you can apply the `@Autowired` annotation to "traditional" setter methods:

```
public class SimpleMovieLister {

    private MovieFinder movieFinder;

    @Autowired
    public void setMovieFinder(MovieFinder movieFinder) {
        this.movieFinder = movieFinder;
    }

    // ...
}
```

JSR 330's @Inject annotation can be used in place of Spring's `@Autowired` annotation in the examples below. See here for more details

You can also apply the annotation to methods with arbitrary names and/or multiple arguments:

```java
public class MovieRecommender {

  private MovieCatalog movieCatalog;

  private CustomerPreferenceDao customerPreferenceDao;

  @Autowired
  public void prepare(MovieCatalog movieCatalog,
                      CustomerPreferenceDao customerPreferenceDao) {
      this.movieCatalog = movieCatalog;
      this.customerPreferenceDao = customerPreferenceDao;
  }

  // ...
}
```

You can apply `@Autowired` to constructors and fields:

```java
public class MovieRecommender {

  @Autowired
  private MovieCatalog movieCatalog;

  private CustomerPreferenceDao customerPreferenceDao;

  @Autowired
  public MovieRecommender(CustomerPreferenceDao customerPreferenceDao) {
      this.customerPreferenceDao = customerPreferenceDao;
  }

  // ...
}
```

It is also possible to provide *all* beans of a particular type from the `ApplicationContext` by adding the annotation to a field or method that expects an array of that type:

```
public class MovieRecommender {

  @Autowired
  private MovieCatalog[] movieCatalogs;

  // ...
}
```

The same applies for typed collections:

```
public class MovieRecommender {

  private Set<MovieCatalog> movieCatalogs;

  @Autowired
  public void setMovieCatalogs(Set<MovieCatalog> movieCatalogs) {
      this.movieCatalogs = movieCatalogs;
  }

  // ...
}
```

Even typed Maps can be autowired as long as the expected key type is `String`. The Map values will contain all beans of the expected type, and the keys will contain the corresponding bean names:

```
public class MovieRecommender {

  private Map<String, MovieCatalog> movieCatalogs;

  @Autowired
  public void setMovieCatalogs(Map<String, MovieCatalog> movieCatalogs) {
```

```
        this.movieCatalogs = movieCatalogs;
    }

    // ...
}
```

By default, the autowiring fails whenever *zero* candidate beans are available; the default behavior is to treat annotated methods, constructors, and fields as indicating *required* dependencies. This behavior can be changed as demonstrated below.

```
public class SimpleMovieLister {

    private MovieFinder movieFinder;

    @Autowired(required=false)
    public void setMovieFinder(MovieFinder movieFinder) {
        this.movieFinder = movieFinder;
    }

    // ...
}
```

> Only *one annotated constructor per-class* can be marked as *required*, but multiple non-required constructors can be annotated. In that case, each is considered among the candidates and Spring uses the *greediest* constructor whose dependencies can be satisfied, that is the constructor that has the largest number of arguments.
> `@Autowired`'s *required* attribute is recommended over the `@Required` annotation. The *required* attribute indicates that the property is not required for autowiring purposes, the property is ignored if it cannot be autowired. `@Required`, on the other hand, is stronger in that it enforces the property that was set by any means supported by the container. If no value is injected, a corresponding exception is raised.

You can also use `@Autowired` for interfaces that are well-known resolvable dependencies: `BeanFactory`, `ApplicationContext`, `Environment`, `ResourceLoader`, `ApplicationEventPublisher`, and `MessageSource`. These interfaces and their extended interfaces, such as `ConfigurableApplicationContext` or `ResourcePatternResolver`, are automatically resolved, with no special setup necessary.

```
public class MovieRecommender {

  @Autowired
  private ApplicationContext context;

  public MovieRecommender() {
  }

  // ...
}
```

`@Autowired`, `@Inject`, `@Resource`, and `@Value` annotations are handled by a Spring `BeanPostProcessor` implementations which in turn means that you *cannot* apply these annotations within your own `BeanPostProcessor` or `BeanFactoryPostProcessor` types (if any). These types must be 'wired up' explicitly via XML or using a Spring `@Bean` method.

5.9.3 Fine-tuning annotation-based autowiring with qualifiers

Because autowiring by type may lead to multiple candidates, it is often necessary to have more control over the selection process. One way to accomplish this is with Spring's `@Qualifier` annotation. You can associate qualifier values with specific arguments, narrowing the set of type matches so that a specific bean is chosen for each argument. In the simplest case, this can be a plain descriptive value:

```
public class MovieRecommender {

  @Autowired
  @Qualifier("main")
```

```
    private MovieCatalog movieCatalog;

    // ...
}
```

The `@Qualifier` annotation can also be specified on individual constructor arguments or method parameters:

```
public class MovieRecommender {

    private MovieCatalog movieCatalog;

    private CustomerPreferenceDao customerPreferenceDao;

    @Autowired
    public void prepare(@Qualifier("main") MovieCatalog movieCatalog,
                        CustomerPreferenceDao customerPreferenceDao) {
        this.movieCatalog = movieCatalog;
        this.customerPreferenceDao = customerPreferenceDao;
    }

    // ...
}
```

The corresponding bean definitions appear as follows. The bean with qualifier value "main" is wired with the constructor argument that is qualified with the same value.

```
<?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.xsd">
```

```
    <context:annotation-config/>

    <bean class="example.SimpleMovieCatalog">
        <qualifier value="main"/>
        <!-- inject any dependencies required by this bean -->
    </bean>

    <bean class="example.SimpleMovieCatalog">
        <qualifier value="action"/>
        <!-- inject any dependencies required by this bean -->
    </bean>

    <bean id="movieRecommender" class="example.MovieRecommender"/>

</beans>
```

For a fallback match, the bean name is considered a default qualifier value. Thus you can define the bean with an id "main" instead of the nested qualifier element, leading to the same matching result. However, although you can use this convention to refer to specific beans by name, `@Autowired` is fundamentally about type-driven injection with optional semantic qualifiers. This means that qualifier values, even with the bean name fallback, always have narrowing semantics within the set of type matches; they do not semantically express a reference to a unique bean id. Good qualifier values are "main" or "EMEA" or "persistent", expressing characteristics of a specific component that are independent from the bean id, which may be auto-generated in case of an anonymous bean definition like the one in the preceding example.

Qualifiers also apply to typed collections, as discussed above, for example, to `Set<MovieCatalog>`. In this case, all matching beans according to the declared qualifiers are injected as a collection. This implies that qualifiers do not have to be unique; they rather simply constitute filtering criteria. For example, you can define multiple `MovieCatalog` beans with the same qualifier value "action"; all of which would be injected into a `Set<MovieCatalog>` annotated with `@Qualifier("action")`.

If you intend to express annotation-driven injection by name, do not primarily use `@Autowired`, even if is technically capable of referring to a bean name through `@Qualifier` values. Instead, use the JSR-250

> `@Resource` annotation, which is semantically defined to identify a specific target component by its unique name, with the declared type being irrelevant for the matching process.
> As a specific consequence of this semantic difference, beans that are themselves defined as a collection or map type cannot be injected through `@Autowired`, because type matching is not properly applicable to them. Use `@Resource` for such beans, referring to the specific collection or map bean by unique name.
> `@Autowired` applies to fields, constructors, and multi-argument methods, allowing for narrowing through qualifier annotations at the parameter level. By contrast, `@Resource` is supported only for fields and bean property setter methods with a single argument. As a consequence, stick with qualifiers if your injection target is a constructor or a multi-argument method.

You can create your own custom qualifier annotations. Simply define an annotation and provide the `@Qualifier` annotation within your definition:

```
@Target({ElementType.FIELD, ElementType.PARAMETER})
@Retention(RetentionPolicy.RUNTIME)
@Qualifier
public @interface Genre {

  String value();
}
```

Then you can provide the custom qualifier on autowired fields and parameters:

```
public class MovieRecommender {

  @Autowired
  @Genre("Action")
  private MovieCatalog actionCatalog;

  private MovieCatalog comedyCatalog;

  @Autowired
```

```
    public void setComedyCatalog(@Genre("Comedy") MovieCatalog comedyCatalog) {
        this.comedyCatalog = comedyCatalog;
    }

    // ...
}
```

Next, provide the information for the candidate bean definitions. You can add `<qualifier/>` tags as sub-elements of the `<bean/>` tag and then specify the `type` and `value` to match your custom qualifier annotations. The type is matched against the fully-qualified class name of the annotation. Or, as a convenience if no risk of conflicting names exists, you can use the short class name. Both approaches are demonstrated in the following example.

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

    <context:annotation-config/>

    <bean class="example.SimpleMovieCatalog">
        <qualifier type="Genre" value="Action"/>
        <!-- inject any dependencies required by this bean -->
    </bean>

    <bean class="example.SimpleMovieCatalog">
        <qualifier type="example.Genre" value="Comedy"/>
        <!-- inject any dependencies required by this bean -->
    </bean>

    <bean id="movieRecommender" class="example.MovieRecommender"/>
```

```
</beans>
```

In Section 5.10, “Classpath scanning and managed components”, you will see an annotation-based alternative to providing the qualifier metadata in XML. Specifically, see Section 5.10.7, “Providing qualifier metadata with annotations”.

In some cases, it may be sufficient to use an annotation without a value. This may be useful when the annotation serves a more generic purpose and can be applied across several different types of dependencies. For example, you may provide an *offline* catalog that would be searched when no Internet connection is available. First define the simple annotation:

```
@Target({ElementType.FIELD, ElementType.PARAMETER})
@Retention(RetentionPolicy.RUNTIME)
@Qualifier
public @interface Offline {

}
```

Then add the annotation to the field or property to be autowired:

```
public class MovieRecommender {

  @Autowired
  @Offline
  private MovieCatalog offlineCatalog;

  // ...
}
```

Now the bean definition only needs a qualifier `type`:

```
<bean class="example.SimpleMovieCatalog">
  <qualifier type="Offline"/>
```

```
  <!-- inject any dependencies required by this bean -->
</bean>
```

You can also define custom qualifier annotations that accept named attributes in addition to or instead of the simple `value` attribute. If multiple attribute values are then specified on a field or parameter to be autowired, a bean definition must match *all* such attribute values to be considered an autowire candidate. As an example, consider the following annotation definition:

```
@Target({ElementType.FIELD, ElementType.PARAMETER})
@Retention(RetentionPolicy.RUNTIME)
@Qualifier
public @interface MovieQualifier {

  String genre();

  Format format();
}
```

In this case `Format` is an enum:

```
public enum Format {

  VHS, DVD, BLURAY
}
```

The fields to be autowired are annotated with the custom qualifier and include values for both attributes: `genre` and `format`.

```
public class MovieRecommender {

  @Autowired
  @MovieQualifier(format=Format.VHS, genre="Action")
  private MovieCatalog actionVhsCatalog;

  @Autowired
  @MovieQualifier(format=Format.VHS, genre="Comedy")
```

```
    private MovieCatalog comedyVhsCatalog;

    @Autowired
    @MovieQualifier(format=Format.DVD, genre="Action")
    private MovieCatalog actionDvdCatalog;

    @Autowired
    @MovieQualifier(format=Format.BLURAY, genre="Comedy")
    private MovieCatalog comedyBluRayCatalog;

    // ...
}
```

Finally, the bean definitions should contain matching qualifier values. This example also demonstrates that bean *meta* attributes may be used instead of the `<qualifier/>` sub-elements. If available, the `<qualifier/>` and its attributes take precedence, but the autowiring mechanism falls back on the values provided within the `<meta/>` tags if no such qualifier is present, as in the last two bean definitions in the following example.

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

  <context:annotation-config/>

  <bean class="example.SimpleMovieCatalog">
      <qualifier type="MovieQualifier">
          <attribute key="format" value="VHS"/>
          <attribute key="genre" value="Action"/>
      </qualifier>
```

```
        <!-- inject any dependencies required by this bean -->
    </bean>

    <bean class="example.SimpleMovieCatalog">
        <qualifier type="MovieQualifier">
            <attribute key="format" value="VHS"/>
            <attribute key="genre" value="Comedy"/>
        </qualifier>
        <!-- inject any dependencies required by this bean -->
    </bean>

    <bean class="example.SimpleMovieCatalog">
        <meta key="format" value="DVD"/>
        <meta key="genre" value="Action"/>
        <!-- inject any dependencies required by this bean -->
    </bean>

    <bean class="example.SimpleMovieCatalog">
        <meta key="format" value="BLURAY"/>
        <meta key="genre" value="Comedy"/>
        <!-- inject any dependencies required by this bean -->
    </bean>

</beans>
```

5.9.4 `CustomAutowireConfigurer`

The `CustomAutowireConfigurer` is a `BeanFactoryPostProcessor` that enables you to register your own custom qualifier annotation types even if they are not annotated with Spring's `@Qualifier` annotation.

```
<bean id="customAutowireConfigurer"
      class="org.springframework.beans.factory.annotation.CustomAutowireConfigurer">
    <property name="customQualifierTypes">
        <set>
```

```
      <set>
        <value>example.CustomQualifier</value>
      </set>
    </property>
</bean>
```

The particular implementation of `AutowireCandidateResolver` that is activated for the application context depends on the Java version. In versions earlier than Java 5, the qualifier annotations are not supported, and therefore autowire candidates are solely determined by the `autowire-candidate` value of each bean definition as well as by any `default-autowire-candidates` pattern(s) available on the `<beans/>` element. In Java 5 or later, the presence of `@Qualifier` annotations and any custom annotations registered with the `CustomAutowireConfigurer` will also play a role.

Regardless of the Java version, when multiple beans qualify as autowire candidates, the determination of a "primary" candidate is the same: if exactly one bean definition among the candidates has a `primary` attribute set to `true`, it will be selected.

5.9.5 `@Resource`

Spring also supports injection using the JSR-250 `@Resource` annotation on fields or bean property setter methods. This is a common pattern in Java EE 5 and 6, for example in JSF 1.2 managed beans or JAX-WS 2.0 endpoints. Spring supports this pattern for Spring-managed objects as well.

`@Resource` takes a name attribute, and by default Spring interprets that value as the bean name to be injected. In other words, it follows *by-name* semantics, as demonstrated in this example:

```
public class SimpleMovieLister {

  private MovieFinder movieFinder;

  @Resource(name="myMovieFinder")
  public void setMovieFinder(MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
  }
}
```

If no name is specified explicitly, the default name is derived from the field name or setter method. In case of a field, it takes the field name; in case of a setter method, it takes the bean property name. So the following example is going to have the bean with name "movieFinder" injected into its setter method:

```
public class SimpleMovieLister {

  private MovieFinder movieFinder;

  @Resource
  public void setMovieFinder(MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
  }
}
```

The name provided with the annotation is resolved as a bean name by the `ApplicationContext` of which the `CommonAnnotationBeanPostProcessor` is aware. The names can be resolved through JNDI if you configure Spring's `SimpleJndiBeanFactory` explicitly. However, it is recommended that you rely on the default behavior and simply use Spring's JNDI lookup capabilities to preserve the level of indirection.

In the exclusive case of `@Resource` usage with no explicit name specified, and similar to `@Autowired`, `@Resource` finds a primary type match instead of a specific named bean and resolves well-known resolvable dependencies: the `BeanFactory`, `, ApplicationContext,` ` ResourceLoader, ApplicationEventPublisher`, and `MessageSource` interfaces.

Thus in the following example, the `customerPreferenceDao` field first looks for a bean named customerPreferenceDao, then falls back to a primary type match for the type `CustomerPreferenceDao`. The "context" field is injected based on the known resolvable dependency type `ApplicationContext`.

```
public class MovieRecommender {

  @Resource
```

```
    private CustomerPreferenceDao customerPreferenceDao;

    @Resource
    private ApplicationContext context;

    public MovieRecommender() {
    }

    // ...
}
```

5.9.6 `@PostConstruct` and `@PreDestroy`

The `CommonAnnotationBeanPostProcessor` not only recognizes the `@Resource` annotation but also the JSR-250 *lifecycle* annotations. Introduced in Spring 2.5, the support for these annotations offers yet another alternative to those described in initialization callbacks and destruction callbacks. Provided that the `CommonAnnotationBeanPostProcessor` is registered within the Spring `ApplicationContext`, a method carrying one of these annotations is invoked at the same point in the lifecycle as the corresponding Spring lifecycle interface method or explicitly declared callback method. In the example below, the cache will be pre-populated upon initialization and cleared upon destruction.

```
public class CachingMovieLister {

    @PostConstruct
    public void populateMovieCache() {
        // populates the movie cache upon initialization...
    }

    @PreDestroy
    public void clearMovieCache() {
        // clears the movie cache upon destruction...
    }
}
```

For details about the effects of combining various lifecycle mechanisms, see the section called “Combining lifecycle mechanisms”.

5.10 Classpath scanning and managed components

Most examples in this chapter use XML to specify the configuration metadata that produces each `BeanDefinition` within the Spring container. The previous section (Section 5.9, “Annotation-based container configuration”) demonstrates how to provide a lot of the configuration metadata through source-level annotations. Even in those examples, however, the "base" bean definitions are explicitly defined in the XML file, while the annotations only drive the dependency injection. This section describes an option for implicitly detecting the *candidate components* by scanning the classpath. Candidate components are classes that match against a filter criteria and have a corresponding bean definition registered with the container. This removes the need to use XML to perform bean registration, instead you can use annotations (for example @Component), AspectJ type expressions, or your own custom filter criteria to select which classes will have bean definitions registered with the container.

Starting with Spring 3.0, many features provided by the Spring JavaConfig project are part of the core Spring Framework. This allows you to define beans using Java rather than using the traditional XML files. Take a look at the `@Configuration`, `@Bean`, `@Import`, and `@DependsOn` annotations for examples of how to use these new features.

5.10.1 `@Component` and further stereotype annotations

In Spring 2.0 and later, the `@Repository` annotation is a marker for any class that fulfills the role or *stereotype* (also known as Data Access Object or DAO) of a repository. Among the uses of this marker is the automatic translation of exceptions as described in Section 15.2.2, “Exception translation”.

Spring 2.5 introduces further stereotype annotations: `@Component`, `@Service`, and `@Controller`. `@Component` is a generic stereotype for any Spring-managed component. `@Repository`, `@Service`, and `@Controller` are specializations of `@Component` for more specific use cases, for example, in the persistence, service, and presentation layers, respectively. Therefore, you can annotate your component classes with `@Component`, but by annotating them with `@Repository`, `@Service`, or `@Controller` instead, your classes are more properly suited for processing by tools or associating with aspects. For example, these stereotype annotations make ideal targets for pointcuts. It is also possible that `@Repository`, `@Service`, and `@Controller` may carry additional semantics in future releases of the Spring Framework. Thus, if you are choosing between using `@Component` or `@Service` for your service layer, `@Service` is clearly the better choice. Similarly, as stated above, `@Repository` is already supported as a marker for automatic exception translation in your persistence layer.

5.10.2 Automatically detecting classes and registering bean definitions

Spring can automatically detect stereotyped classes and register corresponding `BeanDefinition`s with the `ApplicationContext`. For example, the following two classes are eligible for such autodetection:

```
@Service
public class SimpleMovieLister {

  private MovieFinder movieFinder;

  @Autowired
  public SimpleMovieLister(MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
  }
}
```

```
@Repository
public class JpaMovieFinder implements MovieFinder {
  // implementation elided for clarity
}
```

To autodetect these classes and register the corresponding beans, you need to include the following element in XML, where the base-package element is a common parent package for the two classes. (Alternatively, you can specify a comma-separated list that includes the parent package of each class.)

```
<?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.xsd">

   <context:component-scan base-package="org.example"/>

</beans>
```

The use of `<context:component-scan>` implicitly enables the functionality of `<context:annotation-config>`. There is usually no need to include the `<context:annotation-config>` element when using `<context:component-scan>`.

The scanning of classpath packages requires the presence of corresponding directory entries in the classpath. When you build JARs with Ant, make sure that you do *not* activate the files-only switch of the JAR task.

Furthermore, the `AutowiredAnnotationBeanPostProcessor` and `CommonAnnotationBeanPostProcessor` are both included implicitly when you use the component-scan element. That means that the two components are autodetected *and* wired together - all without any bean configuration metadata provided in XML.

You can disable the registration of `AutowiredAnnotationBeanPostProcessor` and `CommonAnnotationBeanPostProcessor` by including the *annotation-config* attribute with a value of false.

5.10.3 Using filters to customize scanning

By default, classes annotated with `@Component`, `@Repository`, `@Service`, `@Controller`, or a custom annotation that itself is annotated with `@Component` are the only detected candidate components. However, you can modify and extend this behavior simply by applying custom filters. Add them as *include-filter* or *exclude-filter* sub-elements of the `component-scan` element. Each filter element requires the `type` and `expression` attributes. The following table describes the filtering options.

Table 5.5. Filter Types

Filter Type	Example Expression	Description
annotation	`org.example.SomeAnnotation`	An annotation to be present at the type level in target components.
assignable	`org.example.SomeClass`	A class (or interface) that the target components are assignable to (extend/implement).
aspectj	`org.example..*Service+`	An AspectJ type expression to be matched by the target components.
regex	`org\.example\.Default.*`	A regex expression to be matched by the target components class names.
custom	`org.example.MyTypeFilter`	A custom implementation of the `org.springframework.core.type .TypeFilter` interface.

The following example shows the XML configuration ignoring all `@Repository` annotations and using "stub" repositories instead.

```
<beans>

  <context:component-scan base-package="org.example">
    <context:include-filter type="regex" expression=".*Stub.*Repository"/>

    <context:exclude-filter type="annotation"
                            expression="org.springframework.stereotype.Repository"/>
  </context:component-scan>

</beans>
```

You can also disable the default filters by providing *use-default-filters="false"* as an attribute of the <component-scan/> element. This will in effect disable automatic detection of classes annotated with `@Component`, `@Repository`, `@Service`, or `@Controller`.

5.10.4 Defining bean metadata within components

Spring components can also contribute bean definition metadata to the container. You do this with the same `@Bean` annotation used to define bean metadata within `@Configuration` annotated classes. Here is a simple example:

```
@Component
public class FactoryMethodComponent {

  @Bean @Qualifier("public")
  public TestBean publicInstance() {
      return new TestBean("publicInstance");
  }

  public void doWork() {
      // Component method implementation omitted
```

```
    }
}
```

This class is a Spring component that has application-specific code contained in its `doWork()` method. However, it also contributes a bean definition that has a factory method referring to the method `publicInstance()`. The `@Bean` annotation identifies the factory method and other bean definition properties, such as a qualifier value through the `@Qualifier` annotation. Other method level annotations that can be specified are `@Scope`, `@Lazy`, and custom qualifier annotations. Autowired fields and methods are supported as previously discussed, with additional support for autowiring of `@Bean` methods:

```
@Component
public class FactoryMethodComponent {

  private static int i;

  @Bean @Qualifier("public")
  public TestBean publicInstance() {
      return new TestBean("publicInstance");
  }

  // use of a custom qualifier and autowiring of method parameters

  @Bean
  protected TestBean protectedInstance(@Qualifier("public") TestBean spouse,
                                       @Value("#{privateInstance.age}") String country) {
      TestBean tb = new TestBean("protectedInstance", 1);
      tb.setSpouse(tb);
      tb.setCountry(country);
      return tb;
  }

  @Bean @Scope(BeanDefinition.SCOPE_SINGLETON)
  private TestBean privateInstance() {
      return new TestBean("privateInstance", i++);
  }
```

```
  @Bean @Scope(value = WebApplicationContext.SCOPE_SESSION,
               proxyMode = ScopedProxyMode.TARGET_CLASS)
  public TestBean requestScopedInstance() {
      return new TestBean("requestScopedInstance", 3);
  }
}
```

The example autowires the `String` method parameter `country` to the value of the `Age` property on another bean named `privateInstance`. A Spring Expression Language element defines the value of the property through the notation `#{ <expression> }`. For `@Value` annotations, an expression resolver is preconfigured to look for bean names when resolving expression text.

The `@Bean` methods in a Spring component are processed differently than their counterparts inside a Spring `@Configuration` class. The difference is that `@Component` classes are not enhanced with CGLIB to intercept the invocation of methods and fields. CGLIB proxying is the means by which invoking methods or fields within `@Configuration` classes `@Bean` methods create bean metadata references to collaborating objects. Methods are *not* invoked with normal Java semantics. In contrast, calling a method or field within a `@Component` classes `@Bean` method *has* standard Java semantics.

5.10.5 Naming autodetected components

When a component is autodetected as part of the scanning process, its bean name is generated by the `BeanNameGenerator` strategy known to that scanner. By default, any Spring stereotype annotation (`@Component`, `@Repository`, `@Service`, and `@Controller`) that contains a `name` value will thereby provide that name to the corresponding bean definition.

If such an annotation contains no `name` value or for any other detected component (such as those discovered by custom filters), the default bean name generator returns the uncapitalized non-qualified class name. For example, if the following two components were detected, the names would be myMovieLister and movieFinderImpl:

```
@Service("myMovieLister")
public class SimpleMovieLister {
```

```
  // ...
}
```

```
@Repository
public class MovieFinderImpl implements MovieFinder {
  // ...
}
```

If you do not want to rely on the default bean-naming strategy, you can provide a custom bean-naming strategy. First, implement the `BeanNameGenerator` interface, and be sure to include a default no-arg constructor. Then, provide the fully-qualified class name when configuring the scanner:

```
<beans>

   <context:component-scan base-package="org.example"
                           name-generator="org.example.MyNameGenerator" />

</beans>
```

As a general rule, consider specifying the name with the annotation whenever other components may be making explicit references to it. On the other hand, the auto-generated names are adequate whenever the container is responsible for wiring.

5.10.6 Providing a scope for autodetected components

As with Spring-managed components in general, the default and most common scope for autodetected components is singleton. However, sometimes you need other scopes, which Spring 2.5 provides with a new `@Scope` annotation. Simply provide the name of the scope within the annotation:

```
@Scope("prototype")
@Repository
```

```
public class MovieFinderImpl implements MovieFinder {
  // ...
}
```

To provide a custom strategy for scope resolution rather than relying on the annotation-based approach, implement the `ScopeMetadataResolver` interface, and be sure to include a default no-arg constructor. Then, provide the fully-qualified class name when configuring the scanner:

```
<beans>

   <context:component-scan base-package="org.example"
                           scope-resolver="org.example.MyScopeResolver" />

</beans>
```

When using certain non-singleton scopes, it may be necessary to generate proxies for the scoped objects. The reasoning is described in the section called “Scoped beans as dependencies”. For this purpose, a *scoped-proxy* attribute is available on the component-scan element. The three possible values are: no, interfaces, and targetClass. For example, the following configuration will result in standard JDK dynamic proxies:

```
<beans>

   <context:component-scan base-package="org.example"
                           scoped-proxy="interfaces" />

</beans>
```

5.10.7 Providing qualifier metadata with annotations

The `@Qualifier` annotation is discussed in Section 5.9.3, “Fine-tuning annotation-based autowiring with qualifiers”. The examples in that section demonstrate the use of the `@Qualifier` annotation and custom qualifier annotations to provide fine-grained control when you resolve autowire candidates. Because those examples were based on XML bean definitions, the qualifier metadata was provided on the candidate bean definitions using the `qualifier` or `meta` sub-elements of the `bean` element in the XML. When relying upon classpath scanning for autodetection of components, you provide the qualifier metadata with type-level annotations on the candidate class. The following three examples demonstrate this technique:

```
@Component
@Qualifier("Action")
public class ActionMovieCatalog implements MovieCatalog {
  // ...
}
```

```
@Component
@Genre("Action")
public class ActionMovieCatalog implements MovieCatalog {
  // ...
}
```

```
@Component
@Offline
public class CachingMovieCatalog implements MovieCatalog {
  // ...
}
```

As with most annotation-based alternatives, keep in mind that the annotation metadata is bound to the class definition itself, while the use of XML allows for multiple beans *of the same type* to provide variations in their qualifier metadata, because that metadata is provided per-instance rather than per-class.

5.11 Using JSR 330 Standard Annotations

Starting with Spring 3.0, Spring offers support for JSR-330 standard annotations (Dependency Injection). Those annotations are scanned in the same way as the Spring annotations. You just need to have the relevant jars in your classpath.

> If you are using Maven, the `javax.inject` artifact is available in the standard Maven repository (http://repo1.maven.org/maven2/javax/inject/javax.inject/1/). You can add the following dependency to your file pom.xml:
>
> ```
> <dependency>
>     <groupId>javax.inject</groupId>
>     <artifactId>javax.inject</artifactId>
>     <version>1</version>
> </dependency>
> ```

5.11.1 Dependency Injection with `@Inject` and `@Named`

Instead of `@Autowired`, `@javax.inject.Inject` may be used as follows:

```
import javax.inject.Inject;

public class SimpleMovieLister {

  private MovieFinder movieFinder;

  @Inject
  public void setMovieFinder(MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
  }
  // ...
}
```

As with `@Autowired`, it is possible to use `@Inject` at the class-level, field-level, method-level and constructor-argument level. If you would like to use a qualified name for the dependency that should be injected, you should use the `@Named` annotation as follows:

```
import javax.inject.Inject;
import javax.inject.Named;

public class SimpleMovieLister {

  private MovieFinder movieFinder;

  @Inject
  public void setMovieFinder(@Named("main") MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
  }
  // ...
}
```

5.11.2 `@Named`: a standard equivalent to the `@Component` annotation

Instead of `@Component`, `@javax.inject.Named` may be used as follows:

```
import javax.inject.Inject;
import javax.inject.Named;

@Named("movieListener")
public class SimpleMovieLister {

  private MovieFinder movieFinder;

  @Inject
  public void setMovieFinder(MovieFinder movieFinder) {
      this.movieFinder = movieFinder;
```

```
    }
    // ...
}
```

It is very common to use `@Component` without specifying a name for the component. `@Named` can be used in a similar fashion:

```
import javax.inject.Inject;
import javax.inject.Named;

@Named
public class SimpleMovieLister {

    private MovieFinder movieFinder;

    @Inject
    public void setMovieFinder(MovieFinder movieFinder) {
        this.movieFinder = movieFinder;
    }
    // ...
}
```

When using `@Named`, it is possible to use component-scanning in the exact same way as when using Spring annotations:

```
<beans>
    <context:component-scan base-package="org.example"/>
</beans>
```

5.11.3 Limitations of the standard approach

When working with standard annotations, it is important to know that some significant features are not available as shown in the table below:

Table 5.6. Spring annotations vs. standard annotations

Spring	javax.inject.*	javax.inject restrictions / comments
@Autowired	@Inject	@Inject has no 'required' attribute
@Component	@Named	—
@Scope("singleton")	@Singleton	The JSR-330 default scope is like Spring's `prototype`. However, in order to keep it consistent with Spring's general defaults, a JSR-330 bean declared in the Spring container is a `singleton` by default. In order to use a scope other than `singleton`, you should use Spring's `@Scope` annotation. `javax.inject` also provides a @Scope annotation. Nevertheless, this one is only intended to be used for creating your own annotations.
@Qualifier	@Named	—
@Value	—	no equivalent
@Required	—	no equivalent
@Lazy	—	no equivalent

5.12 Java-based container configuration

5.12.1 Basic concepts: `@Bean` and `@Configuration`

Full @Configuration vs 'lite' @Beans mode?

When `@Bean` methods are declared within classes that are *not* annotated with `@Configuration` they are referred to as being processed in a 'lite' mode. For example, bean methods declared in a `@Component` or even in a *plain old class* will be considered 'lite'.

Unlike full `@Configuration`, lite `@Bean` methods cannot easily declare inter-bean dependencies. Usually one `@Bean` method should not invoke another `@Bean` method when operating in 'lite' mode.

Only using `@Bean` methods within `@Configuration` classes is a recommended approach of ensuring that 'full' mode is always used. This will prevent the same `@Bean` method from accidentally being invoked multiple times and helps to reduce subtle bugs that can be hard to track down when operating in 'lite' mode.

The central artifacts in Spring's new Java-configuration support are `@Configuration`-annotated classes and `@Bean`-annotated methods.

The `@Bean` annotation is used to indicate that a method instantiates, configures and initializes a new object to be managed by the Spring IoC container. For those familiar with Spring's `<beans/>` XML configuration the `@Bean` annotation plays the same role as the `<bean/>` element. You can use `@Bean` annotated methods with any Spring `@Component`, however, they are most often used with `@Configuration` beans.

Annotating a class with `@Configuration` indicates that its primary purpose is as a source of bean definitions. Furthermore, `@Configuration` classes allow inter-bean dependencies to be defined by simply calling other `@Bean` methods in the same class. The simplest possible `@Configuration` class would read as follows:

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

The `AppConfig` class above would be equivalent to the following Spring `<beans/>` XML:

```
<beans>
  <bean id="myService" class="com.acme.services.MyServiceImpl"/>
</beans>
```

The `@Bean` and `@Configuration` annotations will be discussed in depth in the sections below. First, however, we'll cover the various ways of creating a spring container using Java-based configuration.

5.12.2 Instantiating the Spring container using `AnnotationConfigApplicationContext`

The sections below document Spring's `AnnotationConfigApplicationContext`, new in Spring 3.0. This versatile `ApplicationContext` implementation is capable of accepting not only `@Configuration` classes as input, but also plain `@Component` classes and classes annotated with JSR-330 metadata.

When `@Configuration` classes are provided as input, the `@Configuration` class itself is registered as a bean definition, and all declared `@Bean` methods within the class are also registered as bean definitions.

When `@Component` and JSR-330 classes are provided, they are registered as bean definitions, and it is assumed that DI metadata such as `@Autowired` or `@Inject` are used within those classes where necessary.

Simple construction

In much the same way that Spring XML files are used as input when instantiating a `ClassPathXmlApplicationContext`, `@Configuration` classes may be used as input when instantiating an `AnnotationConfigApplicationContext`. This allows for completely XML-free usage of the Spring container:

```
public static void main(String[] args) {
  ApplicationContext ctx = new AnnotationConfigApplicationContext(AppConfig.class);
  MyService myService = ctx.getBean(MyService.class);
  myService.doStuff();
}
```

As mentioned above, `AnnotationConfigApplicationContext` is not limited to working only with `@Configuration` classes. Any `@Component` or JSR-330 annotated class may be supplied as input to the constructor. For example:

```
public static void main(String[] args) {
  ApplicationContext ctx = new AnnotationConfigApplicationContext(MyServiceImpl.class, Dependency1.class, Depe
  MyService myService = ctx.getBean(MyService.class);
  myService.doStuff();
}
```

The above assumes that `MyServiceImpl`, `Dependency1` and `Dependency2` use Spring dependency injection annotations such as `@Autowired`.

Building the container programmatically using `register(Class<?>...)`

An `AnnotationConfigApplicationContext` may be instantiated using a no-arg constructor and then configured using the `register()` method. This approach is particularly useful when programmatically building an `AnnotationConfigApplicationContext`.

```
public static void main(String[] args) {
  AnnotationConfigApplicationContext ctx = new AnnotationConfigApplicationContext();
  ctx.register(AppConfig.class, OtherConfig.class);
  ctx.register(AdditionalConfig.class);
  ctx.refresh();
  MyService myService = ctx.getBean(MyService.class);
  myService.doStuff();
}
```

Enabling component scanning with `scan(String...)`

Experienced Spring users will be familiar with the following commonly-used XML declaration from Spring's `context:` namespace

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

In the example above, the `com.acme` package will be scanned, looking for any `@Component`-annotated classes, and those classes will be registered as Spring bean definitions within the container. `AnnotationConfigApplicationContext` exposes the `scan(String...)` method to allow for the same component-scanning functionality:

```
public static void main(String[] args) {
  AnnotationConfigApplicationContext ctx = new AnnotationConfigApplicationContext();
  ctx.scan("com.acme");
  ctx.refresh();
  MyService myService = ctx.getBean(MyService.class);
}
```

Remember that `@Configuration` classes are meta-annotated with `@Component`, so they are candidates for component-scanning! In the example above, assuming that `AppConfig` is declared within the `com.acme` package (or any package underneath), it will be picked up during the call to `scan()`, and upon `refresh()` all its `@Bean` methods will be processed and registered as bean definitions within the container.

Support for web applications with `AnnotationConfigWebApplicationContext`

A `WebApplicationContext` variant of `AnnotationConfigApplicationContext` is available with `AnnotationConfigWebApplicationContext`. This implementation may be used when configuring the Spring `ContextLoaderListener` servlet listener, Spring MVC `DispatcherServlet`, etc. What follows is a `web.xml` snippet that configures a typical Spring MVC web application. Note the use of the `contextClass` context-param and init-param:

```
<web-app>
  <!-- Configure ContextLoaderListener to use AnnotationConfigWebApplicationContext
       instead of the default XmlWebApplicationContext -->
  <context-param>
```

```
<context-param>
    <param-name>contextClass</param-name>
    <param-value>
        org.springframework.web.context.support.AnnotationConfigWebApplicationContext
    </param-value>
</context-param>

<!-- Configuration locations must consist of one or more comma- or space-delimited
     fully-qualified @Configuration classes. Fully-qualified packages may also be
     specified for component-scanning -->
<context-param>
    <param-name>contextConfigLocation</param-name>
    <param-value>com.acme.AppConfig</param-value>
</context-param>

<!-- Bootstrap the root application context as usual using ContextLoaderListener -->
<listener>
    <listener-class>org.springframework.web.context.ContextLoaderListener</listener-class>
</listener>

<!-- Declare a Spring MVC DispatcherServlet as usual -->
<servlet>
    <servlet-name>dispatcher</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <!-- Configure DispatcherServlet to use AnnotationConfigWebApplicationContext
         instead of the default XmlWebApplicationContext -->
    <init-param>
        <param-name>contextClass</param-name>

        <param-value>
            org.springframework.web.context.support.AnnotationConfigWebApplicationContext
        </param-value>
    </init-param>
    <!-- Again, config locations must consist of one or more comma- or space-delimited
         and fully-qualified @Configuration classes -->
    <init-param>
```

```
            <param-name>contextConfigLocation</param-name>
            <param-value>com.acme.web.MvcConfig</param-value>
        </init-param>
    </servlet>

    <!-- map all requests for /app/* to the dispatcher servlet -->
    <servlet-mapping>
        <servlet-name>dispatcher</servlet-name>
        <url-pattern>/app/*</url-pattern>
    </servlet-mapping>
</web-app>
```

5.12.3 Using the `@Bean` annotation

`@Bean` is a method-level annotation and a direct analog of the XML `<bean/>` element. The annotation supports some of the attributes offered by `<bean/>`, such as: `init-method`, `destroy-method`, `autowiring` and `name`.

You can use the `@Bean` annotation in a `@Configuration`-annotated or in a `@Component`-annotated class.

Declaring a bean

To declare a bean, simply annotate a method with the `@Bean` annotation. You use this method to register a bean definition within an `ApplicationContext` of the type specified as the method's return value. By default, the bean name will be the same as the method name. The following is a simple example of a `@Bean` method declaration:

```
@Configuration
public class AppConfig {

  @Bean
  public TransferService transferService() {
      return new TransferServiceImpl();
  }
```

```
}
```

The preceding configuration is exactly equivalent to the following Spring XML:

```
<beans>
  <bean id="transferService" class="com.acme.TransferServiceImpl"/>
</beans>
```

Both declarations make a bean named `transferService` available in the `ApplicationContext`, bound to an object instance of type `TransferServiceImpl`:

```
transferService -> com.acme.TransferServiceImpl
```

Receiving lifecycle callbacks

Any classes defined with the `@Bean` annotation support the regular lifecycle callbacks and can use the `@PostConstruct` and `@PreDestroy` annotations from JSR-250, see JSR-250 annotations for further details.

The regular Spring lifecycle callbacks are fully supported as well. If a bean implements `InitializingBean`, `DisposableBean`, or `Lifecycle`, their respective methods are called by the container.

The standard set of `*Aware` interfaces such as `BeanFactoryAware`, `BeanNameAware`, `MessageSourceAware`, `ApplicationContextAware`, and so on are also fully supported.

The `@Bean` annotation supports specifying arbitrary initialization and destruction callback methods, much like Spring XML's `init-method` and `destroy-method` attributes on the `bean` element:

```
public class Foo {
  public void init() {
      // initialization logic
  }
```

```
}

public class Bar {
  public void cleanup() {
      // destruction logic
  }
}

@Configuration
public class AppConfig {
  @Bean(initMethod = "init")
  public Foo foo() {
      return new Foo();
  }
  @Bean(destroyMethod = "cleanup")
  public Bar bar() {
      return new Bar();
  }
}
```

Of course, in the case of `Foo` above, it would be equally as valid to call the `init()` method directly during construction:

```
@Configuration
public class AppConfig {
  @Bean
  public Foo foo() {
      Foo foo = new Foo();
      foo.init();
      return foo;
  }

  // ...
}
```

When you work directly in Java, you can do anything you like with your objects and do not always need to rely on the container lifecycle!

Specifying bean scope

Using the `@Scope` annotation

You can specify that your beans defined with the `@Bean` annotation should have a specific scope. You can use any of the standard scopes specified in the Bean Scopes section.

The default scope is `singleton`, but you can override this with the `@Scope` annotation:

```
@Configuration
public class MyConfiguration {
  @Bean
  @Scope("prototype")
  public Encryptor encryptor() {
      // ...
  }
}
```

`@Scope and scoped-proxy`

Spring offers a convenient way of working with scoped dependencies through scoped proxies. The easiest way to create such a proxy when using the XML configuration is the `<aop:scoped-proxy/>` element. Configuring your beans in Java with a @Scope annotation offers equivalent support with the proxyMode attribute. The default is no proxy (`ScopedProxyMode.NO`), but you can specify `ScopedProxyMode.TARGET_CLASS` or `ScopedProxyMode.INTERFACES`.

If you port the scoped proxy example from the XML reference documentation (see preceding link) to our `@Bean` using Java, it would look like the following:

```
// an HTTP Session-scoped bean exposed as a proxy
@Bean
@Scope(value = "session", proxyMode = ScopedProxyMode.TARGET_CLASS)
public UserPreferences userPreferences() {
 return new UserPreferences();
}

@Bean
public Service userService() {
 UserService service = new SimpleUserService();
 // a reference to the proxied userPreferences bean
 service.setUserPreferences(userPreferences());
 return service;
}
```

Customizing bean naming

By default, configuration classes use a `@Bean` method's name as the name of the resulting bean. This functionality can be overridden, however, with the `name` attribute.

```
@Configuration
public class AppConfig {

  @Bean(name = "myFoo")
  public Foo foo() {
      return new Foo();
  }

}
```

Bean aliasing

As discussed in Section 5.3.1, “Naming beans”, it is sometimes desirable to give a single bean multiple names, otherwise known as *bean aliasing*. The `name` attribute of the `@Bean` annotation accepts a String array for this purpose.

```
@Configuration
public class AppConfig {

  @Bean(name = { "dataSource", "subsystemA-dataSource", "subsystemB-dataSource" })
  public DataSource dataSource() {
      // instantiate, configure and return DataSource bean...
  }

}
```

5.12.4 Using the `@Configuration` annotation

`@Configuration` is a class-level annotation indicating that an object is a source of bean definitions. `@Configuration` classes declare beans via public `@Bean` annotated methods. Calls to `@Bean` methods on `@Configuration` classes can also be used to define inter-bean dependencies. See Section 5.12.1, “Basic concepts: `@Bean` and `@Configuration`” for a general introduction.

Injecting inter-bean dependencies

When `@Bean`s have dependencies on one another, expressing that dependency is as simple as having one bean method call another:

```
@Configuration
public class AppConfig {

  @Bean
  public Foo foo() {
      return new Foo(bar());
  }
```

```
    @Bean
    public Bar bar() {
        return new Bar();
    }

}
```

In the example above, the `foo` bean receives a reference to `bar` via constructor injection.

This method of declaring inter-bean dependencies only works when the `@Bean` method is declared within a `@Configuration` class. You cannot declare inter-bean dependencies using plain `@Component` classes.

Lookup method injection

As noted earlier, lookup method injection is an advanced feature that you should use rarely. It is useful in cases where a singleton-scoped bean has a dependency on a prototype-scoped bean. Using Java for this type of configuration provides a natural means for implementing this pattern.

```
public abstract class CommandManager {
  public Object process(Object commandState) {
      // grab a new instance of the appropriate Command interface
      Command command = createCommand();

      // set the state on the (hopefully brand new) Command instance
      command.setState(commandState);
      return command.execute();
  }

  // okay... but where is the implementation of this method?
  protected abstract Command createCommand();
}
```

Using Java-configuration support , you can create a subclass of `CommandManager` where the abstract `createCommand()` method is overridden in such a way that it looks up a new (prototype) command object:

```
@Bean
@Scope("prototype")
public AsyncCommand asyncCommand() {
  AsyncCommand command = new AsyncCommand();
  // inject dependencies here as required
  return command;
}

@Bean
public CommandManager commandManager() {
  // return new anonymous implementation of CommandManager with command() overridden
  // to return a new prototype Command object
  return new CommandManager() {
      protected Command createCommand() {
          return asyncCommand();
      }
  }
}
```

Further information about how Java-based configuration works internally

The following example shows a `@Bean` annotated method being called twice:

```
@Configuration
public class AppConfig {

  @Bean
  public ClientService clientService1() {
    ClientServiceImpl clientService = new ClientServiceImpl();
    clientService.setClientDao(clientDao());
    return clientService;
```

```
  }
  @Bean
  public ClientService clientService2() {
    ClientServiceImpl clientService = new ClientServiceImpl();
    clientService.setClientDao(clientDao());
    return clientService;
  }

  @Bean
  public ClientDao clientDao() {
    return new ClientDaoImpl();
  }
}
```

`clientDao()` has been called once in `clientService1()` and once in `clientService2()`. Since this method creates a new instance of `ClientDaoImpl` and returns it, you would normally expect having 2 instances (one for each service). That definitely would be problematic: in Spring, instantiated beans have a `singleton` scope by default. This is where the magic comes in: All `@Configuration` classes are subclassed at startup-time with `CGLIB`. In the subclass, the child method checks the container first for any cached (scoped) beans before it calls the parent method and creates a new instance. Note that as of Spring 3.2, it is no longer necessary to add CGLIB to your classpath because CGLIB classes have been repackaged under org.springframework and included directly within the spring-core JAR.

> The behavior could be different according to the scope of your bean. We are talking about singletons here.

> There are a few restrictions due to the fact that CGLIB dynamically adds features at startup-time:
> - Configuration classes should not be final
> - They should have a constructor with no arguments

5.12.5 Composing Java-based configurations

Using the `@Import` annotation

Much as the `<import/>` element is used within Spring XML files to aid in modularizing configurations, the `@Import` annotation allows for loading `@Bean` definitions from another configuration class:

```
@Configuration
public class ConfigA {
  public @Bean A a() { return new A(); }
}

@Configuration
@Import(ConfigA.class)
public class ConfigB {
  public @Bean B b() { return new B(); }
}
```

Now, rather than needing to specify both `ConfigA.class` and `ConfigB.class` when instantiating the context, only `ConfigB` needs to be supplied explicitly:

```
public static void main(String[] args) {
  ApplicationContext ctx = new AnnotationConfigApplicationContext(ConfigB.class);

  // now both beans A and B will be available...
  A a = ctx.getBean(A.class);
  B b = ctx.getBean(B.class);
}
```

This approach simplifies container instantiation, as only one class needs to be dealt with, rather than requiring the developer to remember a potentially large number of `@Configuration` classes during construction.

Injecting dependencies on imported `@Bean` definitions

The example above works, but is simplistic. In most practical scenarios, beans will have dependencies on one another across configuration classes. When using XML, this is not an issue, per se, because there is no compiler involved, and one can simply declare `ref="someBean"` and trust that Spring will work it out during container initialization. Of course, when using `@Configuration` classes, the Java compiler places constraints on the configuration model, in that references to other beans must be valid Java syntax.

Fortunately, solving this problem is simple. Remember that `@Configuration` classes are ultimately just another bean in the container - this means that they can take advantage of `@Autowired` injection metadata just like any other bean!

Let's consider a more real-world scenario with several `@Configuration` classes, each depending on beans declared in the others:

```
@Configuration
public class ServiceConfig {
  private @Autowired AccountRepository accountRepository;

  public @Bean TransferService transferService() {
      return new TransferServiceImpl(accountRepository);
  }
}

@Configuration
public class RepositoryConfig {
  private @Autowired DataSource dataSource;

  public @Bean AccountRepository accountRepository() {
      return new JdbcAccountRepository(dataSource);
  }
}

@Configuration
@Import({ServiceConfig.class, RepositoryConfig.class})
```

```
public class SystemTestConfig {
  public @Bean DataSource dataSource() { /* return new DataSource */ }
}

public static void main(String[] args) {
  ApplicationContext ctx = new AnnotationConfigApplicationContext(SystemTestConfig.class);
  // everything wires up across configuration classes...
  TransferService transferService = ctx.getBean(TransferService.class);
  transferService.transfer(100.00, "A123", "C456");
}
```

Fully-qualifying imported beans for ease of navigation

In the scenario above, using `@Autowired` works well and provides the desired modularity, but determining exactly where the autowired bean definitions are declared is still somewhat ambiguous. For example, as a developer looking at `ServiceConfig`, how do you know exactly where the `@Autowired AccountRepository` bean is declared? It's not explicit in the code, and this may be just fine. Remember that the SpringSource Tool Suite provides tooling that can render graphs showing how everything is wired up - that may be all you need. Also, your Java IDE can easily find all declarations and uses of the `AccountRepository` type, and will quickly show you the location of `@Bean` methods that return that type.

In cases where this ambiguity is not acceptable and you wish to have direct navigation from within your IDE from one `@Configuration` class to another, consider autowiring the configuration classes themselves:

```
@Configuration
public class ServiceConfig {
  private @Autowired RepositoryConfig repositoryConfig;

  public @Bean TransferService transferService() {
      // navigate 'through' the config class to the @Bean method!
      return new TransferServiceImpl(repositoryConfig.accountRepository());
  }
}
```

In the situation above, it is completely explicit where `AccountRepository` is defined. However, `ServiceConfig` is now tightly coupled to `RepositoryConfig`; that's the tradeoff. This tight coupling can be somewhat mitigated by using interface-based or abstract class-based `@Configuration` classes. Consider the following:

```
@Configuration
public class ServiceConfig {
  private @Autowired RepositoryConfig repositoryConfig;

  public @Bean TransferService transferService() {
      return new TransferServiceImpl(repositoryConfig.accountRepository());
  }
}

@Configuration
public interface RepositoryConfig {
  @Bean AccountRepository accountRepository();
}

@Configuration
public class DefaultRepositoryConfig implements RepositoryConfig {
  public @Bean AccountRepository accountRepository() {
      return new JdbcAccountRepository(...);
  }
}

@Configuration
@Import({ServiceConfig.class, DefaultRepositoryConfig.class}) // import the concrete config!
public class SystemTestConfig {
  public @Bean DataSource dataSource() { /* return DataSource */ }
}

public static void main(String[] args) {
  ApplicationContext ctx = new AnnotationConfigApplicationContext(SystemTestConfig.class);
  TransferService transferService = ctx.getBean(TransferService.class);
```

```
    transferService.transfer(100.00, "A123", "C456");
}
```

Now `ServiceConfig` is loosely coupled with respect to the concrete `DefaultRepositoryConfig`, and built-in IDE tooling is still useful: it will be easy for the developer to get a type hierarchy of `RepositoryConfig` implementations. In this way, navigating `@Configuration` classes and their dependencies becomes no different than the usual process of navigating interface-based code.

Combining Java and XML configuration

Spring's `@Configuration` class support does not aim to be a 100% complete replacement for Spring XML. Some facilities such as Spring XML namespaces remain an ideal way to configure the container. In cases where XML is convenient or necessary, you have a choice: either instantiate the container in an "XML-centric" way using, for example, `ClassPathXmlApplicationContext`, or in a "Java-centric" fashion using `AnnotationConfigApplicationContext` and the `@ImportResource` annotation to import XML as needed.

XML-centric use of `@Configuration` classes

It may be preferable to bootstrap the Spring container from XML and include `@Configuration` classes in an ad-hoc fashion. For example, in a large existing codebase that uses Spring XML, it will be easier to create `@Configuration` classes on an as-needed basis and include them from the existing XML files. Below you'll find the options for using `@Configuration` classes in this kind of "XML-centric" situation.

Declaring `@Configuration` classes as plain Spring `<bean/>` elements

Remember that `@Configuration` classes are ultimately just bean definitions in the container. In this example, we create a `@Configuration` class named `AppConfig` and include it within `system-test-config.xml` as a `<bean/>`definition. Because `<context:annotation-config/>` is switched on, the container will recognize the `@Configuration` annotation, and process the `@Bean` methods declared in `AppConfig` properly.

```
@Configuration
public class AppConfig {
  private @Autowired DataSource dataSource;

  public @Bean AccountRepository accountRepository() {
      return new JdbcAccountRepository(dataSource);
  }

  public @Bean TransferService transferService() {
      return new TransferService(accountRepository());
  }
}
```

```
system-test-config.xml
<beans>
  <!-- enable processing of annotations such as @Autowired and @Configuration -->
  <context:annotation-config/>
  <context:property-placeholder location="classpath:/com/acme/jdbc.properties"/>

  <bean class="com.acme.AppConfig"/>

  <bean class="org.springframework.jdbc.datasource.DriverManagerDataSource">
      <property name="url" value="${jdbc.url}"/>
      <property name="username" value="${jdbc.username}"/>
      <property name="password" value="${jdbc.password}"/>
  </bean>
</beans>
```

```
jdbc.properties
jdbc.url=jdbc:hsqldb:hsql://localhost/xdb
jdbc.username=sa
jdbc.password=
```

```
public static void main(String[] args) {
  ApplicationContext ctx = new ClassPathXmlApplicationContext("classpath:/com/acme/system-test-config.xml");
  TransferService transferService = ctx.getBean(TransferService.class);
  // ...
}
```

In `system-test-config.xml` above, the `AppConfig<bean/>` does not declare an `id` element. While it would be acceptable to do so, it is unnecessary given that no other bean will ever refer to it, and it is unlikely that it will be explicitly fetched from the container by name. Likewise with the `DataSource` bean - it is only ever autowired by type, so an explicit bean id is not strictly required.

Using `<context:component-scan/>` to pick up `@Configuration` classes

Because `@Configuration` is meta-annotated with `@Component`, `@Configuration`-annotated classes are automatically candidates for component scanning. Using the same scenario as above, we can redefine `system-test-config.xml` to take advantage of component-scanning. Note that in this case, we don't need to explicitly declare `<context:annotation-config/>`, because `<context:component-scan/>` enables all the same functionality.

system-test-config.xml

```
<beans>
  <!-- picks up and registers AppConfig as a bean definition -->
  <context:component-scan base-package="com.acme"/>
  <context:property-placeholder location="classpath:/com/acme/jdbc.properties"/>

  <bean class="org.springframework.jdbc.datasource.DriverManagerDataSource">
      <property name="url" value="${jdbc.url}"/>
      <property name="username" value="${jdbc.username}"/>
      <property name="password" value="${jdbc.password}"/>
  </bean>
</beans>
```

`@Configuration` class-centric use of XML with `@ImportResource`

In applications where `@Configuration` classes are the primary mechanism for configuring the container, it will still likely be necessary to use at least some XML. In these scenarios, simply use `@ImportResource` and define only as much XML as is needed. Doing so achieves a "Java-centric" approach to configuring the container and keeps XML to a bare minimum.

```
@Configuration
@ImportResource("classpath:/com/acme/properties-config.xml")
public class AppConfig {
  private @Value("${jdbc.url}") String url;
  private @Value("${jdbc.username}") String username;
  private @Value("${jdbc.password}") String password;

  public @Bean DataSource dataSource() {
      return new DriverManagerDataSource(url, username, password);
  }
}
```

```
properties-config.xml
<beans>
  <context:property-placeholder location="classpath:/com/acme/jdbc.properties"/>
</beans>
```

```
jdbc.properties
jdbc.url=jdbc:hsqldb:hsql://localhost/xdb
jdbc.username=sa
jdbc.password=
```

```
public static void main(String[] args) {
  ApplicationContext ctx = new AnnotationConfigApplicationContext(AppConfig.class);
  TransferService transferService = ctx.getBean(TransferService.class);
  // ...
}
```

5.13 Registering a `LoadTimeWeaver`

The `LoadTimeWeaver` is used by Spring to dynamically transform classes as they are loaded into the Java virtual machine (JVM).

To enable load-time weaving add the `@EnableLoadTimeWeaving` to one of your `@Configuration` classes:

```
@Configuration
@EnableLoadTimeWeaving
public class AppConfig {

}
```

Alternatively for XML configuration use the `context:load-time-weaver` element:

```
<beans>
    <context:load-time-weaver/>
</beans>
```

Once configured for the `ApplicationContext`. Any bean within that `ApplicationContext` may implement `LoadTimeWeaverAware`, thereby receiving a reference to the load-time weaver instance. This is particularly useful in combination with Spring's JPA support where load-time weaving may be necessary for JPA class transformation. Consult the `LocalContainerEntityManagerFactoryBean` Javadoc for more detail. For more on AspectJ load-time weaving, see Section 9.8.4, “Load-time weaving with AspectJ in the Spring Framework”.

5.14 Additional Capabilities of the `ApplicationContext`

As was discussed in the chapter introduction, the `org.springframework.beans.factory` package provides basic functionality for managing and manipulating beans, including in a programmatic way. The `org.springframework.context` package adds the `ApplicationContext` interface, which extends the `BeanFactory` interface, in addition to extending other interfaces to provide additional functionality in a more *application framework-oriented style*. Many people use the `ApplicationContext` in a completely declarative fashion, not even creating it programmatically, but instead relying on support classes such as `ContextLoader` to automatically instantiate an `ApplicationContext` as part of the normal startup process of a J2EE web application.

To enhance `BeanFactory` functionality in a more framework-oriented style the context package also provides the following functionality:

- *Access to messages in i18n-style*, through the `MessageSource` interface.
- *Access to resources*, such as URLs and files, through the `ResourceLoader` interface.
- *Event publication* to beans implementing the `ApplicationListener` interface, through the use of the `ApplicationEventPublisher` interface.
- *Loading of multiple (hierarchical) contexts*, allowing each to be focused on one particular layer, such as the web layer of an application, through the `HierarchicalBeanFactory` interface.

5.14.1 Internationalization using `MessageSource`

The `ApplicationContext` interface extends an interface called `MessageSource`, and therefore provides internationalization (i18n) functionality. Spring also provides the interface `HierarchicalMessageSource`, which can resolve messages hierarchically. Together these interfaces provide the foundation upon which Spring effects message resolution. The methods defined on these interfaces include:

- `String getMessage(String code, Object[] args, String default, Locale loc)`: The basic method used to retrieve a message from the `MessageSource`. When no message is found for the specified locale, the default message is used. Any arguments passed in become replacement values, using the `MessageFormat` functionality provided by the standard library.
- `String getMessage(String code, Object[] args, Locale loc)`: Essentially the same as the previous method, but with one difference: no default message can be specified; if the message cannot be found, a `NoSuchMessageException` is thrown.
- `String getMessage(MessageSourceResolvable resolvable, Locale locale)`: All properties used in the preceding methods are also wrapped in a class named `MessageSourceResolvable`, which you can use with this method.

When an `ApplicationContext` is loaded, it automatically searches for a `MessageSource` bean defined in the context. The bean must have the name `messageSource`. If such a bean is found, all calls to the preceding methods are delegated to the message source. If no message source is found, the `ApplicationContext` attempts to find a parent containing a bean with the same name. If it does, it uses that bean as the `MessageSource`. If the `ApplicationContext` cannot find any source for messages, an empty `DelegatingMessageSource` is instantiated in order to be able to accept calls to the methods defined above.

Spring provides two `MessageSource` implementations, `ResourceBundleMessageSource` and `StaticMessageSource`. Both implement `HierarchicalMessageSource` in order to do nested messaging. The `StaticMessageSource` is rarely used but provides programmatic ways to add messages to the source. The `ResourceBundleMessageSource` is shown in the following example:

```
<beans>
<bean id="messageSource"
      class="org.springframework.context.support.ResourceBundleMessageSource">
  <property name="basenames">
    <list>
      <value>format</value>
      <value>exceptions</value>
      <value>windows</value>
    </list>
  </property>
</bean>
</beans>
```

In the example it is assumed you have three resource bundles defined in your classpath called `format`, `exceptions` and `windows`. Any request to resolve a message will be handled in the JDK standard way of resolving messages through ResourceBundles. For the purposes of the example, assume the contents of two of the above resource bundle files are...

```
# in format.properties
message=Alligators rock!
```

```
# in exceptions.properties
argument.required=The {0} argument is required.
```

A program to execute the `MessageSource` functionality is shown in the next example. Remember that all `ApplicationContext` implementations are also `MessageSource` implementations and so can be cast to the `MessageSource` interface.

```
public static void main(String[] args) {
  MessageSource resources = new ClassPathXmlApplicationContext("beans.xml");
  String message = resources.getMessage("message", null, "Default", null);
  System.out.println(message);
}
```

The resulting output from the above program will be...

```
Alligators rock!
```

So to summarize, the `MessageSource` is defined in a file called `beans.xml`, which exists at the root of your classpath. The `messageSource` bean definition refers to a number of resource bundles through its `basenames` property. The three files that are passed in the list to the `basenames` property exist as files at the root of your classpath and are called `format.properties`, `exceptions.properties`, and `windows.properties` respectively.

The next example shows arguments passed to the message lookup; these arguments will be converted into Strings and inserted into placeholders in the lookup message.

```
<beans>

  <!-- this MessageSource is being used in a web application -->
  <bean id="messageSource" class="org.springframework.context.support.ResourceBundleMessageSource">
      <property name="basename" value="exceptions"/>
  </bean>

  <!-- lets inject the above MessageSource into this POJO -->
```

```
    <bean id="example" class="com.foo.Example">
        <property name="messages" ref="messageSource"/>
    </bean>

</beans>
```

```
public class Example {

  private MessageSource messages;

  public void setMessages(MessageSource messages) {
      this.messages = messages;
  }

  public void execute() {
      String message = this.messages.getMessage("argument.required",
          new Object [] {"userDao"}, "Required", null);
      System.out.println(message);
  }

}
```

The resulting output from the invocation of the `execute()` method will be...

```
The userDao argument is required.
```

With regard to internationalization (i18n), Spring's various `MessageSource` implementations follow the same locale resolution and fallback rules as the standard JDK `ResourceBundle`. In short, and continuing with the example `messageSource` defined previously, if you want to resolve messages against the British (en-GB) locale, you would create files called `format_en_GB.properties`, `exceptions_en_GB.properties`, and `windows_en_GB.properties` respectively.

Typically, locale resolution is managed by the surrounding environment of the application. In this example, the locale against which (British) messages will be resolved is specified manually.

```
# in exceptions_en_GB.properties
argument.required=Ebagum lad, the {0} argument is required, I say, required.
```

```
public static void main(final String[] args) {
  MessageSource resources = new ClassPathXmlApplicationContext("beans.xml");
  String message = resources.getMessage("argument.required",
      new Object [] {"userDao"}, "Required", Locale.UK);
  System.out.println(message);
}
```

The resulting output from the running of the above program will be...

```
Ebagum lad, the 'userDao' argument is required, I say, required.
```

You can also use the `MessageSourceAware` interface to acquire a reference to any `MessageSource` that has been defined. Any bean that is defined in an `ApplicationContext` that implements the `MessageSourceAware` interface is injected with the application context's `MessageSource` when the bean is created and configured.

> *As an alternative to `ResourceBundleMessageSource`, Spring provides a `ReloadableResourceBundleMessageSource` class. This variant supports the same bundle file format but is more flexible than the standard JDK based `ResourceBundleMessageSource` implementation.* In particular, it allows for reading files from any Spring resource location (not just from the classpath) and supports hot reloading of bundle property files (while efficiently caching them in between). Check out the `ReloadableResourceBundleMessageSource` javadoc for details.

5.14.2 Standard and Custom Events

Event handling in the `ApplicationContext` is provided through the `ApplicationEvent` class and `ApplicationListener` interface. If a bean that implements the `ApplicationListener` interface is deployed into the context, every time an

`ApplicationEvent` gets published to the `ApplicationContext`, that bean is notified. Essentially, this is the standard *Observer* design pattern. Spring provides the following standard events:

Table 5.7. Built-in Events

Event	Explanation
`ContextRefreshedEvent`	Published when the `ApplicationContext` is initialized or refreshed, for example, using the `refresh()` method on the `ConfigurableApplicationContext` interface. "Initialized" here means that all beans are loaded, post-processor beans are detected and activated, singletons are pre-instantiated, and the `ApplicationContext` object is ready for use. As long as the context has not been closed, a refresh can be triggered multiple times, provided that the chosen `ApplicationContext` actually supports such "hot" refreshes. For example, `XmlWebApplicationContext` supports hot refreshes, but `GenericApplicationContext` does not.
`ContextStartedEvent`	Published when the `ApplicationContext` is started, using the `start()` method on the `ConfigurableApplicationContext` interface. "Started" here means that all `Lifecycle` beans receive an explicit start signal. Typically this signal is used to restart beans after an explicit stop, but it may also be used to start components that have not been configured for autostart , for example, components that have not already started on initialization.
`ContextStoppedEvent`	Published when the `ApplicationContext` is stopped, using the `stop()` method on the `ConfigurableApplicationContext` interface. "Stopped" here means that all `Lifecycle` beans receive an explicit stop signal. A stopped context may be restarted through a `start()` call.
`ContextClosedEvent`	Published when the `ApplicationContext` is closed, using the `close()` method on the `ConfigurableApplicationContext` interface. "Closed" here means that all singleton beans are destroyed. A closed context reaches its end of life; it cannot be refreshed or restarted.

Event	Explanation
`RequestHandledEvent`	A web-specific event telling all beans that an HTTP request has been serviced. This event is published *after* the request is complete. This event is only applicable to web applications using Spring's `DispatcherServlet`.

You can also create and publish your own custom events. This example demonstrates a simple class that extends Spring's `ApplicationEvent` base class:

```
public class BlackListEvent extends ApplicationEvent {
  private final String address;
  private final String test;

  public BlackListEvent(Object source, String address, String test) {
      super(source);
      this.address = address;
      this.test = test;
  }

  // accessor and other methods...
}
```

To publish a custom `ApplicationEvent`, call the `publishEvent()` method on an `ApplicationEventPublisher`. Typically this is done by creating a class that implements `ApplicationEventPublisherAware` and registering it as a Spring bean. The following example demonstrates such a class:

```
public class EmailService implements ApplicationEventPublisherAware {

  private List<String> blackList;
  private ApplicationEventPublisher publisher;

```

```
  public void setBlackList(List<String> blackList) {
      this.blackList = blackList;
  }

  public void setApplicationEventPublisher(ApplicationEventPublisher publisher) {
      this.publisher = publisher;
  }

  public void sendEmail(String address, String text) {
      if (blackList.contains(address)) {
          BlackListEvent event = new BlackListEvent(this, address, text);
          publisher.publishEvent(event);
          return;
      }
      // send email...
  }
}
```

At configuration time, the Spring container will detect that `EmailService` implements `ApplicationEventPublisherAware` and will automatically call `setApplicationEventPublisher()`. In reality, the parameter passed in will be the Spring container itself; you're simply interacting with the application context via its `ApplicationEventPublisher` interface.

To receive the custom `ApplicationEvent`, create a class that implements `ApplicationListener` and register it as a Spring bean. The following example demonstrates such a class:

```
public class BlackListNotifier implements ApplicationListener<BlackListEvent> {

  private String notificationAddress;

  public void setNotificationAddress(String notificationAddress) {
      this.notificationAddress = notificationAddress;
  }

  public void onApplicationEvent(BlackListEvent event) {
```

```
        // notify appropriate parties via notificationAddress...
    }
}
```

Notice that `ApplicationListener` is generically parameterized with the type of your custom event, `BlackListEvent`. This means that the `onApplicationEvent()` method can remain type-safe, avoiding any need for downcasting. You may register as many event listeners as you wish, but note that by default event listeners receive events synchronously. This means the `publishEvent()` method blocks until all listeners have finished processing the event. One advantage of this synchronous and single-threaded approach is that when a listener receives an event, it operates inside the transaction context of the publisher if a transaction context is available. If another strategy for event publication becomes necessary, refer to the JavaDoc for Spring's `ApplicationEventMulticaster` interface.

The following example shows the bean definitions used to register and configure each of the classes above:

```
<bean id="emailService" class="example.EmailService">
  <property name="blackList">
      <list>
          <value>known.spammer@example.org</value>
          <value>known.hacker@example.org</value>
          <value>john.doe@example.org</value>
      </list>
  </property>
</bean>

<bean id="blackListNotifier" class="example.BlackListNotifier">
  <property name="notificationAddress" value="blacklist@example.org"/>
</bean>
```

Putting it all together, when the `sendEmail()` method of the `emailService` bean is called, if there are any emails that should be blacklisted, a custom event of type `BlackListEvent` is published. The `blackListNotifier` bean is registered as an `ApplicationListener` and thus receives the `BlackListEvent`, at which point it can notify appropriate parties.

Spring's eventing mechanism is designed for simple communication between Spring beans within the same application context. However, for more sophisticated enterprise integration needs, the separately-maintained Spring Integration project provides complete support for building lightweight, pattern-oriented, event-driven architectures that build upon the well-known Spring programming model.

5.14.3 Convenient access to low-level resources

For optimal usage and understanding of application contexts, users should generally familiarize themselves with Spring's `Resource` abstraction, as described in the chapter Chapter 6, *Resources*.

An application context is a `ResourceLoader`, which can be used to load `Resource`s. A `Resource` is essentially a more feature rich version of the JDK class `java.net.URL`, in fact, the implementations of the `Resource` wrap an instance of `java.net.URL` where appropriate. A `Resource` can obtain low-level resources from almost any location in a transparent fashion, including from the classpath, a filesystem location, anywhere describable with a standard URL, and some other variations. If the resource location string is a simple path without any special prefixes, where those resources come from is specific and appropriate to the actual application context type.

You can configure a bean deployed into the application context to implement the special callback interface, `ResourceLoaderAware`, to be automatically called back at initialization time with the application context itself passed in as the `ResourceLoader`. You can also expose properties of type `Resource`, to be used to access static resources; they will be injected into it like any other properties. You can specify those `Resource` properties as simple String paths, and rely on a special JavaBean `PropertyEditor` that is automatically registered by the context, to convert those text strings to actual `Resource` objects when the bean is deployed.

The location path or paths supplied to an `ApplicationContext` constructor are actually resource strings, and in simple form are treated appropriately to the specific context implementation. `ClassPathXmlApplicationContext` treats a simple location path as a classpath location. You can also use location paths (resource strings) with special prefixes to force loading of definitions from the classpath or a URL, regardless of the actual context type.

5.14.4 Convenient `ApplicationContext` instantiation for web applications

You can create `ApplicationContext` instances declaratively by using, for example, a `ContextLoader`. Of course you can also create `ApplicationContext` instances programmatically by using one of the `ApplicationContext` implementations.

You can register an `ApplicationContext` using the `ContextLoaderListener` as follows:

```
<context-param>
<param-name>contextConfigLocation</param-name>
<param-value>/WEB-INF/daoContext.xml /WEB-INF/applicationContext.xml</param-value>
</context-param>

<listener>
<listener-class>org.springframework.web.context.ContextLoaderListener</listener-class>
</listener>
```

The listener inspects the `contextConfigLocation` parameter. If the parameter does not exist, the listener uses `/WEB-INF/applicationContext.xml` as a default. When the parameter *does* exist, the listener separates the String by using predefined delimiters (comma, semicolon and whitespace) and uses the values as locations where application contexts will be searched. Ant-style path patterns are supported as well. Examples are `/WEB-INF/*Context.xml` for all files with names ending with "Context.xml", residing in the "WEB-INF" directory, and `/WEB-INF/**/*Context.xml`, for all such files in any subdirectory of "WEB-INF".

5.14.5 Deploying a Spring ApplicationContext as a J2EE RAR file

In Spring 2.5 and later, it is possible to deploy a Spring ApplicationContext as a RAR file, encapsulating the context and all of its required bean classes and library JARs in a J2EE RAR deployment unit. This is the equivalent of bootstrapping a standalone ApplicationContext, just hosted in J2EE environment, being able to access the J2EE servers facilities. RAR deployment is a more natural alternative to scenario of deploying a headless WAR file, in effect, a WAR file without any HTTP entry points that is used only for bootstrapping a Spring ApplicationContext in a J2EE environment.

RAR deployment is ideal for application contexts that do not need HTTP entry points but rather consist only of message endpoints and scheduled jobs. Beans in such a context can use application server resources such as the JTA transaction manager and JNDI-bound JDBC DataSources and JMS ConnectionFactory instances, and may also register with the platform's JMX server - all through Spring's standard transaction management and JNDI and JMX support facilities. Application components can also interact with the application server's JCA WorkManager through Spring's `TaskExecutor` abstraction.

Check out the JavaDoc of the SpringContextResourceAdapter class for the configuration details involved in RAR deployment.

For a simple deployment of a Spring ApplicationContext as a J2EE RAR file: package all application classes into a RAR file, which is a standard JAR file with a different file extension. Add all required library JARs into the root of the RAR archive. Add a "META-INF/ra.xml" deployment descriptor (as shown in `SpringContextResourceAdapter`s JavaDoc) and the corresponding Spring XML bean definition file(s) (typically "META-INF/applicationContext.xml"), and drop the resulting RAR file into your application server's deployment directory.

> Such RAR deployment units are usually self-contained; they do not expose components to the outside world, not even to other modules of the same application. Interaction with a RAR-based ApplicationContext usually occurs through JMS destinations that it shares with other modules. A RAR-based ApplicationContext may also, for example, schedule some jobs, reacting to new files in the file system (or the like). If it needs to allow synchronous access from the outside, it could for example export RMI endpoints, which of course may be used by other application modules on the same machine.

5.15 The BeanFactory

The `BeanFactory` provides the underlying basis for Spring's IoC functionality but it is only used directly in integration with other third-party frameworks and is now largely historical in nature for most users of Spring. The `BeanFactory` and related interfaces, such as `BeanFactoryAware`, `InitializingBean`, `DisposableBean`, are still present in Spring for the purposes of backward compatibility with the large number of third-party frameworks that integrate with Spring. Often third-party components that can not use more modern equivalents such as `@PostConstruct` or `@PreDestroy` in order to remain compatible with JDK 1.4 or to avoid a dependency on JSR-250.

This section provides additional background into the differences between the `BeanFactory` and `ApplicationContext` and how one might access the IoC container directly through a classic singleton lookup.

5.15.1 `BeanFactory` or `ApplicationContext`?

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

Because the `ApplicationContext` includes all functionality of the `BeanFactory`, it is generally recommended over the `BeanFactory`, except for a few situations such as in an `Applet` where memory consumption might be critical and a few extra kilobytes might make a difference. However, for most typical enterprise applications and systems, the `ApplicationContext` is what you will want to use. Spring 2.0 and later makes *heavy* use of the `BeanPostProcessor` extension point (to effect proxying and so on). If you use only a plain `BeanFactory`, a fair amount of support such as transactions and AOP will not take effect, at least not without some extra steps on your part. This situation could be confusing because nothing is actually wrong with the configuration.

The following table lists features provided by the `BeanFactory` and `ApplicationContext` interfaces and implementations.

Table 5.8. Feature Matrix

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

Feature	`BeanFactory`	`ApplicationContext`
`ApplicationEvent` publication	No	Yes

To explicitly register a bean post-processor with a `BeanFactory` implementation, you must write code like this:

```
ConfigurableBeanFactory factory = new XmlBeanFactory(...);

// now register any needed BeanPostProcessor instances
MyBeanPostProcessor postProcessor = new MyBeanPostProcessor();
factory.addBeanPostProcessor(postProcessor);

// now start using the factory
```

To explicitly register a `BeanFactoryPostProcessor` when using a `BeanFactory` implementation, you must write code like this:

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

// bring in some property values from a Properties file
PropertyPlaceholderConfigurer cfg = new PropertyPlaceholderConfigurer();

cfg.setLocation(new FileSystemResource("jdbc.properties"));

// now actually do the replacement
cfg.postProcessBeanFactory(factory);
```

In both cases, the explicit registration step is inconvenient, which is one reason why the various `ApplicationContext` implementations are preferred above plain `BeanFactory` implementations in the vast majority of Spring-backed applications, especially when using `BeanFactoryPostProcessors` and `BeanPostProcessors`. These mechanisms implement important functionality such as property placeholder replacement and AOP.

5.15.2 Glue code and the evil singleton

It is best to write most application code in a dependency-injection (DI) style, where that code is served out of a Spring IoC container, has its own dependencies supplied by the container when it is created, and is completely unaware of the container. However, for the small glue layers of code that are sometimes needed to tie other code together, you sometimes need a singleton (or quasi-singleton) style access to a Spring IoC container. For example, third-party code may try to construct new objects directly (`Class.forName()` style), without the ability to get these objects out of a Spring IoC container. If the object constructed by the third-party code is a small stub or proxy, which then uses a singleton style access to a Spring IoC container to get a real object to delegate to, then inversion of control has still been achieved for the majority of the code (the object coming out of the container). Thus most code is still unaware of the container or how it is accessed, and remains decoupled from other code, with all ensuing benefits. EJBs may also use this stub/proxy approach to delegate to a plain Java implementation object, retrieved from a Spring IoC container. While the Spring IoC container itself ideally does not have to be a singleton, it may be unrealistic in terms of memory usage or initialization times (when using beans in the Spring IoC container such as a Hibernate `SessionFactory`) for each bean to use its own, non-singleton Spring IoC container.

Looking up the application context in a service locator style is sometimes the only option for accessing shared Spring-managed components, such as in an EJB 2.1 environment, or when you want to share a single ApplicationContext as a parent to WebApplicationContexts across WAR files. In this case you should look into using the utility class `ContextSingletonBeanFactoryLocator` locator that is described in this SpringSource team blog entry.

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[1] See Background
[2] See Section 5.4.1, “Dependency injection”