<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** {

*// Number of years to 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*

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](https://download.oracle.com/javase/6/docs/api/java/beans/ConstructorProperties.html) 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-based and setter-based DI for the beans it manages. It also supports setter-based DI after some dependencies have already been injected through the constructor approach. You configure the dependencies in the form of a BeanDefinition, which you use in conjunction with PropertyEditor instances to convert properties from one format to another. However, most Spring users do not work with these classes directly (i.e., programmatically) but rather with XML bean definitions, annotated components (i.e., classes annotated with @Component, @Controller, etc.), or @Bean methods in Java-based @Configuration classes. These sources are then converted internally into instances of BeanDefinition and used to load an entire Spring IoC container instance.

Constructor-based or setter-based DI?

Since you can mix constructor-based and setter-based DI, it is a good rule of thumb to use constructors for mandatory dependencies and setter methods or configuration methods for optional dependencies. Note that use of the [@Required](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-required-annotation) annotation on a setter method can be used to make the property a required dependency.

The Spring team generally advocates constructor injection as it enables one to implement application components as immutable objects and to ensure that required dependencies are not null. Furthermore constructor-injected components are always returned to client (calling) code in a fully initialized state. As a side note, a large number of constructor arguments is a bad code smell, implying that the class likely has too many responsibilities and should be refactored to better address proper separation of concerns.

Setter injection should primarily only be used for optional dependencies that can be assigned reasonable default values within the class. Otherwise, not-null checks must be performed everywhere the code uses the dependency. One benefit of setter injection is that setter methods make objects of that class amenable to reconfiguration or re-injection later. Management through [JMX MBeans](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/integration.html#jmx) is therefore a compelling use case for setter injection.

Use the DI style that makes the most sense for a particular class. Sometimes, when dealing with third-party classes for which you do not have the source, the choice is made for you. For example, if a third-party class does not expose any setter methods, then constructor injection may be the only available form of DI.

##### **Dependency resolution process**

The container performs bean dependency resolution as follows:

* 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.
* 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.
* Each property or constructor argument is an actual definition of the value to set, or a reference to another bean in the container.
* 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. 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 [Bean scopes](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-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. Note that resolution mismatches among those dependencies may show up late, i.e. on first creation of the affected bean.

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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-initializingbean) or the [InitializingBean callback method](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-initializingbean)) 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.

#### **1.4.2. 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. Spring’s [conversion service](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#core-convert-ConversionService-API) is used to convert these 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-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

https://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](https://www.jetbrains.com/idea/) or the [Spring Tool Suite](https://spring.io/tools/sts) (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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes) bean, this typo and the resulting exception may only be discovered long after the container is deployed.

|  |  |
| --- | --- |
|  | The local attribute on the idref element is no longer supported in the 4.0 beans xsd since it does not provide value over a regular bean reference anymore. Simply change your existing idref local references to idref bean when upgrading to the 4.0 schema. |

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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-pfb-1) 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 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>

|  |  |
| --- | --- |
|  | The local attribute on the ref element is no longer supported in the 4.0 beans xsd since it does not provide value over a regular bean reference anymore. Simply change your existing ref local references to ref bean when upgrading to the 4.0 schema. |

##### **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; if specified, the container does not use such a value as an identifier. The container also ignores the scope flag on creation: 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 or to access them independently.

As a corner case, it is possible to receive destruction callbacks from a custom scope, e.g. for a request-scoped inner bean contained within a singleton bean: The creation of the inner bean instance will be tied to its containing bean, but destruction callbacks allow it to participate in the request scope’s lifecycle. This is not a common scenario; inner beans typically simply share their containing bean’s scope.

##### **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**

The Spring container also 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*](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-child-bean-definitions) 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.

###### **Strongly-typed collection**

With the introduction of generic types in Java 5, you can use strongly typed collections. 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 supports extensible configuration formats [with namespaces](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-schemas), 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

https://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

https://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 [XML shortcut with the p-namespace](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-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 [Constructor-based dependency injection](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-constructor-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

https://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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-ctor-arguments-resolution) 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.

#### **1.4.3. 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-singleton) beans only, a corresponding destruction-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. |

#### **1.4.4. Lazy-initialized beans**

By default, ApplicationContext implementations eagerly create and configure all [singleton](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-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>

#### **1.4.5. 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-child-bean-definitions) 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#_footnote_2)], you specify autowire mode for a bean definition with the autowire attribute of the <bean/> element. The autowiring functionality has four modes. You specify autowiring per bean and thus can choose which ones to autowire.

| *Table 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.
* Implement the more fine-grained control available with annotation-based configuration, as described in [Annotation-based container configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-annotation-config).

##### **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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-autowired-annotation)).

|  |  |
| --- | --- |
|  | The autowire-candidate attribute is designed to only affect type-based autowiring. It does not affect explicit references by name, which will get resolved even if the specified bean is not marked as an autowire candidate. As a consequence, autowiring by name will nevertheless inject a bean if the name matches. |

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.

#### **1.4.6. Method injection**

In most application scenarios, most beans in the container are [singletons](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-singleton). 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-aware) by implementing the ApplicationContextAware interface, and by [making a getBean("B") call to the container](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-client) 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](https://spring.io/blog/2004/08/06/method-injection/).

##### **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 bean container will subclass cannot be final, and the method to be overridden cannot be final either. * Unit-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. * Concrete methods are also necessary for component scanning which requires concrete classes to pick up. * A further key limitation is that lookup methods won’t work with factory methods and in particular not with @Bean methods in configuration classes, since the container is not in charge of creating the instance in that case and therefore cannot create a runtime-generated subclass on the fly. |

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="myCommand" 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="myCommand"/>

</bean>

The bean identified as commandManager calls its own method createCommand() whenever it needs a new instance of the myCommand bean. You must be careful to deploy the myCommand bean as a prototype, if that is actually what is needed. If it is as a [singleton](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-singleton), the same instance of the myCommand bean is returned each time.

Alternatively, within the annotation-based component model, you may declare a lookup method through the @Lookup annotation:

**public** **abstract** **class** **CommandManager** {

**public** Object process(Object commandState) {

Command command = createCommand();

command.setState(commandState);

**return** command.execute();

}

@Lookup("myCommand")

**protected** **abstract** Command createCommand();

}

Or, more idiomatically, you may rely on the target bean getting resolved against the declared return type of the lookup method:

**public** **abstract** **class** **CommandManager** {

**public** Object process(Object commandState) {

MyCommand command = createCommand();

command.setState(commandState);

**return** command.execute();

}

@Lookup

**protected** **abstract** MyCommand createCommand();

}

Note that you will typically declare such annotated lookup methods with a concrete stub implementation, in order for them to be compatible with Spring’s component scanning rules where abstract classes get ignored by default. This limitation does not apply in case of explicitly registered or explicitly imported bean classes.

|  |  |
| --- | --- |
|  | Another way of accessing differently scoped target beans is an ObjectFactory/ Provider injection point. Check out [Scoped beans as dependencies](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-other-injection).  The interested reader may also find the ServiceLocatorFactoryBean (in the org.springframework.beans.factory.config package) to be of use. |

##### **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];

...

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.

### **1.5. 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 six scopes, four 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.](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-custom)

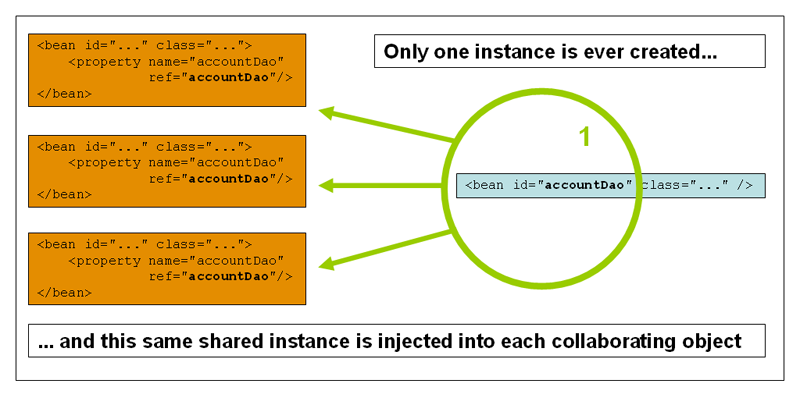
| *Table 3. Bean scopes* | |
| --- | --- |
| **Scope** | **Description** |
| [singleton](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-singleton) | (Default) Scopes a single bean definition to a single object instance per Spring IoC container. |
| [prototype](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-prototype) | Scopes a single bean definition to any number of object instances. |
| [request](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-session) | Scopes a single bean definition to the lifecycle of an HTTP Session. Only valid in the context of a web-aware Spring ApplicationContext. |
| [application](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-application) | Scopes a single bean definition to the lifecycle of a ServletContext. Only valid in the context of a web-aware Spring ApplicationContext. |
| [websocket](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#websocket-stomp-websocket-scope) | Scopes a single bean definition to the lifecycle of a WebSocket. 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](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/support/SimpleThreadScope.html). For instructions on how to register this or any other custom scope, see [Using a custom scope](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-custom-using). |

#### **1.5.1. 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"/>

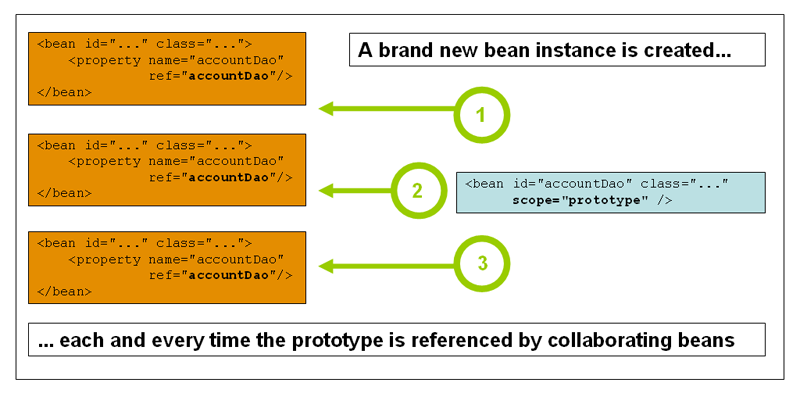
*<!-- the following is equivalent, though redundant (singleton scope is the default) -->*

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

#### **1.5.2. 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:

<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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-extension-bpp), 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 [Lifecycle callbacks](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle).)

#### **1.5.3. 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 [Method injection](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-method-injection)

#### **1.5.4. Request, session, application, and WebSocket scopes**

The request, session, application, and websocket 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, an IllegalStateException will be thrown complaining about an unknown bean scope.

##### **Initial web configuration**

To support the scoping of beans at the request, session, application, and websocket 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, then no special setup is necessary: DispatcherServlet already exposes all relevant state.

If you use a Servlet 2.5 web container, with requests processed outside of Spring’s DispatcherServlet (for example, when using JSF or Struts), you need to register the org.springframework.web.context.request.RequestContextListener ServletRequestListener. For Servlet 3.0+, this can be done programmatically via the WebApplicationInitializer interface. Alternatively, or for older containers, add the following declaration to your web application’s web.xml file:

<web-app>

...

<listener>

<listener-class>

org.springframework.web.context.request.RequestContextListener

</listener-class>

</listener>

...

</web-app>

Alternatively, if there are issues with your listener setup, consider using Spring’s RequestContextFilter. The filter mapping depends on the surrounding web application configuration, so you have to 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 XML configuration for a 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.

When using annotation-driven components or Java Config, the @RequestScope annotation can be used to assign a component to the request scope.

**@RequestScope**

@Component

**public** **class** **LoginAction** {

*// ...*

}

##### **Session scope**

Consider the following XML configuration for a 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.

When using annotation-driven components or Java Config, the @SessionScope annotation can be used to assign a component to the session scope.

**@SessionScope**

@Component

**public** **class** **UserPreferences** {

*// ...*

}

##### **Application scope**

Consider the following XML configuration for a bean definition:

<bean id="appPreferences" class="com.foo.AppPreferences" scope="application"/>

The Spring container creates a new instance of the AppPreferences bean by using the appPreferences bean definition once for the entire web application. That is, the appPreferences bean is scoped at the ServletContext level, stored as a regular ServletContext attribute. This is somewhat similar to a Spring singleton bean but differs in two important ways: It is a singleton per ServletContext, not per Spring 'ApplicationContext' (for which there may be several in any given web application), and it is actually exposed and therefore visible as a ServletContext attribute.

When using annotation-driven components or Java Config, the @ApplicationScope annotation can be used to assign a component to the application scope.

**@ApplicationScope**

@Component

**public** **class** **AppPreferences** {

*// ...*

}

##### **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 of a longer-lived scope, you may choose to 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 (such as an HTTP request) and delegate method calls onto the real object.

|  |  |
| --- | --- |
|  | You may also use <aop:scoped-proxy/> between beans that are scoped as singleton, with the reference then going through an intermediate proxy that is serializable and therefore able to re-obtain the target singleton bean on deserialization.  When declaring <aop:scoped-proxy/> against a bean of scope prototype, every method call on the shared proxy will lead to the creation of a new target instance which the call is then being forwarded to.  Also, scoped proxies are not the only way to access beans from shorter scopes in a lifecycle-safe fashion. You may also simply declare your injection point (i.e. the constructor/setter argument or autowired field) as ObjectFactory<MyTargetBean>, allowing for a getObject() call to retrieve the current instance on demand every time it is needed - without holding on to the instance or storing it separately.  As an extended variant, you may declare ObjectProvider<MyTargetBean> which delivers several additional access variants, including getIfAvailable and getIfUnique.  The JSR-330 variant of this is called Provider, used with a Provider<MyTargetBean> declaration and a corresponding get() call for every retrieval attempt. See [here](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-standard-annotations) for more details on JSR-330 overall. |

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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/aop

https://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 [Choosing the type of proxy to create](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-other-injection-proxies) and [XML Schema-based configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-schemas)). Why do definitions of beans scoped at the request, session 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 (note that 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- and session-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.

|  |  |
| --- | --- |
|  | CGLIB proxies only intercept public method calls! Do not call non-public methods on such a proxy; they will not be delegated to the actual 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 [Proxying mechanisms](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-proxying).

#### **1.5.5. Custom scopes**

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 javadocs](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/config/Scope.html), 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 javadocs 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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/aop

https://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(). |

### **1.6. Customizing the nature of a bean**

#### **1.6.1. 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 [@PostConstruct and @PreDestroy](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-postconstruct-and-predestroy-annotations).  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 [Container Extension Points](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-extension).

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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-postconstruct-and-predestroy-annotations) 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. With Java config, you use the initMethod attribute of @Bean, see [Receiving lifecycle callbacks](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-java-lifecycle-callbacks). For example, the following:

<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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-postconstruct-and-predestroy-annotations) 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/>. With Java config, you use the destroyMethod attribute of @Bean, see [Receiving lifecycle callbacks](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-java-lifecycle-callbacks). 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.

|  |  |
| --- | --- |
|  | The destroy-method attribute of a <bean> element can be assigned a special (inferred) value which instructs Spring to automatically detect a public close or shutdown method on the specific bean class (any class that implements java.lang.AutoCloseable or java.io.Closeable would therefore match). This special (inferred) value can also be set on the default-destroy-method attribute of a <beans> element to apply this behavior to an entire set of beans (see [Default initialization and destroy methods](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-default-init-destroy-methods)). Note that this is the default behavior with Java config. |

##### **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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-initializingbean) and [DisposableBean](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-disposablebean) callback interfaces; custom init() and destroy() methods; and the [@PostConstruct and @PreDestroy annotations](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-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 receives start and stop signals, e.g. for a stop/restart scenario at runtime, 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.

|  |  |
| --- | --- |
|  | Note that the regular org.springframework.context.Lifecycle interface is just a plain contract for explicit start/stop notifications and does NOT imply auto-startup at context refresh time. Consider implementing org.springframework.context.SmartLifecycle instead for fine-grained control over auto-startup of a specific bean (including startup phases). Also, please note that stop notifications are not guaranteed to come before destruction: On regular shutdown, all Lifecycle beans will first receive a stop notification before the general destruction callbacks are being propagated; however, on hot refresh during a context’s lifetime or on aborted refresh attempts, only destroy methods will be called. |

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 ConfigurableApplicationContext interface:

**import** org.springframework.context.ConfigurableApplicationContext;

**import** org.springframework.context.support.ClassPathXmlApplicationContext;

**public** **final** **class** **Boot** {

**public** **static** **void** main(**final** String**[]** args) **throws** Exception {

ConfigurableApplicationContext ctx = **new** ClassPathXmlApplicationContext("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...*

}

}

#### **1.6.2. ApplicationContextAware and BeanNameAware**

When an ApplicationContext creates an object instance that implements the org.springframework.context.ApplicationContextAware interface, the instance 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 [Additional capabilities of the ApplicationContext](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#context-introduction)

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 [Autowiring collaborators](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-autowire)) 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 [@Autowired](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-autowired-annotation).

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 afterPropertiesSet or a custom init-method.

#### **1.6.3. Other Aware interfaces**

Besides ApplicationContextAware and BeanNameAware discussed above, Spring offers a wide range of Aware callback 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 4. Aware interfaces* | | |
| --- | --- | --- |
| **Name** | **Injected Dependency** | **Explained in…​** |
| ApplicationContextAware | Declaring ApplicationContext | [ApplicationContextAware and BeanNameAware](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-aware) |
| ApplicationEventPublisherAware | Event publisher of the enclosing ApplicationContext | [Additional capabilities of the ApplicationContext](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#context-introduction) |
| BeanClassLoaderAware | Class loader used to load the bean classes. | [Instantiating beans](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-class) |
| BeanFactoryAware | Declaring BeanFactory | [ApplicationContextAware and BeanNameAware](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-aware) |
| BeanNameAware | Name of the declaring bean | [ApplicationContextAware and BeanNameAware](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-aware) |
| BootstrapContextAware | Resource adapter BootstrapContext the container runs in. Typically available only in JCA aware ApplicationContexts | [JCA CCI](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/integration.html#cci) |
| LoadTimeWeaverAware | Defined weaver for processing class definition at load time | [Load-time weaving with AspectJ in the Spring Framework](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw) |
| MessageSourceAware | Configured strategy for resolving messages (with support for parametrization and internationalization) | [Additional capabilities of the ApplicationContext](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#context-introduction) |
| NotificationPublisherAware | Spring JMX notification publisher | [Notifications](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/integration.html#jmx-notifications) |
| ResourceLoaderAware | Configured loader for low-level access to resources | [Resources](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#resources) |
| ServletConfigAware | Current ServletConfig the container runs in. Valid only in a web-aware Spring ApplicationContext | [Spring MVC](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc) |
| ServletContextAware | Current ServletContext the container runs in. Valid only in a web-aware Spring ApplicationContext | [Spring MVC](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc) |

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.

### **1.7. 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.

|  |  |
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|  | 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. |

### **1.8. 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.

#### **1.8.1. 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 custom BeanPostProcessor implementations.

You can configure multiple BeanPostProcessor instances, and you can control the order in which these BeanPostProcessors 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 javadocs of the BeanPostProcessor and Ordered interfaces. See also the note below on [programmatic registration of BeanPostProcessors](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-programmatically-registering-beanpostprocessors).

|  |  |
| --- | --- |
|  | BeanPostProcessors operate on bean (or object) instances; that is to say, the Spring IoC container instantiates a bean instance and then BeanPostProcessors do their work.  BeanPostProcessors 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 [Customizing configuration metadata with a BeanFactoryPostProcessor](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-extension-factory-postprocessors). |

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() or 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.

Note that when declaring a BeanPostProcessor using an @Bean factory method on a configuration class, the return type of the factory method should be the implementation class itself or at least the org.springframework.beans.factory.config.BeanPostProcessor interface, clearly indicating the post-processor nature of that bean. Otherwise, the ApplicationContext won’t be able to autodetect it by type before fully creating it. Since a BeanPostProcessor needs to be instantiated early in order to apply to the initialization of other beans in the context, this early type detection is critical.

|  |  |
| --- | --- |
|  | *Programmatically registering BeanPostProcessors*  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. |
|  | *BeanPostProcessors and AOP auto-proxying*  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:

**package** scripting;

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

**public** **class** **InstantiationTracingBeanPostProcessor** **implements** BeanPostProcessor {

*// simply return the instantiated bean as-is*

**public** Object postProcessBeforeInitialization(Object bean, String beanName) {

**return** bean; *// we could potentially return any object reference here...*

}

**public** Object postProcessAfterInitialization(Object bean, String beanName) {

System.out.println("Bean '" + beanName + "' created : " + bean.toString());

**return** bean;

}

}

<?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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/lang

https://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>

*<!--*

*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 dynamic language support is detailed in the chapter entitled [Dynamic language support](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/languages.html#dynamic-language).)

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.

#### **1.8.2. 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 operates on the bean configuration metadata; that is, the Spring IoC container allows a BeanFactoryPostProcessor 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 javadocs of 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 [Customizing beans using a BeanPostProcessor](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-extension-bpp)). 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.

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|  | As with BeanPostProcessors , you typically do not want to configure BeanFactoryPostProcessors 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 Class name substitution 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 PropertyPlaceholderConfigurer javadocs for more information.

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| --- | --- |
|  | 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

1. 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"/>

#### **1.8.3. 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.

### **1.9. 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 them 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-java) 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 [Spring Tool Suite](https://spring.io/tools/sts).

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 [Example: The RequiredAnnotationBeanPostProcessor](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-extension-bpp-examples-rabpp), 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-required-annotation) 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 [Autowiring collaborators](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-autowire) 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-standard-annotations).

|  |  |
| --- | --- |
|  | 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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://www.springframework.org/schema/context/spring-context.xsd">

<context:annotation-config/>

</beans>

(The implicitly registered post-processors include [AutowiredAnnotationBeanPostProcessor](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/annotation/AutowiredAnnotationBeanPostProcessor.html), [CommonAnnotationBeanPostProcessor](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/annotation/CommonAnnotationBeanPostProcessor.html), [PersistenceAnnotationBeanPostProcessor](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/orm/jpa/support/PersistenceAnnotationBeanPostProcessor.html), as well as the aforementioned [RequiredAnnotationBeanPostProcessor](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/annotation/RequiredAnnotationBeanPostProcessor.html).)

|  |  |
| --- | --- |
|  | <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 [The DispatcherServlet](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc-servlet) for more information. |

#### **1.9.1. @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 NullPointerExceptions 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.

#### **1.9.2. @Autowired**

|  |  |
| --- | --- |
|  | JSR 330’s @Inject annotation can be used in place of Spring’s @Autowired annotation in the examples below. See [here](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-standard-annotations) for more details. |

You can apply the @Autowired annotation to constructors:

**public** **class** **MovieRecommender** {

**private** **final** CustomerPreferenceDao customerPreferenceDao;

@Autowired

**public** MovieRecommender(CustomerPreferenceDao customerPreferenceDao) {

this.customerPreferenceDao = customerPreferenceDao;

}

*// ...*

}

|  |  |
| --- | --- |
|  | As of Spring Framework 4.3, an @Autowired annotation on such a constructor is no longer necessary if the target bean only defines one constructor to begin with. However, if several constructors are available, at least one must be annotated to teach the container which one to use. |

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

**public** **class** **SimpleMovieLister** {

**private** MovieFinder movieFinder;

@Autowired

**public** **void** setMovieFinder(MovieFinder movieFinder) {

this.movieFinder = movieFinder;

}

*// ...*

}

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

**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 fields as well and even mix it with constructors:

**public** **class** **MovieRecommender** {

**private** **final** CustomerPreferenceDao customerPreferenceDao;

@Autowired

**private** MovieCatalog movieCatalog;

@Autowired

**public** MovieRecommender(CustomerPreferenceDao customerPreferenceDao) {

this.customerPreferenceDao = customerPreferenceDao;

}

*// ...*

}

|  |  |
| --- | --- |
|  | Make sure that your target components (e.g. MovieCatalog, CustomerPreferenceDao) are consistently declared by the type that you are using for your @Autowired-annotated injection points. Otherwise injection may fail due to no type match found at runtime.  For XML-defined beans or component classes found through a classpath scan, the container usually knows the concrete type upfront. However, for @Bean factory methods, you need to make sure that the declared return type is sufficiently expressive. For components implementing several interfaces or for components potentially referred to by their implementation type, consider declaring the most specific return type on your factory method (at least as specific as required by the injection points referring to your bean). |

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;

}

*// ...*

}

|  |  |
| --- | --- |
|  | Your target beans can implement the org.springframework.core.Ordered interface or use the @Order or standard @Priority annotation if you want items in the array or list to be sorted in a specific order. Otherwise their order will follow the registration order of the corresponding target bean definitions in the container.  The @Order annotation may be declared at target class level but also on @Bean methods, potentially being very individual per bean definition (in case of multiple definitions with the same bean class). @Order values may influence priorities at injection points, but please be aware that they do not influence singleton startup order which is an orthogonal concern determined by dependency relationships and @DependsOn declarations.  Note that the standard javax.annotation.Priority annotation is not available at the @Bean level since it cannot be declared on methods. Its semantics can be modeled through @Order values in combination with @Primary on a single bean per type. |

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 constructor of any given bean class may declare @Autowired with the required attribute set to true, indicating the constructor to autowire when used as a Spring bean. Furthermore, if the required attribute is set to true, only a single constructor may be annotated with @Autowired. If multiple non-required constructors declare the annotation, they will be considered as candidates for autowiring. The constructor with the greatest number of dependencies that can be satisfied by matching beans in the Spring container will be chosen. If none of the candidates can be satisfied, then a primary/default constructor (if present) will be used. If a class only declares a single constructor to begin with, it will always be used, even if not annotated. An annotated constructor does not have to be public.  The required attribute of @Autowired is recommended over the @Required annotation on setter methods. 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 to be set by any means supported by the container. If no value is defined, a corresponding exception is raised. |

Alternatively, you may express the non-required nature of a particular dependency through Java 8’s java.util.Optional:

**public** **class** **SimpleMovieLister** {

@Autowired

**public** **void** setMovieFinder(Optional<MovieFinder> movieFinder) {

...

}

}

As of Spring Framework 5.0, you may also use an @Nullable annotation (of any kind in any package, e.g. javax.annotation.Nullable from JSR-305):

**public** **class** **SimpleMovieLister** {

@Autowired

**public** **void** setMovieFinder(@Nullable MovieFinder movieFinder) {

...

}

}

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 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. |

#### **1.9.3. Fine-tuning annotation-based autowiring with @Primary**

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 @Primary annotation. @Primary indicates that a particular bean should be given preference when multiple beans are candidates to be autowired to a single-valued dependency. If exactly one 'primary' bean exists among the candidates, it will be the autowired value.

Let’s assume we have the following configuration that defines firstMovieCatalog as the primary MovieCatalog.

@Configuration

**public** **class** **MovieConfiguration** {

@Bean

**@Primary**

**public** MovieCatalog firstMovieCatalog() { ... }

@Bean

**public** MovieCatalog secondMovieCatalog() { ... }

*// ...*

}

With such configuration, the following MovieRecommender will be autowired with the firstMovieCatalog.

**public** **class** **MovieRecommender** {

@Autowired

**private** MovieCatalog movieCatalog;

*// ...*

}

The corresponding bean definitions appear as follows.

<?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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://www.springframework.org/schema/context/spring-context.xsd">

<context:annotation-config/>

<bean class="example.SimpleMovieCatalog" primary="true">

*<!-- inject any dependencies required by this bean -->*

</bean>

<bean class="example.SimpleMovieCatalog">

*<!-- inject any dependencies required by this bean -->*

</bean>

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

</beans>

#### **1.9.4. Fine-tuning annotation-based autowiring with qualifiers**

@Primary is an effective way to use autowiring by type with several instances when one primary candidate can be determined. When more control over the selection process is required, Spring’s @Qualifier annotation can be used. 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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://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").

|  |  |
| --- | --- |
|  | Letting qualifier values select against target bean names, within the type-matching candidates, doesn’t even require a @Qualifier annotation at the injection point. If there is no other resolution indicator (e.g. a qualifier or a primary marker), for a non-unique dependency situation, Spring will match the injection point name (i.e. field name or parameter name) against the target bean names and choose the same-named candidate, if any.  That said, if you intend to express annotation-driven injection by name, do not primarily use @Autowired, even if is capable of selecting by bean name among type-matching candidates. 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. @Autowired has rather different semantics: After selecting candidate beans by type, the specified String qualifier value will be considered within those type-selected candidates only, e.g. matching an "account" qualifier against beans marked with the same qualifier label.  For beans that are themselves defined as a collection/map or array type, @Resource is a fine solution, referring to the specific collection or array bean by unique name. That said, as of 4.3, collection/map and array types can be matched through Spring’s @Autowired type matching algorithm as well, as long as the element type information is preserved in @Bean return type signatures or collection inheritance hierarchies. In this case, qualifier values can be used to select among same-typed collections, as outlined in the previous paragraph.  As of 4.3, @Autowired also considers self references for injection, i.e. references back to the bean that is currently injected. Note that self injection is a fallback; regular dependencies on other components always have precedence. In that sense, self references do not participate in regular candidate selection and are therefore in particular never primary; on the contrary, they always end up as lowest precedence. In practice, use self references as a last resort only, e.g. for calling other methods on the same instance through the bean’s transactional proxy: Consider factoring out the affected methods to a separate delegate bean in such a scenario. Alternatively, use @Resource which may obtain a proxy back to the current bean by its 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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://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 [Classpath scanning and managed components](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-classpath-scanning), you will see an annotation-based alternative to providing the qualifier metadata in XML. Specifically, see [Providing qualifier metadata with annotations](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-scanning-qualifiers).

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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://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>

#### **1.9.5. Using generics as autowiring qualifiers**

In addition to the @Qualifier annotation, it is also possible to use Java generic types as an implicit form of qualification. For example, suppose you have the following configuration:

@Configuration

**public** **class** **MyConfiguration** {

@Bean

**public** StringStore stringStore() {

**return** **new** StringStore();

}

@Bean

**public** IntegerStore integerStore() {

**return** **new** IntegerStore();

}

}

Assuming that beans above implement a generic interface, i.e. Store<String> and Store<Integer>, you can @Autowire the Store interface and the generic will be used as a qualifier:

@Autowired

**private** Store<String> s1; *// <String> qualifier, injects the stringStore bean*

@Autowired

**private** Store<Integer> s2; *// <Integer> qualifier, injects the integerStore bean*

Generic qualifiers also apply when autowiring Lists, Maps and Arrays:

*// Inject all Store beans as long as they have an <Integer> generic*

*// Store<String> beans will not appear in this list*

@Autowired

**private** List<Store<Integer>> s;

#### **1.9.6. CustomAutowireConfigurer**

The [CustomAutowireConfigurer](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/annotation/CustomAutowireConfigurer.html) 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>

<value>example.CustomQualifier</value>

</set>

</property>

</bean>

The AutowireCandidateResolver determines autowire candidates by:

* the autowire-candidate value of each bean definition
* any default-autowire-candidates pattern(s) available on the <beans/> element
* the presence of @Qualifier annotations and any custom annotations registered with the CustomAutowireConfigurer

When multiple beans qualify as autowire candidates, the determination of a "primary" is the following: if exactly one bean definition among the candidates has a primary attribute set to true, it will be selected.

#### **1.9.7. @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](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/jndi/support/SimpleJndiBeanFactory.html) 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() {

}

*// ...*

}

#### **1.9.8. @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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-initializingbean) and [destruction callbacks](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-disposablebean). 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 [Combining lifecycle mechanisms](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-combined-effects). |

### **1.10. 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 ([Annotation-based container configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-annotation-config)) 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. |

#### **1.10.1. @Component and further stereotype annotations**

The @Repository annotation is a marker for any class that fulfills the role or stereotype of a repository (also known as Data Access Object or DAO). Among the uses of this marker is the automatic translation of exceptions as described in [Exception translation](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/data-access.html#orm-exception-translation).

Spring provides 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.

#### **1.10.2. Meta-annotations**

Many of the annotations provided by Spring can be used as meta-annotations in your own code. A meta-annotation is simply an annotation that can be applied to another annotation. For example, the @Service annotation mentioned above is meta-annotated with @Component:

@Target(ElementType.TYPE)

@Retention(RetentionPolicy.RUNTIME)

@Documented

**@Component** *// Spring will see this and treat @Service in the same way as @Component*

**public** @interface Service {

*// ....*

}

Meta-annotations can also be combined to create composed annotations. For example, the @RestController annotation from Spring MVC is composed of @Controller and @ResponseBody.

In addition, composed annotations may optionally redeclare attributes from meta-annotations to allow user customization. This can be particularly useful when you want to only expose a subset of the meta-annotation’s attributes. For example, Spring’s @SessionScope annotation hardcodes the scope name to session but still allows customization of the proxyMode.

@Target({ElementType.TYPE, ElementType.METHOD})

@Retention(RetentionPolicy.RUNTIME)

@Documented

@Scope(WebApplicationContext.SCOPE\_SESSION)

**public** @interface SessionScope {

*/\*\**

*\* Alias for {@link Scope#proxyMode}.*

*\* <p>Defaults to {@link ScopedProxyMode#TARGET\_CLASS}.*

*\*/*

@AliasFor(annotation = Scope.class)

ScopedProxyMode proxyMode() **default** ScopedProxyMode.TARGET\_CLASS;

}

@SessionScope can then be used without declaring the proxyMode as follows:

@Service

**@SessionScope**

**public** **class** **SessionScopedService** {

*// ...*

}

Or with an overridden value for the proxyMode as follows:

@Service

**@SessionScope(proxyMode = ScopedProxyMode.INTERFACES)**

**public** **class** **SessionScopedUserService** **implements** UserService {

*// ...*

}

For further details, consult the [Spring Annotation Programming Model](https://github.com/spring-projects/spring-framework/wiki/Spring-Annotation-Programming-Model) wiki page.

#### **1.10.3. Automatically detecting classes and registering bean definitions**

Spring can automatically detect stereotyped classes and register corresponding BeanDefinitions 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 add @ComponentScan to your @Configuration class, where the basePackages attribute is a common parent package for the two classes. (Alternatively, you can specify a comma/semicolon/space-separated list that includes the parent package of each class.)

@Configuration

@ComponentScan(basePackages = "org.example")

**public** **class** **AppConfig** {

...

}

|  |  |
| --- | --- |
|  | For concision, the above may have used the value attribute of the annotation, i.e. @ComponentScan("org.example") |

The following is an alternative using 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:context="http://www.springframework.org/schema/context"

xsi:schemaLocation="http://www.springframework.org/schema/beans

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://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. Also, classpath directories may not get exposed based on security policies in some environments, e.g. standalone apps on JDK 1.7.0\_45 and higher (which requires 'Trusted-Library' setup in your manifests; see <https://stackoverflow.com/questions/19394570/java-jre-7u45-breaks-classloader-getresources>).  On JDK 9’s module path (Jigsaw), Spring’s classpath scanning generally works as expected. However, please make sure that your component classes are exported in your module-info descriptors; if you expect Spring to invoke non-public members of your classes, make sure that they are 'opened' (i.e. using an opens declaration instead of an exports declaration in your module-info descriptor). |

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. |

#### **1.10.4. 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 includeFilters or excludeFilters parameters of the @ComponentScan annotation (or 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. Filter Types* | | |
| --- | --- | --- |
| **Filter Type** | **Example Expression** | **Description** |
| annotation (default) | 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 configuration ignoring all @Repository annotations and using "stub" repositories instead.

@Configuration

@ComponentScan(basePackages = "org.example",

includeFilters = @Filter(type = FilterType.REGEX, pattern = ".\*Stub.\*Repository"),

excludeFilters = @Filter(Repository.class))

**public** **class** **AppConfig** {

...

}

and the equivalent using XML

<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 setting useDefaultFilters=false on the annotation or 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, @Controller, or @Configuration. |

#### **1.10.5. 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.

|  |  |
| --- | --- |
|  | In addition to its role for component initialization, the @Lazy annotation may also be placed on injection points marked with @Autowired or @Inject. In this context, it leads to the injection of a lazy-resolution proxy. |

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(spouse);

tb.setCountry(country);

**return** tb;

}

@Bean

**private** TestBean privateInstance() {

**return** **new** TestBean("privateInstance", i++);

}

@Bean

@RequestScope

**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.

As of Spring Framework 4.3, you may also declare a factory method parameter of type InjectionPoint (or its more specific subclass DependencyDescriptor) in order to access the requesting injection point that triggers the creation of the current bean. Note that this will only apply to the actual creation of bean instances, not to the injection of existing instances. As a consequence, this feature makes most sense for beans of prototype scope. For other scopes, the factory method will only ever see the injection point which triggered the creation of a new bean instance in the given scope: for example, the dependency that triggered the creation of a lazy singleton bean. Use the provided injection point metadata with semantic care in such scenarios.

@Component

**public** **class** **FactoryMethodComponent** {

@Bean @Scope("prototype")

**public** TestBean prototypeInstance(InjectionPoint injectionPoint) {

**return** **new** TestBean("prototypeInstance for " + injectionPoint.getMember());

}

}

The @Bean methods in a regular 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 @Bean methods in @Configuration classes creates bean metadata references to collaborating objects; such methods are not invoked with normal Java semantics but rather go through the container in order to provide the usual lifecycle management and proxying of Spring beans even when referring to other beans via programmatic calls to @Bean methods. In contrast, invoking a method or field in an @Bean method within a plain @Component class has standard Java semantics, with no special CGLIB processing or other constraints applying.

|  |  |
| --- | --- |
|  | You may declare @Bean methods as static, allowing for them to be called without creating their containing configuration class as an instance. This makes particular sense when defining post-processor beans, e.g. of type BeanFactoryPostProcessor or BeanPostProcessor, since such beans will get initialized early in the container lifecycle and should avoid triggering other parts of the configuration at that point.  Note that calls to static @Bean methods will never get intercepted by the container, not even within @Configuration classes (see above). This is due to technical limitations: CGLIB subclassing can only override non-static methods. As a consequence, a direct call to another @Bean method will have standard Java semantics, resulting in an independent instance being returned straight from the factory method itself.  The Java language visibility of @Bean methods does not have an immediate impact on the resulting bean definition in Spring’s container. You may freely declare your factory methods as you see fit in non-@Configuration classes and also for static methods anywhere. However, regular @Bean methods in @Configuration classes need to be overridable, i.e. they must not be declared as private or final.  @Bean methods will also be discovered on base classes of a given component or configuration class, as well as on Java 8 default methods declared in interfaces implemented by the component or configuration class. This allows for a lot of flexibility in composing complex configuration arrangements, with even multiple inheritance being possible through Java 8 default methods as of Spring 4.2.  Finally, note that a single class may hold multiple @Bean methods for the same bean, as an arrangement of multiple factory methods to use depending on available dependencies at runtime. This is the same algorithm as for choosing the "greediest" constructor or factory method in other configuration scenarios: The variant with the largest number of satisfiable dependencies will be picked at construction time, analogous to how the container selects between multiple @Autowired constructors. |

#### **1.10.6. 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 component classes 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](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/support/BeanNameGenerator.html) interface, and be sure to include a default no-arg constructor. Then, provide the fully-qualified class name when configuring the scanner: |

@Configuration

@ComponentScan(basePackages = "org.example", nameGenerator = MyNameGenerator.class)

**public** **class** **AppConfig** {

...

}

<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.

#### **1.10.7. 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 a different scope which can be specified via the @Scope annotation. Simply provide the name of the scope within the annotation:

@Scope("prototype")

@Repository

**public** **class** **MovieFinderImpl** **implements** MovieFinder {

*// ...*

}

|  |  |
| --- | --- |
|  | @Scope annotations are only introspected on the concrete bean class (for annotated components) or the factory method (for @Bean methods). In contrast to XML bean definitions, there is no notion of bean definition inheritance, and inheritance hierarchies at the class level are irrelevant for metadata purposes. |

For details on web-specific scopes such as "request"/"session" in a Spring context, see [Request, session, application, and WebSocket scopes](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-other). Like the pre-built annotations for those scopes, you may also compose your own scoping annotations using Spring’s meta-annotation approach: e.g. a custom annotation meta-annotated with @Scope("prototype"), possibly also declaring a custom scoped-proxy mode.

|  |  |
| --- | --- |
|  | To provide a custom strategy for scope resolution rather than relying on the annotation-based approach, implement the [ScopeMetadataResolver](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/annotation/ScopeMetadataResolver.html) interface, and be sure to include a default no-arg constructor. Then, provide the fully-qualified class name when configuring the scanner: |

@Configuration

@ComponentScan(basePackages = "org.example", scopeResolver = MyScopeResolver.class)

**public** **class** **AppConfig** {

...

}

<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 [Scoped beans as dependencies](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-other-injection). 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:

@Configuration

@ComponentScan(basePackages = "org.example", scopedProxy = ScopedProxyMode.INTERFACES)

**public** **class** **AppConfig** {

...

}

<beans>

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

</beans>

#### **1.10.8. Providing qualifier metadata with annotations**

The @Qualifier annotation is discussed in [Fine-tuning annotation-based autowiring with qualifiers](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-autowired-annotation-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. |

#### **1.10.9. Generating an index of candidate components**

While classpath scanning is very fast, it is possible to improve the startup performance of large applications by creating a static list of candidates at compilation time. In this mode, all modules of the application must use this mechanism as, when the ApplicationContext detects such index, it will automatically use it rather than scanning the classpath.

To generate the index, simply add an additional dependency to each module that contains components that are target for component scan directives:

<dependencies>

<dependency>

<groupId>org.springframework</groupId>

<artifactId>spring-context-indexer</artifactId>

<version>5.0.20.RELEASE</version>

<optional>true</optional>

</dependency>

</dependencies>

Or, using Gradle:

dependencies {

compileOnly("org.springframework:spring-context-indexer:5.0.20.RELEASE")

}

That process will generate a META-INF/spring.components file that is going to be included in the jar.

|  |  |
| --- | --- |
|  | When working with this mode in your IDE, the spring-context-indexer must be registered as an annotation processor to make sure the index is up to date when candidate components are updated. |
|  | The index is enabled automatically when a META-INF/spring.components is found on the classpath. If an index is partially available for some libraries (or use cases) but couldn’t be built for the whole application, you can fallback to a regular classpath arrangement (i.e. as no index was present at all) by setting spring.index.ignore to true, either as a system property or in a spring.properties file at the root of the classpath. |

### **1.11. 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 ( <https://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> |

#### **1.11.1. 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;

}

**public** **void** listMovies() {

this.movieFinder.findMovies(...);

...

}

}

As with @Autowired, it is possible to use @Inject at the field level, method level and constructor-argument level. Furthermore, you may declare your injection point as a Provider, allowing for on-demand access to beans of shorter scopes or lazy access to other beans through a Provider.get() call. As a variant of the example above:

**import** javax.inject.Inject;

**import** javax.inject.Provider;

**public** **class** **SimpleMovieLister** {

**private** Provider<MovieFinder> movieFinder;

@Inject

**public** **void** setMovieFinder(Provider<MovieFinder> movieFinder) {

this.movieFinder = movieFinder;

}

**public** **void** listMovies() {

this.movieFinder.get().findMovies(...);

...

}

}

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;

}

*// ...*

}

Like @Autowired, @Inject can also be used with java.util.Optional or @Nullable. This is even more applicable here since @Inject does not have a required attribute.

**public** **class** **SimpleMovieLister** {

@Inject

**public** **void** setMovieFinder(Optional<MovieFinder> movieFinder) {

...

}

}

**public** **class** **SimpleMovieLister** {

@Inject

**public** **void** setMovieFinder(@Nullable MovieFinder movieFinder) {

...

}

}

#### **1.11.2. @Named and @ManagedBean: standard equivalents to the @Component annotation**

Instead of @Component, @javax.inject.Named or javax.annotation.ManagedBean may be used as follows:

**import** javax.inject.Inject;

**import** javax.inject.Named;

@Named("movieListener") *// @ManagedBean("movieListener") could be used as well*

**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 or @ManagedBean, it is possible to use component scanning in the exact same way as when using Spring annotations:

@Configuration

@ComponentScan(basePackages = "org.example")

**public** **class** **AppConfig** {

...

}

|  |  |
| --- | --- |
|  | In contrast to @Component, the JSR-330 @Named and the JSR-250 ManagedBean annotations are not composable. Please use Spring’s stereotype model for building custom component annotations. |

#### **1.11.3. Limitations of JSR-330 standard annotations**

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

| *Table 6. Spring component model elements vs. JSR-330 variants* | | |
| --- | --- | --- |
| **Spring** | **javax.inject.\*** | **javax.inject restrictions / comments** |
| @Autowired | @Inject | @Inject has no 'required' attribute; can be used with Java 8’s Optional instead. |
| @Component | @Named / @ManagedBean | JSR-330 does not provide a composable model, just a way to identify named components. |
| @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](https://download.oracle.com/javaee/6/api/javax/inject/Scope.html) annotation. Nevertheless, this one is only intended to be used for creating your own annotations. |
| @Qualifier | @Qualifier / @Named | javax.inject.Qualifier is just a meta-annotation for building custom qualifiers. Concrete String qualifiers (like Spring’s @Qualifier with a value) can be associated through javax.inject.Named. |
| @Value | - | no equivalent |
| @Required | - | no equivalent |
| @Lazy | - | no equivalent |
| ObjectFactory | Provider | javax.inject.Provider is a direct alternative to Spring’s ObjectFactory, just with a shorter get() method name. It can also be used in combination with Spring’s @Autowired or with non-annotated constructors and setter methods. |

### **1.12. Java-based container configuration**

#### **1.12.1. Basic concepts: @Bean and @Configuration**

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>

Full @Configuration vs 'lite' @Bean 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. Bean methods declared in a @Component or even in a plain old class will be considered 'lite', with a different primary purpose of the containing class and an @Bean method just being a sort of bonus there. For example, service components may expose management views to the container through an additional @Bean method on each applicable component class. In such scenarios, @Bean methods are a simple general-purpose factory method mechanism.

Unlike full @Configuration, lite @Bean methods cannot declare inter-bean dependencies. Instead, they operate on their containing component’s internal state and optionally on arguments that they may declare. Such an @Bean method should therefore not invoke other @Bean methods; each such method is literally just a factory method for a particular bean reference, without any special runtime semantics. The positive side-effect here is that no CGLIB subclassing has to be applied at runtime, so there are no limitations in terms of class design (i.e. the containing class may nevertheless be final etc).

In common scenarios, @Bean methods are to be declared within @Configuration classes, ensuring that 'full' mode is always used and that cross-method references will therefore get redirected to the container’s lifecycle management. This will prevent the same @Bean method from accidentally being invoked through a regular Java call which helps to reduce subtle bugs that can be hard to track down when operating in 'lite' mode.

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.

#### **1.12.2. 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, Dependency2.class);

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…​)**

To enable component scanning, just annotate your @Configuration class as follows:

@Configuration

@ComponentScan(basePackages = "com.acme")

**public** **class** **AppConfig** {

...

}

|  |  |
| --- | --- |
|  | Experienced Spring users will be familiar with the XML declaration equivalent 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-meta-annotations) 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>

<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>

#### **1.12.3. 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-initializingbean), [destroy-method](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-lifecycle-disposablebean), [autowiring](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-autowire) 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** TransferServiceImpl 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

You may also declare your @Bean method with an interface (or base class) return type:

@Configuration

**public** **class** **AppConfig** {

@Bean

**public** TransferService transferService() {

**return** **new** TransferServiceImpl();

}

}

However, this limits the visibility for advance type prediction to the specified interface type (TransferService) then, with the full type (TransferServiceImpl) only known to the container once the affected singleton bean has been instantiated. Non-lazy singleton beans get instantiated according to their declaration order, so you may see different type matching results depending on when another component tries to match by a non-declared type (such as @Autowired TransferServiceImpl which will only resolve once the "transferService" bean has been instantiated).

|  |  |
| --- | --- |
|  | If you consistently refer to your types by a declared service interface, your @Bean return types may safely join that design decision. However, for components implementing several interfaces or for components potentially referred to by their implementation type, it is safer to declare the most specific return type possible (at least as specific as required by the injection points referring to your bean). |

##### **Bean dependencies**

A @Bean annotated method can have an arbitrary number of parameters describing the dependencies required to build that bean. For instance if our TransferService requires an AccountRepository we can materialize that dependency via a method parameter:

@Configuration

**public** **class** **AppConfig** {

@Bean

**public** TransferService transferService(AccountRepository accountRepository) {

**return** **new** TransferServiceImpl(accountRepository);

}

}

The resolution mechanism is pretty much identical to constructor-based dependency injection, see [the relevant section](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-constructor-injection) for more details.

##### **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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-postconstruct-and-predestroy-annotations) for further details.

The regular Spring [lifecycle](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-nature) 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-beanfactory), [BeanNameAware](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-aware), [MessageSourceAware](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#context-functionality-messagesource), [ApplicationContextAware](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-aware), 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();

}

}

|  |  |
| --- | --- |
|  | By default, beans defined using Java config that have a public close or shutdown method are automatically enlisted with a destruction callback. If you have a public close or shutdown method and you do not wish for it to be called when the container shuts down, simply add @Bean(destroyMethod="") to your bean definition to disable the default (inferred) mode.  You may want to do that by default for a resource that you acquire via JNDI as its lifecycle is managed outside the application. In particular, make sure to always do it for a DataSource as it is known to be problematic on Java EE application servers.  @Bean(destroyMethod="")  **public** DataSource dataSource() **throws** NamingException {  **return** (DataSource) jndiTemplate.lookup("MyDS");  }  Also, with @Bean methods, you will typically choose to use programmatic JNDI lookups: either using Spring’s JndiTemplate/JndiLocatorDelegate helpers or straight JNDI InitialContext usage, but not the JndiObjectFactoryBean variant which would force you to declare the return type as the FactoryBean type instead of the actual target type, making it harder to use for cross-reference calls in other @Bean methods that intend to refer to the provided resource here. |

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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes-other-injection). 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

**@SessionScope**

**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 [Naming beans](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-beanname), 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({"dataSource", "subsystemA-dataSource", "subsystemB-dataSource"})

**public** DataSource dataSource() {

*// instantiate, configure and return DataSource bean...*

}

}

##### **Bean description**

Sometimes it is helpful to provide a more detailed textual description of a bean. This can be particularly useful when beans are exposed (perhaps via JMX) for monitoring purposes.

To add a description to a @Bean the [@Description](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/annotation/Description.html) annotation can be used:

@Configuration

**public** **class** **AppConfig** {

@Bean

**@Description("Provides a basic example of a bean")**

**public** Foo foo() {

**return** **new** Foo();

}

}

#### **1.12.4. 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 [Basic concepts: @Bean and @Configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-java-basic-concepts) for a general introduction.

##### **Injecting inter-bean dependencies**

When @Beans 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-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.cglib 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, in particular that configuration classes must not be final. However, as of 4.3, any constructors are allowed on configuration classes, including the use of @Autowired or a single non-default constructor declaration for default injection.  If you prefer to avoid any CGLIB-imposed limitations, consider declaring your @Bean methods on non-@Configuration classes, e.g. on plain @Component classes instead. Cross-method calls between @Bean methods won’t get intercepted then, so you’ll have to exclusively rely on dependency injection at the constructor or method level there. |

#### **1.12.5. 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** {

@Bean

**public** A a() {

**return** **new** A();

}

}

@Configuration

@Import(ConfigA.class)

**public** **class** **ConfigB** {

@Bean

**public** 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.

|  |  |
| --- | --- |
|  | As of Spring Framework 4.2, @Import also supports references to regular component classes, analogous to the AnnotationConfigApplicationContext.register method. This is particularly useful if you’d like to avoid component scanning, using a few configuration classes as entry points for explicitly defining all your components. |

###### **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. As [we already discussed](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-java-dependencies), @Bean method can have an arbitrary number of parameters describing the bean dependencies. Let’s consider a more real-world scenario with several @Configuration classes, each depending on beans declared in the others:

@Configuration

**public** **class** **ServiceConfig** {

@Bean

**public** TransferService transferService(AccountRepository accountRepository) {

**return** **new** TransferServiceImpl(accountRepository);

}

}

@Configuration

**public** **class** **RepositoryConfig** {

@Bean

**public** AccountRepository accountRepository(DataSource dataSource) {

**return** **new** JdbcAccountRepository(dataSource);

}

}

@Configuration

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

**public** **class** **SystemTestConfig** {

@Bean

**public** 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");

}

There is another way to achieve the same result. Remember that @Configuration classes are ultimately just another bean in the container: This means that they can take advantage of @Autowired and @Value injection etc just like any other bean!

|  |  |
| --- | --- |
|  | Make sure that the dependencies you inject that way are of the simplest kind only. @Configuration classes are processed quite early during the initialization of the context and forcing a dependency to be injected this way may lead to unexpected early initialization. Whenever possible, resort to parameter-based injection as in the example above.  Also, be particularly careful with BeanPostProcessor and BeanFactoryPostProcessor definitions via @Bean. Those should usually be declared as static @Bean methods, not triggering the instantiation of their containing configuration class. Otherwise, @Autowired and @Value won’t work on the configuration class itself since it is being created as a bean instance too early. |

@Configuration

**public** **class** **ServiceConfig** {

@Autowired

**private** AccountRepository accountRepository;

@Bean

**public** TransferService transferService() {

**return** **new** TransferServiceImpl(accountRepository);

}

}

@Configuration

**public** **class** **RepositoryConfig** {

**private** **final** DataSource dataSource;

@Autowired

**public** RepositoryConfig(DataSource dataSource) {

this.dataSource = dataSource;

}

@Bean

**public** AccountRepository accountRepository() {

**return** **new** JdbcAccountRepository(dataSource);

}

}

@Configuration

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

**public** **class** **SystemTestConfig** {

@Bean

**public** 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");

}

|  |  |
| --- | --- |
|  | Constructor injection in @Configuration classes is only supported as of Spring Framework 4.3. Note also that there is no need to specify @Autowired if the target bean defines only one constructor; in the example above, @Autowired is not necessary on the RepositoryConfig constructor. |

*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 [Spring Tool Suite](https://spring.io/tools/sts) 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** {

@Autowired

**private** RepositoryConfig repositoryConfig;

@Bean

**public** 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** {

@Autowired

**private** RepositoryConfig repositoryConfig;

@Bean

**public** TransferService transferService() {

**return** **new** TransferServiceImpl(repositoryConfig.accountRepository());

}

}

@Configuration

**public** **interface** **RepositoryConfig** {

@Bean

AccountRepository accountRepository();

}

@Configuration

**public** **class** **DefaultRepositoryConfig** **implements** RepositoryConfig {

@Bean

**public** AccountRepository accountRepository() {

**return** **new** JdbcAccountRepository(...);

}

}

@Configuration

@Import({ServiceConfig.class, DefaultRepositoryConfig.class}) *// import the concrete config!*

**public** **class** **SystemTestConfig** {

@Bean

**public** 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.

|  |  |
| --- | --- |
|  | If you would like to influence the startup creation order of certain beans, consider declaring some of them as @Lazy (for creation on first access instead of on startup) or as @DependsOn on certain other beans (making sure that specific other beans will be created before the current bean, beyond what the latter’s direct dependencies imply). |

##### **Conditionally include @Configuration classes or @Bean methods**

It is often useful to conditionally enable or disable a complete @Configuration class, or even individual @Bean methods, based on some arbitrary system state. One common example of this is to use the @Profile annotation to activate beans only when a specific profile has been enabled in the Spring Environment (see [Bean definition profiles](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-definition-profiles) for details).

The @Profile annotation is actually implemented using a much more flexible annotation called [@Conditional](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/annotation/Conditional.html). The @Conditional annotation indicates specific org.springframework.context.annotation.Condition implementations that should be consulted before a @Bean is registered.

Implementations of the Condition interface simply provide a matches(…​) method that returns true or false. For example, here is the actual Condition implementation used for @Profile:

@Override

**public** **boolean** matches(ConditionContext context, AnnotatedTypeMetadata metadata) {

**if** (context.getEnvironment() != null) {

*// Read the @Profile annotation attributes*

MultiValueMap<String, Object> attrs = metadata.getAllAnnotationAttributes(Profile.class.getName());

**if** (attrs != null) {

**for** (Object value : attrs.get("value")) {

**if** (context.getEnvironment().acceptsProfiles(((String**[]**) value))) {

**return** true;

}

}

**return** false;

}

}

**return** true;

}

See the [@Conditional javadocs](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/annotation/Conditional.html) for more detail.

##### **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** {

@Autowired

**private** DataSource dataSource;

@Bean

**public** AccountRepository accountRepository() {

**return** **new** JdbcAccountRepository(dataSource);

}

@Bean

**public** 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 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** {

@Value("${jdbc.url}")

**private** String url;

@Value("${jdbc.username}")

**private** String username;

@Value("${jdbc.password}")

**private** String password;

@Bean

**public** 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);

*// ...*

}

### **1.13. Environment abstraction**

The [Environment](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/core/env/Environment.html) is an abstraction integrated in the container that models two key aspects of the application environment: [profiles](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-definition-profiles) and [properties](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-property-source-abstraction).

A profile is a named, logical group of bean definitions to be registered with the container only if the given profile is active. Beans may be assigned to a profile whether defined in XML or via annotations. The role of the Environment object with relation to profiles is in determining which profiles (if any) are currently active, and which profiles (if any) should be active by default.

Properties play an important role in almost all applications, and may originate from a variety of sources: properties files, JVM system properties, system environment variables, JNDI, servlet context parameters, ad-hoc Properties objects, Maps, and so on. The role of the Environment object with relation to properties is to provide the user with a convenient service interface for configuring property sources and resolving properties from them.

#### **1.13.1. Bean definition profiles**

Bean definition profiles is a mechanism in the core container that allows for registration of different beans in different environments. The word environment can mean different things to different users and this feature can help with many use cases, including:

* working against an in-memory datasource in development vs looking up that same datasource from JNDI when in QA or production
* registering monitoring infrastructure only when deploying an application into a performance environment
* registering customized implementations of beans for customer A vs. customer B deployments

Let’s consider the first use case in a practical application that requires a DataSource. In a test environment, the configuration may look like this:

@Bean

**public** DataSource dataSource() {

**return** **new** EmbeddedDatabaseBuilder()

.setType(EmbeddedDatabaseType.HSQL)

.addScript("my-schema.sql")

.addScript("my-test-data.sql")

.build();

}

Let’s now consider how this application will be deployed into a QA or production environment, assuming that the datasource for the application will be registered with the production application server’s JNDI directory. Our dataSource bean now looks like this:

@Bean(destroyMethod="")

**public** DataSource dataSource() **throws** Exception {

Context ctx = **new** InitialContext();

**return** (DataSource) ctx.lookup("java:comp/env/jdbc/datasource");

}

The problem is how to switch between using these two variations based on the current environment. Over time, Spring users have devised a number of ways to get this done, usually relying on a combination of system environment variables and XML <import/> statements containing ${placeholder} tokens that resolve to the correct configuration file path depending on the value of an environment variable. Bean definition profiles is a core container feature that provides a solution to this problem.

If we generalize the example use case above of environment-specific bean definitions, we end up with the need to register certain bean definitions in certain contexts, while not in others. You could say that you want to register a certain profile of bean definitions in situation A, and a different profile in situation B. Let’s first see how we can update our configuration to reflect this need.

##### **@Profile**

The [@Profile](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/annotation/Profile.html) annotation allows you to indicate that a component is eligible for registration when one or more specified profiles are active. Using our example above, we can rewrite the dataSource configuration as follows:

@Configuration

**@Profile("development")**

**public** **class** **StandaloneDataConfig** {

@Bean

**public** DataSource dataSource() {

**return** **new** EmbeddedDatabaseBuilder()

.setType(EmbeddedDatabaseType.HSQL)

.addScript("classpath:com/bank/config/sql/schema.sql")

.addScript("classpath:com/bank/config/sql/test-data.sql")

.build();

}

}

@Configuration

**@Profile("production")**

**public** **class** **JndiDataConfig** {

@Bean(destroyMethod="")

**public** DataSource dataSource() **throws** Exception {

Context ctx = **new** InitialContext();

**return** (DataSource) ctx.lookup("java:comp/env/jdbc/datasource");

}

}

|  |  |
| --- | --- |
|  | As mentioned before, with @Bean methods, you will typically choose to use programmatic JNDI lookups: either using Spring’s JndiTemplate/JndiLocatorDelegate helpers or the straight JNDI InitialContext usage shown above, but not the JndiObjectFactoryBean variant which would force you to declare the return type as the FactoryBean type. |

@Profile can be used as a [meta-annotation](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-meta-annotations) for the purpose of creating a custom composed annotation. The following example defines a custom @Production annotation that can be used as a drop-in replacement for @Profile("production"):

@Target(ElementType.TYPE)

@Retention(RetentionPolicy.RUNTIME)

**@Profile("production")**

**public** @interface Production {

}

|  |  |
| --- | --- |
|  | If a @Configuration class is marked with @Profile, all of the @Bean methods and @Import annotations associated with that class will be bypassed unless one or more of the specified profiles are active. If a @Component or @Configuration class is marked with @Profile({"p1", "p2"}), that class will not be registered/processed unless profiles 'p1' and/or 'p2' have been activated. If a given profile is prefixed with the NOT operator (!), the annotated element will be registered if the profile is **not** active. For example, given @Profile({"p1", "!p2"}), registration will occur if profile 'p1' is active or if profile 'p2' is not active. |

@Profile can also be declared at the method level to include only one particular bean of a configuration class, e.g. for alternative variants of a particular bean:

@Configuration

**public** **class** **AppConfig** {

@Bean("dataSource")

**@Profile("development")**

**public** DataSource standaloneDataSource() {

**return** **new** EmbeddedDatabaseBuilder()

.setType(EmbeddedDatabaseType.HSQL)

.addScript("classpath:com/bank/config/sql/schema.sql")

.addScript("classpath:com/bank/config/sql/test-data.sql")

.build();

}

@Bean("dataSource")

**@Profile("production")**

**public** DataSource jndiDataSource() **throws** Exception {

Context ctx = **new** InitialContext();

**return** (DataSource) ctx.lookup("java:comp/env/jdbc/datasource");

}

}

|  |  |
| --- | --- |
|  | With @Profile on @Bean methods, a special scenario may apply: In the case of overloaded @Bean methods of the same Java method name (analogous to constructor overloading), an @Profile condition needs to be consistently declared on all overloaded methods. If the conditions are inconsistent, only the condition on the first declaration among the overloaded methods will matter. @Profile can therefore not be used to select an overloaded method with a particular argument signature over another; resolution between all factory methods for the same bean follows Spring’s constructor resolution algorithm at creation time.  If you would like to define alternative beans with different profile conditions, use distinct Java method names pointing to the same bean name via the @Bean name attribute, as indicated in the example above. If the argument signatures are all the same (e.g. all of the variants have no-arg factory methods), this is the only way to represent such an arrangement in a valid Java class in the first place (since there can only be one method of a particular name and argument signature). |

##### **XML bean definition profiles**

The XML counterpart is the profile attribute of the <beans> element. Our sample configuration above can be rewritten in two XML files as follows:

<beans profile="development"

xmlns="http://www.springframework.org/schema/beans"

xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

xmlns:jdbc="http://www.springframework.org/schema/jdbc"

xsi:schemaLocation="...">

<jdbc:embedded-database id="dataSource">

<jdbc:script location="classpath:com/bank/config/sql/schema.sql"/>

<jdbc:script location="classpath:com/bank/config/sql/test-data.sql"/>

</jdbc:embedded-database>

</beans>

<beans profile="production"

xmlns="http://www.springframework.org/schema/beans"

xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

xmlns:jee="http://www.springframework.org/schema/jee"

xsi:schemaLocation="...">

<jee:jndi-lookup id="dataSource" jndi-name="java:comp/env/jdbc/datasource"/>

</beans>

It is also possible to avoid that split and nest <beans/> elements within the same file:

<beans xmlns="http://www.springframework.org/schema/beans"

xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

xmlns:jdbc="http://www.springframework.org/schema/jdbc"

xmlns:jee="http://www.springframework.org/schema/jee"

xsi:schemaLocation="...">

*<!-- other bean definitions -->*

<beans profile="development">

<jdbc:embedded-database id="dataSource">

<jdbc:script location="classpath:com/bank/config/sql/schema.sql"/>

<jdbc:script location="classpath:com/bank/config/sql/test-data.sql"/>

</jdbc:embedded-database>

</beans>

<beans profile="production">

<jee:jndi-lookup id="dataSource" jndi-name="java:comp/env/jdbc/datasource"/>

</beans>

</beans>

The spring-bean.xsd has been constrained to allow such elements only as the last ones in the file. This should help provide flexibility without incurring clutter in the XML files.

##### **Activating a profile**

Now that we have updated our configuration, we still need to instruct Spring which profile is active. If we started our sample application right now, we would see a NoSuchBeanDefinitionException thrown, because the container could not find the Spring bean named dataSource.

Activating a profile can be done in several ways, but the most straightforward is to do it programmatically against the Environment API which is available via an ApplicationContext:

AnnotationConfigApplicationContext ctx = **new** AnnotationConfigApplicationContext();

ctx.getEnvironment().setActiveProfiles("development");

ctx.register(SomeConfig.class, StandaloneDataConfig.class, JndiDataConfig.class);

ctx.refresh();

In addition, profiles may also be activated declaratively through the spring.profiles.active property which may be specified through system environment variables, JVM system properties, servlet context parameters in web.xml, or even as an entry in JNDI (see [PropertySource abstraction](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-property-source-abstraction)). In integration tests, active profiles can be declared via the @ActiveProfiles annotation in the spring-test module (see [Context configuration with environment profiles](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/testing.html#testcontext-ctx-management-env-profiles)).

Note that profiles are not an "either-or" proposition; it is possible to activate multiple profiles at once. Programmatically, simply provide multiple profile names to the setActiveProfiles() method, which accepts String…​ varargs:

ctx.getEnvironment().setActiveProfiles("profile1", "profile2");

Declaratively, spring.profiles.active may accept a comma-separated list of profile names:

-Dspring.profiles.active="profile1,profile2"

##### **Default profile**

The default profile represents the profile that is enabled by default. Consider the following:

@Configuration

**@Profile("default")**

**public** **class** **DefaultDataConfig** {

@Bean

**public** DataSource dataSource() {

**return** **new** EmbeddedDatabaseBuilder()

.setType(EmbeddedDatabaseType.HSQL)

.addScript("classpath:com/bank/config/sql/schema.sql")

.build();

}

}

If no profile is active, the dataSource above will be created; this can be seen as a way to provide a default definition for one or more beans. If any profile is enabled, the default profile will not apply.

The name of the default profile can be changed using setDefaultProfiles() on the Environment or declaratively using the spring.profiles.default property.

#### **1.13.2. PropertySource abstraction**

Spring’s Environment abstraction provides search operations over a configurable hierarchy of property sources. To explain fully, consider the following:

ApplicationContext ctx = **new** GenericApplicationContext();

Environment env = ctx.getEnvironment();

**boolean** containsFoo = env.containsProperty("foo");

System.out.println("Does my environment contain the 'foo' property? " + containsFoo);

In the snippet above, we see a high-level way of asking Spring whether the foo property is defined for the current environment. To answer this question, the Environment object performs a search over a set of [PropertySource](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/core/env/PropertySource.html) objects. A PropertySource is a simple abstraction over any source of key-value pairs, and Spring’s [StandardEnvironment](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/core/env/StandardEnvironment.html) is configured with two PropertySource objects — one representing the set of JVM system properties (a la System.getProperties()) and one representing the set of system environment variables (a la System.getenv()).

|  |  |
| --- | --- |
|  | These default property sources are present for StandardEnvironment, for use in standalone applications. [StandardServletEnvironment](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/web/context/support/StandardServletEnvironment.html) is populated with additional default property sources including servlet config and servlet context parameters. It can optionally enable a [JndiPropertySource](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/jndi/JndiPropertySource.html). See the javadocs for details. |

Concretely, when using the StandardEnvironment, the call to env.containsProperty("foo") will return true if a foo system property or foo environment variable is present at runtime.

|  |  |
| --- | --- |
|  | The search performed is hierarchical. By default, system properties have precedence over environment variables, so if the foo property happens to be set in both places during a call to env.getProperty("foo"), the system property value will 'win' and be returned preferentially over the environment variable. Note that property values will not get merged but rather completely overridden by a preceding entry.  For a common StandardServletEnvironment, the full hierarchy looks as follows, with the highest-precedence entries at the top:   * ServletConfig parameters (if applicable, e.g. in case of a DispatcherServlet context) * ServletContext parameters (web.xml context-param entries) * JNDI environment variables ("java:comp/env/" entries) * JVM system properties ("-D" command-line arguments) * JVM system environment (operating system environment variables) |

Most importantly, the entire mechanism is configurable. Perhaps you have a custom source of properties that you’d like to integrate into this search. No problem — simply implement and instantiate your own PropertySource and add it to the set of PropertySources for the current Environment:

ConfigurableApplicationContext ctx = **new** GenericApplicationContext();

MutablePropertySources sources = ctx.getEnvironment().getPropertySources();

sources.addFirst(**new** MyPropertySource());

In the code above, MyPropertySource has been added with highest precedence in the search. If it contains a foo property, it will be detected and returned ahead of any foo property in any other PropertySource. The [MutablePropertySources](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/core/env/MutablePropertySources.html) API exposes a number of methods that allow for precise manipulation of the set of property sources.

#### **1.13.3. @PropertySource**

The [@PropertySource](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/annotation/PropertySource.html) annotation provides a convenient and declarative mechanism for adding a PropertySource to Spring’s Environment.

Given a file "app.properties" containing the key/value pair testbean.name=myTestBean, the following @Configuration class uses @PropertySource in such a way that a call to testBean.getName() will return "myTestBean".

@Configuration

**@PropertySource("classpath:/com/myco/app.properties")**

**public** **class** **AppConfig** {

@Autowired

Environment env;

@Bean

**public** TestBean testBean() {

TestBean testBean = **new** TestBean();

testBean.setName(env.getProperty("testbean.name"));

**return** testBean;

}

}

Any ${…​} placeholders present in a @PropertySource resource location will be resolved against the set of property sources already registered against the environment. For example:

@Configuration

@PropertySource("classpath:/com/${my.placeholder:default/path}/app.properties")

**public** **class** **AppConfig** {

@Autowired

Environment env;

@Bean

**public** TestBean testBean() {

TestBean testBean = **new** TestBean();

testBean.setName(env.getProperty("testbean.name"));

**return** testBean;

}

}

Assuming that "my.placeholder" is present in one of the property sources already registered, e.g. system properties or environment variables, the placeholder will be resolved to the corresponding value. If not, then "default/path" will be used as a default. If no default is specified and a property cannot be resolved, an IllegalArgumentException will be thrown.

|  |  |
| --- | --- |
|  | The @PropertySource annotation is repeatable according to Java 8 conventions. However, all such @PropertySource annotations need to be declared at the same level: either directly on the configuration class or as meta-annotations within the same custom annotation. Mixing of direct annotations and meta-annotations is not recommended since direct annotations will effectively override meta-annotations. |

#### **1.13.4. Placeholder resolution in statements**

Historically, the value of placeholders in elements could be resolved only against JVM system properties or environment variables. No longer is this the case. Because the Environment abstraction is integrated throughout the container, it’s easy to route resolution of placeholders through it. This means that you may configure the resolution process in any way you like: change the precedence of searching through system properties and environment variables, or remove them entirely; add your own property sources to the mix as appropriate.

Concretely, the following statement works regardless of where the customer property is defined, as long as it is available in the Environment:

<beans>

<import resource="com/bank/service/${customer}-config.xml"/>

</beans>

### **1.14. 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](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/data-access.html#orm-jpa) where load-time weaving may be necessary for JPA class transformation. Consult the LocalContainerEntityManagerFactoryBean javadocs for more detail. For more on AspectJ load-time weaving, see [Load-time weaving with AspectJ in the Spring Framework](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw).

### **1.15. 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](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/context/ApplicationContext.html) 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 Java EE 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 namely 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.

#### **1.15.1. 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 javadocs for details. |

#### **1.15.2. 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.

|  |  |
| --- | --- |
|  | As of Spring 4.2, the event infrastructure has been significantly improved and offer an [annotation-based model](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#context-functionality-events-annotation) as well as the ability to publish any arbitrary event, that is an object that does not necessarily extend from ApplicationEvent. When such an object is published we wrap it in an event for you. |

Spring provides the following standard events:

| *Table 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. |
| 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 content;

**public** BlackListEvent(Object source, String address, String content) {

super(source);

this.address = address;

this.content = content;

}

*// 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 content) {

**if** (blackList.contains(address)) {

publisher.publishEvent(**new** BlackListEvent(this, address, content));

**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](https://projects.spring.io/spring-integration/) project provides complete support for building lightweight, [pattern-oriented](https://www.enterpriseintegrationpatterns.com/), event-driven architectures that build upon the well-known Spring programming model. |

##### **Annotation-based event listeners**

As of Spring 4.2, an event listener can be registered on any public method of a managed bean via the EventListener annotation. The BlackListNotifier can be rewritten as follows:

**public** **class** **BlackListNotifier** {

**private** String notificationAddress;

**public** **void** setNotificationAddress(String notificationAddress) {

this.notificationAddress = notificationAddress;

}

@EventListener

**public** **void** processBlackListEvent(BlackListEvent event) {

*// notify appropriate parties via notificationAddress...*

}

}

As you can see above, the method signature once again declares the event type it listens to, but this time with a flexible name and without implementing a specific listener interface. The event type can also be narrowed through generics as long as the actual event type resolves your generic parameter in its implementation hierarchy.

If your method should listen to several events or if you want to define it with no parameter at all, the event type(s) can also be specified on the annotation itself:

@EventListener({ContextStartedEvent.class, ContextRefreshedEvent.class})

**public** **void** handleContextStart() {

...

}

It is also possible to add additional runtime filtering via the condition attribute of the annotation that defines a [SpEL expression](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#expressions) that should match to actually invoke the method for a particular event.

For instance, our notifier can be rewritten to be only invoked if the content attribute of the event is equal to foo:

@EventListener(condition = "#blEvent.content == 'foo'")

**public** **void** processBlackListEvent(BlackListEvent blEvent) {

*// notify appropriate parties via notificationAddress...*

}

Each SpEL expression evaluates against a dedicated context. The next table lists the items made available to the context so one can use them for conditional event processing:

| *Table 8. Event SpEL available metadata* | | | |
| --- | --- | --- | --- |
| **Name** | **Location** | **Description** | **Example** |
| Event | root object | The actual ApplicationEvent | #root.event |
| Arguments array | root object | The arguments (as array) used for invoking the target | #root.args[0] |
| Argument name | evaluation context | Name of any of the method arguments. If for some reason the names are not available (e.g. no debug information), the argument names are also available under the #a<#arg> where #arg stands for the argument index (starting from 0). | #blEvent or #a0 (one can also use #p0 or #p<#arg> notation as an alias). |

Note that #root.event allows you to access to the underlying event, even if your method signature actually refers to an arbitrary object that was published.

If you need to publish an event as the result of processing another, just change the method signature to return the event that should be published, something like:

@EventListener

**public** ListUpdateEvent handleBlackListEvent(BlackListEvent event) {

*// notify appropriate parties via notificationAddress and*

*// then publish a ListUpdateEvent...*

}

|  |  |
| --- | --- |
|  | This feature is not supported for [asynchronous listeners](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#context-functionality-events-async). |

This new method will publish a new ListUpdateEvent for every BlackListEvent handled by the method above. If you need to publish several events, just return a Collection of events instead.

##### **Asynchronous Listeners**

If you want a particular listener to process events asynchronously, simply reuse the [regular @Async support](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/integration.html#scheduling-annotation-support-async):

@EventListener

@Async

**public** **void** processBlackListEvent(BlackListEvent event) {

*// BlackListEvent is processed in a separate thread*

}

Be aware of the following limitations when using asynchronous events:

1. If the event listener throws an Exception it will not be propagated to the caller, check AsyncUncaughtExceptionHandler for more details.
2. Such event listener cannot send replies. If you need to send another event as the result of the processing, inject ApplicationEventPublisher to send the event manually.

##### **Ordering listeners**

If you need the listener to be invoked before another one, just add the @Order annotation to the method declaration:

@EventListener

@Order(42)

**public** **void** processBlackListEvent(BlackListEvent event) {

*// notify appropriate parties via notificationAddress...*

}

##### **Generic events**

You may also use generics to further define the structure of your event. Consider an EntityCreatedEvent<T> where T is the type of the actual entity that got created. You can create the following listener definition to only receive EntityCreatedEvent for a Person:

@EventListener

**public** **void** onPersonCreated(EntityCreatedEvent<Person> event) {

...

}

Due to type erasure, this will only work if the event that is fired resolves the generic parameter(s) on which the event listener filters on (that is something like class PersonCreatedEvent extends EntityCreatedEvent<Person> { …​ }).

In certain circumstances, this may become quite tedious if all events follow the same structure (as it should be the case for the event above). In such a case, you can implement ResolvableTypeProvider to guide the framework beyond what the runtime environment provides:

**public** **class** **EntityCreatedEvent**<T> **extends** ApplicationEvent **implements** ResolvableTypeProvider {

**public** EntityCreatedEvent(T entity) {

super(entity);

}

@Override

**public** ResolvableType getResolvableType() {

**return** ResolvableType.forClassWithGenerics(getClass(),

ResolvableType.forInstance(getSource()));

}

}

|  |  |
| --- | --- |
|  | This works not only for ApplicationEvent but any arbitrary object that you’d send as an event. |

#### **1.15.3. 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 [Resources](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#resources).

An application context is a ResourceLoader, which can be used to load Resources. 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.

#### **1.15.4. 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".

#### **1.15.5. Deploying a Spring ApplicationContext as a Java EE RAR file**

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 Java EE RAR deployment unit. This is the equivalent of bootstrapping a standalone ApplicationContext, just hosted in Java EE environment, being able to access the Java EE servers facilities. RAR deployment is 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 Java EE 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](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/jca/context/SpringContextResourceAdapter.html) class for the configuration details involved in RAR deployment.

For a simple deployment of a Spring ApplicationContext as a Java EE 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 SpringContextResourceAdapters 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. |

### **1.16. The BeanFactory**

The BeanFactory API provides the underlying basis for Spring’s IoC functionality. Its specific contracts are mostly used in integration with other parts of Spring and related third-party frameworks, and its DefaultListableBeanFactory implementation is a key delegate within the higher-level GenericApplicationContext container.

BeanFactory and related interfaces such as BeanFactoryAware, InitializingBean, DisposableBean are important integration points for other framework components: not requiring any annotations or even reflection, they allow for very efficient interaction between the container and its components. Application-level beans may use the same callback interfaces but will typically prefer declarative dependency injection instead, either via annotations or through programmatic configuration.

Note that the core BeanFactory API level and its DefaultListableBeanFactory implementation do not make assumptions about the configuration format or any component annotations to be used. All of these flavors come in through extensions such as XmlBeanDefinitionReader and AutowiredAnnotationBeanPostProcessor, operating on shared BeanDefinition objects as a core metadata representation. This is the essence of what makes Spring’s container so flexible and extensible.

The following section explains the differences between the BeanFactory and ApplicationContext container levels and the implications on bootstrapping.

#### **1.16.1. BeanFactory or ApplicationContext?**

Use an ApplicationContext unless you have a good reason for not doing so, with GenericApplicationContext and its subclass AnnotationConfigApplicationContext as the common implementations for custom bootstrapping. These are the primary entry points to Spring’s core container for all common purposes: loading of configuration files, triggering a classpath scan, programmatically registering bean definitions and annotated classes, and as of 5.0 also registering functional bean definitions.

Because an ApplicationContext includes all functionality of a BeanFactory, it is generally recommended over a plain BeanFactory, except for a scenarios where full control over bean processing is needed. Within an ApplicationContext such as the GenericApplicationContext implementation, several kinds of beans will be detected by convention (i.e. by bean name or by bean type), in particular post-processors, whereas a plain DefaultListableBeanFactory is agnostic about any special beans.

For many extended container features such as annotation processing and AOP proxying, the [BeanPostProcessor extension point](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-extension-bpp) is essential. If you use only a plain DefaultListableBeanFactory, such post-processors will not get detected and activated by default. This situation could be confusing because nothing is actually wrong with your bean configuration; it is rather the container which needs to be fully bootstrapped through additional setup in such a scenario.

The following table lists features provided by the BeanFactory and ApplicationContext interfaces and implementations.

| *Table 9. Feature Matrix* | | |
| --- | --- | --- |
| **Feature** | BeanFactory | ApplicationContext |
| Bean instantiation/wiring | Yes | Yes |
| Integrated lifecycle management | No | Yes |
| Automatic BeanPostProcessor registration | No | Yes |
| Automatic BeanFactoryPostProcessor registration | No | Yes |
| Convenient MessageSource access (for internalization) | No | Yes |
| Built-in ApplicationEvent publication mechanism | No | Yes |

To explicitly register a bean post-processor with a DefaultListableBeanFactory, you need to programmatically call addBeanPostProcessor:

DefaultListableBeanFactory factory = **new** DefaultListableBeanFactory();

*// populate the factory with bean definitions*

*// now register any needed BeanPostProcessor instances*

factory.addBeanPostProcessor(**new** AutowiredAnnotationBeanPostProcessor());

factory.addBeanPostProcessor(**new** MyBeanPostProcessor());

*// now start using the factory*

To apply a BeanFactoryPostProcessor to a plain DefaultListableBeanFactory, you need to call its postProcessBeanFactory method:

DefaultListableBeanFactory factory = **new** DefaultListableBeanFactory();

XmlBeanDefinitionReader reader = **new** XmlBeanDefinitionReader(factory);

reader.loadBeanDefinitions(**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 steps are inconvenient, which is why the various ApplicationContext variants are preferred over a plain DefaultListableBeanFactory in Spring-backed applications, especially when relying on BeanFactoryPostProcessors and BeanPostProcessors for extended container functionality in a typical enterprise setup.

|  |  |
| --- | --- |
|  | An AnnotationConfigApplicationContext has all common annotation post-processors registered out of the box and may bring in additional processors underneath the covers through configuration annotations such as @EnableTransactionManagement. At the abstraction level of Spring’s annotation-based configuration model, the notion of bean post-processors becomes a mere internal container detail. |

## 2. Resources

### **2.1. Introduction**

Java’s standard java.net.URL class and standard handlers for various URL prefixes unfortunately are not quite adequate enough for all access to low-level resources. For example, there is no standardized URL implementation that may be used to access a resource that needs to be obtained from the classpath, or relative to a ServletContext. While it is possible to register new handlers for specialized URL prefixes (similar to existing handlers for prefixes such as http:), this is generally quite complicated, and the URL interface still lacks some desirable functionality, such as a method to check for the existence of the resource being pointed to.

### **2.2. The Resource interface**

Spring’s Resource interface is meant to be a more capable interface for abstracting access to low-level resources.

**public** **interface** **Resource** **extends** InputStreamSource {

**boolean** exists();

**boolean** isOpen();

URL getURL() **throws** IOException;

File getFile() **throws** IOException;

Resource createRelative(String relativePath) **throws** IOException;

String getFilename();

String getDescription();

}

**public** **interface** **InputStreamSource** {

InputStream getInputStream() **throws** IOException;

}

Some of the most important methods from the Resource interface are:

* getInputStream(): locates and opens the resource, returning an InputStream for reading from the resource. It is expected that each invocation returns a fresh InputStream. It is the responsibility of the caller to close the stream.
* exists(): returns a boolean indicating whether this resource actually exists in physical form.
* isOpen(): returns a boolean indicating whether this resource represents a handle with an open stream. If true, the InputStream cannot be read multiple times, and must be read once only and then closed to avoid resource leaks. Will be false for all usual resource implementations, with the exception of InputStreamResource.
* getDescription(): returns a description for this resource, to be used for error output when working with the resource. This is often the fully qualified file name or the actual URL of the resource.

Other methods allow you to obtain an actual URL or File object representing the resource (if the underlying implementation is compatible, and supports that functionality).

The Resource abstraction is used extensively in Spring itself, as an argument type in many method signatures when a resource is needed. Other methods in some Spring APIs (such as the constructors to various ApplicationContext implementations), take a String which in unadorned or simple form is used to create a Resource appropriate to that context implementation, or via special prefixes on the String path, allow the caller to specify that a specific Resource implementation must be created and used.

While the Resource interface is used a lot with Spring and by Spring, it’s actually very useful to use as a general utility class by itself in your own code, for access to resources, even when your code doesn’t know or care about any other parts of Spring. While this couples your code to Spring, it really only couples it to this small set of utility classes, which are serving as a more capable replacement for URL, and can be considered equivalent to any other library you would use for this purpose.

It is important to note that the Resource abstraction does not replace functionality: it wraps it where possible. For example, a UrlResource wraps a URL, and uses the wrapped URL to do its work.

### **2.3. Built-in Resource implementations**

There are a number of Resource implementations that come supplied straight out of the box in Spring:

#### **2.3.1. UrlResource**

The UrlResource wraps a java.net.URL, and may be used to access any object that is normally accessible via a URL, such as files, an HTTP target, an FTP target, etc. All URLs have a standardized String representation, such that appropriate standardized prefixes are used to indicate one URL type from another. This includes file: for accessing filesystem paths, http: for accessing resources via the HTTP protocol, ftp: for accessing resources via FTP, etc.

A UrlResource is created by Java code explicitly using the UrlResource constructor, but will often be created implicitly when you call an API method which takes a String argument which is meant to represent a path. For the latter case, a JavaBeans PropertyEditor will ultimately decide which type of Resource to create. If the path string contains a few well-known (to it, that is) prefixes such as classpath:, it will create an appropriate specialized Resource for that prefix. However, if it doesn’t recognize the prefix, it will assume the this is just a standard URL string, and will create a UrlResource.

#### **2.3.2. ClassPathResource**

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

This Resource implementation supports resolution as java.io.File if the class path resource resides in the file system, but not for classpath resources which reside in a jar and have not been expanded (by the servlet engine, or whatever the environment is) to the filesystem. To address this the various Resource implementations always support resolution as a java.net.URL.

A ClassPathResource is created by Java code explicitly using the ClassPathResource constructor, but will often be created implicitly when you call an API method which takes a String argument which is meant to represent a path. For the latter case, a JavaBeans PropertyEditor will recognize the special prefix classpath: on the string path, and create a ClassPathResource in that case.

#### **2.3.3. FileSystemResource**

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

#### **2.3.4. ServletContextResource**

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

This always supports stream access and URL access, but only allows java.io.File access when the web application archive is expanded and the resource is physically on the filesystem. Whether or not it’s expanded and on the filesystem like this, or accessed directly from the JAR or somewhere else like a DB (it’s conceivable) is actually dependent on the Servlet container.

#### **2.3.5. InputStreamResource**

A Resource implementation for a given InputStream. This should only be used if no specific Resource implementation is applicable. In particular, prefer ByteArrayResource or any of the file-based Resource implementations where possible.

In contrast to other Resource implementations, this is a descriptor for an already opened resource - therefore returning true from isOpen(). Do not use it if you need to keep the resource descriptor somewhere, or if you need to read a stream multiple times.

#### **2.3.6. ByteArrayResource**

This is a Resource implementation for a given byte array. It creates a ByteArrayInputStream for the given byte array.

It’s useful for loading content from any given byte array, without having to resort to a single-use InputStreamResource.

### **2.4. The ResourceLoader**

The ResourceLoader interface is meant to be implemented by objects that can return (i.e. load) Resource instances.

**public** **interface** **ResourceLoader** {

Resource getResource(String location);

}

All application contexts implement the ResourceLoader interface, and therefore all application contexts may be used to obtain Resource instances.

When you call getResource() on a specific application context, and the location path specified doesn’t have a specific prefix, you will get back a Resource type that is appropriate to that particular application context. For example, assume the following snippet of code was executed against a ClassPathXmlApplicationContext instance:

Resource template = ctx.getResource("some/resource/path/myTemplate.txt");

What would be returned would be a ClassPathResource; if the same method was executed against a FileSystemXmlApplicationContext instance, you’d get back a FileSystemResource. For a WebApplicationContext, you’d get back a ServletContextResource, and so on.

As such, you can load resources in a fashion appropriate to the particular application context.

On the other hand, you may also force ClassPathResource to be used, regardless of the application context type, by specifying the special classpath: prefix:

Resource template = ctx.getResource("classpath:some/resource/path/myTemplate.txt");

Similarly, one can force a UrlResource to be used by specifying any of the standard java.net.URL prefixes:

Resource template = ctx.getResource("file:///some/resource/path/myTemplate.txt");

Resource template = ctx.getResource("https://myhost.com/resource/path/myTemplate.txt");

The following table summarizes the strategy for converting Strings to Resources:

| *Table 10. Resource strings* | | |
| --- | --- | --- |
| **Prefix** | **Example** | **Explanation** |
| classpath: | classpath:com/myapp/config.xml | Loaded from the classpath. |
| file: | [file:///data/config.xml](file:///\\data\config.xml) | Loaded as a URL, from the filesystem. [[3](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#_footnote_3)] |
| http: | <https://myserver/logo.png> | Loaded as a URL. |
| (none) | /data/config.xml | Depends on the underlying ApplicationContext. |

### **2.5. The ResourceLoaderAware interface**

The ResourceLoaderAware interface is a special callback interface which identifies components that expect to be provided with a ResourceLoader reference:

**public** **interface** **ResourceLoaderAware** {

**void** setResourceLoader(ResourceLoader resourceLoader);

}

When a class implements ResourceLoaderAware and is deployed into an application context (as a Spring-managed bean), it is recognized as ResourceLoaderAware by the application context. The application context will then invoke the setResourceLoader(ResourceLoader), supplying itself as the argument (remember, all application contexts in Spring implement the ResourceLoader interface).

Of course, since an ApplicationContext is a ResourceLoader, the bean could also implement the ApplicationContextAware interface and use the supplied application context directly to load resources, but in general, it’s better to use the specialized ResourceLoader interface if that’s all that’s needed. The code would just be coupled to the resource loading interface, which can be considered a utility interface, and not the whole Spring ApplicationContext interface.

As of Spring 2.5, you can rely upon autowiring of the ResourceLoader as an alternative to implementing the ResourceLoaderAware interface. The "traditional" constructor and byType autowiring modes (as described in [Autowiring collaborators](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-autowire)) are now capable of providing a dependency of type ResourceLoader for either a constructor argument or setter method parameter respectively. For more flexibility (including the ability to autowire fields and multiple parameter methods), consider using the new annotation-based autowiring features. In that case, the ResourceLoader will be autowired into a field, constructor argument, or method parameter that is expecting the ResourceLoader type as long as the field, constructor, or method in question carries the @Autowired annotation. For more information, see [@Autowired](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-autowired-annotation).

### **2.6. Resources as dependencies**

If the bean itself is going to determine and supply the resource path through some sort of dynamic process, it probably makes sense for the bean to use the ResourceLoader interface to load resources. Consider as an example the loading of a template of some sort, where the specific resource that is needed depends on the role of the user. If the resources are static, it makes sense to eliminate the use of the ResourceLoader interface completely, and just have the bean expose the Resource properties it needs, and expect that they will be injected into it.

What makes it trivial to then inject these properties, is that all application contexts register and use a special JavaBeans PropertyEditor which can convert String paths to Resource objects. So if myBean has a template property of type Resource, it can be configured with a simple string for that resource, as follows:

<bean id="myBean" class="...">

<property name="template" value="some/resource/path/myTemplate.txt"/>

</bean>

Note that the resource path has no prefix, so because the application context itself is going to be used as the ResourceLoader, the resource itself will be loaded via a ClassPathResource, FileSystemResource, or ServletContextResource (as appropriate) depending on the exact type of the context.

If there is a need to force a specific Resource type to be used, then a prefix may be used. The following two examples show how to force a ClassPathResource and a UrlResource (the latter being used to access a filesystem file).

<property name="template" value="classpath:some/resource/path/myTemplate.txt">

<property name="template" value="file:///some/resource/path/myTemplate.txt"/>

### **2.7. Application contexts and Resource paths**

#### **2.7.1. Constructing application contexts**

An application context constructor (for a specific application context type) generally takes a string or array of strings as the location path(s) of the resource(s) such as XML files that make up the definition of the context.

When such a location path doesn’t have a prefix, the specific Resource type built from that path and used to load the bean definitions, depends on and is appropriate to the specific application context. For example, if you create a ClassPathXmlApplicationContext as follows:

ApplicationContext ctx = **new** ClassPathXmlApplicationContext("conf/appContext.xml");

The bean definitions will be loaded from the classpath, as a ClassPathResource will be used. But if you create a FileSystemXmlApplicationContext as follows:

ApplicationContext ctx =

**new** FileSystemXmlApplicationContext("conf/appContext.xml");

The bean definition will be loaded from a filesystem location, in this case relative to the current working directory.

Note that the use of the special classpath prefix or a standard URL prefix on the location path will override the default type of Resource created to load the definition. So this FileSystemXmlApplicationContext…​

ApplicationContext ctx =

**new** FileSystemXmlApplicationContext("classpath:conf/appContext.xml");

1. will actually load its bean definitions from the classpath. However, it is still a FileSystemXmlApplicationContext. If it is subsequently used as a ResourceLoader, any unprefixed paths will still be treated as filesystem paths.

##### **Constructing ClassPathXmlApplicationContext instances - shortcuts**

The ClassPathXmlApplicationContext exposes a number of constructors to enable convenient instantiation. The basic idea is that one supplies merely a string array containing just the filenames of the XML files themselves (without the leading path information), and one also supplies a Class; the ClassPathXmlApplicationContext will derive the path information from the supplied class.

An example will hopefully make this clear. Consider a directory layout that looks like this:

com/

foo/

services.xml

daos.xml

MessengerService.class

A ClassPathXmlApplicationContext instance composed of the beans defined in the 'services.xml' and 'daos.xml' could be instantiated like so…​

ApplicationContext ctx = **new** ClassPathXmlApplicationContext(

**new** String**[]** {"services.xml", "daos.xml"}, MessengerService.class);

Please do consult the ClassPathXmlApplicationContext javadocs for details on the various constructors.

#### **2.7.2. Wildcards in application context constructor resource paths**

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

One use for this mechanism is when doing component-style application assembly. All components can 'publish' context definition fragments to a well-known location path, and when the final application context is created using the same path prefixed via classpath\*:, all component fragments will be picked up automatically.

Note that this wildcarding is specific to use of resource paths in application context constructors (or when using the PathMatcher utility class hierarchy directly), and is resolved at construction time. It has nothing to do with the Resource type itself. It’s not possible to use the classpath\*: prefix to construct an actual Resource, as a resource points to just one resource at a time.

##### **Ant-style Patterns**

When the path location contains an Ant-style pattern, for example:

/WEB-INF/\*-context.xml

com/mycompany/\*\*/applicationContext.xml

file:C:/some/path/\*-context.xml

classpath:com/mycompany/\*\*/applicationContext.xml

The resolver follows a more complex but defined procedure to try to resolve the wildcard. It produces a Resource for the path up to the last non-wildcard segment and obtains a URL from it. If this URL is not a jar: URL or container-specific variant (e.g. zip: in WebLogic, wsjar in WebSphere, etc.), then a java.io.File is obtained from it and used to resolve the wildcard by traversing the filesystem. In the case of a jar URL, the resolver either gets a java.net.JarURLConnection from it or manually parses the jar URL and then traverses the contents of the jar file to resolve the wildcards.

###### **Implications on portability**

If the specified path is already a file URL (either explicitly, or implicitly because the base ResourceLoader is a filesystem one), then wildcarding is guaranteed to work in a completely portable fashion.

If the specified path is a classpath location, then the resolver must obtain the last non-wildcard path segment URL via a Classloader.getResource() call. Since this is just a node of the path (not the file at the end) it is actually undefined (in the ClassLoader javadocs) exactly what sort of a URL is returned in this case. In practice, it is always a java.io.File representing the directory, where the classpath resource resolves to a filesystem location, or a jar URL of some sort, where the classpath resource resolves to a jar location. Still, there is a portability concern on this operation.

If a jar URL is obtained for the last non-wildcard segment, the resolver must be able to get a java.net.JarURLConnection from it, or manually parse the jar URL, to be able to walk the contents of the jar, and resolve the wildcard. This will work in most environments, but will fail in others, and it is strongly recommended that the wildcard resolution of resources coming from jars be thoroughly tested in your specific environment before you rely on it.

##### **The classpath\*: prefix**

When constructing an XML-based application context, a location string may use the special classpath\*: prefix:

ApplicationContext ctx =

**new** ClassPathXmlApplicationContext("classpath\*:conf/appContext.xml");

This special prefix specifies that all classpath resources that match the given name must be obtained (internally, this essentially happens via a ClassLoader.getResources(…​) call), and then merged to form the final application context definition.

|  |  |
| --- | --- |
|  | The wildcard classpath relies on the getResources() method of the underlying classloader. As most application servers nowadays supply their own classloader implementation, the behavior might differ especially when dealing with jar files. A simple test to check if classpath\* works is to use the classloader to load a file from within a jar on the classpath: getClass().getClassLoader().getResources("<someFileInsideTheJar>"). Try this test with files that have the same name but are placed inside two different locations. In case an inappropriate result is returned, check the application server documentation for settings that might affect the classloader behavior. |

The classpath\*: prefix can also be combined with a PathMatcher pattern in the rest of the location path, for example classpath\*:META-INF/\*-beans.xml. In this case, the resolution strategy is fairly simple: a ClassLoader.getResources() call is used on the last non-wildcard path segment to get all the matching resources in the class loader hierarchy, and then off each resource the same PathMatcher resolution strategy described above is used for the wildcard subpath.

##### **Other notes relating to wildcards**

Please note that classpath\*: when combined with Ant-style patterns will only work reliably with at least one root directory before the pattern starts, unless the actual target files reside in the file system. This means that a pattern like classpath\*:\*.xml might not retrieve files from the root of jar files but rather only from the root of expanded directories.

Spring’s ability to retrieve classpath entries originates from the JDK’s ClassLoader.getResources() method which only returns file system locations for a passed-in empty string (indicating potential roots to search). Spring evaluates URLClassLoader runtime configuration and the "java.class.path" manifest in jar files as well but this is not guaranteed to lead to portable behavior.

|  |  |
| --- | --- |
|  | 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. Also, classpath directories may not get exposed based on security policies in some environments, e.g. standalone apps on JDK 1.7.0\_45 and higher (which requires 'Trusted-Library' setup in your manifests; see <https://stackoverflow.com/questions/19394570/java-jre-7u45-breaks-classloader-getresources>).  On JDK 9’s module path (Jigsaw), Spring’s classpath scanning generally works as expected. Putting resources into a dedicated directory is highly recommendable here as well, avoiding the aforementioned portability problems with searching the jar file root level. |

Ant-style patterns with classpath: resources are not guaranteed to find matching resources if the root package to search is available in multiple class path locations. This is because a resource such as

com/mycompany/package1/service-context.xml

may be in only one location, but when a path such as

classpath:com/mycompany/\*\*/service-context.xml

is used to try to resolve it, the resolver will work off the (first) URL returned by getResource("com/mycompany");. If this base package node exists in multiple classloader locations, the actual end resource may not be underneath. Therefore, preferably, use " `classpath\*:`" with the same Ant-style pattern in such a case, which will search all class path locations that contain the root package.

#### **2.7.3. FileSystemResource caveats**

A FileSystemResource that is not attached to a FileSystemApplicationContext (that is, a FileSystemApplicationContext is not the actual ResourceLoader) will treat absolute vs. relative paths as you would expect. Relative paths are relative to the current working directory, while absolute paths are relative to the root of the filesystem.

For backwards compatibility (historical) reasons however, this changes when the FileSystemApplicationContext is the ResourceLoader. The FileSystemApplicationContext simply forces all attached FileSystemResource instances to treat all location paths as relative, whether they start with a leading slash or not. In practice, this means the following are equivalent:

ApplicationContext ctx =

**new** FileSystemXmlApplicationContext("conf/context.xml");

ApplicationContext ctx =

**new** FileSystemXmlApplicationContext("/conf/context.xml");

As are the following: (Even though it would make sense for them to be different, as one case is relative and the other absolute.)

FileSystemXmlApplicationContext ctx = ...;

ctx.getResource("some/resource/path/myTemplate.txt");

FileSystemXmlApplicationContext ctx = ...;

ctx.getResource("/some/resource/path/myTemplate.txt");

In practice, if true absolute filesystem paths are needed, it is better to forgo the use of absolute paths with FileSystemResource / FileSystemXmlApplicationContext, and just force the use of a UrlResource, by using the file: URL prefix.

*// actual context type doesn't matter, the Resource will always be UrlResource*

ctx.getResource("file:///some/resource/path/myTemplate.txt");

*// force this FileSystemXmlApplicationContext to load its definition via a UrlResource*

ApplicationContext ctx =

**new** FileSystemXmlApplicationContext("file:///conf/context.xml");

## 3. Validation, Data Binding, and Type Conversion

### **3.1. Introduction**

JSR-303/JSR-349 Bean Validation

Spring Framework 4.0 supports Bean Validation 1.0 (JSR-303) and Bean Validation 1.1 (JSR-349) in terms of setup support, also adapting it to Spring’s Validator interface.

An application can choose to enable Bean Validation once globally, as described in [Spring Validation](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#validation-beanvalidation), and use it exclusively for all validation needs.

An application can also register additional Spring Validator instances per DataBinder instance, as described in [Configuring a DataBinder](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#validation-binder). This may be useful for plugging in validation logic without the use of annotations.

There are pros and cons for considering validation as business logic, and Spring offers a design for validation (and data binding) that does not exclude either one of them. Specifically validation should not be tied to the web tier, should be easy to localize and it should be possible to plug in any validator available. Considering the above, Spring has come up with a Validator interface that is both basic and eminently usable in every layer of an application.

Data binding is useful for allowing user input to be dynamically bound to the domain model of an application (or whatever objects you use to process user input). Spring provides the so-called DataBinder to do exactly that. The Validator and the DataBinder make up the validation package, which is primarily used in but not limited to the MVC framework.

The BeanWrapper is a fundamental concept in the Spring Framework and is used in a lot of places. However, you probably will not have the need to use the BeanWrapper directly. Because this is reference documentation however, we felt that some explanation might be in order. We will explain the BeanWrapper in this chapter since, if you were going to use it at all, you would most likely do so when trying to bind data to objects.

Spring’s DataBinder and the lower-level BeanWrapper both use PropertyEditors to parse and format property values. The PropertyEditor concept is part of the JavaBeans specification, and is also explained in this chapter. Spring 3 introduces a "core.convert" package that provides a general type conversion facility, as well as a higher-level "format" package for formatting UI field values. These new packages may be used as simpler alternatives to PropertyEditors, and will also be discussed in this chapter.

### **3.2. Validation using Spring’s Validator interface**

Spring features a Validator interface that you can use to validate objects. The Validator interface works using an Errors object so that while validating, validators can report validation failures to the Errors object.

Let’s consider a small data object:

**public** **class** **Person** {

**private** String name;

**private** **int** age;

*// the usual getters and setters...*

}

We’re going to provide validation behavior for the Person class by implementing the following two methods of the org.springframework.validation.Validator interface:

* supports(Class) - Can this Validator validate instances of the supplied Class?
* validate(Object, org.springframework.validation.Errors) - validates the given object and in case of validation errors, registers those with the given Errors object

Implementing a Validator is fairly straightforward, especially when you know of the ValidationUtils helper class that the Spring Framework also provides.

**public** **class** **PersonValidator** **implements** Validator {

*/\*\**

*\* This Validator validates \*just\* Person instances*

*\*/*

**public** **boolean** supports(Class clazz) {

**return** Person.class.equals(clazz);

}

**public** **void** validate(Object obj, Errors e) {

ValidationUtils.rejectIfEmpty(e, "name", "name.empty");

Person p = (Person) obj;

**if** (p.getAge() < 0) {

e.rejectValue("age", "negativevalue");

} **else** **if** (p.getAge() > 110) {

e.rejectValue("age", "too.darn.old");

}

}

}

As you can see, the static rejectIfEmpty(..) method on the ValidationUtils class is used to reject the 'name' property if it is null or the empty string. Have a look at the ValidationUtils javadocs to see what functionality it provides besides the example shown previously.

While it is certainly possible to implement a single Validator class to validate each of the nested objects in a rich object, it may be better to encapsulate the validation logic for each nested class of object in its own Validator implementation. A simple example of a 'rich' object would be a Customer that is composed of two String properties (a first and second name) and a complex Address object. Address objects may be used independently of Customer objects, and so a distinct AddressValidator has been implemented. If you want your CustomerValidator to reuse the logic contained within the AddressValidator class without resorting to copy-and-paste, you can dependency-inject or instantiate an AddressValidator within your CustomerValidator, and use it like so:

**public** **class** **CustomerValidator** **implements** Validator {

**private** **final** Validator addressValidator;

**public** CustomerValidator(Validator addressValidator) {

**if** (addressValidator == null) {

**throw** **new** IllegalArgumentException("The supplied [Validator] is " +

"required and must not be null.");

}

**if** (!addressValidator.supports(Address.class)) {

**throw** **new** IllegalArgumentException("The supplied [Validator] must " +

"support the validation of [Address] instances.");

}

this.addressValidator = addressValidator;

}

*/\*\**

*\* This Validator validates Customer instances, and any subclasses of Customer too*

*\*/*

**public** **boolean** supports(Class clazz) {

**return** Customer.class.isAssignableFrom(clazz);

}

**public** **void** validate(Object target, Errors errors) {

ValidationUtils.rejectIfEmptyOrWhitespace(errors, "firstName", "field.required");

ValidationUtils.rejectIfEmptyOrWhitespace(errors, "surname", "field.required");

Customer customer = (Customer) target;

**try** {

errors.pushNestedPath("address");

ValidationUtils.invokeValidator(this.addressValidator, customer.getAddress(), errors);

} **finally** {

errors.popNestedPath();

}

}

}

Validation errors are reported to the Errors object passed to the validator. In case of Spring Web MVC you can use <spring:bind/> tag to inspect the error messages, but of course you can also inspect the errors object yourself. More information about the methods it offers can be found in the javadocs.

### **3.3. Resolving codes to error messages**

We’ve talked about databinding and validation. Outputting messages corresponding to validation errors is the last thing we need to discuss. In the example we’ve shown above, we rejected the name and the age field. If we’re going to output the error messages by using a MessageSource, we will do so using the error code we’ve given when rejecting the field ('name' and 'age' in this case). When you call (either directly, or indirectly, using for example the ValidationUtils class) rejectValue or one of the other reject methods from the Errors interface, the underlying implementation will not only register the code you’ve passed in, but also a number of additional error codes. What error codes it registers is determined by the MessageCodesResolver that is used. By default, the DefaultMessageCodesResolver is used, which for example not only registers a message with the code you gave, but also messages that include the field name you passed to the reject method. So in case you reject a field using rejectValue("age", "too.darn.old"), apart from the too.darn.old code, Spring will also register too.darn.old.age and too.darn.old.age.int (so the first will include the field name and the second will include the type of the field); this is done as a convenience to aid developers in targeting error messages and suchlike.

More information on the MessageCodesResolver and the default strategy can be found online in the javadocs of [MessageCodesResolver](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/validation/MessageCodesResolver.html) and [DefaultMessageCodesResolver](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/validation/DefaultMessageCodesResolver.html), respectively.

### **3.4. Bean manipulation and the BeanWrapper**

The org.springframework.beans package adheres to the JavaBeans standard provided by Oracle. A JavaBean is simply a class with a default no-argument constructor, which follows a naming convention where (by way of an example) a property named bingoMadness would have a setter method setBingoMadness(..) and a getter method getBingoMadness(). For more information about JavaBeans and the specification, please refer to Oracle’s website ( [javabeans](https://docs.oracle.com/javase/6/docs/api/java/beans/package-summary.html)).

One quite important class in the beans package is the BeanWrapper interface and its corresponding implementation ( BeanWrapperImpl). As quoted from the javadocs, the BeanWrapper offers functionality to set and get property values (individually or in bulk), get property descriptors, and to query properties to determine if they are readable or writable. Also, the BeanWrapper offers support for nested properties, enabling the setting of properties on sub-properties to an unlimited depth. Then, the BeanWrapper supports the ability to add standard JavaBeans PropertyChangeListeners and VetoableChangeListeners, without the need for supporting code in the target class. Last but not least, the BeanWrapper provides support for the setting of indexed properties. The BeanWrapper usually isn’t used by application code directly, but by the DataBinder and the BeanFactory.

The way the BeanWrapper works is partly indicated by its name: it wraps a bean to perform actions on that bean, like setting and retrieving properties.

#### **3.4.1. Setting and getting basic and nested properties**

Setting and getting properties is done using the setPropertyValue(s) and getPropertyValue(s) methods that both come with a couple of overloaded variants. They’re all described in more detail in the javadocs Spring comes with. What’s important to know is that there are a couple of conventions for indicating properties of an object. A couple of examples:

| *Table 11. Examples of properties* | |
| --- | --- |
| **Expression** | **Explanation** |
| name | Indicates the property name corresponding to the methods getName() or isName() and setName(..) |
| account.name | Indicates the nested property name of the property account corresponding e.g. to the methods getAccount().setName() or getAccount().getName() |
| account[2] | Indicates the third element of the indexed property account. Indexed properties can be of type array, list or other naturally ordered collection |
| account[COMPANYNAME] | Indicates the value of the map entry indexed by the key COMPANYNAME of the Map property account |

Below you’ll find some examples of working with the BeanWrapper to get and set properties.

(This next section is not vitally important to you if you’re not planning to work with the BeanWrapper directly. If you’re just using the DataBinder and the BeanFactory and their out-of-the-box implementation, you should skip ahead to the section about PropertyEditors.)

Consider the following two classes:

**public** **class** **Company** {

**private** String name;

**private** Employee managingDirector;

**public** String getName() {

**return** this.name;

}

**public** **void** setName(String name) {

this.name = name;

}

**public** Employee getManagingDirector() {

**return** this.managingDirector;

}

**public** **void** setManagingDirector(Employee managingDirector) {

this.managingDirector = managingDirector;

}

}

**public** **class** **Employee** {

**private** String name;

**private** **float** salary;

**public** String getName() {

**return** this.name;

}

**public** **void** setName(String name) {

this.name = name;

}

**public** **float** getSalary() {

**return** salary;

}

**public** **void** setSalary(**float** salary) {

this.salary = salary;

}

}

The following code snippets show some examples of how to retrieve and manipulate some of the properties of instantiated Companies and Employees:

BeanWrapper company = **new** BeanWrapperImpl(**new** Company());

*// setting the company name..*

company.setPropertyValue("name", "Some Company Inc.");

*// ... can also be done like this:*

PropertyValue value = **new** PropertyValue("name", "Some Company Inc.");

company.setPropertyValue(value);

*// ok, let's create the director and tie it to the company:*

BeanWrapper jim = **new** BeanWrapperImpl(**new** Employee());

jim.setPropertyValue("name", "Jim Stravinsky");

company.setPropertyValue("managingDirector", jim.getWrappedInstance());

*// retrieving the salary of the managingDirector through the company*

Float salary = (Float) company.getPropertyValue("managingDirector.salary");

#### **3.4.2. Built-in PropertyEditor implementations**

Spring uses the concept of PropertyEditors to effect the conversion between an Object and a String. If you think about it, it sometimes might be handy to be able to represent properties in a different way than the object itself. For example, a Date can be represented in a human readable way (as the String '2007-14-09'), while we’re still able to convert the human readable form back to the original date (or even better: convert any date entered in a human readable form, back to Date objects). This behavior can be achieved by registering custom editors, of type java.beans.PropertyEditor. Registering custom editors on a BeanWrapper or alternately in a specific IoC container as mentioned in the previous chapter, gives it the knowledge of how to convert properties to the desired type. Read more about PropertyEditors in the javadocs of the java.beans package provided by Oracle.

A couple of examples where property editing is used in Spring:

* setting properties on beans is done using PropertyEditors. When mentioning String as the value of a property of some bean you’re declaring in XML file, Spring will (if the setter of the corresponding property has Class parameter) use the ClassEditor to try to resolve the parameter to a Class object.
* parsing HTTP request parameters in Spring’s MVC framework is done using all kinds of PropertyEditors that you can manually bind in all subclasses of the CommandController.

Spring has a number of built-in PropertyEditors to make life easy. Each of those is listed below and they are all located in the org.springframework.beans.propertyeditors package. Most, but not all (as indicated below), are registered by default by BeanWrapperImpl. Where the property editor is configurable in some fashion, you can of course still register your own variant to override the default one:

| *Table 12. Built-in PropertyEditors* | |
| --- | --- |
| **Class** | **Explanation** |
| ByteArrayPropertyEditor | Editor for byte arrays. Strings will simply be converted to their corresponding byte representations. Registered by default by BeanWrapperImpl. |
| ClassEditor | Parses Strings representing classes to actual classes and the other way around. When a class is not found, an IllegalArgumentException is thrown. Registered by default by BeanWrapperImpl. |
| CustomBooleanEditor | Customizable property editor for Boolean properties. Registered by default by BeanWrapperImpl, but, can be overridden by registering custom instance of it as custom editor. |
| CustomCollectionEditor | Property editor for Collections, converting any source Collection to a given target Collection type. |
| CustomDateEditor | Customizable property editor for java.util.Date, supporting a custom DateFormat. NOT registered by default. Must be user registered as needed with appropriate format. |
| CustomNumberEditor | Customizable property editor for any Number subclass like Integer, Long, Float, Double. Registered by default by BeanWrapperImpl, but can be overridden by registering custom instance of it as a custom editor. |
| FileEditor | Capable of resolving Strings to java.io.File objects. Registered by default by BeanWrapperImpl. |
| InputStreamEditor | One-way property editor, capable of taking a text string and producing (via an intermediate ResourceEditor and Resource) an InputStream, so InputStream properties may be directly set as Strings. Note that the default usage will not close the InputStream for you! Registered by default by BeanWrapperImpl. |
| LocaleEditor | Capable of resolving Strings to Locale objects and vice versa (the String format is [country][variant], which is the same thing the toString() method of Locale provides). Registered by default by BeanWrapperImpl. |
| PatternEditor | Capable of resolving Strings to java.util.regex.Pattern objects and vice versa. |
| PropertiesEditor | Capable of converting Strings (formatted using the format as defined in the javadocs of the java.util.Properties class) to Properties objects. Registered by default by BeanWrapperImpl. |
| StringTrimmerEditor | Property editor that trims Strings. Optionally allows transforming an empty string into a null value. NOT registered by default; must be user registered as needed. |
| URLEditor | Capable of resolving a String representation of a URL to an actual URL object. Registered by default by BeanWrapperImpl. |

Spring uses the java.beans.PropertyEditorManager to set the search path for property editors that might be needed. The search path also includes sun.bean.editors, which includes PropertyEditor implementations for types such as Font, Color, and most of the primitive types. Note also that the standard JavaBeans infrastructure will automatically discover PropertyEditor classes (without you having to register them explicitly) if they are in the same package as the class they handle, and have the same name as that class, with 'Editor' appended; for example, one could have the following class and package structure, which would be sufficient for the FooEditor class to be recognized and used as the PropertyEditor for Foo-typed properties.

com

chank

pop

Foo

FooEditor // the PropertyEditor for the Foo class

Note that you can also use the standard BeanInfo JavaBeans mechanism here as well (described [in not-amazing-detail here](https://docs.oracle.com/javase/tutorial/javabeans/advanced/customization.html)). Find below an example of using the BeanInfo mechanism for explicitly registering one or more PropertyEditor instances with the properties of an associated class.

com

chank

pop

Foo

FooBeanInfo // the BeanInfo for the Foo class

Here is the Java source code for the referenced FooBeanInfo class. This would associate a CustomNumberEditor with the age property of the Foo class.

**public** **class** **FooBeanInfo** **extends** SimpleBeanInfo {

**public** PropertyDescriptor**[]** getPropertyDescriptors() {

**try** {

**final** PropertyEditor numberPE = **new** CustomNumberEditor(Integer.class, true);

PropertyDescriptor ageDescriptor = **new** PropertyDescriptor("age", Foo.class) {

**public** PropertyEditor createPropertyEditor(Object bean) {

**return** numberPE;

};

};

**return** **new** PropertyDescriptor**[]** { ageDescriptor };

}

**catch** (IntrospectionException ex) {

**throw** **new** Error(ex.toString());

}

}

}

##### **Registering additional custom PropertyEditors**

When setting bean properties as a string value, a Spring IoC container ultimately uses standard JavaBeans PropertyEditors to convert these Strings to the complex type of the property. Spring pre-registers a number of custom PropertyEditors (for example, to convert a classname expressed as a string into a real Class object). Additionally, Java’s standard JavaBeans PropertyEditor lookup mechanism allows a PropertyEditor for a class simply to be named appropriately and placed in the same package as the class it provides support for, to be found automatically.

If there is a need to register other custom PropertyEditors, there are several mechanisms available. The most manual approach, which is not normally convenient or recommended, is to simply use the registerCustomEditor() method of the ConfigurableBeanFactory interface, assuming you have a BeanFactory reference. Another, slightly more convenient, mechanism is to use a special bean factory post-processor called CustomEditorConfigurer. Although bean factory post-processors can be used with BeanFactory implementations, the CustomEditorConfigurer has a nested property setup, so it is strongly recommended that it is used with the ApplicationContext, where it may be deployed in similar fashion to any other bean, and automatically detected and applied.

Note that all bean factories and application contexts automatically use a number of built-in property editors, through their use of something called a BeanWrapper to handle property conversions. The standard property editors that the BeanWrapper registers are listed in [the previous section](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-beans-conversion). Additionally, ApplicationContexts also override or add an additional number of editors to handle resource lookups in a manner appropriate to the specific application context type.

Standard JavaBeans PropertyEditor instances are used to convert property values expressed as strings to the actual complex type of the property. CustomEditorConfigurer, a bean factory post-processor, may be used to conveniently add support for additional PropertyEditor instances to an ApplicationContext.

Consider a user class ExoticType, and another class DependsOnExoticType which needs ExoticType set as a property:

**package** example;

**public** **class** **ExoticType** {

**private** String name;

**public** ExoticType(String name) {

this.name = name;

}

}

**public** **class** **DependsOnExoticType** {

**private** ExoticType type;

**public** **void** setType(ExoticType type) {

this.type = type;

}

}

When things are properly set up, we want to be able to assign the type property as a string, which a PropertyEditor will behind the scenes convert into an actual ExoticType instance:

<bean id="sample" class="example.DependsOnExoticType">

<property name="type" value="aNameForExoticType"/>

</bean>

The PropertyEditor implementation could look similar to this:

*// converts string representation to ExoticType object*

**package** example;

**public** **class** **ExoticTypeEditor** **extends** PropertyEditorSupport {

**public** **void** setAsText(String text) {

setValue(**new** ExoticType(text.toUpperCase()));

}

}

Finally, we use CustomEditorConfigurer to register the new PropertyEditor with the ApplicationContext, which will then be able to use it as needed:

<bean class="org.springframework.beans.factory.config.CustomEditorConfigurer">

<property name="customEditors">

<map>

<entry key="example.ExoticType" value="example.ExoticTypeEditor"/>

</map>

</property>

</bean>

###### **Using PropertyEditorRegistrars**

Another mechanism for registering property editors with the Spring container is to create and use a PropertyEditorRegistrar. This interface is particularly useful when you need to use the same set of property editors in several different situations: write a corresponding registrar and reuse that in each case. PropertyEditorRegistrars work in conjunction with an interface called PropertyEditorRegistry, an interface that is implemented by the Spring BeanWrapper (and DataBinder). PropertyEditorRegistrars are particularly convenient when used in conjunction with the CustomEditorConfigurer (introduced [here](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-beans-conversion-customeditor-registration)), which exposes a property called setPropertyEditorRegistrars(..): PropertyEditorRegistrars added to a CustomEditorConfigurer in this fashion can easily be shared with DataBinder and Spring MVC Controllers. Furthermore, it avoids the need for synchronization on custom editors: a PropertyEditorRegistrar is expected to create fresh PropertyEditor instances for each bean creation attempt.

Using a PropertyEditorRegistrar is perhaps best illustrated with an example. First off, you need to create your own PropertyEditorRegistrar implementation:

**package** com.foo.editors.spring;

**public** **final** **class** **CustomPropertyEditorRegistrar** **implements** PropertyEditorRegistrar {

**public** **void** registerCustomEditors(PropertyEditorRegistry registry) {

*// it is expected that new PropertyEditor instances are created*

registry.registerCustomEditor(ExoticType.class, **new** ExoticTypeEditor());

*// you could register as many custom property editors as are required here...*

}

}

See also the org.springframework.beans.support.ResourceEditorRegistrar for an example PropertyEditorRegistrar implementation. Notice how in its implementation of the registerCustomEditors(..) method it creates new instances of each property editor.

Next we configure a CustomEditorConfigurer and inject an instance of our CustomPropertyEditorRegistrar into it:

<bean class="org.springframework.beans.factory.config.CustomEditorConfigurer">

<property name="propertyEditorRegistrars">

<list>

<ref bean="customPropertyEditorRegistrar"/>

</list>

</property>

</bean>

<bean id="customPropertyEditorRegistrar"

class="com.foo.editors.spring.CustomPropertyEditorRegistrar"/>

Finally, and in a bit of a departure from the focus of this chapter, for those of you using [Spring’s MVC web framework](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc), using PropertyEditorRegistrars in conjunction with data-binding Controllers (such as SimpleFormController) can be very convenient. Find below an example of using a PropertyEditorRegistrar in the implementation of an initBinder(..) method:

**public** **final** **class** **RegisterUserController** **extends** SimpleFormController {

**private** **final** PropertyEditorRegistrar customPropertyEditorRegistrar;

**public** RegisterUserController(PropertyEditorRegistrar propertyEditorRegistrar) {

this.customPropertyEditorRegistrar = propertyEditorRegistrar;

}

**protected** **void** initBinder(HttpServletRequest request,

ServletRequestDataBinder binder) **throws** Exception {

**this.customPropertyEditorRegistrar.registerCustomEditors(binder);**

}

*// other methods to do with registering a User*

}

This style of PropertyEditor registration can lead to concise code (the implementation of initBinder(..) is just one line long!), and allows common PropertyEditor registration code to be encapsulated in a class and then shared amongst as many Controllers as needed.

### **3.5. Spring Type Conversion**

Spring 3 introduces a core.convert package that provides a general type conversion system. The system defines an SPI to implement type conversion logic, as well as an API to execute type conversions at runtime. Within a Spring container, this system can be used as an alternative to PropertyEditors to convert externalized bean property value strings to required property types. The public API may also be used anywhere in your application where type conversion is needed.

#### **3.5.1. Converter SPI**

The SPI to implement type conversion logic is simple and strongly typed:

**package** org.springframework.core.convert.converter;

**public** **interface** **Converter**<S, T> {

T convert(S source);

}

To create your own converter, simply implement the interface above. Parameterize S as the type you are converting from, and T as the type you are converting to. Such a converter can also be applied transparently if a collection or array of S needs to be converted to an array or collection of T, provided that a delegating array/collection converter has been registered as well (which DefaultConversionService does by default).

For each call to convert(S), the source argument is guaranteed to be NOT null. Your Converter may throw any unchecked exception if conversion fails; specifically, an IllegalArgumentException should be thrown to report an invalid source value. Take care to ensure that your Converter implementation is thread-safe.

Several converter implementations are provided in the core.convert.support package as a convenience. These include converters from Strings to Numbers and other common types. Consider StringToInteger as an example for a typical Converter implementation:

**package** org.springframework.core.convert.support;

**final** **class** **StringToInteger** **implements** Converter<String, Integer> {

**public** Integer convert(String source) {

**return** Integer.valueOf(source);

}

}

#### **3.5.2. ConverterFactory**

When you need to centralize the conversion logic for an entire class hierarchy (for example, when converting from String to Enum objects), you can implement ConverterFactory, as the following example shows:

**package** org.springframework.core.convert.converter;

**public** **interface** **ConverterFactory**<S, R> {

<T **extends** R> Converter<S, T> getConverter(Class<T> targetType);

}

Parameterize S to be the type you are converting from and R to be the base type defining the range of classes you can convert to. Then implement getConverter(Class<T>), where T is a subclass of R.

Consider the StringToEnumConverterFactory as an example:

**package** org.springframework.core.convert.support;

**final** **class** **StringToEnumConverterFactory** **implements** ConverterFactory<String, Enum> {

**public** <T **extends** Enum> Converter<String, T> getConverter(Class<T> targetType) {

**return** **new** StringToEnumConverter(targetType);

}

**private** **final** **class** **StringToEnumConverter**<T **extends** Enum> **implements** Converter<String, T> {

**private** Class<T> enumType;

**public** StringToEnumConverter(Class<T> enumType) {

this.enumType = enumType;

}

**public** T convert(String source) {

**return** (T) Enum.valueOf(this.enumType, source.trim());

}

}

}

#### **3.5.3. GenericConverter**

When you require a sophisticated Converter implementation, consider using the GenericConverter interface. With a more flexible but less strongly typed signature than Converter, a GenericConverter supports converting between multiple source and target types. In addition, a GenericConverter makes available source and target field context that you can use when you implement your conversion logic. Such context lets a type conversion be driven by a field annotation or by generic information declared on a field signature. The following listing shows the interface definition of GenericConverter:

**package** org.springframework.core.convert.converter;

**public** **interface** **GenericConverter** {

**public** Set<ConvertiblePair> getConvertibleTypes();

Object convert(Object source, TypeDescriptor sourceType, TypeDescriptor targetType);

}

To implement a GenericConverter, have getConvertibleTypes() return the supported source→target type pairs. Then implement convert(Object, TypeDescriptor, TypeDescriptor) to contain your conversion logic. The source TypeDescriptor provides access to the source field that holds the value being converted. The target TypeDescriptor provides access to the target field where the converted value is to be set.

A good example of a GenericConverter is a converter that converts between a Java array and a collection. Such an ArrayToCollectionConverter introspects the field that declares the target collection type to resolve the collection’s element type. This lets each element in the source array be converted to the collection element type before the collection is set on the target field.

|  |  |
| --- | --- |
|  | Because GenericConverter is a more complex SPI interface, only use it when you need it. Favor Converter or ConverterFactory for basic type conversion needs. |

##### **ConditionalGenericConverter**

Sometimes you only want a Converter to execute if a specific condition holds true. For example, you might only want to execute a Converter if a specific annotation is present on the target field. Or you might only want to execute a Converter if a specific method, such as a static valueOf method, is defined on the target class. ConditionalGenericConverter is the union of the GenericConverter and ConditionalConverter interfaces that allows you to define such custom matching criteria:

**public** **interface** **ConditionalConverter** {

**boolean** matches(TypeDescriptor sourceType, TypeDescriptor targetType);

}

**public** **interface** **ConditionalGenericConverter** **extends** GenericConverter, ConditionalConverter {

}

A good example of a ConditionalGenericConverter is an EntityConverter that converts between an persistent entity identifier and an entity reference. Such a EntityConverter might only match if the target entity type declares a static finder method e.g. findAccount(Long). You would perform such a finder method check in the implementation of matches(TypeDescriptor, TypeDescriptor).

#### **3.5.4. ConversionService API**

The ConversionService defines a unified API for executing type conversion logic at runtime. Converters are often executed behind this facade interface:

**package** org.springframework.core.convert;

**public** **interface** **ConversionService** {

**boolean** canConvert(Class<?> sourceType, Class<?> targetType);

<T> T convert(Object source, Class<T> targetType);

**boolean** canConvert(TypeDescriptor sourceType, TypeDescriptor targetType);

Object convert(Object source, TypeDescriptor sourceType, TypeDescriptor targetType);

}

Most ConversionService implementations also implement ConverterRegistry, which provides an SPI for registering converters. Internally, a ConversionService implementation delegates to its registered converters to carry out type conversion logic.

A robust ConversionService implementation is provided in the core.convert.support package. GenericConversionService is the general-purpose implementation suitable for use in most environments. ConversionServiceFactory provides a convenient factory for creating common ConversionService configurations.

#### **3.5.5. Configuring a ConversionService**

A ConversionService is a stateless object designed to be instantiated at application startup, then shared between multiple threads. In a Spring application, you typically configure a ConversionService instance per Spring container (or ApplicationContext). That ConversionService will be picked up by Spring and then used whenever a type conversion needs to be performed by the framework. You may also inject this ConversionService into any of your beans and invoke it directly.

|  |  |
| --- | --- |
|  | If no ConversionService is registered with Spring, the original PropertyEditor-based system is used. |

To register a default ConversionService with Spring, add the following bean definition with id conversionService:

<bean id="conversionService"

class="org.springframework.context.support.ConversionServiceFactoryBean"/>

A default ConversionService can convert between strings, numbers, enums, collections, maps, and other common types. To supplement or override the default converters with your own custom converter(s), set the converters property. Property values may implement either of the Converter, ConverterFactory, or GenericConverter interfaces.

<bean id="conversionService"

class="org.springframework.context.support.ConversionServiceFactoryBean">

<property name="converters">

<set>

<bean class="example.MyCustomConverter"/>

</set>

</property>

</bean>

It is also common to use a ConversionService within a Spring MVC application. See [Conversion and Formatting](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc-config-conversion) in the Spring MVC chapter.

In certain situations you may wish to apply formatting during conversion. See [FormatterRegistry SPI](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#format-FormatterRegistry-SPI) for details on using FormattingConversionServiceFactoryBean.

#### **3.5.6. Using a ConversionService programmatically**

To work with a ConversionService instance programmatically, simply inject a reference to it like you would for any other bean:

@Service

**public** **class** **MyService** {

@Autowired

**public** MyService(ConversionService conversionService) {

this.conversionService = conversionService;

}

**public** **void** doIt() {

this.conversionService.convert(...)

}

}

For most use cases, the convert method specifying the targetType can be used but it will not work with more complex types such as a collection of a parameterized element. If you want to convert a List of Integer to a List of String programmatically, for instance, you need to provide a formal definition of the source and target types.

Fortunately, TypeDescriptor provides various options to make that straightforward:

DefaultConversionService cs = **new** DefaultConversionService();

List<Integer> input = ....

cs.convert(input,

TypeDescriptor.forObject(input), *// List<Integer> type descriptor*

TypeDescriptor.collection(List.class, TypeDescriptor.valueOf(String.class)));

Note that DefaultConversionService registers converters automatically which are appropriate for most environments. This includes collection converters, scalar converters, and also basic Object to String converters. The same converters can be registered with any ConverterRegistry using the static addDefaultConverters method on the DefaultConversionService class.

Converters for value types will be reused for arrays and collections, so there is no need to create a specific converter to convert from a Collection of S to a Collection of T, assuming that standard collection handling is appropriate.

### **3.6. Spring Field Formatting**

As discussed in the previous section, [core.convert](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#core-convert) is a general-purpose type conversion system. It provides a unified ConversionService API as well as a strongly-typed Converter SPI for implementing conversion logic from one type to another. A Spring Container uses this system to bind bean property values. In addition, both the Spring Expression Language (SpEL) and DataBinder use this system to bind field values. For example, when SpEL needs to coerce a Short to a Long to complete an expression.setValue(Object bean, Object value) attempt, the core.convert system performs the coercion.

Now consider the type conversion requirements of a typical client environment such as a web or desktop application. In such environments, you typically convert from String to support the client postback process, as well as back to String to support the view rendering process. In addition, you often need to localize String values. The more general core.convert Converter SPI does not address such formatting requirements directly. To directly address them, Spring 3 introduces a convenient Formatter SPI that provides a simple and robust alternative to PropertyEditors for client environments.

In general, you can use the Converter SPI when you need to implement general-purpose type conversion logic — for example, for converting between a java.util.Date and a Long. You can use the Formatter SPI when you work in a client environment (such as a web application) and need to parse and print localized field values. The ConversionService provides a unified type conversion API for both SPIs.

#### **3.6.1. Formatter SPI**

The Formatter SPI to implement field formatting logic is simple and strongly typed:

**package** org.springframework.format;

**public** **interface** **Formatter**<T> **extends** Printer<T>, Parser<T> {

}

Where Formatter extends from the Printer and Parser building-block interfaces:

**public** **interface** **Printer**<T> {

String print(T fieldValue, Locale locale);

}

**import** java.text.ParseException;

**public** **interface** **Parser**<T> {

T parse(String clientValue, Locale locale) **throws** ParseException;

}

To create your own Formatter, implement the Formatter interface shown earlier. Parameterize T to be the type of object you wish to format — for example, java.util.Date. Implement the print() operation to print an instance of T for display in the client locale. Implement the parse() operation to parse an instance of T from the formatted representation returned from the client locale. Your Formatter should throw a ParseException or an IllegalArgumentException if a parse attempt fails. Take care to ensure that your Formatter implementation is thread-safe.

The format subpackages provide several Formatter implementations as a convenience. The number package provides NumberStyleFormatter, CurrencyStyleFormatter, and PercentStyleFormatter to format Number objects that use a java.text.NumberFormat. The datetime package provides a DateFormatter to format java.util.Date objects with a java.text.DateFormat. The datetime.joda package provides comprehensive datetime formatting support based on the [Joda-Time library](http://joda-time.sourceforge.net/).

The following DateFormatter is an example Formatter implementation:

**package** org.springframework.format.datetime;

**public** **final** **class** **DateFormatter** **implements** Formatter<Date> {

**private** String pattern;

**public** DateFormatter(String pattern) {

this.pattern = pattern;

}

**public** String print(Date date, Locale locale) {

**if** (date == null) {

**return** "";

}

**return** getDateFormat(locale).format(date);

}

**public** Date parse(String formatted, Locale locale) **throws** ParseException {

**if** (formatted.length() == 0) {

**return** null;

}

**return** getDateFormat(locale).parse(formatted);

}

**protected** DateFormat getDateFormat(Locale locale) {

DateFormat dateFormat = **new** SimpleDateFormat(this.pattern, locale);

dateFormat.setLenient(false);

**return** dateFormat;

}

}

The Spring team welcomes community-driven Formatter contributions; see [jira.spring.io](https://jira.spring.io/browse/SPR) to contribute.

#### **3.6.2. Annotation-driven Formatting**

As you will see, field formatting can be configured by field type or annotation. To bind an Annotation to a formatter, implement AnnotationFormatterFactory:

**package** org.springframework.format;

**public** **interface** **AnnotationFormatterFactory**<A **extends** Annotation> {

Set<Class<?>> getFieldTypes();

Printer<?> getPrinter(A annotation, Class<?> fieldType);

Parser<?> getParser(A annotation, Class<?> fieldType);

}

Parameterize A to be the field annotationType you wish to associate formatting logic with, for example org.springframework.format.annotation.DateTimeFormat. Have getFieldTypes() return the types of fields the annotation may be used on. Have getPrinter() return a Printer to print the value of an annotated field. Have getParser() return a Parser to parse a clientValue for an annotated field.

The example AnnotationFormatterFactory implementation below binds the @NumberFormat Annotation to a formatter. This annotation allows either a number style or pattern to be specified:

**public** **final** **class** **NumberFormatAnnotationFormatterFactory**

**implements** AnnotationFormatterFactory<NumberFormat> {

**public** Set<Class<?>> getFieldTypes() {

**return** **new** HashSet<Class<?>>(asList(**new** Class<?>**[]** {

Short.class, Integer.class, Long.class, Float.class,

Double.class, BigDecimal.class, BigInteger.class }));

}

**public** Printer<Number> getPrinter(NumberFormat annotation, Class<?> fieldType) {

**return** configureFormatterFrom(annotation, fieldType);

}

**public** Parser<Number> getParser(NumberFormat annotation, Class<?> fieldType) {

**return** configureFormatterFrom(annotation, fieldType);

}

**private** Formatter<Number> configureFormatterFrom(NumberFormat annotation, Class<?> fieldType) {

**if** (!annotation.pattern().isEmpty()) {

**return** **new** NumberStyleFormatter(annotation.pattern());

} **else** {

Style style = annotation.style();

**if** (style == Style.PERCENT) {

**return** **new** PercentStyleFormatter();

} **else** **if** (style == Style.CURRENCY) {

**return** **new** CurrencyStyleFormatter();

} **else** {

**return** **new** NumberStyleFormatter();

}

}

}

}

To trigger formatting, simply annotate fields with @NumberFormat:

**public** **class** **MyModel** {

@NumberFormat(style=Style.CURRENCY)

**private** BigDecimal decimal;

}

##### **Format Annotation API**

A portable format annotation API exists in the org.springframework.format.annotation package. You can use @NumberFormat to format Number fields such as Double and Long, and @DateTimeFormat to format java.util.Date, java.util.Calendar, Long (for millisecond timestamps) as well as JSR-310 java.time and Joda-Time value types.

The following example uses @DateTimeFormat to format a java.util.Date as an ISO Date (yyyy-MM-dd):

**public** **class** **MyModel** {

@DateTimeFormat(iso=ISO.DATE)

**private** Date date;

}

#### **3.6.3. FormatterRegistry SPI**

The FormatterRegistry is an SPI for registering formatters and converters. FormattingConversionService is an implementation of FormatterRegistry suitable for most environments. This implementation may be configured programmatically or declaratively as a Spring bean using FormattingConversionServiceFactoryBean. Because this implementation also implements ConversionService, it can be directly configured for use with Spring’s DataBinder and the Spring Expression Language (SpEL).

Review the FormatterRegistry SPI below:

**package** org.springframework.format;

**public** **interface** **FormatterRegistry** **extends** ConverterRegistry {

**void** addFormatterForFieldType(Class<?> fieldType, Printer<?> printer, Parser<?> parser);

**void** addFormatterForFieldType(Class<?> fieldType, Formatter<?> formatter);

**void** addFormatterForFieldType(Formatter<?> formatter);

**void** addFormatterForAnnotation(AnnotationFormatterFactory<?, ?> factory);

}

As shown above, Formatters can be registered by fieldType or annotation.

The FormatterRegistry SPI allows you to configure Formatting rules centrally, instead of duplicating such configuration across your Controllers. For example, you might want to enforce that all Date fields are formatted a certain way, or fields with a specific annotation are formatted in a certain way. With a shared FormatterRegistry, you define these rules once and they are applied whenever formatting is needed.

#### **3.6.4. FormatterRegistrar SPI**

The FormatterRegistrar is an SPI for registering formatters and converters through the FormatterRegistry:

**package** org.springframework.format;

**public** **interface** **FormatterRegistrar** {

**void** registerFormatters(FormatterRegistry registry);

}

A FormatterRegistrar is useful when registering multiple related converters and formatters for a given formatting category, such as Date formatting. It can also be useful where declarative registration is insufficient. For example when a formatter needs to be indexed under a specific field type different from its own <T> or when registering a Printer/Parser pair. The next section provides more information on converter and formatter registration.

#### **3.6.5. Configuring Formatting in Spring MVC**

See [Conversion and Formatting](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc-config-conversion) in the Spring MVC chapter.

### **3.7. Configuring a global date & time format**

By default, date and time fields that are not annotated with @DateTimeFormat are converted from strings using the DateFormat.SHORT style. If you prefer, you can change this by defining your own global format.

You will need to ensure that Spring does not register default formatters, and instead you should register all formatters manually. Use the org.springframework.format.datetime.joda.JodaTimeFormatterRegistrar or org.springframework.format.datetime.DateFormatterRegistrar class depending on whether you use the Joda-Time library.

For example, the following Java configuration will register a global ' `yyyyMMdd’ format. This example does not depend on the Joda-Time library:

@Configuration

**public** **class** **AppConfig** {

@Bean

**public** FormattingConversionService conversionService() {

*// Use the DefaultFormattingConversionService but do not register defaults*

DefaultFormattingConversionService conversionService = **new** DefaultFormattingConversionService(false);

*// Ensure @NumberFormat is still supported*

conversionService.addFormatterForFieldAnnotation(**new** NumberFormatAnnotationFormatterFactory());

*// Register date conversion with a specific global format*

DateFormatterRegistrar registrar = **new** DateFormatterRegistrar();

registrar.setFormatter(**new** DateFormatter("yyyyMMdd"));

registrar.registerFormatters(conversionService);

**return** conversionService;

}

}

If you prefer XML based configuration you can use a FormattingConversionServiceFactoryBean. Here is the same example, this time using Joda Time:

<?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

https://www.springframework.org/schema/beans/spring-beans.xsd>

<bean id="conversionService" class="org.springframework.format.support.FormattingConversionServiceFactoryBean">

<property name="registerDefaultFormatters" value="false" />

<property name="formatters">

<set>

<bean class="org.springframework.format.number.NumberFormatAnnotationFormatterFactory" />

</set>

</property>

<property name="formatterRegistrars">

<set>

<bean class="org.springframework.format.datetime.joda.JodaTimeFormatterRegistrar">

<property name="dateFormatter">

<bean class="org.springframework.format.datetime.joda.DateTimeFormatterFactoryBean">

<property name="pattern" value="yyyyMMdd"/>

</bean>

</property>

</bean>

</set>

</property>

</bean>

</beans>

|  |  |
| --- | --- |
|  | Joda-Time provides separate distinct types to represent date, time and date-time values. The dateFormatter, timeFormatter and dateTimeFormatter properties of the JodaTimeFormatterRegistrar should be used to configure the different formats for each type. The DateTimeFormatterFactoryBean provides a convenient way to create formatters. |

If you are using Spring MVC remember to explicitly configure the conversion service that is used. For Java based @Configuration this means extending the WebMvcConfigurationSupport class and overriding the mvcConversionService() method. For XML you should use the 'conversion-service' attribute of the mvc:annotation-driven element. See [Conversion and Formatting](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc-config-conversion) for details.

### **3.8. Spring Validation**

Spring 3 introduces several enhancements to its validation support. First, the JSR-303 Bean Validation API is now fully supported. Second, when used programmatically, Spring’s DataBinder can now validate objects as well as bind to them. Third, Spring MVC now has support for declaratively validating @Controller inputs.

#### **3.8.1. Overview of the JSR-303 Bean Validation API**

JSR-303 standardizes validation constraint declaration and metadata for the Java platform. Using this API, you annotate domain model properties with declarative validation constraints and the runtime enforces them. There are a number of built-in constraints you can take advantage of. You may also define your own custom constraints.

To illustrate, consider a simple PersonForm model with two properties:

**public** **class** **PersonForm** {

**private** String name;

**private** **int** age;

}

JSR-303 allows you to define declarative validation constraints against such properties:

**public** **class** **PersonForm** {

@NotNull

@Size(max=64)

**private** String name;

@Min(0)

**private** **int** age;

}

When an instance of this class is validated by a JSR-303 Validator, these constraints will be enforced.

For general information on JSR-303/JSR-349, see the [Bean Validation website](https://beanvalidation.org/). For information on the specific capabilities of the default reference implementation, see the [Hibernate Validator](https://www.hibernate.org/412.html) documentation. To learn how to setup a Bean Validation provider as a Spring bean, keep reading.

#### **3.8.2. Configuring a Bean Validation Provider**

Spring provides full support for the Bean Validation API. This includes convenient support for bootstrapping a JSR-303/JSR-349 Bean Validation provider as a Spring bean. This allows for a javax.validation.ValidatorFactory or javax.validation.Validator to be injected wherever validation is needed in your application.

Use the LocalValidatorFactoryBean to configure a default Validator as a Spring bean:

<bean id="validator"

class="org.springframework.validation.beanvalidation.LocalValidatorFactoryBean"/>

The basic configuration above will trigger Bean Validation to initialize using its default bootstrap mechanism. A JSR-303/JSR-349 provider, such as Hibernate Validator, is expected to be present in the classpath and will be detected automatically.

##### **Injecting a Validator**

LocalValidatorFactoryBean implements both javax.validation.ValidatorFactory and javax.validation.Validator, as well as Spring’s org.springframework.validation.Validator. You may inject a reference to either of these interfaces into beans that need to invoke validation logic.

Inject a reference to javax.validation.Validator if you prefer to work with the Bean Validation API directly:

**import** javax.validation.Validator;

@Service

**public** **class** **MyService** {

@Autowired

**private** Validator validator;

Inject a reference to org.springframework.validation.Validator if your bean requires the Spring Validation API:

**import** org.springframework.validation.Validator;

@Service

**public** **class** **MyService** {

@Autowired

**private** Validator validator;

}

##### **Configuring Custom Constraints**

Each Bean Validation constraint consists of two parts. First, a @Constraint annotation that declares the constraint and its configurable properties. Second, an implementation of the javax.validation.ConstraintValidator interface that implements the constraint’s behavior. To associate a declaration with an implementation, each @Constraint annotation references a corresponding ConstraintValidator implementation class. At runtime, a ConstraintValidatorFactory instantiates the referenced implementation when the constraint annotation is encountered in your domain model.

By default, the LocalValidatorFactoryBean configures a SpringConstraintValidatorFactory that uses Spring to create ConstraintValidator instances. This allows your custom ConstraintValidators to benefit from dependency injection like any other Spring bean.

Shown below is an example of a custom @Constraint declaration, followed by an associated ConstraintValidator implementation that uses Spring for dependency injection:

@Target({ElementType.METHOD, ElementType.FIELD})

@Retention(RetentionPolicy.RUNTIME)

@Constraint(validatedBy=MyConstraintValidator.class)

**public** @interface MyConstraint {

}

**import** javax.validation.ConstraintValidator;

**public** **class** **MyConstraintValidator** **implements** ConstraintValidator {

@Autowired;

**private** Foo aDependency;

...

}

As you can see, a ConstraintValidator implementation may have its dependencies @Autowired like any other Spring bean.

##### **Spring-driven Method Validation**

The method validation feature supported by Bean Validation 1.1, and as a custom extension also by Hibernate Validator 4.3, can be integrated into a Spring context through a MethodValidationPostProcessor bean definition:

<bean class="org.springframework.validation.beanvalidation.MethodValidationPostProcessor"/>

In order to be eligible for Spring-driven method validation, all target classes need to be annotated with Spring’s @Validated annotation, optionally declaring the validation groups to use. Check out the MethodValidationPostProcessor javadocs for setup details with Hibernate Validator and Bean Validation 1.1 providers.

##### **Additional Configuration Options**

The default LocalValidatorFactoryBean configuration should prove sufficient for most cases. There are a number of configuration options for various Bean Validation constructs, from message interpolation to traversal resolution. See the LocalValidatorFactoryBean javadocs for more information on these options.

#### **3.8.3. Configuring a DataBinder**

Since Spring 3, a DataBinder instance can be configured with a Validator. Once configured, the Validator may be invoked by calling binder.validate(). Any validation Errors are automatically added to the binder’s BindingResult.

When working with the DataBinder programmatically, this can be used to invoke validation logic after binding to a target object:

Foo target = **new** Foo();

DataBinder binder = **new** DataBinder(target);

binder.setValidator(**new** FooValidator());

*// bind to the target object*

binder.bind(propertyValues);

*// validate the target object*

binder.validate();

*// get BindingResult that includes any validation errors*

BindingResult results = binder.getBindingResult();

A DataBinder can also be configured with multiple Validator instances via dataBinder.addValidators and dataBinder.replaceValidators. This is useful when combining globally configured Bean Validation with a Spring Validator configured locally on a DataBinder instance. See [[validation-mvc-configuring]](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#validation-mvc-configuring).

#### **3.8.4. Spring MVC 3 Validation**

See [Validation](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web.html#mvc-config-validation) in the Spring MVC chapter.

## 4. Spring Expression Language (SpEL)

### **4.1. Introduction**

The Spring Expression Language (SpEL for short) is a powerful expression language that supports querying and manipulating an object graph at runtime. The language syntax is similar to Unified EL but offers additional features, most notably method invocation and basic string templating functionality.

While there are several other Java expression languages available — OGNL, MVEL, and JBoss EL, to name a few — the Spring Expression Language was created to provide the Spring community with a single well supported expression language that can be used across all the products in the Spring portfolio. Its language features are driven by the requirements of the projects in the Spring portfolio, including tooling requirements for code completion support within the Eclipse based Spring Tool Suite. That said, SpEL is based on a technology agnostic API allowing other expression language implementations to be integrated should the need arise.

While SpEL serves as the foundation for expression evaluation within the Spring portfolio, it is not directly tied to Spring and can be used independently. In order to be self contained, many of the examples in this chapter use SpEL as if it were an independent expression language. This requires creating a few bootstrapping infrastructure classes such as the parser. Most Spring users will not need to deal with this infrastructure and will instead only author expression strings for evaluation. An example of this typical use is the integration of SpEL into creating XML or annotated based bean definitions as shown in the section [Expression support for defining bean definitions](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#expressions-beandef).

This chapter covers the features of the expression language, its API, and its language syntax. In several places an Inventor and Inventor’s Society classes are used as the target objects for expression evaluation. These class declarations and the data used to populate them are listed at the end of the chapter.

The expression language supports the following functionality:

* Literal expressions
* Boolean and relational operators
* Regular expressions
* Class expressions
* Accessing properties, arrays, lists, maps
* Method invocation
* Relational operators
* Assignment
* Calling constructors
* Bean references
* Array construction
* Inline lists
* Inline maps
* Ternary operator
* Variables
* User defined functions
* Collection projection
* Collection selection
* Templated expressions

### **4.2. Evaluation**

This section introduces the simple use of SpEL interfaces and its expression language. The complete language reference can be found in the section [Language Reference](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#expressions-language-ref).

The following code introduces the SpEL API to evaluate the literal string expression 'Hello World'.

ExpressionParser parser = **new** SpelExpressionParser();

Expression exp = parser.parseExpression("**'Hello World'**");

String message = (String) exp.getValue();

The value of the message variable is simply 'Hello World'.

The SpEL classes and interfaces you are most likely to use are located in the packages org.springframework.expression and its sub packages such as spel.support.

The interface ExpressionParser is responsible for parsing an expression string. In this example the expression string is a string literal denoted by the surrounding single quotes. The interface Expression is responsible for evaluating the previously defined expression string. There are two exceptions that can be thrown, ParseException and EvaluationException when calling parser.parseExpression and exp.getValue respectively.

SpEL supports a wide range of features, such as calling methods, accessing properties, and calling constructors.

As an example of method invocation, we call the concat method on the string literal.

ExpressionParser parser = **new** SpelExpressionParser();

Expression exp = parser.parseExpression("**'Hello World'.concat('!')**");

String message = (String) exp.getValue();

The value of message is now 'Hello World!'.

As an example of calling a JavaBean property, the String property Bytes can be called as shown below.

ExpressionParser parser = **new** SpelExpressionParser();

*// invokes 'getBytes()'*

Expression exp = parser.parseExpression("**'Hello World'.bytes**");

**byte[]** bytes = (**byte[]**) exp.getValue();

SpEL also supports nested properties by using the standard dot notation (such as prop1.prop2.prop3) and also the corresponding setting of property values. Public fields may also be accessed.

The following example shows how to use dot notation to get the length of a literal:

ExpressionParser parser = **new** SpelExpressionParser();

*// invokes 'getBytes().length'*

Expression exp = parser.parseExpression("**'Hello World'.bytes.length**");

**int** length = (Integer) exp.getValue();

The String’s constructor can be called instead of using a string literal.

ExpressionParser parser = **new** SpelExpressionParser();

Expression exp = parser.parseExpression("**new String('hello world').toUpperCase()**");

String message = exp.getValue(String.class);

Note the use of the generic method public <T> T getValue(Class<T> desiredResultType). Using this method removes the need to cast the value of the expression to the desired result type. An EvaluationException will be thrown if the value cannot be cast to the type T or converted using the registered type converter.

The more common usage of SpEL is to provide an expression string that is evaluated against a specific object instance (called the root object). The example shows how to retrieve the name property from an instance of the Inventor class or create a boolean condition:

*// Create and set a calendar*

GregorianCalendar c = **new** GregorianCalendar();

c.set(1856, 7, 9);

*// The constructor arguments are name, birthday, and nationality.*

Inventor tesla = **new** Inventor("Nikola Tesla", c.getTime(), "Serbian");

ExpressionParser parser = **new** SpelExpressionParser();

Expression exp = parser.parseExpression("**name**");

String name = (String) exp.getValue(tesla);

*// name == "Nikola Tesla"*

exp = parser.parseExpression("name == 'Nikola Tesla'");

**boolean** result = exp.getValue(tesla, Boolean.class);

*// result == true*

#### **4.2.1. EvaluationContext**

The interface EvaluationContext is used when evaluating an expression to resolve properties, methods, or fields and to help perform type conversion. There are two out-of-the-box implementations.

* SimpleEvaluationContext — exposes a subset of essential SpEL language features and configuration options, for categories of expressions that do not require the full extent of the SpEL language syntax and should be meaningfully restricted. Examples include but are not limited to data binding expressions, property-based filters, and others.
* StandardEvaluationContext — exposes the full set of SpEL language features and configuration options. You may use it to specify a default root object and to configure every available evaluation-related strategy.

SimpleEvaluationContext is designed to support only a subset of the SpEL language syntax. It excludes Java type references, constructors, and bean references. It also requires that one explicitly choose the level of support for properties and methods in expressions. By default, the create() static factory method enables only read access to properties. You can also obtain a builder to configure the exact level of support needed, targeting one or some combination of the following:

1. Custom PropertyAccessor only (no reflection)
2. Data binding properties for read-only access
3. Data binding properties for read and write

##### **Type conversion**

By default SpEL uses the conversion service available in Spring core (org.springframework.core.convert.ConversionService). This conversion service comes with many converters built in for common conversions but is also fully extensible so custom conversions between types can be added. Additionally it has the key capability that it is generics aware. This means that when working with generic types in expressions, SpEL will attempt conversions to maintain type correctness for any objects it encounters.

What does this mean in practice? Suppose assignment, using setValue(), is being used to set a List property. The type of the property is actually List<Boolean>. SpEL will recognize that the elements of the list need to be converted to Boolean before being placed in it. A simple example:

**class** **Simple** {

**public** List<Boolean> booleanList = **new** ArrayList<Boolean>();

}

Simple simple = **new** Simple();

simple.booleanList.add(true);

EvaluationContext context = SimpleEvaluationContext.forReadOnlyDataBinding().build();

*// "false" is passed in here as a String. SpEL and the conversion service*

*// will recognize that it needs to be a Boolean and convert it accordingly.*

parser.parseExpression("booleanList[0]").setValue(context, simple, "false");

*// b will be false*

Boolean b = simple.booleanList.get(0);

#### **4.2.2. Parser configuration**

It is possible to configure the SpEL expression parser using a parser configuration object (org.springframework.expression.spel.SpelParserConfiguration). The configuration object controls the behavior of some of the expression components. For example, if indexing into an array or collection and the element at the specified index is null it is possible to automatically create the element. This is useful when using expressions made up of a chain of property references. If indexing into an array or list and specifying an index that is beyond the end of the current size of the array or list it is possible to automatically grow the array or list to accommodate that index.

**class** **Demo** {

**public** List<String> list;

}

*// Turn on:*

*// - auto null reference initialization*

*// - auto collection growing*

SpelParserConfiguration config = **new** SpelParserConfiguration(true,true);

ExpressionParser parser = **new** SpelExpressionParser(config);

Expression expression = parser.parseExpression("list[3]");

Demo demo = **new** Demo();

Object o = expression.getValue(demo);

*// demo.list will now be a real collection of 4 entries*

*// Each entry is a new empty String*

It is also possible to configure the behaviour of the SpEL expression compiler.

#### **4.2.3. SpEL compilation**

Spring Framework 4.1 includes a basic expression compiler. Expressions are usually interpreted, which provides a lot of dynamic flexibility during evaluation but does not provide optimum performance. For occasional expression usage, this is fine, but, when used by other components such as Spring Integration, performance can be very important, and there is no real need for the dynamism.

The SpEL compiler is intended to address this need. During evaluation, the compiler generates a Java class that embodies the expression behavior at runtime and uses that class to achieve much faster expression evaluation. Due to the lack of typing around expressions, the compiler uses information gathered during the interpreted evaluations of an expression when performing compilation. For example, it does not know the type of a property reference purely from the expression, but during the first interpreted evaluation, it finds out what it is. Of course, basing compilation on such derived information can cause trouble later if the types of the various expression elements change over time. For this reason, compilation is best suited to expressions whose type information is not going to change on repeated evaluations.

For a basic expression like this:

someArray[0].someProperty.someOtherProperty < 0.1

which involves array access, some property derefencing and numeric operations, the performance gain can be very noticeable. In an example micro benchmark run of 50000 iterations, it was taking 75ms to evaluate using only the interpreter and just 3ms using the compiled version of the expression.

##### **Compiler configuration**

The compiler is not turned on by default, but there are two ways to turn it on. It can be turned on using the parser configuration process discussed earlier or via a system property when SpEL usage is embedded inside another component. This section discusses both of these options.

It is important to understand that there are a few modes the compiler can operate in, captured in an enum (org.springframework.expression.spel.SpelCompilerMode). The modes are as follows:

* OFF - The compiler is switched off; this is the default.
* IMMEDIATE - In immediate mode the expressions are compiled as soon as possible. This is typically after the first interpreted evaluation. If the compiled expression fails (typically due to a type changing, as described above) then the caller of the expression evaluation will receive an exception.
* MIXED - In mixed mode the expressions silently switch between interpreted and compiled mode over time. After some number of interpreted runs they will switch to compiled form and if something goes wrong with the compiled form (like a type changing, as described above) then the expression will automatically switch back to interpreted form again. Sometime later it may generate another compiled form and switch to it. Basically the exception that the user gets in IMMEDIATE mode is instead handled internally.

IMMEDIATE mode exists because MIXED mode could cause issues for expressions that have side effects. If a compiled expression blows up after partially succeeding it may have already done something that has affected the state of the system. If this has happened the caller may not want it to silently re-run in interpreted mode since part of the expression may be running twice.

After selecting a mode, use the SpelParserConfiguration to configure the parser:

SpelParserConfiguration config = **new** SpelParserConfiguration(SpelCompilerMode.IMMEDIATE,

this.getClass().getClassLoader());

SpelExpressionParser parser = **new** SpelExpressionParser(config);

Expression expr = parser.parseExpression("payload");

MyMessage message = **new** MyMessage();

Object payload = expr.getValue(message);

When you specify the compiler mode, you can also specify a classloader (passing null is allowed). Compiled expressions are defined in a child classloader created under any that is supplied. It is important to ensure that, if a classloader is specified, it can see all the types involved in the expression evaluation process. If you do not specify a classloader, a default classloader is used (typically the context classloader for the thread that is running during expression evaluation).

The second way to configure the compiler is for use when SpEL is embedded inside some other component and it may not be possible to configure it through a configuration object. In these cases, it is possible to use a system property. You can set the spring.expression.compiler.mode property to one of the SpelCompilerMode enum values (off, immediate, or mixed).

##### **Compiler limitations**

Since Spring Framework 4.1, the basic compilation framework is in place. However, the framework does not yet support compiling every kind of expression. The initial focus has been on the common expressions that are likely to be used in performance-critical contexts. The following kinds of expression cannot be compiled at the moment:

* expressions involving assignment
* expressions relying on the conversion service
* expressions using custom resolvers or accessors
* expressions using selection or projection

More and more types of expression will be compilable in the future.

### **4.3. Expressions in bean definitions**

You can use SpEL expressions with XML-based or annotation-based configuration metadata for defining BeanDefinition instances. In both cases, the syntax to define the expression is of the form #{ <expression string> }.

#### **4.3.1. XML configuration**

A property or constructor argument value can be set by using expressions, as the following example shows:

<bean id="numberGuess" class="org.spring.samples.NumberGuess">

<property name="randomNumber" value="#{ T(java.lang.Math).random() \* 100.0 }"/>

*<!-- other properties -->*

</bean>

All beans in the application context are available as predefined variables with their common bean name. This includes standard context beans such as environment (of type org.springframework.core.env.Environment) as well as systemProperties and systemEnvironment (of type Map<String, Object>) for access to the runtime environment.

The following example shows access to the systemProperties bean as a SpEL variable:

<bean id="taxCalculator" class="org.spring.samples.TaxCalculator">

<property name="defaultLocale" value="#{ systemProperties['user.region'] }"/>

*<!-- other properties -->*

</bean>

Note that you do not have to prefix the predefined variable with the # symbol here.

You can also refer to other bean properties by name, as the following example shows:

<bean id="numberGuess" class="org.spring.samples.NumberGuess">

<property name="randomNumber" value="#{ T(java.lang.Math).random() \* 100.0 }"/>

*<!-- other properties -->*

</bean>

<bean id="shapeGuess" class="org.spring.samples.ShapeGuess">

<property name="initialShapeSeed" value="#{ numberGuess.randomNumber }"/>

*<!-- other properties -->*

</bean>

#### **4.3.2. Annotation config**

To specify a default value, you can place the @Value annotation on fields, methods, and method or constructor parameters.

The following example sets the default value of a field variable:

**public** **static** **class** **FieldValueTestBean**

@Value("#{ systemProperties['user.region'] }")

**private** String defaultLocale;

**public** **void** setDefaultLocale(String defaultLocale) {

this.defaultLocale = defaultLocale;

}

**public** String getDefaultLocale() {

**return** this.defaultLocale;

}

}

The following example shows the equivalent but on a property setter method:

**public** **static** **class** **PropertyValueTestBean**

**private** String defaultLocale;

@Value("#{ systemProperties['user.region'] }")

**public** **void** setDefaultLocale(String defaultLocale) {

this.defaultLocale = defaultLocale;

}

**public** String getDefaultLocale() {

**return** this.defaultLocale;

}

}

Autowired methods and constructors can also use the @Value annotation, as the following examples show:

**public** **class** **SimpleMovieLister** {

**private** MovieFinder movieFinder;

**private** String defaultLocale;

@Autowired

**public** **void** configure(MovieFinder movieFinder,

@Value("#{ systemProperties['user.region'] }") String defaultLocale) {

this.movieFinder = movieFinder;

this.defaultLocale = defaultLocale;

}

*// ...*

}

**public** **class** **MovieRecommender** {

**private** String defaultLocale;

**private** CustomerPreferenceDao customerPreferenceDao;

@Autowired

**public** MovieRecommender(CustomerPreferenceDao customerPreferenceDao,

@Value("#{systemProperties['user.country']}") String defaultLocale) {

this.customerPreferenceDao = customerPreferenceDao;

this.defaultLocale = defaultLocale;

}

*// ...*

}

### **4.4. Language Reference**

#### **4.4.1. Literal expressions**

The types of literal expressions supported are strings, numeric values (int, real, hex), boolean and null. Strings are delimited by single quotes. To put a single quote itself in a string, use two single quote characters.

The following listing shows simple usage of literals. Typically they would not be used in isolation like this but rather as part of a more complex expression, for example using a literal on one side of a logical comparison operator.

ExpressionParser parser = **new** SpelExpressionParser();

*// evals to "Hello World"*

String helloWorld = (String) parser.parseExpression("'Hello World'").getValue();

**double** avogadrosNumber = (Double) parser.parseExpression("6.0221415E+23").getValue();

*// evals to 2147483647*

**int** maxValue = (Integer) parser.parseExpression("0x7FFFFFFF").getValue();

**boolean** trueValue = (Boolean) parser.parseExpression("true").getValue();

Object nullValue = parser.parseExpression("null").getValue();

Numbers support the use of the negative sign, exponential notation, and decimal points. By default real numbers are parsed using Double.parseDouble().

#### **4.4.2. Properties, Arrays, Lists, Maps, Indexers**

Navigating with property references is easy: just use a period to indicate a nested property value. The instances of the Inventor class, pupin, and tesla, were populated with data listed in the section [Classes used in the examples](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#expressions-example-classes). To navigate "down" and get Tesla’s year of birth and Pupin’s city of birth the following expressions are used.

*// evals to 1856*

**int** year = (Integer) parser.parseExpression("Birthdate.Year + 1900").getValue(context);

String city = (String) parser.parseExpression("placeOfBirth.City").getValue(context);

Case insensitivity is allowed for the first letter of property names. The contents of arrays and lists are obtained using square bracket notation.

ExpressionParser parser = **new** SpelExpressionParser();

EvaluationContext context = SimpleEvaluationContext.forReadOnlyDataBinding().build();

*// Inventions Array*

*// evaluates to "Induction motor"*

String invention = parser.parseExpression("inventions[3]").getValue(

context, tesla, String.class);

*// Members List*

*// evaluates to "Nikola Tesla"*

String name = parser.parseExpression("Members[0].Name").getValue(

context, ieee, String.class);

*// List and Array navigation*

*// evaluates to "Wireless communication"*

String invention = parser.parseExpression("Members[0].Inventions[6]").getValue(

context, ieee, String.class);

The contents of maps are obtained by specifying the literal key value within the brackets. In this case, because keys for the Officers map are strings, we can specify string literals.

*// Officer's Dictionary*

Inventor pupin = parser.parseExpression("Officers['president']").getValue(

societyContext, Inventor.class);

*// evaluates to "Idvor"*

String city = parser.parseExpression("Officers['president'].PlaceOfBirth.City").getValue(

societyContext, String.class);

*// setting values*

parser.parseExpression("Officers['advisors'][0].PlaceOfBirth.Country").setValue(

societyContext, "Croatia");

#### **4.4.3. Inline lists**

Lists can be expressed directly in an expression using {} notation.

*// evaluates to a Java list containing the four numbers*

List numbers = (List) parser.parseExpression("{1,2,3,4}").getValue(context);

List listOfLists = (List) parser.parseExpression("{{'a','b'},{'x','y'}}").getValue(context);

{} by itself means an empty list. For performance reasons, if the list is itself entirely composed of fixed literals then a constant list is created to represent the expression, rather than building a new list on each evaluation.

#### **4.4.4. Inline Maps**

Maps can also be expressed directly in an expression using {key:value} notation.

*// evaluates to a Java map containing the two entries*

Map inventorInfo = (Map) parser.parseExpression("{name:'Nikola',dob:'10-July-1856'}").getValue(context);

Map mapOfMaps = (Map) parser.parseExpression("{name:{first:'Nikola',last:'Tesla'},dob:{day:10,month:'July',year:1856}}").getValue(context);

{:} by itself means an empty map. For performance reasons, if the map is itself composed of fixed literals or other nested constant structures (lists or maps) then a constant map is created to represent the expression, rather than building a new map on each evaluation. Quoting of the map keys is optional, the examples above are not using quoted keys.

#### **4.4.5. Array construction**

Arrays can be built using the familiar Java syntax, optionally supplying an initializer to have the array populated at construction time.

**int[]** numbers1 = (**int[]**) parser.parseExpression("new int[4]").getValue(context);

*// Array with initializer*

**int[]** numbers2 = (**int[]**) parser.parseExpression("new int[]{1,2,3}").getValue(context);

*// Multi dimensional array*

**int[][]** numbers3 = (**int[][]**) parser.parseExpression("new int[4][5]").getValue(context);

It is not currently allowed to supply an initializer when constructing a multi-dimensional array.

#### **4.4.6. Methods**

Methods are invoked using typical Java programming syntax. You may also invoke methods on literals. Varargs are also supported.

*// string literal, evaluates to "bc"*

String bc = parser.parseExpression("'abc'.substring(1, 3)").getValue(String.class);

*// evaluates to true*

**boolean** isMember = parser.parseExpression("isMember('Mihajlo Pupin')").getValue(

societyContext, Boolean.class);

#### **4.4.7. Operators**

##### **Relational operators**

The relational operators; equal, not equal, less than, less than or equal, greater than, and greater than or equal are supported using standard operator notation.

*// evaluates to true*

**boolean** trueValue = parser.parseExpression("2 == 2").getValue(Boolean.class);

*// evaluates to false*

**boolean** falseValue = parser.parseExpression("2 < -5.0").getValue(Boolean.class);

*// evaluates to true*

**boolean** trueValue = parser.parseExpression("'black' < 'block'").getValue(Boolean.class);

|  |  |
| --- | --- |
|  | Greater/less-than comparisons against null follow a simple rule: null is treated as nothing here (i.e. NOT as zero). As a consequence, any other value is always greater than null (X > null is always true) and no other value is ever less than nothing (X < null is always false).  If you prefer numeric comparisons instead, please avoid number-based null comparisons in favor of comparisons against zero (e.g. X > 0 or X < 0). |

In addition to standard relational operators SpEL supports the instanceof and regular expression based matches operator.

*// evaluates to false*

**boolean** falseValue = parser.parseExpression(

"'xyz' instanceof T(Integer)").getValue(Boolean.class);

*// evaluates to true*

**boolean** trueValue = parser.parseExpression(

"'5.00' matches '^-?\\d+(\\.\\d{2})?$'").getValue(Boolean.class);

*//evaluates to false*

**boolean** falseValue = parser.parseExpression(

"'5.0067' matches '^-?\\d+(\\.\\d{2})?$'").getValue(Boolean.class);

|  |  |
| --- | --- |
|  | Be careful with primitive types as they are immediately boxed up to the wrapper type, so 1 instanceof T(int) evaluates to false while 1 instanceof T(Integer) evaluates to true, as expected. |

Each symbolic operator can also be specified as a purely alphabetic equivalent. This avoids problems where the symbols used have special meaning for the document type in which the expression is embedded (eg. an XML document). The textual equivalents are shown here: lt (<), gt (>), le (<=), ge (>=), eq (==), ne (!=), div (/), mod (%), not (!). These are case insensitive.

##### **Logical operators**

The logical operators that are supported are and, or, and not. Their use is demonstrated below.

*// -- AND --*

*// evaluates to false*

**boolean** falseValue = parser.parseExpression("true and false").getValue(Boolean.class);

*// evaluates to true*

String expression = "isMember('Nikola Tesla') and isMember('Mihajlo Pupin')";

**boolean** trueValue = parser.parseExpression(expression).getValue(societyContext, Boolean.class);

*// -- OR --*

*// evaluates to true*

**boolean** trueValue = parser.parseExpression("true or false").getValue(Boolean.class);

*// evaluates to true*

String expression = "isMember('Nikola Tesla') or isMember('Albert Einstein')";

**boolean** trueValue = parser.parseExpression(expression).getValue(societyContext, Boolean.class);

*// -- NOT --*

*// evaluates to false*

**boolean** falseValue = parser.parseExpression("!true").getValue(Boolean.class);

*// -- AND and NOT --*

String expression = "isMember('Nikola Tesla') and !isMember('Mihajlo Pupin')";

**boolean** falseValue = parser.parseExpression(expression).getValue(societyContext, Boolean.class);

##### **Mathematical operators**

The addition operator can be used on both numbers and strings. Subtraction, multiplication and division can be used only on numbers. Other mathematical operators supported are modulus (%) and exponential power (^). Standard operator precedence is enforced. These operators are demonstrated below.

*// Addition*

**int** two = parser.parseExpression("1 + 1").getValue(Integer.class); *// 2*

String testString = parser.parseExpression(

"'test' + ' ' + 'string'").getValue(String.class); *// 'test string'*

*// Subtraction*

**int** four = parser.parseExpression("1 - -3").getValue(Integer.class); *// 4*

**double** d = parser.parseExpression("1000.00 - 1e4").getValue(Double.class); *// -9000*

*// Multiplication*

**int** six = parser.parseExpression("-2 \* -3").getValue(Integer.class); *// 6*

**double** twentyFour = parser.parseExpression("2.0 \* 3e0 \* 4").getValue(Double.class); *// 24.0*

*// Division*

**int** minusTwo = parser.parseExpression("6 / -3").getValue(Integer.class); *// -2*

**double** one = parser.parseExpression("8.0 / 4e0 / 2").getValue(Double.class); *// 1.0*

*// Modulus*

**int** three = parser.parseExpression("7 % 4").getValue(Integer.class); *// 3*

**int** one = parser.parseExpression("8 / 5 % 2").getValue(Integer.class); *// 1*

*// Operator precedence*

**int** minusTwentyOne = parser.parseExpression("1+2-3\*8").getValue(Integer.class); *// -21*

#### **4.4.8. Assignment**

Setting of a property is done by using the assignment operator. This would typically be done within a call to setValue but can also be done inside a call to getValue.

Inventor inventor = **new** Inventor();

EvaluationContext context = SimpleEvaluationContext.forReadWriteDataBinding().build();

parser.parseExpression("Name").setValue(context, inventor, "Aleksandar Seovic");

*// alternatively*

String aleks = parser.parseExpression(

"Name = 'Aleksandar Seovic'").getValue(context, inventor, String.class);

#### **4.4.9. Types**

The special T operator can be used to specify an instance of java.lang.Class (the type). Static methods are invoked using this operator as well. The StandardEvaluationContext uses a TypeLocator to find types and the StandardTypeLocator (which can be replaced) is built with an understanding of the java.lang package. This means T() references to types within java.lang do not need to be fully qualified, but all other type references must be.

Class dateClass = parser.parseExpression("T(java.util.Date)").getValue(Class.class);

Class stringClass = parser.parseExpression("T(String)").getValue(Class.class);

**boolean** trueValue = parser.parseExpression(

"T(java.math.RoundingMode).CEILING < T(java.math.RoundingMode).FLOOR")

.getValue(Boolean.class);

#### **4.4.10. Constructors**

Constructors can be invoked using the new operator. The fully qualified class name should be used for all but the primitive type and String (where int, float, etc, can be used).

Inventor einstein = p.parseExpression(

"new org.spring.samples.spel.inventor.Inventor('Albert Einstein', 'German')")

.getValue(Inventor.class);

*//create new inventor instance within add method of List*

p.parseExpression(

"Members.add(new org.spring.samples.spel.inventor.Inventor(

'Albert Einstein', 'German'))").getValue(societyContext);

#### **4.4.11. Variables**

Variables can be referenced in the expression using the syntax #variableName. Variables are set using the method setVariable on EvaluationContext implementations.

Inventor tesla = **new** Inventor("Nikola Tesla", "Serbian");

EvaluationContext context = SimpleEvaluationContext.forReadWriteDataBinding().build();

context.setVariable("newName", "Mike Tesla");

parser.parseExpression("Name = #newName").getValue(context, tesla);

System.out.println(tesla.getName()) *// "Mike Tesla"*

##### **The #this and #root variables**

The variable #this is always defined and refers to the current evaluation object (against which unqualified references are resolved). The variable #root is always defined and refers to the root context object. Although #this may vary as components of an expression are evaluated, #root always refers to the root.

*// create an array of integers*

List<Integer> primes = **new** ArrayList<Integer>();

primes.addAll(Arrays.asList(2,3,5,7,11,13,17));

*// create parser and set variable 'primes' as the array of integers*

ExpressionParser parser = **new** SpelExpressionParser();

EvaluationContext context = SimpleEvaluationContext.forReadOnlyDataAccess();

context.setVariable("primes", primes);

*// all prime numbers > 10 from the list (using selection ?{...})*

*// evaluates to [11, 13, 17]*

List<Integer> primesGreaterThanTen = (List<Integer>) parser.parseExpression(

"#primes.?[#this>10]").getValue(context);

#### **4.4.12. Functions**

You can extend SpEL by registering user defined functions that can be called within the expression string. The function is registered through the EvaluationContext.

Method method = ...;

EvaluationContext context = SimpleEvaluationContext.forReadOnlyDataBinding().build();

context.setVariable("myFunction", method);

For example, given a utility method to reverse a string is shown below:

**public** **abstract** **class** **StringUtils** {

**public** **static** String reverseString(String input) {

StringBuilder backwards = **new** StringBuilder(input.length());

**for** (**int** i = 0; i < input.length(); i++)

backwards.append(input.charAt(input.length() - 1 - i));

}

**return** backwards.toString();

}

}

The above method can then be registered and used as follows:

ExpressionParser parser = **new** SpelExpressionParser();

EvaluationContext context = SimpleEvaluationContext.forReadOnlyDataBinding().build();

context.setVariable("reverseString",

StringUtils.class.getDeclaredMethod("reverseString", String.class));

String helloWorldReversed = parser.parseExpression(

"#reverseString('hello')").getValue(context, String.class);

#### **4.4.13. Bean references**

If the evaluation context has been configured with a bean resolver it is possible to look up beans from an expression using the @ symbol.

ExpressionParser parser = **new** SpelExpressionParser();

StandardEvaluationContext context = **new** StandardEvaluationContext();

context.setBeanResolver(**new** MyBeanResolver());

*// This will end up calling resolve(context,"foo") on MyBeanResolver during evaluation*

Object bean = parser.parseExpression("@foo").getValue(context);

To access a factory bean itself, the bean name should instead be prefixed with an & symbol.

ExpressionParser parser = **new** SpelExpressionParser();

StandardEvaluationContext context = **new** StandardEvaluationContext();

context.setBeanResolver(**new** MyBeanResolver());

*// This will end up calling resolve(context,"&foo") on MyBeanResolver during evaluation*

Object bean = parser.parseExpression("&foo").getValue(context);

#### **4.4.14. Ternary Operator (If-Then-Else)**

You can use the ternary operator for performing if-then-else conditional logic inside the expression. A minimal example is:

String falseString = parser.parseExpression(

"false ? 'trueExp' : 'falseExp'").getValue(String.class);

In this case, the boolean false results in returning the string value 'falseExp'. A more realistic example is shown below.

parser.parseExpression("Name").setValue(societyContext, "IEEE");

societyContext.setVariable("queryName", "Nikola Tesla");

expression = "isMember(#queryName)? #queryName + ' is a member of the ' " +

"+ Name + ' Society' : #queryName + ' is not a member of the ' + Name + ' Society'";

String queryResultString = parser.parseExpression(expression)

.getValue(societyContext, String.class);

*// queryResultString = "Nikola Tesla is a member of the IEEE Society"*

Also see the next section on the Elvis operator for an even shorter syntax for the ternary operator.

#### **4.4.15. The Elvis Operator**

The Elvis operator is a shortening of the ternary operator syntax and is used in the [Groovy](http://www.groovy-lang.org/operators.html#_elvis_operator) language. With the ternary operator syntax, you usually have to repeat a variable twice, as the following example shows:

String name = "Elvis Presley";

String displayName = (name != null ? name : "Unknown");

Instead, you can use the Elvis operator (named for the resemblance to Elvis' hair style). The following example shows how to use the Elvis operator:

ExpressionParser parser = **new** SpelExpressionParser();

String name = parser.parseExpression("name?:'Unknown'").getValue(**new** Inventor(), String.class);

System.out.println(name); *// 'Unknown'*

The following listing shows a more complex example:

ExpressionParser parser = **new** SpelExpressionParser();

EvaluationContext context = SimpleEvaluationContext.forReadOnlyDataBinding().build();

Inventor tesla = **new** Inventor("Nikola Tesla", "Serbian");

String name = parser.parseExpression("Name?:'Elvis Presley'").getValue(context, tesla, String.class);

System.out.println(name); *// Nikola Tesla*

tesla.setName(null);

name = parser.parseExpression("Name?:'Elvis Presley'").getValue(context, tesla, String.class);

System.out.println(name); *// Elvis Presley*

#### **4.4.16. Safe Navigation operator**

The Safe Navigation operator is used to avoid a NullPointerException and comes from the [Groovy](http://www.groovy-lang.org/operators.html#_safe_navigation_operator) language. Typically when you have a reference to an object you might need to verify that it is not null before accessing methods or properties of the object. To avoid this, the safe navigation operator will simply return null instead of throwing an exception.

ExpressionParser parser = **new** SpelExpressionParser();

EvaluationContext context = SimpleEvaluationContext.forReadOnlyDataBinding().build();

Inventor tesla = **new** Inventor("Nikola Tesla", "Serbian");

tesla.setPlaceOfBirth(**new** PlaceOfBirth("Smiljan"));

String city = parser.parseExpression("PlaceOfBirth?.City").getValue(context, tesla, String.class);

System.out.println(city); *// Smiljan*

tesla.setPlaceOfBirth(null);

city = parser.parseExpression("PlaceOfBirth?.City").getValue(context, tesla, String.class);

System.out.println(city); *// null - does not throw NullPointerException!!!*

|  |  |
| --- | --- |
|  | The Elvis operator can be used to apply default values in expressions, e.g. in an @Value expression:  @Value("#{systemProperties['pop3.port'] ?: 25}")  This will inject a system property pop3.port if it is defined or 25 if not. |

#### **4.4.17. Collection Selection**

Selection is a powerful expression language feature that allows you to transform some source collection into another by selecting from its entries.

Selection uses the syntax .?[selectionExpression]. This will filter the collection and return a new collection containing a subset of the original elements. For example, selection would allow us to easily get a list of Serbian inventors:

List<Inventor> list = (List<Inventor>) parser.parseExpression(

"Members.?[Nationality == 'Serbian']").getValue(societyContext);

Selection is possible upon both lists and maps. In the former case the selection criteria is evaluated against each individual list element whilst against a map the selection criteria is evaluated against each map entry (objects of the Java type Map.Entry). Map entries have their key and value accessible as properties for use in the selection.

This expression will return a new map consisting of those elements of the original map where the entry value is less than 27.

Map newMap = parser.parseExpression("map.?[value<27]").getValue();

In addition to returning all the selected elements, it is possible to retrieve just the first or the last value. To obtain the first entry matching the selection the syntax is .^[selectionExpression] whilst to obtain the last matching selection the syntax is .$[selectionExpression].

#### **4.4.18. Collection Projection**

Projection allows a collection to drive the evaluation of a sub-expression and the result is a new collection. The syntax for projection is .![projectionExpression]. Most easily understood by example, suppose we have a list of inventors but want the list of cities where they were born. Effectively we want to evaluate 'placeOfBirth.city' for every entry in the inventor list. Using projection:

*// returns ['Smiljan', 'Idvor' ]*

List placesOfBirth = (List)parser.parseExpression("Members.![placeOfBirth.city]");

A map can also be used to drive projection and in this case the projection expression is evaluated against each entry in the map (represented as a Java Map.Entry). The result of a projection across a map is a list consisting of the evaluation of the projection expression against each map entry.

#### **4.4.19. Expression templating**

Expression templates allow a mixing of literal text with one or more evaluation blocks. Each evaluation block is delimited with prefix and suffix characters that you can define, a common choice is to use #{ } as the delimiters. For example,

String randomPhrase = parser.parseExpression(

"random number is #{T(java.lang.Math).random()}",

**new** TemplateParserContext()).getValue(String.class);

*// evaluates to "random number is 0.7038186818312008"*

The string is evaluated by concatenating the literal text 'random number is ' with the result of evaluating the expression inside the #{ } delimiter, in this case the result of calling that random() method. The second argument to the method parseExpression() is of the type ParserContext. The ParserContext interface is used to influence how the expression is parsed in order to support the expression templating functionality. The definition of TemplateParserContext is shown below.

**public** **class** **TemplateParserContext** **implements** ParserContext {

**public** String getExpressionPrefix() {

**return** "#{";

}

**public** String getExpressionSuffix() {

**return** "}";

}

**public** **boolean** isTemplate() {

**return** true;

}

}

### **4.5. Classes used in the examples**

Inventor.java

**package** org.spring.samples.spel.inventor;

**import** java.util.Date;

**import** java.util.GregorianCalendar;

**public** **class** **Inventor** {

**private** String name;

**private** String nationality;

**private** String**[]** inventions;

**private** Date birthdate;

**private** PlaceOfBirth placeOfBirth;

**public** Inventor(String name, String nationality) {

GregorianCalendar c= **new** GregorianCalendar();

this.name = name;

this.nationality = nationality;

this.birthdate = c.getTime();

}

**public** Inventor(String name, Date birthdate, String nationality) {

this.name = name;

this.nationality = nationality;

this.birthdate = birthdate;

}

**public** Inventor() {

}

**public** String getName() {

**return** name;

}

**public** **void** setName(String name) {

this.name = name;

}

**public** String getNationality() {

**return** nationality;

}

**public** **void** setNationality(String nationality) {

this.nationality = nationality;

}

**public** Date getBirthdate() {

**return** birthdate;

}

**public** **void** setBirthdate(Date birthdate) {

this.birthdate = birthdate;

}

**public** PlaceOfBirth getPlaceOfBirth() {

**return** placeOfBirth;

}

**public** **void** setPlaceOfBirth(PlaceOfBirth placeOfBirth) {

this.placeOfBirth = placeOfBirth;

}

**public** **void** setInventions(String**[]** inventions) {

this.inventions = inventions;

}

**public** String**[]** getInventions() {

**return** inventions;

}

}

PlaceOfBirth.java

**package** org.spring.samples.spel.inventor;

**public** **class** **PlaceOfBirth** {

**private** String city;

**private** String country;

**public** PlaceOfBirth(String city) {

this.city=city;

}

**public** PlaceOfBirth(String city, String country) {

this(city);

this.country = country;

}

**public** String getCity() {

**return** city;

}

**public** **void** setCity(String s) {

this.city = s;

}

**public** String getCountry() {

**return** country;

}

**public** **void** setCountry(String country) {

this.country = country;

}

}

Society.java

**package** org.spring.samples.spel.inventor;

**import** java.util.\*;

**public** **class** **Society** {

**private** String name;

**public** **static** String Advisors = "advisors";

**public** **static** String President = "president";

**private** List<Inventor> members = **new** ArrayList<Inventor>();

**private** Map officers = **new** HashMap();

**public** List getMembers() {

**return** members;

}

**public** Map getOfficers() {

**return** officers;

}

**public** String getName() {

**return** name;

}

**public** **void** setName(String name) {

this.name = name;

}

**public** **boolean** isMember(String name) {

**for** (Inventor inventor : members) {

**if** (inventor.getName().equals(name)) {

**return** true;

}

}

**return** false;

}

}

## 5. Aspect Oriented Programming with Spring

### **5.1. Introduction**

Aspect-Oriented Programming (AOP) complements Object-Oriented Programming (OOP) by providing another way of thinking about program structure. The key unit of modularity in OOP is the class, whereas in AOP the unit of modularity is the aspect. Aspects enable the modularization of concerns such as transaction management that cut across multiple types and objects. (Such concerns are often termed crosscutting concerns in AOP literature.)

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

Spring 2.0+ AOP

Spring 2.0 introduced a simpler and more powerful way of writing custom aspects using either a [schema-based approach](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-schema) or the [@AspectJ annotation style](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj). Both of these styles offer fully typed advice and use of the AspectJ pointcut language, while still using Spring AOP for weaving.

The Spring 2.0+ schema- and @AspectJ-based AOP support is discussed in this chapter. The lower-level AOP support, as commonly exposed in Spring 1.2 applications, is discussed in [the following chapter](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-api).

AOP is used in the Spring Framework to…​

* …​ provide declarative enterprise services, especially as a replacement for EJB declarative services. The most important such service is [declarative transaction management](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#transaction-declarative).
* …​ allow users to implement custom aspects, complementing their use of OOP with AOP.

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|  | If you are interested only in generic declarative services or other pre-packaged declarative middleware services such as pooling, you do not need to work directly with Spring AOP, and can skip most of this chapter. |

#### **5.1.1. AOP concepts**

Let us begin by defining some central AOP concepts and terminology. These terms are not Spring-specific…​ unfortunately, AOP terminology is not particularly intuitive; however, it would be even more confusing if Spring used its own terminology.

* Aspect: a modularization of a concern that cuts across multiple classes. Transaction management is a good example of a crosscutting concern in enterprise Java applications. In Spring AOP, aspects are implemented using regular classes (the [schema-based approach](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-schema)) or regular classes annotated with the @Aspect annotation (the [@AspectJ style](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj)).
* Join point: a point during the execution of a program, such as the execution of a method or the handling of an exception. In Spring AOP, a join point always represents a method execution.
* Advice: action taken by an aspect at a particular join point. Different types of advice include "around", "before" and "after" advice. (Advice types are discussed below.) Many AOP frameworks, including Spring, model an advice as an interceptor, maintaining a chain of interceptors around the join point.
* Pointcut: a predicate that matches join points. Advice is associated with a pointcut expression and runs at any join point matched by the pointcut (for example, the execution of a method with a certain name). The concept of join points as matched by pointcut expressions is central to AOP, and Spring uses the AspectJ pointcut expression language by default.
* Introduction: declaring additional methods or fields on behalf of a type. Spring AOP allows you to introduce new interfaces (and a corresponding implementation) to any advised object. For example, you could use an introduction to make a bean implement an IsModified interface, to simplify caching. (An introduction is known as an inter-type declaration in the AspectJ community.)
* Target object: object being advised by one or more aspects. Also referred to as the advised object. Since Spring AOP is implemented using runtime proxies, this object will always be a proxied object.
* AOP proxy: an object created by the AOP framework in order to implement the aspect contracts (advise method executions and so on). In the Spring Framework, an AOP proxy will be a JDK dynamic proxy or a CGLIB proxy.
* Weaving: linking aspects with other application types or objects to create an advised object. This can be done at compile time (using the AspectJ compiler, for example), load time, or at runtime. Spring AOP, like other pure Java AOP frameworks, performs weaving at runtime.

Types of advice:

* Before advice: Advice that executes before a join point, but which does not have the ability to prevent execution flow proceeding to the join point (unless it throws an exception).
* After returning advice: Advice to be executed after a join point completes normally: for example, if a method returns without throwing an exception.
* After throwing advice: Advice to be executed if a method exits by throwing an exception.
* After (finally) advice: Advice to be executed regardless of the means by which a join point exits (normal or exceptional return).
* Around advice: Advice that surrounds a join point such as a method invocation. This is the most powerful kind of advice. Around advice can perform custom behavior before and after the method invocation. It is also responsible for choosing whether to proceed to the join point or to shortcut the advised method execution by returning its own return value or throwing an exception.

Around advice is the most general kind of advice. Since Spring AOP, like AspectJ, provides a full range of advice types, we recommend that you use the least powerful advice type that can implement the required behavior. For example, if you need only to update a cache with the return value of a method, you are better off implementing an after returning advice than an around advice, although an around advice can accomplish the same thing. Using the most specific advice type provides a simpler programming model with less potential for errors. For example, you do not need to invoke the proceed() method on the JoinPoint used for around advice, and hence cannot fail to invoke it.

In Spring 2.0, all advice parameters are statically typed, so that you work with advice parameters of the appropriate type (the type of the return value from a method execution for example) rather than Object arrays.

The concept of join points, matched by pointcuts, is the key to AOP which distinguishes it from older technologies offering only interception. Pointcuts enable advice to be targeted independently of the Object-Oriented hierarchy. For example, an around advice providing declarative transaction management can be applied to a set of methods spanning multiple objects (such as all business operations in the service layer).

#### **5.1.2. Spring AOP capabilities and goals**

Spring AOP is implemented in pure Java. There is no need for a special compilation process. Spring AOP does not need to control the class loader hierarchy, and is thus suitable for use in a Servlet container or application server.

Spring AOP currently supports only method execution join points (advising the execution of methods on Spring beans). Field interception is not implemented, although support for field interception could be added without breaking the core Spring AOP APIs. If you need to advise field access and update join points, consider a language such as AspectJ.

Spring AOP’s approach to AOP differs from that of most other AOP frameworks. The aim is not to provide the most complete AOP implementation (although Spring AOP is quite capable); it is rather to provide a close integration between AOP implementation and Spring IoC to help solve common problems in enterprise applications.

Thus, for example, the Spring Framework’s AOP functionality is normally used in conjunction with the Spring IoC container. Aspects are configured using normal bean definition syntax (although this allows powerful "autoproxying" capabilities): this is a crucial difference from other AOP implementations. There are some things you cannot do easily or efficiently with Spring AOP, such as advise very fine-grained objects (such as domain objects typically): AspectJ is the best choice in such cases. However, our experience is that Spring AOP provides an excellent solution to most problems in enterprise Java applications that are amenable to AOP.

Spring AOP will never strive to compete with AspectJ to provide a comprehensive AOP solution. We believe that both proxy-based frameworks like Spring AOP and full-blown frameworks such as AspectJ are valuable, and that they are complementary, rather than in competition. Spring seamlessly integrates Spring AOP and IoC with AspectJ, to enable all uses of AOP to be catered for within a consistent Spring-based application architecture. This integration does not affect the Spring AOP API or the AOP Alliance API: Spring AOP remains backward-compatible. See [the following chapter](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-api) for a discussion of the Spring AOP APIs.

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|  | One of the central tenets of the Spring Framework is that of non-invasiveness; this is the idea that you should not be forced to introduce framework-specific classes and interfaces into your business/domain model. However, in some places the Spring Framework does give you the option to introduce Spring Framework-specific dependencies into your codebase: the rationale in giving you such options is because in certain scenarios it might be just plain easier to read or code some specific piece of functionality in such a way. The Spring Framework (almost) always offers you the choice though: you have the freedom to make an informed decision as to which option best suits your particular use case or scenario.  One such choice that is relevant to this chapter is that of which AOP framework (and which AOP style) to choose. You have the choice of AspectJ and/or Spring AOP, and you also have the choice of either the @AspectJ annotation-style approach or the Spring XML configuration-style approach. The fact that this chapter chooses to introduce the @AspectJ-style approach first should not be taken as an indication that the Spring team favors the @AspectJ annotation-style approach over the Spring XML configuration-style.  See [Choosing which AOP declaration style to use](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-choosing) for a more complete discussion of the whys and wherefores of each style. |

#### **5.1.3. AOP Proxies**

Spring AOP defaults to using standard JDK dynamic proxies for AOP proxies. This enables any interface (or set of interfaces) to be proxied.

Spring AOP can also use CGLIB proxies. This is necessary to proxy classes rather than interfaces. CGLIB is used by default if a business object does not implement an interface. As it is good practice to program to interfaces rather than classes; business classes normally will implement one or more business interfaces. It is possible to [force the use of CGLIB](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-proxying), in those (hopefully rare) cases where you need to advise a method that is not declared on an interface, or where you need to pass a proxied object to a method as a concrete type.

It is important to grasp the fact that Spring AOP is proxy-based. See [Understanding AOP proxies](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-understanding-aop-proxies) for a thorough examination of exactly what this implementation detail actually means.

### **5.2. @AspectJ support**

@AspectJ refers to a style of declaring aspects as regular Java classes annotated with annotations. The @AspectJ style was introduced by the [AspectJ project](https://www.eclipse.org/aspectj) as part of the AspectJ 5 release. Spring interprets the same annotations as AspectJ 5, using a library supplied by AspectJ for pointcut parsing and matching. The AOP runtime is still pure Spring AOP though, and there is no dependency on the AspectJ compiler or weaver.

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|  | Using the AspectJ compiler and weaver enables use of the full AspectJ language, and is discussed in [Using AspectJ with Spring applications](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-using-aspectj). |

#### **5.2.1. Enabling @AspectJ Support**

To use @AspectJ aspects in a Spring configuration you need to enable Spring support for configuring Spring AOP based on @AspectJ aspects, and autoproxying beans based on whether or not they are advised by those aspects. By autoproxying we mean that if Spring determines that a bean is advised by one or more aspects, it will automatically generate a proxy for that bean to intercept method invocations and ensure that advice is executed as needed.

The @AspectJ support can be enabled with XML or Java style configuration. In either case you will also need to ensure that AspectJ’s aspectjweaver.jar library is on the classpath of your application (version 1.8 or later). This library is available in the 'lib' directory of an AspectJ distribution or via the Maven Central repository.

##### **Enabling @AspectJ Support with Java configuration**

To enable @AspectJ support with Java @Configuration add the @EnableAspectJAutoProxy annotation:

@Configuration

@EnableAspectJAutoProxy

**public** **class** **AppConfig** {

}

##### **Enabling @AspectJ Support with XML configuration**

To enable @AspectJ support with XML based configuration use the aop:aspectj-autoproxy element:

<aop:aspectj-autoproxy/>

This assumes that you are using schema support as described in [XML Schema-based configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-schemas). See [the AOP schema](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-schemas-aop) for how to import the tags in the aop namespace.

#### **5.2.2. Declaring an aspect**

With the @AspectJ support enabled, any bean defined in your application context with a class that is an @AspectJ aspect (has the @Aspect annotation) will be automatically detected by Spring and used to configure Spring AOP. The following example shows the minimal definition required for a not-very-useful aspect:

A regular bean definition in the application context, pointing to a bean class that has the @Aspect annotation:

<bean id="myAspect" class="org.xyz.NotVeryUsefulAspect">

*<!-- configure properties of aspect here as normal -->*

</bean>

And the NotVeryUsefulAspect class definition, annotated with org.aspectj.lang.annotation.Aspect annotation;

**package** org.xyz;

**import** org.aspectj.lang.annotation.Aspect;

@Aspect

**public** **class** **NotVeryUsefulAspect** {

}

Aspects (classes annotated with @Aspect) may have methods and fields just like any other class. They may also contain pointcut, advice, and introduction (inter-type) declarations.

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|  | *Autodetecting aspects through component scanning*  You may register aspect classes as regular beans in your Spring XML configuration, or autodetect them through classpath scanning - just like any other Spring-managed bean. However, note that the @Aspect annotation is not sufficient for autodetection in the classpath: For that purpose, you need to add a separate @Component annotation (or alternatively a custom stereotype annotation that qualifies, as per the rules of Spring’s component scanner). |
|  | *Advising aspects with other aspects?*  In Spring AOP, it is not possible to have aspects themselves be the target of advice from other aspects. The @Aspect annotation on a class marks it as an aspect, and hence excludes it from auto-proxying. |

#### **5.2.3. Declaring a pointcut**

Recall that pointcuts determine join points of interest, and thus enable us to control when advice executes. Spring AOP only supports method execution join points for Spring beans, so you can think of a pointcut as matching the execution of methods on Spring beans. A pointcut declaration has two parts: a signature comprising a name and any parameters, and a pointcut expression that determines exactly which method executions we are interested in. In the @AspectJ annotation-style of AOP, a pointcut signature is provided by a regular method definition, and the pointcut expression is indicated using the @Pointcut annotation (the method serving as the pointcut signature must have a void return type).

An example will help make this distinction between a pointcut signature and a pointcut expression clear. The following example defines a pointcut named 'anyOldTransfer' that will match the execution of any method named 'transfer':

@Pointcut("execution(\* transfer(..))")*// the pointcut expression*

**private** **void** anyOldTransfer() {}*// the pointcut signature*

The pointcut expression that forms the value of the @Pointcut annotation is a regular AspectJ 5 pointcut expression. For a full discussion of AspectJ’s pointcut language, see the [AspectJ Programming Guide](https://www.eclipse.org/aspectj/doc/released/progguide/index.html) (and for extensions, the [AspectJ 5 Developers Notebook](https://www.eclipse.org/aspectj/doc/released/adk15notebook/index.html)) or one of the books on AspectJ such as "Eclipse AspectJ" by Colyer et. al. or "AspectJ in Action" by Ramnivas Laddad.

##### **Supported Pointcut Designators**

Spring AOP supports the following AspectJ pointcut designators (PCD) for use in pointcut expressions:

Other pointcut types

The full AspectJ pointcut language supports additional pointcut designators that are not supported in Spring. These are: call, get, set, preinitialization, staticinitialization, initialization, handler, adviceexecution, withincode, cflow, cflowbelow, if, @this, and @withincode. Use of these pointcut designators in pointcut expressions interpreted by Spring AOP will result in an IllegalArgumentException being thrown.

The set of pointcut designators supported by Spring AOP may be extended in future releases to support more of the AspectJ pointcut designators.

* execution - for matching method execution join points, this is the primary pointcut designator you will use when working with Spring AOP
* within - limits matching to join points within certain types (simply the execution of a method declared within a matching type when using Spring AOP)
* this - limits matching to join points (the execution of methods when using Spring AOP) where the bean reference (Spring AOP proxy) is an instance of the given type
* target - limits matching to join points (the execution of methods when using Spring AOP) where the target object (application object being proxied) is an instance of the given type
* args - limits matching to join points (the execution of methods when using Spring AOP) where the arguments are instances of the given types
* @target - limits matching to join points (the execution of methods when using Spring AOP) where the class of the executing object has an annotation of the given type
* @args - limits matching to join points (the execution of methods when using Spring AOP) where the runtime type of the actual arguments passed have annotations of the given type(s)
* @within - limits matching to join points within types that have the given annotation (the execution of methods declared in types with the given annotation when using Spring AOP)
* @annotation - limits matching to join points where the subject of the join point (method being executed in Spring AOP) has the given annotation

Because Spring AOP limits matching to only method execution join points, the discussion of the pointcut designators above gives a narrower definition than you will find in the AspectJ programming guide. In addition, AspectJ itself has type-based semantics and at an execution join point both this and target refer to the same object - the object executing the method. Spring AOP is a proxy-based system and differentiates between the proxy object itself (bound to this) and the target object behind the proxy (bound to target).

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|  | Due to the proxy-based nature of Spring’s AOP framework, calls within the target object are by definition not intercepted. For JDK proxies, only public interface method calls on the proxy can be intercepted. With CGLIB, public and protected method calls on the proxy will be intercepted, and even package-visible methods if necessary. However, common interactions through proxies should always be designed through public signatures.  Note that pointcut definitions are generally matched against any intercepted method. If a pointcut is strictly meant to be public-only, even in a CGLIB proxy scenario with potential non-public interactions through proxies, it needs to be defined accordingly.  If your interception needs include method calls or even constructors within the target class, consider the use of Spring-driven [native AspectJ weaving](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw) instead of Spring’s proxy-based AOP framework. This constitutes a different mode of AOP usage with different characteristics, so be sure to make yourself familiar with weaving first before making a decision. |

Spring AOP also supports an additional PCD named bean. This PCD allows you to limit the matching of join points to a particular named Spring bean, or to a set of named Spring beans (when using wildcards). The bean PCD has the following form:

bean(idOrNameOfBean)

The idOrNameOfBean token can be the name of any Spring bean: limited wildcard support using the \* character is provided, so if you establish some naming conventions for your Spring beans you can quite easily write a bean PCD expression to pick them out. As is the case with other pointcut designators, the bean PCD can be &&'ed, ||'ed, and ! (negated) too.

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|  | Please note that the bean PCD is only supported in Spring AOP - and not in native AspectJ weaving. It is a Spring-specific extension to the standard PCDs that AspectJ defines and therefore not available for aspects declared in the @Aspect model.  The bean PCD operates at the instance level (building on the Spring bean name concept) rather than at the type level only (which is what weaving-based AOP is limited to). Instance-based pointcut designators are a special capability of Spring’s proxy-based AOP framework and its close integration with the Spring bean factory, where it is natural and straightforward to identify specific beans by name. |

##### **Combining pointcut expressions**

Pointcut expressions can be combined using '&&', '||' and '!'. It is also possible to refer to pointcut expressions by name. The following example shows three pointcut expressions: anyPublicOperation (which matches if a method execution join point represents the execution of any public method); inTrading (which matches if a method execution is in the trading module), and tradingOperation (which matches if a method execution represents any public method in the trading module).

@Pointcut("execution(public \* \*(..))")

**private** **void** anyPublicOperation() {}

@Pointcut("within(com.xyz.someapp.trading..\*)")

**private** **void** inTrading() {}

@Pointcut("anyPublicOperation() && inTrading()")

**private** **void** tradingOperation() {}

It is a best practice to build more complex pointcut expressions out of smaller named components as shown above. When referring to pointcuts by name, normal Java visibility rules apply (you can see private pointcuts in the same type, protected pointcuts in the hierarchy, public pointcuts anywhere and so on). Visibility does not affect pointcut matching.

##### **Sharing common pointcut definitions**

When working with enterprise applications, you often want to refer to modules of the application and particular sets of operations from within several aspects. We recommend defining a "SystemArchitecture" aspect that captures common pointcut expressions for this purpose. A typical such aspect would look as follows:

**package** com.xyz.someapp;

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.Pointcut;

@Aspect

**public** **class** **SystemArchitecture** {

*/\*\**

*\* A join point is in the web layer if the method is defined*

*\* in a type in the com.xyz.someapp.web package or any sub-package*

*\* under that.*

*\*/*

@Pointcut("within(com.xyz.someapp.web..\*)")

**public** **void** inWebLayer() {}

*/\*\**

*\* A join point is in the service layer if the method is defined*

*\* in a type in the com.xyz.someapp.service package or any sub-package*

*\* under that.*

*\*/*

@Pointcut("within(com.xyz.someapp.service..\*)")

**public** **void** inServiceLayer() {}

*/\*\**

*\* A join point is in the data access layer if the method is defined*

*\* in a type in the com.xyz.someapp.dao package or any sub-package*

*\* under that.*

*\*/*

@Pointcut("within(com.xyz.someapp.dao..\*)")

**public** **void** inDataAccessLayer() {}

*/\*\**

*\* A business service is the execution of any method defined on a service*

*\* interface. This definition assumes that interfaces are placed in the*

*\* "service" package, and that implementation types are in sub-packages.*

*\**

*\* If you group service interfaces by functional area (for example,*

*\* in packages com.xyz.someapp.abc.service and com.xyz.someapp.def.service) then*

*\* the pointcut expression "execution(\* com.xyz.someapp..service.\*.\*(..))"*

*\* could be used instead.*

*\**

*\* Alternatively, you can write the expression using the 'bean'*

*\* PCD, like so "bean(\*Service)". (This assumes that you have*

*\* named your Spring service beans in a consistent fashion.)*

*\*/*

@Pointcut("execution(\* com.xyz.someapp..service.\*.\*(..))")

**public** **void** businessService() {}

*/\*\**

*\* A data access operation is the execution of any method defined on a*

*\* dao interface. This definition assumes that interfaces are placed in the*

*\* "dao" package, and that implementation types are in sub-packages.*

*\*/*

@Pointcut("execution(\* com.xyz.someapp.dao.\*.\*(..))")

**public** **void** dataAccessOperation() {}

}

The pointcuts defined in such an aspect can be referred to anywhere that you need a pointcut expression. For example, to make the service layer transactional, you could write:

<aop:config>

<aop:advisor

pointcut="com.xyz.someapp.SystemArchitecture.businessService()"

advice-ref="tx-advice"/>

</aop:config>

<tx:advice id="tx-advice">

<tx:attributes>

<tx:method name="\*" propagation="REQUIRED"/>

</tx:attributes>

</tx:advice>

The <aop:config> and <aop:advisor> elements are discussed in [Schema-based AOP support](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-schema). The transaction elements are discussed in [Transaction Management](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/data-access.html#transaction).

##### **Examples**

Spring AOP users are likely to use the execution pointcut designator the most often. The format of an execution expression is:

execution(modifiers-pattern? ret-type-pattern declaring-type-pattern?name-pattern(param-pattern)

**throws**-pattern?)

All parts except the returning type pattern (ret-type-pattern in the snippet above), name pattern, and parameters pattern are optional. The returning type pattern determines what the return type of the method must be in order for a join point to be matched. Most frequently you will use \* as the returning type pattern, which matches any return type. A fully-qualified type name will match only when the method returns the given type. The name pattern matches the method name. You can use the \* wildcard as all or part of a name pattern. If specifying a declaring type pattern then include a trailing . to join it to the name pattern component. The parameters pattern is slightly more complex: () matches a method that takes no parameters, whereas (..) matches any number of parameters (zero or more). The pattern (\*) matches a method taking one parameter of any type, (\*,String) matches a method taking two parameters, the first can be of any type, the second must be a String. Consult the [Language Semantics](https://www.eclipse.org/aspectj/doc/released/progguide/semantics-pointcuts.html) section of the AspectJ Programming Guide for more information.

Some examples of common pointcut expressions are given below.

* the execution of any public method:

execution(**public** \* \*(..))

* the execution of any method with a name beginning with "set":

execution(\* set\*(..))

* the execution of any method defined by the AccountService interface:

execution(\* com.xyz.service.AccountService.\*(..))

* the execution of any method defined in the service package:

execution(\* com.xyz.service.\*.\*(..))

* the execution of any method defined in the service package or a sub-package:

execution(\* com.xyz.service..\*.\*(..))

* any join point (method execution only in Spring AOP) within the service package:

within(com.xyz.service.\*)

* any join point (method execution only in Spring AOP) within the service package or a sub-package:

within(com.xyz.service..\*)

* any join point (method execution only in Spring AOP) where the proxy implements the AccountService interface:

this(com.xyz.service.AccountService)

|  |  |
| --- | --- |
|  | 'this' is more commonly used in a binding form :- see the following section on advice for how to make the proxy object available in the advice body. |

* any join point (method execution only in Spring AOP) where the target object implements the AccountService interface:

target(com.xyz.service.AccountService)

|  |  |
| --- | --- |
|  | 'target' is more commonly used in a binding form :- see the following section on advice for how to make the target object available in the advice body. |

* any join point (method execution only in Spring AOP) which takes a single parameter, and where the argument passed at runtime is Serializable:

args(java.io.Serializable)

|  |  |
| --- | --- |
|  | 'args' is more commonly used in a binding form :- see the following section on advice for how to make the method arguments available in the advice body. |

Note that the pointcut given in this example is different to execution(\* \*(java.io.Serializable)): the args version matches if the argument passed at runtime is Serializable, the execution version matches if the method signature declares a single parameter of type Serializable.

* any join point (method execution only in Spring AOP) where the target object has an @Transactional annotation:

@target(org.springframework.transaction.annotation.Transactional)

|  |  |
| --- | --- |
|  | '@target' can also be used in a binding form :- see the following section on advice for how to make the annotation object available in the advice body. |

* any join point (method execution only in Spring AOP) where the declared type of the target object has an @Transactional annotation:

@within(org.springframework.transaction.annotation.Transactional)

|  |  |
| --- | --- |
|  | '@within' can also be used in a binding form :- see the following section on advice for how to make the annotation object available in the advice body. |

* any join point (method execution only in Spring AOP) where the executing method has an @Transactional annotation:

@annotation(org.springframework.transaction.annotation.Transactional)

|  |  |
| --- | --- |
|  | '@annotation' can also be used in a binding form :- see the following section on advice for how to make the annotation object available in the advice body. |

* any join point (method execution only in Spring AOP) which takes a single parameter, and where the runtime type of the argument passed has the @Classified annotation:

@args(com.xyz.security.Classified)

|  |  |
| --- | --- |
|  | '@args' can also be used in a binding form :- see the following section on advice for how to make the annotation object(s) available in the advice body. |

* any join point (method execution only in Spring AOP) on a Spring bean named tradeService:

bean(tradeService)

* any join point (method execution only in Spring AOP) on Spring beans having names that match the wildcard expression \*Service:

bean(\*Service)

##### **Writing good pointcuts**

During compilation, AspectJ processes pointcuts in order to try and optimize matching performance. Examining code and determining if each join point matches (statically or dynamically) a given pointcut is a costly process. (A dynamic match means the match cannot be fully determined from static analysis and a test will be placed in the code to determine if there is an actual match when the code is running). On first encountering a pointcut declaration, AspectJ will rewrite it into an optimal form for the matching process. What does this mean? Basically pointcuts are rewritten in DNF (Disjunctive Normal Form) and the components of the pointcut are sorted such that those components that are cheaper to evaluate are checked first. This means you do not have to worry about understanding the performance of various pointcut designators and may supply them in any order in a pointcut declaration.

However, AspectJ can only work with what it is told, and for optimal performance of matching you should think about what they are trying to achieve and narrow the search space for matches as much as possible in the definition. The existing designators naturally fall into one of three groups: kinded, scoping and context:

* Kinded designators are those which select a particular kind of join point. For example: execution, get, set, call, handler
* Scoping designators are those which select a group of join points of interest (of probably many kinds). For example: within, withincode
* Contextual designators are those that match (and optionally bind) based on context. For example: this, target, @annotation

A well written pointcut should try and include at least the first two types (kinded and scoping), whilst the contextual designators may be included if wishing to match based on join point context, or bind that context for use in the advice. Supplying either just a kinded designator or just a contextual designator will work but could affect weaving performance (time and memory used) due to all the extra processing and analysis. Scoping designators are very fast to match and their usage means AspectJ can very quickly dismiss groups of join points that should not be further processed - that is why a good pointcut should always include one if possible.

#### **5.2.4. Declaring advice**

Advice is associated with a pointcut expression, and runs before, after, or around method executions matched by the pointcut. The pointcut expression may be either a simple reference to a named pointcut, or a pointcut expression declared in place.

##### **Before advice**

Before advice is declared in an aspect using the @Before annotation:

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.Before;

@Aspect

**public** **class** **BeforeExample** {

@Before("com.xyz.myapp.SystemArchitecture.dataAccessOperation()")

**public** **void** doAccessCheck() {

*// ...*

}

}

If using an in-place pointcut expression we could rewrite the above example as:

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.Before;

@Aspect

**public** **class** **BeforeExample** {

@Before("execution(\* com.xyz.myapp.dao.\*.\*(..))")

**public** **void** doAccessCheck() {

*// ...*

}

}

##### **After returning advice**

After returning advice runs when a matched method execution returns normally. It is declared using the @AfterReturning annotation:

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.AfterReturning;

@Aspect

**public** **class** **AfterReturningExample** {

@AfterReturning("com.xyz.myapp.SystemArchitecture.dataAccessOperation()")

**public** **void** doAccessCheck() {

*// ...*

}

}

|  |  |
| --- | --- |
|  | Note: it is of course possible to have multiple advice declarations, and other members as well, all inside the same aspect. We’re just showing a single advice declaration in these examples to focus on the issue under discussion at the time. |

Sometimes you need access in the advice body to the actual value that was returned. You can use the form of @AfterReturning that binds the return value for this:

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.AfterReturning;

@Aspect

**public** **class** **AfterReturningExample** {

@AfterReturning(

pointcut="com.xyz.myapp.SystemArchitecture.dataAccessOperation()",

returning="retVal")

**public** **void** doAccessCheck(Object retVal) {

*// ...*

}

}

The name used in the returning attribute must correspond to the name of a parameter in the advice method. When a method execution returns, the return value will be passed to the advice method as the corresponding argument value. A returning clause also restricts matching to only those method executions that return a value of the specified type ( Object in this case, which will match any return value).

Please note that it is not possible to return a totally different reference when using after-returning advice.

##### **After throwing advice**

After throwing advice runs when a matched method execution exits by throwing an exception. It is declared using the @AfterThrowing annotation:

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.AfterThrowing;

@Aspect

**public** **class** **AfterThrowingExample** {

@AfterThrowing("com.xyz.myapp.SystemArchitecture.dataAccessOperation()")

**public** **void** doRecoveryActions() {

*// ...*

}

}

Often you want the advice to run only when exceptions of a given type are thrown, and you also often need access to the thrown exception in the advice body. Use the throwing attribute to both restrict matching (if desired, use Throwable as the exception type otherwise) and bind the thrown exception to an advice parameter.

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.AfterThrowing;

@Aspect

**public** **class** **AfterThrowingExample** {

@AfterThrowing(

pointcut="com.xyz.myapp.SystemArchitecture.dataAccessOperation()",

throwing="ex")

**public** **void** doRecoveryActions(DataAccessException ex) {

*// ...*

}

}

The name used in the throwing attribute must correspond to the name of a parameter in the advice method. When a method execution exits by throwing an exception, the exception will be passed to the advice method as the corresponding argument value. A throwing clause also restricts matching to only those method executions that throw an exception of the specified type ( DataAccessException in this case).

##### **After (finally) advice**

After (finally) advice runs however a matched method execution exits. It is declared using the @After annotation. After advice must be prepared to handle both normal and exception return conditions. It is typically used for releasing resources, etc.

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.After;

@Aspect

**public** **class** **AfterFinallyExample** {

@After("com.xyz.myapp.SystemArchitecture.dataAccessOperation()")

**public** **void** doReleaseLock() {

*// ...*

}

}

##### **Around advice**

The final kind of advice is around advice. Around advice runs "around" a matched method execution. It has the opportunity to do work both before and after the method executes, and to determine when, how, and even if, the method actually gets to execute at all. Around advice is often used if you need to share state before and after a method execution in a thread-safe manner (starting and stopping a timer for example). Always use the least powerful form of advice that meets your requirements (i.e. don’t use around advice if simple before advice would do).

Around advice is declared using the @Around annotation. The first parameter of the advice method must be of type ProceedingJoinPoint. Within the body of the advice, calling proceed() on the ProceedingJoinPoint causes the underlying method to execute. The proceed method may also be called passing in an Object[] - the values in the array will be used as the arguments to the method execution when it proceeds.

|  |  |
| --- | --- |
|  | The behavior of proceed when called with an Object[] is a little different than the behavior of proceed for around advice compiled by the AspectJ compiler. For around advice written using the traditional AspectJ language, the number of arguments passed to proceed must match the number of arguments passed to the around advice (not the number of arguments taken by the underlying join point), and the value passed to proceed in a given argument position supplants the original value at the join point for the entity the value was bound to (Don’t worry if this doesn’t make sense right now!). The approach taken by Spring is simpler and a better match to its proxy-based, execution only semantics. You only need to be aware of this difference if you are compiling @AspectJ aspects written for Spring and using proceed with arguments with the AspectJ compiler and weaver. There is a way to write such aspects that is 100% compatible across both Spring AOP and AspectJ, and this is discussed in the following section on advice parameters. |

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.Around;

**import** org.aspectj.lang.ProceedingJoinPoint;

@Aspect

**public** **class** **AroundExample** {

@Around("com.xyz.myapp.SystemArchitecture.businessService()")

**public** Object doBasicProfiling(ProceedingJoinPoint pjp) **throws** Throwable {

*// start stopwatch*

Object retVal = pjp.proceed();

*// stop stopwatch*

**return** retVal;

}

}

The value returned by the around advice will be the return value seen by the caller of the method. A simple caching aspect for example could return a value from a cache if it has one, and invoke proceed() if it does not. Note that proceed may be invoked once, many times, or not at all within the body of the around advice, all of these are quite legal.

##### **Advice parameters**

Spring offers fully typed advice - meaning that you declare the parameters you need in the advice signature (as we saw for the returning and throwing examples above) rather than work with Object[] arrays all the time. We’ll see how to make argument and other contextual values available to the advice body in a moment. First let’s take a look at how to write generic advice that can find out about the method the advice is currently advising.

###### **Access to the current JoinPoint**

Any advice method may declare as its first parameter, a parameter of type org.aspectj.lang.JoinPoint (please note that around advice is required to declare a first parameter of type ProceedingJoinPoint, which is a subclass of JoinPoint. The JoinPoint interface provides a number of useful methods such as getArgs() (returns the method arguments), getThis() (returns the proxy object), getTarget() (returns the target object), getSignature() (returns a description of the method that is being advised) and toString() (prints a useful description of the method being advised). Please do consult the javadocs for full details.

###### **Passing parameters to advice**

We’ve already seen how to bind the returned value or exception value (using after returning and after throwing advice). To make argument values available to the advice body, you can use the binding form of args. If a parameter name is used in place of a type name in an args expression, then the value of the corresponding argument will be passed as the parameter value when the advice is invoked. An example should make this clearer. Suppose you want to advise the execution of dao operations that take an Account object as the first parameter, and you need access to the account in the advice body. You could write the following:

@Before("com.xyz.myapp.SystemArchitecture.dataAccessOperation() && args(account,..)")

**public** **void** validateAccount(Account account) {

*// ...*

}

The args(account,..) part of the pointcut expression serves two purposes: firstly, it restricts matching to only those method executions where the method takes at least one parameter, and the argument passed to that parameter is an instance of Account; secondly, it makes the actual Account object available to the advice via the account parameter.

Another way of writing this is to declare a pointcut that "provides" the Account object value when it matches a join point, and then just refer to the named pointcut from the advice. This would look as follows:

@Pointcut("com.xyz.myapp.SystemArchitecture.dataAccessOperation() && args(account,..)")

**private** **void** accountDataAccessOperation(Account account) {}

@Before("accountDataAccessOperation(account)")

**public** **void** validateAccount(Account account) {

*// ...*

}

The interested reader is once more referred to the AspectJ programming guide for more details.

The proxy object ( this), target object ( target), and annotations ( @within, @target, @annotation, @args) can all be bound in a similar fashion. The following example shows how you could match the execution of methods annotated with an @Auditable annotation, and extract the audit code.

First the definition of the @Auditable annotation:

@Retention(RetentionPolicy.RUNTIME)

@Target(ElementType.METHOD)

**public** @interface Auditable {

AuditCode value();

}

And then the advice that matches the execution of @Auditable methods:

@Before("com.xyz.lib.Pointcuts.anyPublicMethod() && @annotation(auditable)")

**public** **void** audit(Auditable auditable) {

AuditCode code = auditable.value();

*// ...*

}

###### **Advice parameters and generics**

Spring AOP can handle generics used in class declarations and method parameters. Suppose you have a generic type like this:

**public** **interface** **Sample**<T> {

**void** sampleGenericMethod(T param);

**void** sampleGenericCollectionMethod(Collection<T> param);

}

You can restrict interception of method types to certain parameter types by simply typing the advice parameter to the parameter type you want to intercept the method for:

@Before("execution(\* ..Sample+.sampleGenericMethod(\*)) && args(param)")

**public** **void** beforeSampleMethod(MyType param) {

*// Advice implementation*

}

That this works is pretty obvious as we already discussed above. However, it’s worth pointing out that this won’t work for generic collections. So you cannot define a pointcut like this:

@Before("execution(\* ..Sample+.sampleGenericCollectionMethod(\*)) && args(param)")

**public** **void** beforeSampleMethod(Collection<MyType> param) {

*// Advice implementation*

}

To make this work we would have to inspect every element of the collection, which is not reasonable as we also cannot decide how to treat null values in general. To achieve something similar to this you have to type the parameter to Collection<?> and manually check the type of the elements.

###### **Determining argument names**

The parameter binding in advice invocations relies on matching names used in pointcut expressions to declared parameter names in (advice and pointcut) method signatures. Parameter names are not available through Java reflection, so Spring AOP uses the following strategies to determine parameter names:

* If the parameter names have been specified by the user explicitly, then the specified parameter names are used: both the advice and the pointcut annotations have an optional "argNames" attribute which can be used to specify the argument names of the annotated method - these argument names are available at runtime. For example:

@Before(value="com.xyz.lib.Pointcuts.anyPublicMethod() && target(bean) && @annotation(auditable)",

argNames="bean,auditable")

**public** **void** audit(Object bean, Auditable auditable) {

AuditCode code = auditable.value();

*// ... use code and bean*

}

If the first parameter is of the JoinPoint, ProceedingJoinPoint, or JoinPoint.StaticPart type, you may leave out the name of the parameter from the value of the "argNames" attribute. For example, if you modify the preceding advice to receive the join point object, the "argNames" attribute need not include it:

@Before(value="com.xyz.lib.Pointcuts.anyPublicMethod() && target(bean) && @annotation(auditable)",

argNames="bean,auditable")

**public** **void** audit(JoinPoint jp, Object bean, Auditable auditable) {

AuditCode code = auditable.value();

*// ... use code, bean, and jp*

}

The special treatment given to the first parameter of the JoinPoint, ProceedingJoinPoint, and JoinPoint.StaticPart types is particularly convenient for advice that do not collect any other join point context. In such situations, you may simply omit the "argNames" attribute. For example, the following advice need not declare the "argNames" attribute:

@Before("com.xyz.lib.Pointcuts.anyPublicMethod()")

**public** **void** audit(JoinPoint jp) {

*// ... use jp*

}

* Using the 'argNames' attribute is a little clumsy, so if the 'argNames' attribute has not been specified, then Spring AOP will look at the debug information for the class and try to determine the parameter names from the local variable table. This information will be present as long as the classes have been compiled with debug information ( '-g:vars' at a minimum). The consequences of compiling with this flag on are: (1) your code will be slightly easier to understand (reverse engineer), (2) the class file sizes will be very slightly bigger (typically inconsequential), (3) the optimization to remove unused local variables will not be applied by your compiler. In other words, you should encounter no difficulties building with this flag on.

|  |  |
| --- | --- |
|  | If an @AspectJ aspect has been compiled by the AspectJ compiler (ajc) even without the debug information then there is no need to add the argNames attribute as the compiler will retain the needed information. |

* If the code has been compiled without the necessary debug information, then Spring AOP will attempt to deduce the pairing of binding variables to parameters (for example, if only one variable is bound in the pointcut expression, and the advice method only takes one parameter, the pairing is obvious!). If the binding of variables is ambiguous given the available information, then an AmbiguousBindingException will be thrown.
* If all of the above strategies fail then an IllegalArgumentException will be thrown.

###### **Proceeding with arguments**

We remarked earlier that we would describe how to write a proceed call with arguments that works consistently across Spring AOP and AspectJ. The solution is simply to ensure that the advice signature binds each of the method parameters in order. For example:

@Around("execution(List<Account> find\*(..)) && " +

"com.xyz.myapp.SystemArchitecture.inDataAccessLayer() && " +

"args(accountHolderNamePattern)")

**public** Object preProcessQueryPattern(ProceedingJoinPoint pjp,

String accountHolderNamePattern) **throws** Throwable {

String newPattern = preProcess(accountHolderNamePattern);

**return** pjp.proceed(**new** Object**[]** {newPattern});

}

In many cases you will be doing this binding anyway (as in the example above).

##### **Advice ordering**

What happens when multiple pieces of advice all want to run at the same join point? Spring AOP follows the same precedence rules as AspectJ to determine the order of advice execution. The highest precedence advice runs first "on the way in" (so given two pieces of before advice, the one with highest precedence runs first). "On the way out" from a join point, the highest precedence advice runs last (so given two pieces of after advice, the one with the highest precedence will run second).

When two pieces of advice defined in different aspects both need to run at the same join point, unless you specify otherwise the order of execution is undefined. You can control the order of execution by specifying precedence. This is done in the normal Spring way by either implementing the org.springframework.core.Ordered interface in the aspect class or annotating it with the Order annotation. Given two aspects, the aspect returning the lower value from Ordered.getOrder() (or the annotation value) has the higher precedence.

When two pieces of advice defined in the same aspect both need to run at the same join point, the ordering is undefined (since there is no way to retrieve the declaration order via reflection for javac-compiled classes). Consider collapsing such advice methods into one advice method per join point in each aspect class, or refactor the pieces of advice into separate aspect classes - which can be ordered at the aspect level.

#### **5.2.5. Introductions**

Introductions (known as inter-type declarations in AspectJ) enable an aspect to declare that advised objects implement a given interface, and to provide an implementation of that interface on behalf of those objects.

An introduction is made using the @DeclareParents annotation. This annotation is used to declare that matching types have a new parent (hence the name). For example, given an interface UsageTracked, and an implementation of that interface DefaultUsageTracked, the following aspect declares that all implementors of service interfaces also implement the UsageTracked interface. (In order to expose statistics via JMX for example.)

@Aspect

**public** **class** **UsageTracking** {

@DeclareParents(value="com.xzy.myapp.service.\*+", defaultImpl=DefaultUsageTracked.class)

**public** **static** UsageTracked mixin;

@Before("com.xyz.myapp.SystemArchitecture.businessService() && this(usageTracked)")

**public** **void** recordUsage(UsageTracked usageTracked) {

usageTracked.incrementUseCount();

}

}

The interface to be implemented is determined by the type of the annotated field. The value attribute of the @DeclareParents annotation is an AspectJ type pattern :- any bean of a matching type will implement the UsageTracked interface. Note that in the before advice of the above example, service beans can be directly used as implementations of the UsageTracked interface. If accessing a bean programmatically you would write the following:

UsageTracked usageTracked = (UsageTracked) context.getBean("myService");

#### **5.2.6. Aspect instantiation models**

|  |  |
| --- | --- |
|  | (This is an advanced topic, so if you are just starting out with AOP you can safely skip it until later.) |

By default there will be a single instance of each aspect within the application context. AspectJ calls this the singleton instantiation model. It is possible to define aspects with alternate lifecycles :- Spring supports AspectJ’s perthis and pertarget instantiation models ( percflow, percflowbelow, and pertypewithin are not currently supported).

A "perthis" aspect is declared by specifying a perthis clause in the @Aspect annotation. Let’s look at an example, and then we’ll explain how it works.

@Aspect("perthis(com.xyz.myapp.SystemArchitecture.businessService())")

**public** **class** **MyAspect** {

**private** **int** someState;

@Before(com.xyz.myapp.SystemArchitecture.businessService())

**public** **void** recordServiceUsage() {

*// ...*

}

}

The effect of the 'perthis' clause is that one aspect instance will be created for each unique service object executing a business service (each unique object bound to 'this' at join points matched by the pointcut expression). The aspect instance is created the first time that a method is invoked on the service object. The aspect goes out of scope when the service object goes out of scope. Before the aspect instance is created, none of the advice within it executes. As soon as the aspect instance has been created, the advice declared within it will execute at matched join points, but only when the service object is the one this aspect is associated with. See the AspectJ programming guide for more information on per-clauses.

The 'pertarget' instantiation model works in exactly the same way as perthis, but creates one aspect instance for each unique target object at matched join points.

#### **5.2.7. Example**

Now that you have seen how all the constituent parts work, let’s put them together to do something useful!

The execution of business services can sometimes fail due to concurrency issues (for example, deadlock loser). If the operation is retried, it is quite likely to succeed next time round. For business services where it is appropriate to retry in such conditions (idempotent operations that don’t need to go back to the user for conflict resolution), we’d like to transparently retry the operation to avoid the client seeing a PessimisticLockingFailureException. This is a requirement that clearly cuts across multiple services in the service layer, and hence is ideal for implementing via an aspect.

Because we want to retry the operation, we will need to use around advice so that we can call proceed multiple times. Here’s how the basic aspect implementation looks:

@Aspect

**public** **class** **ConcurrentOperationExecutor** **implements** Ordered {

**private** **static** **final** **int** DEFAULT\_MAX\_RETRIES = 2;

**private** **int** maxRetries = DEFAULT\_MAX\_RETRIES;

**private** **int** order = 1;

**public** **void** setMaxRetries(**int** maxRetries) {

this.maxRetries = maxRetries;

}

**public** **int** getOrder() {

**return** this.order;

}

**public** **void** setOrder(**int** order) {

this.order = order;

}

@Around("com.xyz.myapp.SystemArchitecture.businessService()")

**public** Object doConcurrentOperation(ProceedingJoinPoint pjp) **throws** Throwable {

**int** numAttempts = 0;

PessimisticLockingFailureException lockFailureException;

**do** {

numAttempts++;

**try** {

**return** pjp.proceed();

}

**catch**(PessimisticLockingFailureException ex) {

lockFailureException = ex;

}

} **while**(numAttempts <= this.maxRetries);

**throw** lockFailureException;

}

}

Note that the aspect implements the Ordered interface so we can set the precedence of the aspect higher than the transaction advice (we want a fresh transaction each time we retry). The maxRetries and order properties will both be configured by Spring. The main action happens in the doConcurrentOperation around advice. Notice that for the moment we’re applying the retry logic to all businessService()s. We try to proceed, and if we fail with an PessimisticLockingFailureException we simply try again unless we have exhausted all of our retry attempts.

The corresponding Spring configuration is:

<aop:aspectj-autoproxy/>

<bean id="concurrentOperationExecutor" class="com.xyz.myapp.service.impl.ConcurrentOperationExecutor">

<property name="maxRetries" value="3"/>

<property name="order" value="100"/>

</bean>

To refine the aspect so that it only retries idempotent operations, we might define an Idempotent annotation:

@Retention(RetentionPolicy.RUNTIME)

**public** @interface Idempotent {

*// marker annotation*

}

and use the annotation to annotate the implementation of service operations. The change to the aspect to only retry idempotent operations simply involves refining the pointcut expression so that only @Idempotent operations match:

@Around("com.xyz.myapp.SystemArchitecture.businessService() && " +

"@annotation(com.xyz.myapp.service.Idempotent)")

**public** Object doConcurrentOperation(ProceedingJoinPoint pjp) **throws** Throwable {

...

}

### **5.3. Schema-based AOP support**

If you prefer an XML-based format, then Spring also offers support for defining aspects using the new "aop" namespace tags. The exact same pointcut expressions and advice kinds are supported as when using the @AspectJ style, hence in this section we will focus on the new syntax and refer the reader to the discussion in the previous section ([@AspectJ support](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj)) for an understanding of writing pointcut expressions and the binding of advice parameters.

To use the aop namespace tags described in this section, you need to import the spring-aop schema as described in [XML Schema-based configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-schemas). See [the AOP schema](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-schemas-aop) for how to import the tags in the aop namespace.

Within your Spring configurations, all aspect and advisor elements must be placed within an <aop:config> element (you can have more than one <aop:config> element in an application context configuration). An <aop:config> element can contain pointcut, advisor, and aspect elements (note these must be declared in that order).

|  |  |
| --- | --- |
|  | The <aop:config> style of configuration makes heavy use of Spring’s [auto-proxying](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-autoproxy) mechanism. This can cause issues (such as advice not being woven) if you are already using explicit auto-proxying via the use of BeanNameAutoProxyCreator or suchlike. The recommended usage pattern is to use either just the <aop:config> style, or just the AutoProxyCreator style. |

#### **5.3.1. Declaring an aspect**

Using the schema support, an aspect is simply a regular Java object defined as a bean in your Spring application context. The state and behavior is captured in the fields and methods of the object, and the pointcut and advice information is captured in the XML.

An aspect is declared using the <aop:aspect> element, and the backing bean is referenced using the ref attribute:

<aop:config>

<aop:aspect id="myAspect" ref="aBean">

...

</aop:aspect>

</aop:config>

<bean id="aBean" class="...">

...

</bean>

The bean backing the aspect ("aBean" in this case) can of course be configured and dependency injected just like any other Spring bean.

#### **5.3.2. Declaring a pointcut**

A named pointcut can be declared inside an <aop:config> element, enabling the pointcut definition to be shared across several aspects and advisors.

A pointcut representing the execution of any business service in the service layer could be defined as follows:

<aop:config>

<aop:pointcut id="businessService"

expression="execution(\* com.xyz.myapp.service.\*.\*(..))"/>

</aop:config>

Note that the pointcut expression itself is using the same AspectJ pointcut expression language as described in [@AspectJ support](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj). If you are using the schema based declaration style, you can refer to named pointcuts defined in types (@Aspects) within the pointcut expression. Another way of defining the above pointcut would be:

<aop:config>

<aop:pointcut id="businessService"

expression="com.xyz.myapp.SystemArchitecture.businessService()"/>

</aop:config>

Assuming you have a SystemArchitecture aspect as described in [Sharing common pointcut definitions](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-common-pointcuts).

Declaring a pointcut inside an aspect is very similar to declaring a top-level pointcut:

<aop:config>

<aop:aspect id="myAspect" ref="aBean">

<aop:pointcut id="businessService"

expression="execution(\* com.xyz.myapp.service.\*.\*(..))"/>

...

</aop:aspect>

</aop:config>

Much the same way in an @AspectJ aspect, pointcuts declared using the schema based definition style may collect join point context. For example, the following pointcut collects the 'this' object as the join point context and passes it to advice:

<aop:config>

<aop:aspect id="myAspect" ref="aBean">

<aop:pointcut id="businessService"

expression="execution(\* com.xyz.myapp.service.\*.\*(..)) &amp;&amp; this(service)"/>

<aop:before pointcut-ref="businessService" method="monitor"/>

...

</aop:aspect>

</aop:config>

The advice must be declared to receive the collected join point context by including parameters of the matching names:

**public** **void** monitor(Object service) {

...

}

When combining pointcut sub-expressions, && is awkward within an XML document, and so the keywords and, or, and not can be used in place of &&, ||, and ! respectively. For example, the previous pointcut may be better written as:

<aop:config>

<aop:aspect id="myAspect" ref="aBean">

<aop:pointcut id="businessService"

expression="execution(\* com.xyz.myapp.service.**.**(..)) **and** this(service)"/>

<aop:before pointcut-ref="businessService" method="monitor"/>

...

</aop:aspect>

</aop:config>

Note that pointcuts defined in this way are referred to by their XML id and cannot be used as named pointcuts to form composite pointcuts. The named pointcut support in the schema based definition style is thus more limited than that offered by the @AspectJ style.

#### **5.3.3. Declaring advice**

The same five advice kinds are supported as for the @AspectJ style, and they have exactly the same semantics.

##### **Before advice**

Before advice runs before a matched method execution. It is declared inside an <aop:aspect> using the <aop:before> element.

<aop:aspect id="beforeExample" ref="aBean">

<aop:before

pointcut-ref="dataAccessOperation"

method="doAccessCheck"/>

...

</aop:aspect>

Here dataAccessOperation is the id of a pointcut defined at the top ( <aop:config>) level. To define the pointcut inline instead, replace the pointcut-ref attribute with a pointcut attribute:

<aop:aspect id="beforeExample" ref="aBean">

<aop:before

pointcut="execution(\* com.xyz.myapp.dao.\*.\*(..))"

method="doAccessCheck"/>

...

</aop:aspect>

As we noted in the discussion of the @AspectJ style, using named pointcuts can significantly improve the readability of your code.

The method attribute identifies a method ( doAccessCheck) that provides the body of the advice. This method must be defined for the bean referenced by the aspect element containing the advice. Before a data access operation is executed (a method execution join point matched by the pointcut expression), the "doAccessCheck" method on the aspect bean will be invoked.

##### **After returning advice**

After returning advice runs when a matched method execution completes normally. It is declared inside an <aop:aspect> in the same way as before advice. For example:

<aop:aspect id="afterReturningExample" ref="aBean">

<aop:after-returning

pointcut-ref="dataAccessOperation"

method="doAccessCheck"/>

...

</aop:aspect>

Just as in the @AspectJ style, it is possible to get hold of the return value within the advice body. Use the returning attribute to specify the name of the parameter to which the return value should be passed:

<aop:aspect id="afterReturningExample" ref="aBean">

<aop:after-returning

pointcut-ref="dataAccessOperation"

returning="retVal"

method="doAccessCheck"/>

...

</aop:aspect>

The doAccessCheck method must declare a parameter named retVal. The type of this parameter constrains matching in the same way as described for @AfterReturning. For example, the method signature may be declared as:

**public** **void** doAccessCheck(Object retVal) {...

##### **After throwing advice**

After throwing advice executes when a matched method execution exits by throwing an exception. It is declared inside an <aop:aspect> using the after-throwing element:

<aop:aspect id="afterThrowingExample" ref="aBean">

<aop:after-throwing

pointcut-ref="dataAccessOperation"

method="doRecoveryActions"/>

...

</aop:aspect>

Just as in the @AspectJ style, it is possible to get hold of the thrown exception within the advice body. Use the throwing attribute to specify the name of the parameter to which the exception should be passed:

<aop:aspect id="afterThrowingExample" ref="aBean">

<aop:after-throwing

pointcut-ref="dataAccessOperation"

throwing="dataAccessEx"

method="doRecoveryActions"/>

...

</aop:aspect>

The doRecoveryActions method must declare a parameter named dataAccessEx. The type of this parameter constrains matching in the same way as described for @AfterThrowing. For example, the method signature may be declared as:

**public** **void** doRecoveryActions(DataAccessException dataAccessEx) {...

##### **After (finally) advice**

After (finally) advice runs however a matched method execution exits. It is declared using the after element:

<aop:aspect id="afterFinallyExample" ref="aBean">

<aop:after

pointcut-ref="dataAccessOperation"

method="doReleaseLock"/>

...

</aop:aspect>

##### **Around advice**

The final kind of advice is around advice. Around advice runs "around" a matched method execution. It has the opportunity to do work both before and after the method executes, and to determine when, how, and even if, the method actually gets to execute at all. Around advice is often used if you need to share state before and after a method execution in a thread-safe manner (starting and stopping a timer for example). Always use the least powerful form of advice that meets your requirements; don’t use around advice if simple before advice would do.

Around advice is declared using the aop:around element. The first parameter of the advice method must be of type ProceedingJoinPoint. Within the body of the advice, calling proceed() on the ProceedingJoinPoint causes the underlying method to execute. The proceed method may also be calling passing in an Object[] - the values in the array will be used as the arguments to the method execution when it proceeds. See [Around advice](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj-around-advice) for notes on calling proceed with an Object[].

<aop:aspect id="aroundExample" ref="aBean">

<aop:around

pointcut-ref="businessService"

method="doBasicProfiling"/>

...

</aop:aspect>

The implementation of the doBasicProfiling advice would be exactly the same as in the @AspectJ example (minus the annotation of course):

**public** Object doBasicProfiling(ProceedingJoinPoint pjp) **throws** Throwable {

*// start stopwatch*

Object retVal = pjp.proceed();

*// stop stopwatch*

**return** retVal;

}

##### **Advice parameters**

The schema based declaration style supports fully typed advice in the same way as described for the @AspectJ support - by matching pointcut parameters by name against advice method parameters. See [Advice parameters](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj-advice-params) for details. If you wish to explicitly specify argument names for the advice methods (not relying on the detection strategies previously described) then this is done using the arg-names attribute of the advice element, which is treated in the same manner to the "argNames" attribute in an advice annotation as described in [Determining argument names](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj-advice-params-names). For example:

<aop:before

pointcut="com.xyz.lib.Pointcuts.anyPublicMethod() and @annotation(auditable)"

method="audit"

arg-names="auditable"/>

The arg-names attribute accepts a comma-delimited list of parameter names.

Find below a slightly more involved example of the XSD-based approach that illustrates some around advice used in conjunction with a number of strongly typed parameters.

**package** x.y.service;

**public** **interface** **FooService** {

Foo getFoo(String fooName, **int** age);

}

**public** **class** **DefaultFooService** **implements** FooService {

**public** Foo getFoo(String name, **int** age) {

**return** **new** Foo(name, age);

}

}

Next up is the aspect. Notice the fact that the profile(..) method accepts a number of strongly-typed parameters, the first of which happens to be the join point used to proceed with the method call: the presence of this parameter is an indication that the profile(..) is to be used as around advice:

**package** x.y;

**import** org.aspectj.lang.ProceedingJoinPoint;

**import** org.springframework.util.StopWatch;

**public** **class** **SimpleProfiler** {

**public** Object profile(ProceedingJoinPoint call, String name, **int** age) **throws** Throwable {

StopWatch clock = **new** StopWatch("Profiling for '" + name + "' and '" + age + "'");

**try** {

clock.start(call.toShortString());

**return** call.proceed();

} **finally** {

clock.stop();

System.out.println(clock.prettyPrint());

}

}

}

Finally, here is the XML configuration that is required to effect the execution of the above advice for a particular join point:

<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 https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/aop https://www.springframework.org/schema/aop/spring-aop.xsd">

*<!-- this is the object that will be proxied by Spring's AOP infrastructure -->*

<bean id="fooService" class="x.y.service.DefaultFooService"/>

*<!-- this is the actual advice itself -->*

<bean id="profiler" class="x.y.SimpleProfiler"/>

<aop:config>

<aop:aspect ref="profiler">

<aop:pointcut id="theExecutionOfSomeFooServiceMethod"

expression="execution(\* x.y.service.FooService.getFoo(String,int))

and args(name, age)"/>

<aop:around pointcut-ref="theExecutionOfSomeFooServiceMethod"

method="profile"/>

</aop:aspect>

</aop:config>

</beans>

If we had the following driver script, we would get output something like this on standard output:

**import** org.springframework.beans.factory.BeanFactory;

**import** org.springframework.context.support.ClassPathXmlApplicationContext;

**import** x.y.service.FooService;

**public** **final** **class** **Boot** {

**public** **static** **void** main(**final** String**[]** args) **throws** Exception {

BeanFactory ctx = **new** ClassPathXmlApplicationContext("x/y/plain.xml");

FooService foo = (FooService) ctx.getBean("fooService");

foo.getFoo("Pengo", 12);

}

}

StopWatch 'Profiling for 'Pengo' and '12'': running time (millis) = 0

-----------------------------------------

ms % Task name

-----------------------------------------

00000 ? execution(getFoo)

##### **Advice ordering**

When multiple advice needs to execute at the same join point (executing method) the ordering rules are as described in [Advice ordering](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj-advice-ordering). The precedence between aspects is determined by either adding the Order annotation to the bean backing the aspect or by having the bean implement the Ordered interface.

#### **5.3.4. Introductions**

Introductions (known as inter-type declarations in AspectJ) enable an aspect to declare that advised objects implement a given interface, and to provide an implementation of that interface on behalf of those objects.

An introduction is made using the aop:declare-parents element inside an aop:aspect This element is used to declare that matching types have a new parent (hence the name). For example, given an interface UsageTracked, and an implementation of that interface DefaultUsageTracked, the following aspect declares that all implementors of service interfaces also implement the UsageTracked interface. (In order to expose statistics via JMX for example.)

<aop:aspect id="usageTrackerAspect" ref="usageTracking">

<aop:declare-parents

types-matching="com.xzy.myapp.service.\*+"

implement-interface="com.xyz.myapp.service.tracking.UsageTracked"

default-impl="com.xyz.myapp.service.tracking.DefaultUsageTracked"/>

<aop:before

pointcut="com.xyz.myapp.SystemArchitecture.businessService()

and this(usageTracked)"

method="recordUsage"/>

</aop:aspect>

The class backing the usageTracking bean would contain the method:

**public** **void** recordUsage(UsageTracked usageTracked) {

usageTracked.incrementUseCount();

}

The interface to be implemented is determined by implement-interface attribute. The value of the types-matching attribute is an AspectJ type pattern :- any bean of a matching type will implement the UsageTracked interface. Note that in the before advice of the above example, service beans can be directly used as implementations of the UsageTracked interface. If accessing a bean programmatically you would write the following:

UsageTracked usageTracked = (UsageTracked) context.getBean("myService");

#### **5.3.5. Aspect instantiation models**

The only supported instantiation model for schema-defined aspects is the singleton model. Other instantiation models may be supported in future releases.

#### **5.3.6. Advisors**

The concept of "advisors" is brought forward from the AOP support defined in Spring and does not have a direct equivalent in AspectJ. An advisor is like a small self-contained aspect that has a single piece of advice. The advice itself is represented by a bean, and must implement one of the advice interfaces described in [Advice types in Spring](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-api-advice-types). Advisors can take advantage of AspectJ pointcut expressions though.

Spring supports the advisor concept with the <aop:advisor> element. You will most commonly see it used in conjunction with transactional advice, which also has its own namespace support in Spring. Here’s how it looks:

<aop:config>

<aop:pointcut id="businessService"

expression="execution(\* com.xyz.myapp.service.\*.\*(..))"/>

<aop:advisor

pointcut-ref="businessService"

advice-ref="tx-advice"/>

</aop:config>

<tx:advice id="tx-advice">

<tx:attributes>

<tx:method name="\*" propagation="REQUIRED"/>

</tx:attributes>

</tx:advice>

As well as the pointcut-ref attribute used in the above example, you can also use the pointcut attribute to define a pointcut expression inline.

To define the precedence of an advisor so that the advice can participate in ordering, use the order attribute to define the Ordered value of the advisor.

#### **5.3.7. Example**

Let’s see how the concurrent locking failure retry example from [Example](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ataspectj-example) looks when rewritten using the schema support.

The execution of business services can sometimes fail due to concurrency issues (for example, deadlock loser). If the operation is retried, it is quite likely it will succeed next time round. For business services where it is appropriate to retry in such conditions (idempotent operations that don’t need to go back to the user for conflict resolution), we’d like to transparently retry the operation to avoid the client seeing a PessimisticLockingFailureException. This is a requirement that clearly cuts across multiple services in the service layer, and hence is ideal for implementing via an aspect.

Because we want to retry the operation, we’ll need to use around advice so that we can call proceed multiple times. Here’s how the basic aspect implementation looks (it’s just a regular Java class using the schema support):

**public** **class** **ConcurrentOperationExecutor** **implements** Ordered {

**private** **static** **final** **int** DEFAULT\_MAX\_RETRIES = 2;

**private** **int** maxRetries = DEFAULT\_MAX\_RETRIES;

**private** **int** order = 1;

**public** **void** setMaxRetries(**int** maxRetries) {

this.maxRetries = maxRetries;

}

**public** **int** getOrder() {

**return** this.order;

}

**public** **void** setOrder(**int** order) {

this.order = order;

}

**public** Object doConcurrentOperation(ProceedingJoinPoint pjp) **throws** Throwable {

**int** numAttempts = 0;

PessimisticLockingFailureException lockFailureException;

**do** {

numAttempts++;

**try** {

**return** pjp.proceed();

}

**catch**(PessimisticLockingFailureException ex) {

lockFailureException = ex;

}

} **while**(numAttempts <= this.maxRetries);

**throw** lockFailureException;

}

}

Note that the aspect implements the Ordered interface so we can set the precedence of the aspect higher than the transaction advice (we want a fresh transaction each time we retry). The maxRetries and order properties will both be configured by Spring. The main action happens in the doConcurrentOperation around advice method. We try to proceed, and if we fail with a PessimisticLockingFailureException we simply try again unless we have exhausted all of our retry attempts.

|  |  |
| --- | --- |
|  | This class is identical to the one used in the @AspectJ example, but with the annotations removed. |

The corresponding Spring configuration is:

<aop:config>

<aop:aspect id="concurrentOperationRetry" ref="concurrentOperationExecutor">

<aop:pointcut id="idempotentOperation"

expression="execution(\* com.xyz.myapp.service.\*.\*(..))"/>

<aop:around

pointcut-ref="idempotentOperation"

method="doConcurrentOperation"/>

</aop:aspect>

</aop:config>

<bean id="concurrentOperationExecutor"

class="com.xyz.myapp.service.impl.ConcurrentOperationExecutor">

<property name="maxRetries" value="3"/>

<property name="order" value="100"/>

</bean>

Notice that for the time being we assume that all business services are idempotent. If this is not the case we can refine the aspect so that it only retries genuinely idempotent operations, by introducing an Idempotent annotation:

@Retention(RetentionPolicy.RUNTIME)

**public** @interface Idempotent {

*// marker annotation*

}

and using the annotation to annotate the implementation of service operations. The change to the aspect to retry only idempotent operations simply involves refining the pointcut expression so that only @Idempotent operations match:

<aop:pointcut id="idempotentOperation"

expression="execution(\* com.xyz.myapp.service.\*.\*(..)) and

@annotation(com.xyz.myapp.service.Idempotent)"/>

### **5.4. Choosing which AOP declaration style to use**

Once you have decided that an aspect is the best approach for implementing a given requirement, how do you decide between using Spring AOP or AspectJ, and between the Aspect language (code) style, @AspectJ annotation style, or the Spring XML style? These decisions are influenced by a number of factors including application requirements, development tools, and team familiarity with AOP.

#### **5.4.1. Spring AOP or full AspectJ?**

Use the simplest thing that can work. Spring AOP is simpler than using full AspectJ as there is no requirement to introduce the AspectJ compiler / weaver into your development and build processes. If you only need to advise the execution of operations on Spring beans, then Spring AOP is the right choice. If you need to advise objects not managed by the Spring container (such as domain objects typically), then you will need to use AspectJ. You will also need to use AspectJ if you wish to advise join points other than simple method executions (for example, field get or set join points, and so on).

When using AspectJ, you have the choice of the AspectJ language syntax (also known as the "code style") or the @AspectJ annotation style. Clearly, if you are not using Java 5+ then the choice has been made for you…​ use the code style. If aspects play a large role in your design, and you are able to use the [AspectJ Development Tools (AJDT)](https://www.eclipse.org/ajdt/) plugin for Eclipse, then the AspectJ language syntax is the preferred option: it is cleaner and simpler because the language was purposefully designed for writing aspects. If you are not using Eclipse, or have only a few aspects that do not play a major role in your application, then you may want to consider using the @AspectJ style and sticking with a regular Java compilation in your IDE, and adding an aspect weaving phase to your build script.

#### **5.4.2. @AspectJ or XML for Spring AOP?**

If you have chosen to use Spring AOP, then you have a choice of @AspectJ or XML style. There are various tradeoffs to consider.

The XML style will be most familiar to existing Spring users and it is backed by genuine POJOs. When using AOP as a tool to configure enterprise services then XML can be a good choice (a good test is whether you consider the pointcut expression to be a part of your configuration you might want to change independently). With the XML style arguably it is clearer from your configuration what aspects are present in the system.

The XML style has two disadvantages. Firstly it does not fully encapsulate the implementation of the requirement it addresses in a single place. The DRY principle says that there should be a single, unambiguous, authoritative representation of any piece of knowledge within a system. When using the XML style, the knowledge of how a requirement is implemented is split across the declaration of the backing bean class, and the XML in the configuration file. When using the @AspectJ style there is a single module - the aspect - in which this information is encapsulated. Secondly, the XML style is slightly more limited in what it can express than the @AspectJ style: only the "singleton" aspect instantiation model is supported, and it is not possible to combine named pointcuts declared in XML. For example, in the @AspectJ style you can write something like:

@Pointcut(execution(\* get\*()))

**public** **void** propertyAccess() {}

@Pointcut(execution(org.xyz.Account+ \*(..))

**public** **void** operationReturningAnAccount() {}

@Pointcut(propertyAccess() && operationReturningAnAccount())

**public** **void** accountPropertyAccess() {}

In the XML style I can declare the first two pointcuts:

<aop:pointcut id="propertyAccess"

expression="execution(\* get\*())"/>

<aop:pointcut id="operationReturningAnAccount"

expression="execution(org.xyz.Account+ \*(..))"/>

The downside of the XML approach is that you cannot define the accountPropertyAccess pointcut by combining these definitions.

The @AspectJ style supports additional instantiation models, and richer pointcut composition. It has the advantage of keeping the aspect as a modular unit. It also has the advantage the @AspectJ aspects can be understood (and thus consumed) both by Spring AOP and by AspectJ - so if you later decide you need the capabilities of AspectJ to implement additional requirements then it is very easy to migrate to an AspectJ-based approach. On balance the Spring team prefer the @AspectJ style whenever you have aspects that do more than simple "configuration" of enterprise services.

### **5.5. Mixing aspect types**

It is perfectly possible to mix @AspectJ style aspects using the autoproxying support, schema-defined <aop:aspect> aspects, <aop:advisor> declared advisors and even proxies and interceptors defined using the Spring 1.2 style in the same configuration. All of these are implemented using the same underlying support mechanism and will co-exist without any difficulty.

### **5.6. Proxying mechanisms**

Spring AOP uses either JDK dynamic proxies or CGLIB to create the proxy for a given target object. (JDK dynamic proxies are preferred whenever you have a choice).

If the target object to be proxied implements at least one interface then a JDK dynamic proxy will be used. All of the interfaces implemented by the target type will be proxied. If the target object does not implement any interfaces then a CGLIB proxy will be created.

If you want to force the use of CGLIB proxying (for example, to proxy every method defined for the target object, not just those implemented by its interfaces) you can do so. However, there are some issues to consider:

* final methods cannot be advised, as they cannot be overridden.
* As of Spring 3.2, it is no longer necessary to add CGLIB to your project classpath, as CGLIB classes are repackaged under org.springframework and included directly in the spring-core JAR. This means that CGLIB-based proxy support 'just works' in the same way that JDK dynamic proxies always have.
* As of Spring 4.0, the constructor of your proxied object will NOT be called twice anymore since the CGLIB proxy instance will be created via Objenesis. Only if your JVM does not allow for constructor bypassing, you might see double invocations and corresponding debug log entries from Spring’s AOP support.

To force the use of CGLIB proxies set the value of the proxy-target-class attribute of the <aop:config> element to true:

<aop:config proxy-target-class="true">

*<!-- other beans defined here... -->*

</aop:config>

To force CGLIB proxying when using the @AspectJ autoproxy support, set the 'proxy-target-class' attribute of the <aop:aspectj-autoproxy> element to true:

<aop:aspectj-autoproxy proxy-target-class="true"/>

|  |  |
| --- | --- |
|  | Multiple <aop:config/> sections are collapsed into a single unified auto-proxy creator at runtime, which applies the strongest proxy settings that any of the <aop:config/> sections (typically from different XML bean definition files) specified. This also applies to the <tx:annotation-driven/> and <aop:aspectj-autoproxy/> elements.  To be clear: using proxy-target-class="true" on <tx:annotation-driven/>, <aop:aspectj-autoproxy/> or <aop:config/> elements will force the use of CGLIB proxies for all three of them. |

#### **5.6.1. Understanding AOP proxies**

Spring AOP is proxy-based. It is vitally important that you grasp the semantics of what that last statement actually means before you write your own aspects or use any of the Spring AOP-based aspects supplied with the Spring Framework.

Consider first the scenario where you have a plain-vanilla, un-proxied, nothing-special-about-it, straight object reference, as illustrated by the following code snippet.

**public** **class** **SimplePojo** **implements** Pojo {

**public** **void** foo() {

*// this next method invocation is a direct call on the 'this' reference*

this.bar();

}

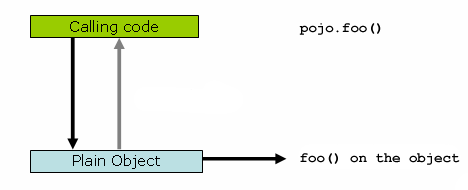
**public** **void** bar() {

*// some logic...*

}

}

If you invoke a method on an object reference, the method is invoked directly on that object reference, as can be seen below.



**public** **class** **Main** {

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

Pojo pojo = **new** SimplePojo();

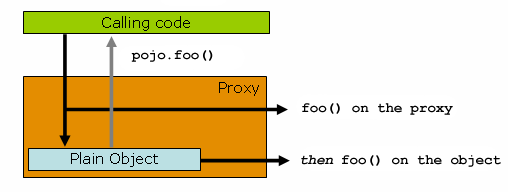
*// this is a direct method call on the 'pojo' reference*

pojo.foo();

}

}

Things change slightly when the reference that client code has is a proxy. Consider the following diagram and code snippet.



**public** **class** **Main** {

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

ProxyFactory factory = **new** ProxyFactory(**new** SimplePojo());

factory.addInterface(Pojo.class);

factory.addAdvice(**new** RetryAdvice());

Pojo pojo = (Pojo) factory.getProxy();

*// this is a method call on the proxy!*

pojo.foo();

}

}

The key thing to understand here is that the client code inside the main(..) of the Main class has a reference to the proxy. This means that method calls on that object reference will be calls on the proxy, and as such the proxy will be able to delegate to all of the interceptors (advice) that are relevant to that particular method call. However, once the call has finally reached the target object, the SimplePojo reference in this case, any method calls that it may make on itself, such as this.bar() or this.foo(), are going to be invoked against the this reference, and not the proxy. This has important implications. It means that self-invocation is not going to result in the advice associated with a method invocation getting a chance to execute.

Okay, so what is to be done about this? The best approach (the term best is used loosely here) is to refactor your code such that the self-invocation does not happen. For sure, this does entail some work on your part, but it is the best, least-invasive approach. The next approach is absolutely horrendous, and I am almost reticent to point it out precisely because it is so horrendous. You can (choke!) totally tie the logic within your class to Spring AOP by doing this:

**public** **class** **SimplePojo** **implements** Pojo {

**public** **void** foo() {

*// this works, but... gah!*

((Pojo) AopContext.currentProxy()).bar();

}

**public** **void** bar() {

*// some logic...*

}

}

This totally couples your code to Spring AOP, and it makes the class itself aware of the fact that it is being used in an AOP context, which flies in the face of AOP. It also requires some additional configuration when the proxy is being created:

**public** **class** **Main** {

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

ProxyFactory factory = **new** ProxyFactory(**new** SimplePojo());

factory.adddInterface(Pojo.class);

factory.addAdvice(**new** RetryAdvice());

factory.setExposeProxy(true);

Pojo pojo = (Pojo) factory.getProxy();

*// this is a method call on the proxy!*

pojo.foo();

}

}

Finally, it must be noted that AspectJ does not have this self-invocation issue because it is not a proxy-based AOP framework.

### **5.7. Programmatic creation of @AspectJ Proxies**

In addition to declaring aspects in your configuration using either <aop:config> or <aop:aspectj-autoproxy>, it is also possible programmatically to create proxies that advise target objects. For the full details of Spring’s AOP API, see the next chapter. Here we want to focus on the ability to automatically create proxies using @AspectJ aspects.

The class org.springframework.aop.aspectj.annotation.AspectJProxyFactory can be used to create a proxy for a target object that is advised by one or more @AspectJ aspects. Basic usage for this class is very simple, as illustrated below. See the javadocs for full information.

*// create a factory that can generate a proxy for the given target object*

AspectJProxyFactory factory = **new** AspectJProxyFactory(targetObject);

*// add an aspect, the class must be an @AspectJ aspect*

*// you can call this as many times as you need with different aspects*

factory.addAspect(SecurityManager.class);

*// you can also add existing aspect instances, the type of the object supplied must be an @AspectJ aspect*

factory.addAspect(usageTracker);

*// now get the proxy object...*

MyInterfaceType proxy = factory.getProxy();

### **5.8. Using AspectJ with Spring applications**

Everything we’ve covered so far in this chapter is pure Spring AOP. In this section, we’re going to look at how you can use the AspectJ compiler/weaver instead of, or in addition to, Spring AOP if your needs go beyond the facilities offered by Spring AOP alone.

Spring ships with a small AspectJ aspect library, which is available standalone in your distribution as spring-aspects.jar; you’ll need to add this to your classpath in order to use the aspects in it. [Using AspectJ to dependency inject domain objects with Spring](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-atconfigurable) and [Other Spring aspects for AspectJ](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-ajlib-other) discuss the content of this library and how you can use it. [Configuring AspectJ aspects using Spring IoC](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-configure) discusses how to dependency inject AspectJ aspects that are woven using the AspectJ compiler. Finally, [Load-time weaving with AspectJ in the Spring Framework](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw) provides an introduction to load-time weaving for Spring applications using AspectJ.

#### **5.8.1. Using AspectJ to dependency inject domain objects with Spring**

The Spring container instantiates and configures beans defined in your application context. It is also possible to ask a bean factory to configure a pre-existing object given the name of a bean definition containing the configuration to be applied. The spring-aspects.jar contains an annotation-driven aspect that exploits this capability to allow dependency injection of any object. The support is intended to be used for objects created outside of the control of any container. Domain objects often fall into this category because they are often created programmatically using the new operator, or by an ORM tool as a result of a database query.

The @Configurable annotation marks a class as eligible for Spring-driven configuration. In the simplest case it can be used just as a marker annotation:

**package** com.xyz.myapp.domain;

**import** org.springframework.beans.factory.annotation.Configurable;

@Configurable

**public** **class** **Account** {

*// ...*

}

When used as a marker interface in this way, Spring will configure new instances of the annotated type ( Account in this case) using a bean definition (typically prototype-scoped) with the same name as the fully-qualified type name ( com.xyz.myapp.domain.Account). Since the default name for a bean is the fully-qualified name of its type, a convenient way to declare the prototype definition is simply to omit the id attribute:

<bean class="com.xyz.myapp.domain.Account" scope="prototype">

<property name="fundsTransferService" ref="fundsTransferService"/>

</bean>

If you want to explicitly specify the name of the prototype bean definition to use, you can do so directly in the annotation:

**package** com.xyz.myapp.domain;

**import** org.springframework.beans.factory.annotation.Configurable;

@Configurable("account")

**public** **class** **Account** {

*// ...*

}

Spring will now look for a bean definition named "account" and use that as the definition to configure new Account instances.

You can also use autowiring to avoid having to specify a dedicated bean definition at all. To have Spring apply autowiring use the autowire property of the @Configurable annotation: specify either @Configurable(autowire=Autowire.BY\_TYPE) or @Configurable(autowire=Autowire.BY\_NAME for autowiring by type or by name respectively. As an alternative, as of Spring 2.5 it is preferable to specify explicit, annotation-driven dependency injection for your @Configurable beans by using @Autowired or @Inject at the field or method level (see [Annotation-based container configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-annotation-config) for further details).

Finally you can enable Spring dependency checking for the object references in the newly created and configured object by using the dependencyCheck attribute (for example: @Configurable(autowire=Autowire.BY\_NAME,dependencyCheck=true)). If this attribute is set to true, then Spring will validate after configuration that all properties (which are not primitives or collections) have been set.

Using the annotation on its own does nothing of course. It is the AnnotationBeanConfigurerAspect in spring-aspects.jar that acts on the presence of the annotation. In essence the aspect says "after returning from the initialization of a new object of a type annotated with @Configurable, configure the newly created object using Spring in accordance with the properties of the annotation". In this context, initialization refers to newly instantiated objects (e.g., objects instantiated with the new operator) as well as to Serializable objects that are undergoing deserialization (e.g., via [readResolve()](https://docs.oracle.com/javase/6/docs/api/java/io/Serializable.html)).

|  |  |
| --- | --- |
|  | One of the key phrases in the above paragraph is 'in essence'. For most cases, the exact semantics of 'after returning from the initialization of a new object' will be fine…​ in this context, 'after initialization' means that the dependencies will be injected after the object has been constructed - this means that the dependencies will not be available for use in the constructor bodies of the class. If you want the dependencies to be injected before the constructor bodies execute, and thus be available for use in the body of the constructors, then you need to define this on the @Configurable declaration like so:  @Configurable(preConstruction=true)  You can find out more information about the language semantics of the various pointcut types in AspectJ [in this appendix](https://www.eclipse.org/aspectj/doc/next/progguide/semantics-joinPoints.html) of the [AspectJ Programming Guide](https://www.eclipse.org/aspectj/doc/next/progguide/index.html). |

For this to work the annotated types must be woven with the AspectJ weaver - you can either use a build-time Ant or Maven task to do this (see for example the [AspectJ Development Environment Guide](https://www.eclipse.org/aspectj/doc/released/devguide/antTasks.html)) or load-time weaving (see [Load-time weaving with AspectJ in the Spring Framework](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw)). The AnnotationBeanConfigurerAspect itself needs configuring by Spring (in order to obtain a reference to the bean factory that is to be used to configure new objects). If you are using Java based configuration simply add @EnableSpringConfigured to any @Configuration class.

@Configuration

@EnableSpringConfigured

**public** **class** **AppConfig** {

}

If you prefer XML based configuration, the Spring [context namespace](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-schemas-context) defines a convenient context:spring-configured element:

<context:spring-configured/>

Instances of @Configurable objects created before the aspect has been configured will result in a message being issued to the debug log and no configuration of the object taking place. An example might be a bean in the Spring configuration that creates domain objects when it is initialized by Spring. In this case you can use the "depends-on" bean attribute to manually specify that the bean depends on the configuration aspect.

<bean id="myService"

class="com.xzy.myapp.service.MyService"

depends-on="org.springframework.beans.factory.aspectj.AnnotationBeanConfigurerAspect">

*<!-- ... -->*

</bean>

|  |  |
| --- | --- |
|  | Do not activate @Configurable processing through the bean configurer aspect unless you really mean to rely on its semantics at runtime. In particular, make sure that you do not use @Configurable on bean classes which are registered as regular Spring beans with the container: You would get double initialization otherwise, once through the container and once through the aspect. |

##### **Unit testing @Configurable objects**

One of the goals of the @Configurable support is to enable independent unit testing of domain objects without the difficulties associated with hard-coded lookups. If @Configurable types have not been woven by AspectJ, the annotation has no affect during unit testing, and you can simply set mock or stub property references in the object under test and proceed as normal. If @Configurable types have been woven by AspectJ then you can still unit test outside of the container as normal, but you will see a warning message each time that you construct a @Configurable object indicating that it has not been configured by Spring.

##### **Working with multiple application contexts**

The AnnotationBeanConfigurerAspect used to implement the @Configurable support is an AspectJ singleton aspect. The scope of a singleton aspect is the same as the scope of static members, that is to say there is one aspect instance per classloader that defines the type. This means that if you define multiple application contexts within the same classloader hierarchy you need to consider where to define the @EnableSpringConfigured bean and where to place spring-aspects.jar on the classpath.

Consider a typical Spring web-app configuration with a shared parent application context defining common business services and everything needed to support them, and one child application context per servlet containing definitions particular to that servlet. All of these contexts will co-exist within the same classloader hierarchy, and so the AnnotationBeanConfigurerAspect can only hold a reference to one of them. In this case we recommend defining the @EnableSpringConfigured bean in the shared (parent) application context: this defines the services that you are likely to want to inject into domain objects. A consequence is that you cannot configure domain objects with references to beans defined in the child (servlet-specific) contexts using the @Configurable mechanism (probably not something you want to do anyway!).

When deploying multiple web-apps within the same container, ensure that each web-application loads the types in spring-aspects.jar using its own classloader (for example, by placing spring-aspects.jar in 'WEB-INF/lib'). If spring-aspects.jar is only added to the container wide classpath (and hence loaded by the shared parent classloader), all web applications will share the same aspect instance which is probably not what you want.

#### **5.8.2. Other Spring aspects for AspectJ**

In addition to the @Configurable aspect, spring-aspects.jar contains an AspectJ aspect that can be used to drive Spring’s transaction management for types and methods annotated with the @Transactional annotation. This is primarily intended for users who want to use the Spring Framework’s transaction support outside of the Spring container.

The aspect that interprets @Transactional annotations is the AnnotationTransactionAspect. When using this aspect, you must annotate the implementation class (and/or methods within that class), not the interface (if any) that the class implements. AspectJ follows Java’s rule that annotations on interfaces are not inherited.

A @Transactional annotation on a class specifies the default transaction semantics for the execution of any public operation in the class.

A @Transactional annotation on a method within the class overrides the default transaction semantics given by the class annotation (if present). Methods of any visibility may be annotated, including private methods. Annotating non-public methods directly is the only way to get transaction demarcation for the execution of such methods.

|  |  |
| --- | --- |
|  | Since Spring Framework 4.2, spring-aspects provides a similar aspect that offers the exact same features for the standard javax.transaction.Transactional annotation. Check JtaAnnotationTransactionAspect for more details. |

For AspectJ programmers that want to use the Spring configuration and transaction management support but don’t want to (or cannot) use annotations, spring-aspects.jar also contains abstract aspects you can extend to provide your own pointcut definitions. See the sources for the AbstractBeanConfigurerAspect and AbstractTransactionAspect aspects for more information. As an example, the following excerpt shows how you could write an aspect to configure all instances of objects defined in the domain model using prototype bean definitions that match the fully-qualified class names:

**public** aspect DomainObjectConfiguration **extends** AbstractBeanConfigurerAspect {

**public** DomainObjectConfiguration() {

setBeanWiringInfoResolver(**new** ClassNameBeanWiringInfoResolver());

}

*// the creation of a new bean (any object in the domain model)*

**protected** pointcut beanCreation(Object beanInstance) :

initialization(**new**(..)) &&

SystemArchitecture.inDomainModel() &&

this(beanInstance);

}

#### **5.8.3. Configuring AspectJ aspects using Spring IoC**

When using AspectJ aspects with Spring applications, it is natural to both want and expect to be able to configure such aspects using Spring. The AspectJ runtime itself is responsible for aspect creation, and the means of configuring the AspectJ created aspects via Spring depends on the AspectJ instantiation model (the per-xxx clause) used by the aspect.

The majority of AspectJ aspects are singleton aspects. Configuration of these aspects is very easy: simply create a bean definition referencing the aspect type as normal, and include the bean attribute 'factory-method="aspectOf"'. This ensures that Spring obtains the aspect instance by asking AspectJ for it rather than trying to create an instance itself. For example:

<bean id="profiler" class="com.xyz.profiler.Profiler"

factory-method="aspectOf">

<property name="profilingStrategy" ref="jamonProfilingStrategy"/>

</bean>

Non-singleton aspects are harder to configure: however it is possible to do so by creating prototype bean definitions and using the @Configurable support from spring-aspects.jar to configure the aspect instances once they have bean created by the AspectJ runtime.

If you have some @AspectJ aspects that you want to weave with AspectJ (for example, using load-time weaving for domain model types) and other @AspectJ aspects that you want to use with Spring AOP, and these aspects are all configured using Spring, then you will need to tell the Spring AOP @AspectJ autoproxying support which exact subset of the @AspectJ aspects defined in the configuration should be used for autoproxying. You can do this by using one or more <include/> elements inside the <aop:aspectj-autoproxy/> declaration. Each <include/> element specifies a name pattern, and only beans with names matched by at least one of the patterns will be used for Spring AOP autoproxy configuration:

<aop:aspectj-autoproxy>

<aop:include name="thisBean"/>

<aop:include name="thatBean"/>

</aop:aspectj-autoproxy>

|  |  |
| --- | --- |
|  | Do not be misled by the name of the <aop:aspectj-autoproxy/> element: using it will result in the creation of Spring AOP proxies. The @AspectJ style of aspect declaration is just being used here, but the AspectJ runtime is not involved. |

#### **5.8.4. Load-time weaving with AspectJ in the Spring Framework**

Load-time weaving (LTW) refers to the process of weaving AspectJ aspects into an application’s class files as they are being loaded into the Java virtual machine (JVM). The focus of this section is on configuring and using LTW in the specific context of the Spring Framework: this section is not an introduction to LTW though. For full details on the specifics of LTW and configuring LTW with just AspectJ (with Spring not being involved at all), see the [LTW section of the AspectJ Development Environment Guide](https://www.eclipse.org/aspectj/doc/released/devguide/ltw.html).

The value-add that the Spring Framework brings to AspectJ LTW is in enabling much finer-grained control over the weaving process. 'Vanilla' AspectJ LTW is effected using a Java (5+) agent, which is switched on by specifying a VM argument when starting up a JVM. It is thus a JVM-wide setting, which may be fine in some situations, but often is a little too coarse. Spring-enabled LTW enables you to switch on LTW on a per-ClassLoader basis, which obviously is more fine-grained and which can make more sense in a 'single-JVM-multiple-application' environment (such as is found in a typical application server environment).

Further, [in certain environments](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw-environments), this support enables load-time weaving without making any modifications to the application server’s launch script that will be needed to add -javaagent:path/to/aspectjweaver.jar or (as we describe later in this section) -javaagent:path/to/org.springframework.instrument-{version}.jar (previously named spring-agent.jar). Developers simply modify one or more files that form the application context to enable load-time weaving instead of relying on administrators who typically are in charge of the deployment configuration such as the launch script.

Now that the sales pitch is over, let us first walk through a quick example of AspectJ LTW using Spring, followed by detailed specifics about elements introduced in the following example. For a complete example, please see the [Petclinic sample application](https://github.com/spring-projects/spring-petclinic).

##### **A first example**

Let us assume that you are an application developer who has been tasked with diagnosing the cause of some performance problems in a system. Rather than break out a profiling tool, what we are going to do is switch on a simple profiling aspect that will enable us to very quickly get some performance metrics, so that we can then apply a finer-grained profiling tool to that specific area immediately afterwards.

|  |  |
| --- | --- |
|  | The example presented here uses XML style configuration, it is also possible to configure and use @AspectJ with [Java Configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-java). Specifically the @EnableLoadTimeWeaving annotation can be used as an alternative to <context:load-time-weaver/> (see [below](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw-spring) for details). |

Here is the profiling aspect. Nothing too fancy, just a quick-and-dirty time-based profiler, using the @AspectJ-style of aspect declaration.

**package** foo;

**import** org.aspectj.lang.ProceedingJoinPoint;

**import** org.aspectj.lang.annotation.Aspect;

**import** org.aspectj.lang.annotation.Around;

**import** org.aspectj.lang.annotation.Pointcut;

**import** org.springframework.util.StopWatch;

**import** org.springframework.core.annotation.Order;

@Aspect

**public** **class** **ProfilingAspect** {

@Around("methodsToBeProfiled()")

**public** Object profile(ProceedingJoinPoint pjp) **throws** Throwable {

StopWatch sw = **new** StopWatch(getClass().getSimpleName());

**try** {

sw.start(pjp.getSignature().getName());

**return** pjp.proceed();

} **finally** {

sw.stop();

System.out.println(sw.prettyPrint());

}

}

@Pointcut("execution(public \* foo..\*.\*(..))")

**public** **void** methodsToBeProfiled(){}

}

We will also need to create an META-INF/aop.xml file, to inform the AspectJ weaver that we want to weave our ProfilingAspect into our classes. This file convention, namely the presence of a file (or files) on the Java classpath called META-INF/aop.xml is standard AspectJ.

<!DOCTYPE aspectj PUBLIC "-//AspectJ//DTD//EN" "https://www.eclipse.org/aspectj/dtd/aspectj.dtd">

<aspectj>

<weaver>

*<!-- only weave classes in our application-specific packages -->*

<include within="foo.\*"/>

</weaver>

<aspects>

*<!-- weave in just this aspect -->*

<aspect name="foo.ProfilingAspect"/>

</aspects>

</aspectj>

Now to the Spring-specific portion of the configuration. We need to configure a LoadTimeWeaver (all explained later, just take it on trust for now). This load-time weaver is the essential component responsible for weaving the aspect configuration in one or more META-INF/aop.xml files into the classes in your application. The good thing is that it does not require a lot of configuration, as can be seen below (there are some more options that you can specify, but these are detailed later).

<?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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://www.springframework.org/schema/context/spring-context.xsd">

*<!-- a service object; we will be profiling its methods -->*

<bean id="entitlementCalculationService"

class="foo.StubEntitlementCalculationService"/>

*<!-- this switches on the load-time weaving -->*

**<context:load-time-weaver/>**

</beans>

Now that all the required artifacts are in place - the aspect, the META-INF/aop.xml file, and the Spring configuration -, let us create a simple driver class with a main(..) method to demonstrate the LTW in action.

**package** foo;

**import** org.springframework.context.support.ClassPathXmlApplicationContext;

**public** **final** **class** **Main** {

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

ApplicationContext ctx = **new** ClassPathXmlApplicationContext("beans.xml", Main.class);

EntitlementCalculationService entitlementCalculationService

= (EntitlementCalculationService) ctx.getBean("entitlementCalculationService");

*// the profiling aspect is 'woven' around this method execution*

entitlementCalculationService.calculateEntitlement();

}

}

There is one last thing to do. The introduction to this section did say that one could switch on LTW selectively on a per- ClassLoader basis with Spring, and this is true. However, just for this example, we are going to use a Java agent (supplied with Spring) to switch on the LTW. This is the command line we will use to run the above Main class:

java -javaagent:C:/projects/foo/lib/global/spring-instrument.jar foo.Main

The -javaagent is a flag for specifying and enabling [agents to instrument programs running on the JVM](https://docs.oracle.com/javase/6/docs/api/java/lang/instrument/package-summary.html). The Spring Framework ships with such an agent, the InstrumentationSavingAgent, which is packaged in the spring-instrument.jar that was supplied as the value of the -javaagent argument in the above example.

The output from the execution of the Main program will look something like that below. (I have introduced a Thread.sleep(..) statement into the calculateEntitlement() implementation so that the profiler actually captures something other than 0 milliseconds - the 01234 milliseconds is not an overhead introduced by the AOP :) )

Calculating entitlement

StopWatch 'ProfilingAspect': running time (millis) = 1234

------ ----- ----------------------------

ms % Task name

------ ----- ----------------------------

01234 100% calculateEntitlement

Since this LTW is effected using full-blown AspectJ, we are not just limited to advising Spring beans; the following slight variation on the Main program will yield the same result.

**package** foo;

**import** org.springframework.context.support.ClassPathXmlApplicationContext;

**public** **final** **class** **Main** {

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

**new** ClassPathXmlApplicationContext("beans.xml", Main.class);

EntitlementCalculationService entitlementCalculationService =

**new** StubEntitlementCalculationService();

*// the profiling aspect will be 'woven' around this method execution*

entitlementCalculationService.calculateEntitlement();

}

}

Notice how in the above program we are simply bootstrapping the Spring container, and then creating a new instance of the StubEntitlementCalculationService totally outside the context of Spring…​ the profiling advice still gets woven in.

The example admittedly is simplistic…​ however the basics of the LTW support in Spring have all been introduced in the above example, and the rest of this section will explain the 'why' behind each bit of configuration and usage in detail.

|  |  |
| --- | --- |
|  | The ProfilingAspect used in this example may be basic, but it is quite useful. It is a nice example of a development-time aspect that developers can use during development (of course), and then quite easily exclude from builds of the application being deployed into UAT or production. |

##### **Aspects**

The aspects that you use in LTW have to be AspectJ aspects. They can be written in either the AspectJ language itself or you can write your aspects in the @AspectJ-style. It means that your aspects are then both valid AspectJ and Spring AOP aspects. Furthermore, the compiled aspect classes need to be available on the classpath.

##### **'META-INF/aop.xml'**

The AspectJ LTW infrastructure is configured using one or more META-INF/aop.xml files, that are on the Java classpath (either directly, or more typically in jar files).

The structure and contents of this file is detailed in the main AspectJ reference documentation, and the interested reader is [referred to that resource](https://www.eclipse.org/aspectj/doc/released/devguide/ltw-configuration.html). (I appreciate that this section is brief, but the aop.xml file is 100% AspectJ - there is no Spring-specific information or semantics that apply to it, and so there is no extra value that I can contribute either as a result), so rather than rehash the quite satisfactory section that the AspectJ developers wrote, I am just directing you there.)

##### **Required libraries (JARS)**

At a minimum you will need the following libraries to use the Spring Framework’s support for AspectJ LTW:

* spring-aop.jar (version 2.5 or later, plus all mandatory dependencies)
* aspectjweaver.jar (version 1.6.8 or later)

If you are using the [Spring-provided agent to enable instrumentation](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw-environment-generic), you will also need:

* spring-instrument.jar

##### **Spring configuration**

The key component in Spring’s LTW support is the LoadTimeWeaver interface (in the org.springframework.instrument.classloading package), and the numerous implementations of it that ship with the Spring distribution. A LoadTimeWeaver is responsible for adding one or more java.lang.instrument.ClassFileTransformers to a ClassLoader at runtime, which opens the door to all manner of interesting applications, one of which happens to be the LTW of aspects.

|  |  |
| --- | --- |
|  | If you are unfamiliar with the idea of runtime class file transformation, you are encouraged to read the javadoc API documentation for the java.lang.instrument package before continuing. This is not a huge chore because there is - rather annoyingly - precious little documentation there…​ the key interfaces and classes will at least be laid out in front of you for reference as you read through this section. |

Configuring a LoadTimeWeaver for a particular ApplicationContext can be as easy as adding one line. (Please note that you almost certainly will need to be using an ApplicationContext as your Spring container - typically a BeanFactory will not be enough because the LTW support makes use of BeanFactoryPostProcessors.)

To enable the Spring Framework’s LTW support, you need to configure a LoadTimeWeaver, which typically is done using the @EnableLoadTimeWeaving annotation.

@Configuration

@EnableLoadTimeWeaving

**public** **class** **AppConfig** {

}

Alternatively, if you prefer XML based configuration, use the <context:load-time-weaver/> element. Note that the element is defined in 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

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://www.springframework.org/schema/context/spring-context.xsd">

<context:load-time-weaver/>

</beans>

The above configuration will define and register a number of LTW-specific infrastructure beans for you automatically, such as a LoadTimeWeaver and an AspectJWeavingEnabler. The default LoadTimeWeaver is the DefaultContextLoadTimeWeaver class, which attempts to decorate an automatically detected LoadTimeWeaver: the exact type of LoadTimeWeaver that will be 'automatically detected' is dependent upon your runtime environment (summarized in the following table).

| *Table 13. DefaultContextLoadTimeWeaver LoadTimeWeavers* | |
| --- | --- |
| **Runtime Environment** | LoadTimeWeaver**implementation** |
| Running in Oracle’s [WebLogic](https://www.oracle.com/technetwork/middleware/weblogic/overview/index-085209.html) | WebLogicLoadTimeWeaver |
| Running in Oracle’s [GlassFish](https://glassfish.dev.java.net/) | GlassFishLoadTimeWeaver |
| Running in [Apache Tomcat](https://tomcat.apache.org/) | TomcatLoadTimeWeaver |
| Running in Red Hat’s [JBoss AS](https://www.jboss.org/jbossas/) or [WildFly](https://www.wildfly.org/) | JBossLoadTimeWeaver |
| Running in IBM’s [WebSphere](https://www-01.ibm.com/software/webservers/appserv/was/) | WebSphereLoadTimeWeaver |
| JVM started with Spring InstrumentationSavingAgent (java -javaagent:path/to/spring-instrument.jar) | InstrumentationLoadTimeWeaver |
| Fallback, expecting the underlying ClassLoader to follow common conventions (e.g. applicable to TomcatInstrumentableClassLoader and [Resin](https://www.caucho.com/)) | ReflectiveLoadTimeWeaver |

Note that these are just the LoadTimeWeavers that are autodetected when using the DefaultContextLoadTimeWeaver: it is of course possible to specify exactly which LoadTimeWeaver implementation that you wish to use.

To specify a specific LoadTimeWeaver with Java configuration implement the LoadTimeWeavingConfigurer interface and override the getLoadTimeWeaver() method:

@Configuration

@EnableLoadTimeWeaving

**public** **class** **AppConfig** **implements** LoadTimeWeavingConfigurer {

@Override

**public** LoadTimeWeaver getLoadTimeWeaver() {

**return** **new** ReflectiveLoadTimeWeaver();

}

}

If you are using XML based configuration you can specify the fully-qualified classname as the value of the weaver-class attribute on the <context:load-time-weaver/> element:

<?xml version="1.0" encoding="UTF-8"?>

<beans xmlns="http://www.springframework.org/schema/beans"

xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

xmlns:context="http://www.springframework.org/schema/context"

xsi:schemaLocation="

http://www.springframework.org/schema/beans

https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context

https://www.springframework.org/schema/context/spring-context.xsd">

<context:load-time-weaver

weaver-class="org.springframework.instrument.classloading.ReflectiveLoadTimeWeaver"/>

</beans>

The LoadTimeWeaver that is defined and registered by the configuration can be later retrieved from the Spring container using the well-known name loadTimeWeaver. Remember that the LoadTimeWeaver exists just as a mechanism for Spring’s LTW infrastructure to add one or more ClassFileTransformers. The actual ClassFileTransformer that does the LTW is the ClassPreProcessorAgentAdapter (from the org.aspectj.weaver.loadtime package) class. See the class-level javadocs of the ClassPreProcessorAgentAdapter class for further details, because the specifics of how the weaving is actually effected is beyond the scope of this section.

There is one final attribute of the configuration left to discuss: the aspectjWeaving attribute (or aspectj-weaving if you are using XML). This is a simple attribute that controls whether LTW is enabled or not; it is as simple as that. It accepts one of three possible values, summarized below, with the default value being autodetect if the attribute is not present.

| *Table 14. AspectJ weaving attribute values* | | |
| --- | --- | --- |
| **Annotation Value** | **XML Value** | **Explanation** |
| ENABLED | on | AspectJ weaving is on, and aspects will be woven at load-time as appropriate. |
| DISABLED | off | LTW is off…​ no aspect will be woven at load-time. |
| AUTODETECT | autodetect | If the Spring LTW infrastructure can find at least one META-INF/aop.xml file, then AspectJ weaving is on, else it is off. This is the default value. |

##### **Environment-specific configuration**

This last section contains any additional settings and configuration that you will need when using Spring’s LTW support in environments such as application servers and web containers.

###### **Tomcat**

Historically, [Apache Tomcat](https://tomcat.apache.org/)'s default class loader did not support class transformation which is why Spring provides an enhanced implementation that addresses this need. Named TomcatInstrumentableClassLoader, the loader works on Tomcat 6.0 and above.

|  |  |
| --- | --- |
|  | Do not define TomcatInstrumentableClassLoader anymore on Tomcat 8.0 and higher. Instead, let Spring automatically use Tomcat’s new native InstrumentableClassLoader facility through the TomcatLoadTimeWeaver strategy. |

If you still need to use TomcatInstrumentableClassLoader, it can be registered individually for each web application as follows:

* Copy org.springframework.instrument.tomcat.jar into $CATALINA\_HOME/lib, where $CATALINA\_HOME represents the root of the Tomcat installation)
* Instruct Tomcat to use the custom class loader (instead of the default) by editing the web application context file:

<Context path="/myWebApp" docBase="/my/webApp/location">

<Loader

loaderClass="org.springframework.instrument.classloading.tomcat.TomcatInstrumentableClassLoader"/>

</Context>

Apache Tomcat (6.0+) supports several context locations:

* server configuration file - $CATALINA\_HOME/conf/server.xml
* default context configuration - $CATALINA\_HOME/conf/context.xml - that affects all deployed web applications
* per-web application configuration which can be deployed either on the server-side at $CATALINA\_HOME/conf/[enginename]/[hostname]/[webapp]-context.xml or embedded inside the web-app archive at META-INF/context.xml

For efficiency, the embedded per-web-app configuration style is recommended because it will impact only applications that use the custom class loader and does not require any changes to the server configuration. See the Tomcat 6.0.x [documentation](https://tomcat.apache.org/tomcat-6.0-doc/config/context.html) for more details about available context locations.

Alternatively, consider the use of the Spring-provided generic VM agent, to be specified in Tomcat’s launch script (see above). This will make instrumentation available to all deployed web applications, no matter what ClassLoader they happen to run on.

###### **WebLogic, WebSphere, Resin, GlassFish, JBoss**

Recent versions of WebLogic Server (version 10 and above), IBM WebSphere Application Server (version 7 and above), Resin (3.1 and above) and JBoss (6.x or above) provide a ClassLoader that is capable of local instrumentation. Spring’s native LTW leverages such ClassLoaders to enable AspectJ weaving. You can enable LTW by simply activating load-time weaving as described earlier. Specifically, you do not need to modify the launch script to add -javaagent:path/to/spring-instrument.jar.

Note that GlassFish instrumentation-capable ClassLoader is available only in its EAR environment. For GlassFish web applications, follow the Tomcat setup instructions as outlined above.

Note that on JBoss 6.x, the app server scanning needs to be disabled to prevent it from loading the classes before the application actually starts. A quick workaround is to add to your artifact a file named WEB-INF/jboss-scanning.xml with the following content:

<scanning xmlns="urn:jboss:scanning:1.0"/>

###### **Generic Java applications**

When class instrumentation is required in environments that do not support or are not supported by the existing LoadTimeWeaver implementations, a JDK agent can be the only solution. For such cases, Spring provides InstrumentationLoadTimeWeaver, which requires a Spring-specific (but very general) VM agent, org.springframework.instrument-{version}.jar (previously named spring-agent.jar).

To use it, you must start the virtual machine with the Spring agent, by supplying the following JVM options:

-javaagent:/path/to/org.springframework.instrument-{version}.jar

Note that this requires modification of the VM launch script which may prevent you from using this in application server environments (depending on your operation policies). Additionally, the JDK agent will instrument the entire VM which can prove expensive.

For performance reasons, it is recommended to use this configuration only if your target environment (such as [Jetty](https://www.eclipse.org/jetty/)) does not have (or does not support) a dedicated LTW.

### **5.9. Further Resources**

More information on AspectJ can be found on the [AspectJ website](https://www.eclipse.org/aspectj).

The book Eclipse AspectJ by Adrian Colyer et. al. (Addison-Wesley, 2005) provides a comprehensive introduction and reference for the AspectJ language.

The book AspectJ in Action, Second Edition by Ramnivas Laddad (Manning, 2009) comes highly recommended; the focus of the book is on AspectJ, but a lot of general AOP themes are explored (in some depth).

## 6. Spring AOP APIs

### **6.1. Introduction**

The previous chapter described the Spring’s support for AOP using @AspectJ and schema-based aspect definitions. In this chapter we discuss the lower-level Spring AOP APIs and the AOP support typically used in Spring 1.2 applications. For new applications, we recommend the use of the Spring 2.0 and later AOP support described in the previous chapter, but when working with existing applications, or when reading books and articles, you may come across Spring 1.2 style examples. Spring 5 remains backwards compatible with Spring 1.2 and everything described in this chapter is fully supported in Spring 5.

### **6.2. Pointcut API in Spring**

Let’s look at how Spring handles the crucial pointcut concept.

#### **6.2.1. Concepts**

Spring’s pointcut model enables pointcut reuse independent of advice types. It’s possible to target different advice using the same pointcut.

The org.springframework.aop.Pointcut interface is the central interface, used to target advices to particular classes and methods. The complete interface is shown below:

**public** **interface** **Pointcut** {

ClassFilter getClassFilter();

MethodMatcher getMethodMatcher();

}

Splitting the Pointcut interface into two parts allows reuse of class and method matching parts, and fine-grained composition operations (such as performing a "union" with another method matcher).

The ClassFilter interface is used to restrict the pointcut to a given set of target classes. If the matches() method always returns true, all target classes will be matched:

**public** **interface** **ClassFilter** {

**boolean** matches(Class clazz);

}

The MethodMatcher interface is normally more important. The complete interface is shown below:

**public** **interface** **MethodMatcher** {

**boolean** matches(Method m, Class targetClass);

**boolean** isRuntime();

**boolean** matches(Method m, Class targetClass, Object**[]** args);

}

The matches(Method, Class) method is used to test whether this pointcut will ever match a given method on a target class. This evaluation can be performed when an AOP proxy is created, to avoid the need for a test on every method invocation. If the 2-argument matches method returns true for a given method, and the isRuntime() method for the MethodMatcher returns true, the 3-argument matches method will be invoked on every method invocation. This enables a pointcut to look at the arguments passed to the method invocation immediately before the target advice is to execute.

Most MethodMatchers are static, meaning that their isRuntime() method returns false. In this case, the 3-argument matches method will never be invoked.

|  |  |
| --- | --- |
|  | If possible, try to make pointcuts static, allowing the AOP framework to cache the results of pointcut evaluation when an AOP proxy is created. |

#### **6.2.2. Operations on pointcuts**

Spring supports operations on pointcuts: notably, union and intersection.

* Union means the methods that either pointcut matches.
* Intersection means the methods that both pointcuts match.
* Union is usually more useful.
* Pointcuts can be composed using the static methods in the org.springframework.aop.support.Pointcuts class, or using the ComposablePointcut class in the same package. However, using AspectJ pointcut expressions is usually a simpler approach.

#### **6.2.3. AspectJ expression pointcuts**

Since 2.0, the most important type of pointcut used by Spring is org.springframework.aop.aspectj.AspectJExpressionPointcut. This is a pointcut that uses an AspectJ supplied library to parse an AspectJ pointcut expression string.

See the previous chapter for a discussion of supported AspectJ pointcut primitives.

#### **6.2.4. Convenience pointcut implementations**

Spring provides several convenient pointcut implementations. Some can be used out of the box; others are intended to be subclassed in application-specific pointcuts.

##### **Static pointcuts**

Static pointcuts are based on method and target class, and cannot take into account the method’s arguments. Static pointcuts are sufficient - and best - for most usages. It’s possible for Spring to evaluate a static pointcut only once, when a method is first invoked: after that, there is no need to evaluate the pointcut again with each method invocation.

Let’s consider some static pointcut implementations included with Spring.

###### **Regular expression pointcuts**

One obvious way to specify static pointcuts is regular expressions. Several AOP frameworks besides Spring make this possible. org.springframework.aop.support.JdkRegexpMethodPointcut is a generic regular expression pointcut that uses the regular expression support in the JDK.

With the JdkRegexpMethodPointcut class, you can provide a list of pattern strings. If any of these is a match, the pointcut evaluates to true. (As a consequence, the resulting pointcut is effectively the union of the specified patterns.)

The usage is shown below:

<bean id="settersAndAbsquatulatePointcut"

class="org.springframework.aop.support.JdkRegexpMethodPointcut">

<property name="patterns">

<list>

<value>.\*set.\*</value>

<value>.\*absquatulate</value>

</list>

</property>

</bean>

Spring provides a convenience class, RegexpMethodPointcutAdvisor, that allows us to also reference an Advice (remember that an Advice can be an interceptor, before advice, throws advice etc.). Behind the scenes, Spring will use a JdkRegexpMethodPointcut. Using RegexpMethodPointcutAdvisor simplifies wiring, as the one bean encapsulates both pointcut and advice, as shown below:

<bean id="settersAndAbsquatulateAdvisor"

class="org.springframework.aop.support.RegexpMethodPointcutAdvisor">

<property name="advice">

<ref bean="beanNameOfAopAllianceInterceptor"/>

</property>

<property name="patterns">

<list>

<value>.\*set.\*</value>

<value>.\*absquatulate</value>

</list>

</property>

</bean>

RegexpMethodPointcutAdvisor can be used with any Advice type.

###### **Attribute-driven pointcuts**

An important type of static pointcut is a metadata-driven pointcut. This uses the values of metadata attributes: typically, source-level metadata.

##### **Dynamic pointcuts**

Dynamic pointcuts are costlier to evaluate than static pointcuts. They take into account method arguments, as well as static information. This means that they must be evaluated with every method invocation; the result cannot be cached, as arguments will vary.

The main example is the control flow pointcut.

###### **Control flow pointcuts**

Spring control flow pointcuts are conceptually similar to AspectJ cflow pointcuts, although less powerful. (There is currently no way to specify that a pointcut executes below a join point matched by another pointcut.) A control flow pointcut matches the current call stack. For example, it might fire if the join point was invoked by a method in the com.mycompany.web package, or by the SomeCaller class. Control flow pointcuts are specified using the org.springframework.aop.support.ControlFlowPointcut class.

|  |  |
| --- | --- |
|  | Control flow pointcuts are significantly more expensive to evaluate at runtime than even other dynamic pointcuts. In Java 1.4, the cost is about 5 times that of other dynamic pointcuts. |

#### **6.2.5. Pointcut superclasses**

Spring provides useful pointcut superclasses to help you to implement your own pointcuts.

Because static pointcuts are most useful, you’ll probably subclass StaticMethodMatcherPointcut, as shown below. This requires implementing just one abstract method (although it’s possible to override other methods to customize behavior):

**class** **TestStaticPointcut** **extends** StaticMethodMatcherPointcut {

**public** **boolean** matches(Method m, Class targetClass) {

*// return true if custom criteria match*

}

}

There are also superclasses for dynamic pointcuts.

You can use custom pointcuts with any advice type in Spring 1.0 RC2 and above.

#### **6.2.6. Custom pointcuts**

Because pointcuts in Spring AOP are Java classes, rather than language features (as in AspectJ) it’s possible to declare custom pointcuts, whether static or dynamic. Custom pointcuts in Spring can be arbitrarily complex. However, using the AspectJ pointcut expression language is recommended if possible.

|  |  |
| --- | --- |
|  | Later versions of Spring may offer support for "semantic pointcuts" as offered by JAC: for example, "all methods that change instance variables in the target object." |

### **6.3. Advice API in Spring**

Let’s now look at how Spring AOP handles advice.

#### **6.3.1. Advice lifecycles**

Each advice is a Spring bean. An advice instance can be shared across all advised objects, or unique to each advised object. This corresponds to per-class or per-instance advice.

Per-class advice is used most often. It is appropriate for generic advice such as transaction advisors. These do not depend on the state of the proxied object or add new state; they merely act on the method and arguments.

Per-instance advice is appropriate for introductions, to support mixins. In this case, the advice adds state to the proxied object.

It’s possible to use a mix of shared and per-instance advice in the same AOP proxy.

#### **6.3.2. Advice types in Spring**

Spring provides several advice types out of the box, and is extensible to support arbitrary advice types. Let us look at the basic concepts and standard advice types.

##### **Interception around advice**

The most fundamental advice type in Spring is interception around advice.

Spring is compliant with the AOP Alliance interface for around advice using method interception. MethodInterceptors implementing around advice should implement the following interface:

**public** **interface** **MethodInterceptor** **extends** Interceptor {

Object invoke(MethodInvocation invocation) **throws** Throwable;

}

The MethodInvocation argument to the invoke() method exposes the method being invoked; the target join point; the AOP proxy; and the arguments to the method. The invoke() method should return the invocation’s result: the return value of the join point.

A simple MethodInterceptor implementation looks as follows:

**public** **class** **DebugInterceptor** **implements** MethodInterceptor {

**public** Object invoke(MethodInvocation invocation) **throws** Throwable {

System.out.println("Before: invocation=[" + invocation + "]");

Object rval = invocation.proceed();

System.out.println("Invocation returned");

**return** rval;

}

}

Note the call to the MethodInvocation’s proceed() method. This proceeds down the interceptor chain towards the join point. Most interceptors will invoke this method, and return its return value. However, a MethodInterceptor, like any around advice, can return a different value or throw an exception rather than invoke the proceed method. However, you don’t want to do this without good reason!

|  |  |
| --- | --- |
|  | MethodInterceptors offer interoperability with other AOP Alliance-compliant AOP implementations. The other advice types discussed in the remainder of this section implement common AOP concepts, but in a Spring-specific way. While there is an advantage in using the most specific advice type, stick with MethodInterceptor around advice if you are likely to want to run the aspect in another AOP framework. Note that pointcuts are not currently interoperable between frameworks, and the AOP Alliance does not currently define pointcut interfaces. |

##### **Before advice**

A simpler advice type is a before advice. This does not need a MethodInvocation object, since it will only be called before entering the method.

The main advantage of a before advice is that there is no need to invoke the proceed() method, and therefore no possibility of inadvertently failing to proceed down the interceptor chain.

The MethodBeforeAdvice interface is shown below. (Spring’s API design would allow for field before advice, although the usual objects apply to field interception and it’s unlikely that Spring will ever implement it).

**public** **interface** **MethodBeforeAdvice** **extends** BeforeAdvice {

**void** before(Method m, Object**[]** args, Object target) **throws** Throwable;

}

Note the return type is void. Before advice can insert custom behavior before the join point executes, but cannot change the return value. If a before advice throws an exception, this will abort further execution of the interceptor chain. The exception will propagate back up the interceptor chain. If it is unchecked, or on the signature of the invoked method, it will be passed directly to the client; otherwise it will be wrapped in an unchecked exception by the AOP proxy.

An example of a before advice in Spring, which counts all method invocations:

**public** **class** **CountingBeforeAdvice** **implements** MethodBeforeAdvice {

**private** **int** count;

**public** **void** before(Method m, Object**[]** args, Object target) **throws** Throwable {

++count;

}

**public** **int** getCount() {

**return** count;

}

}

|  |  |
| --- | --- |
|  | Before advice can be used with any pointcut. |

##### **Throws advice**

Throws advice is invoked after the return of the join point if the join point threw an exception. Spring offers typed throws advice. Note that this means that the org.springframework.aop.ThrowsAdvice interface does not contain any methods: It is a tag interface identifying that the given object implements one or more typed throws advice methods. These should be in the form of:

afterThrowing([Method, args, target], subclassOfThrowable)

Only the last argument is required. The method signatures may have either one or four arguments, depending on whether the advice method is interested in the method and arguments. The following classes are examples of throws advice.

The advice below is invoked if a RemoteException is thrown (including subclasses):

**public** **class** **RemoteThrowsAdvice** **implements** ThrowsAdvice {

**public** **void** afterThrowing(RemoteException ex) **throws** Throwable {

*// Do something with remote exception*

}

}

The following advice is invoked if a ServletException is thrown. Unlike the above advice, it declares 4 arguments, so that it has access to the invoked method, method arguments and target object:

**public** **class** **ServletThrowsAdviceWithArguments** **implements** ThrowsAdvice {

**public** **void** afterThrowing(Method m, Object**[]** args, Object target, ServletException ex) {

*// Do something with all arguments*

}

}

The final example illustrates how these two methods could be used in a single class, which handles both RemoteException and ServletException. Any number of throws advice methods can be combined in a single class.

**public** **static** **class** **CombinedThrowsAdvice** **implements** ThrowsAdvice {

**public** **void** afterThrowing(RemoteException ex) **throws** Throwable {

*// Do something with remote exception*

}

**public** **void** afterThrowing(Method m, Object**[]** args, Object target, ServletException ex) {

*// Do something with all arguments*

}

}

|  |  |
| --- | --- |
|  | If a throws-advice method throws an exception itself, it will override the original exception (i.e. change the exception thrown to the user). The overriding exception will typically be a RuntimeException; this is compatible with any method signature. However, if a throws-advice method throws a checked exception, it will have to match the declared exceptions of the target method and is hence to some degree coupled to specific target method signatures. Do not throw an undeclared checked exception that is incompatible with the target method’s signature! |
|  | Throws advice can be used with any pointcut. |

##### **After Returning advice**

An after returning advice in Spring must implement the org.springframework.aop.AfterReturningAdvice interface, shown below:

**public** **interface** **AfterReturningAdvice** **extends** Advice {

**void** afterReturning(Object returnValue, Method m, Object**[]** args, Object target)

**throws** Throwable;

}

An after returning advice has access to the return value (which it cannot modify), invoked method, methods arguments and target.

The following after returning advice counts all successful method invocations that have not thrown exceptions:

**public** **class** **CountingAfterReturningAdvice** **implements** AfterReturningAdvice {

**private** **int** count;

**public** **void** afterReturning(Object returnValue, Method m, Object**[]** args, Object target)

**throws** Throwable {

++count;

}

**public** **int** getCount() {

**return** count;

}

}

This advice doesn’t change the execution path. If it throws an exception, this will be thrown up the interceptor chain instead of the return value.

|  |  |
| --- | --- |
|  | After returning advice can be used with any pointcut. |

##### **Introduction advice**

Spring treats introduction advice as a special kind of interception advice.

Introduction requires an IntroductionAdvisor, and an IntroductionInterceptor, implementing the following interface:

**public** **interface** **IntroductionInterceptor** **extends** MethodInterceptor {

**boolean** implementsInterface(Class intf);

}

The invoke() method inherited from the AOP Alliance MethodInterceptor interface must implement the introduction: that is, if the invoked method is on an introduced interface, the introduction interceptor is responsible for handling the method call - it cannot invoke proceed().

Introduction advice cannot be used with any pointcut, as it applies only at class, rather than method, level. You can only use introduction advice with the IntroductionAdvisor, which has the following methods:

**public** **interface** **IntroductionAdvisor** **extends** Advisor, IntroductionInfo {

ClassFilter getClassFilter();

**void** validateInterfaces() **throws** IllegalArgumentException;

}

**public** **interface** **IntroductionInfo** {

Class**[]** getInterfaces();

}

There is no MethodMatcher, and hence no Pointcut, associated with introduction advice. Only class filtering is logical.

The getInterfaces() method returns the interfaces introduced by this advisor.

The validateInterfaces() method is used internally to see whether or not the introduced interfaces can be implemented by the configured IntroductionInterceptor.

Let’s look at a simple example from the Spring test suite. Let’s suppose we want to introduce the following interface to one or more objects:

**public** **interface** **Lockable** {

**void** lock();

**void** unlock();

**boolean** locked();

}

This illustrates a mixin. We want to be able to cast advised objects to Lockable, whatever their type, and call lock and unlock methods. If we call the lock() method, we want all setter methods to throw a LockedException. Thus we can add an aspect that provides the ability to make objects immutable, without them having any knowledge of it: a good example of AOP.

Firstly, we’ll need an IntroductionInterceptor that does the heavy lifting. In this case, we extend the org.springframework.aop.support.DelegatingIntroductionInterceptor convenience class. We could implement IntroductionInterceptor directly, but using DelegatingIntroductionInterceptor is best for most cases.

The DelegatingIntroductionInterceptor is designed to delegate an introduction to an actual implementation of the introduced interface(s), concealing the use of interception to do so. The delegate can be set to any object using a constructor argument; the default delegate (when the no-arg constructor is used) is this. Thus in the example below, the delegate is the LockMixin subclass of DelegatingIntroductionInterceptor. Given a delegate (by default itself), a DelegatingIntroductionInterceptor instance looks for all interfaces implemented by the delegate (other than IntroductionInterceptor), and will support introductions against any of them. It’s possible for subclasses such as LockMixin to call the suppressInterface(Class intf) method to suppress interfaces that should not be exposed. However, no matter how many interfaces an IntroductionInterceptor is prepared to support, the IntroductionAdvisor used will control which interfaces are actually exposed. An introduced interface will conceal any implementation of the same interface by the target.

Thus LockMixin extends DelegatingIntroductionInterceptor and implements Lockable itself. The superclass automatically picks up that Lockable can be supported for introduction, so we don’t need to specify that. We could introduce any number of interfaces in this way.

Note the use of the locked instance variable. This effectively adds additional state to that held in the target object.

**public** **class** **LockMixin** **extends** DelegatingIntroductionInterceptor **implements** Lockable {

**private** **boolean** locked;

**public** **void** lock() {

this.locked = true;

}

**public** **void** unlock() {

this.locked = false;

}

**public** **boolean** locked() {

**return** this.locked;

}

**public** Object invoke(MethodInvocation invocation) **throws** Throwable {

**if** (locked() && invocation.getMethod().getName().indexOf("set") == 0) {

**throw** **new** LockedException();

}

**return** super.invoke(invocation);

}

}

Often it isn’t necessary to override the invoke() method: the DelegatingIntroductionInterceptor implementation - which calls the delegate method if the method is introduced, otherwise proceeds towards the join point - is usually sufficient. In the present case, we need to add a check: no setter method can be invoked if in locked mode.

The introduction advisor required is simple. All it needs to do is hold a distinct LockMixin instance, and specify the introduced interfaces - in this case, just Lockable. A more complex example might take a reference to the introduction interceptor (which would be defined as a prototype): in this case, there’s no configuration relevant for a LockMixin, so we simply create it using new.

**public** **class** **LockMixinAdvisor** **extends** DefaultIntroductionAdvisor {

**public** LockMixinAdvisor() {

super(**new** LockMixin(), Lockable.class);

}

}

We can apply this advisor very simply: it requires no configuration. (However, it is necessary: It’s impossible to use an IntroductionInterceptor without an IntroductionAdvisor.) As usual with introductions, the advisor must be per-instance, as it is stateful. We need a different instance of LockMixinAdvisor, and hence LockMixin, for each advised object. The advisor comprises part of the advised object’s state.

We can apply this advisor programmatically, using the Advised.addAdvisor() method, or (the recommended way) in XML configuration, like any other advisor. All proxy creation choices discussed below, including "auto proxy creators," correctly handle introductions and stateful mixins.

### **6.4. Advisor API in Spring**

In Spring, an Advisor is an aspect that contains just a single advice object associated with a pointcut expression.

Apart from the special case of introductions, any advisor can be used with any advice. org.springframework.aop.support.DefaultPointcutAdvisor is the most commonly used advisor class. For example, it can be used with a MethodInterceptor, BeforeAdvice or ThrowsAdvice.

It is possible to mix advisor and advice types in Spring in the same AOP proxy. For example, you could use a interception around advice, throws advice and before advice in one proxy configuration: Spring will automatically create the necessary interceptor chain.

### **6.5. Using the ProxyFactoryBean to create AOP proxies**

If you’re using the Spring IoC container (an ApplicationContext or BeanFactory) for your business objects - and you should be! - you will want to use one of Spring’s AOP FactoryBeans. (Remember that a factory bean introduces a layer of indirection, enabling it to create objects of a different type.)

|  |  |
| --- | --- |
|  | The Spring AOP support also uses factory beans under the covers. |

The basic way to create an AOP proxy in Spring is to use the org.springframework.aop.framework.ProxyFactoryBean. This gives complete control over the pointcuts and advice that will apply, and their ordering. However, there are simpler options that are preferable if you don’t need such control.

#### **6.5.1. Basics**

The ProxyFactoryBean, like other Spring FactoryBean implementations, introduces a level of indirection. If you define a ProxyFactoryBean with name foo, what objects referencing foo see is not the ProxyFactoryBean instance itself, but an object created by the ProxyFactoryBean's implementation of the getObject() method. This method will create an AOP proxy wrapping a target object.

One of the most important benefits of using a ProxyFactoryBean or another IoC-aware class to create AOP proxies, is that it means that advices and pointcuts can also be managed by IoC. This is a powerful feature, enabling certain approaches that are hard to achieve with other AOP frameworks. For example, an advice may itself reference application objects (besides the target, which should be available in any AOP framework), benefiting from all the pluggability provided by Dependency Injection.

#### **6.5.2. JavaBean properties**

In common with most FactoryBean implementations provided with Spring, the ProxyFactoryBean class is itself a JavaBean. Its properties are used to:

* Specify the target you want to proxy.
* Specify whether to use CGLIB (see below and also [JDK- and CGLIB-based proxies](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-pfb-proxy-types)).

Some key properties are inherited from org.springframework.aop.framework.ProxyConfig (the superclass for all AOP proxy factories in Spring). These key properties include:

* proxyTargetClass: true if the target class is to be proxied, rather than the target class' interfaces. If this property value is set to true, then CGLIB proxies will be created (but see also [JDK- and CGLIB-based proxies](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-pfb-proxy-types)).
* optimize: controls whether or not aggressive optimizations are applied to proxies created via CGLIB. One should not blithely use this setting unless one fully understands how the relevant AOP proxy handles optimization. This is currently used only for CGLIB proxies; it has no effect with JDK dynamic proxies.
* frozen: if a proxy configuration is frozen, then changes to the configuration are no longer allowed. This is useful both as a slight optimization and for those cases when you don’t want callers to be able to manipulate the proxy (via the Advised interface) after the proxy has been created. The default value of this property is false, so changes such as adding additional advice are allowed.
* exposeProxy: determines whether or not the current proxy should be exposed in a ThreadLocal so that it can be accessed by the target. If a target needs to obtain the proxy and the exposeProxy property is set to true, the target can use the AopContext.currentProxy() method.

Other properties specific to ProxyFactoryBean include:

* proxyInterfaces: array of String interface names. If this isn’t supplied, a CGLIB proxy for the target class will be used (but see also [JDK- and CGLIB-based proxies](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-pfb-proxy-types)).
* interceptorNames: String array of Advisor, interceptor or other advice names to apply. Ordering is significant, on a first come-first served basis. That is to say that the first interceptor in the list will be the first to be able to intercept the invocation.

The names are bean names in the current factory, including bean names from ancestor factories. You can’t mention bean references here since doing so would result in the ProxyFactoryBean ignoring the singleton setting of the advice.

You can append an interceptor name with an asterisk ( \*). This will result in the application of all advisor beans with names starting with the part before the asterisk to be applied. An example of using this feature can be found in [Using 'global' advisors](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-global-advisors).

* singleton: whether or not the factory should return a single object, no matter how often the getObject() method is called. Several FactoryBean implementations offer such a method. The default value is true. If you want to use stateful advice - for example, for stateful mixins - use prototype advices along with a singleton value of false.

#### **6.5.3. JDK- and CGLIB-based proxies**

This section serves as the definitive documentation on how the ProxyFactoryBean chooses to create one of either a JDK- and CGLIB-based proxy for a particular target object (that is to be proxied).

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| --- | --- |
|  | The behavior of the ProxyFactoryBean with regard to creating JDK- or CGLIB-based proxies changed between versions 1.2.x and 2.0 of Spring. The ProxyFactoryBean now exhibits similar semantics with regard to auto-detecting interfaces as those of the TransactionProxyFactoryBean class. |

If the class of a target object that is to be proxied (hereafter simply referred to as the target class) doesn’t implement any interfaces, then a CGLIB-based proxy will be created. This is the easiest scenario, because JDK proxies are interface based, and no interfaces means JDK proxying isn’t even possible. One simply plugs in the target bean, and specifies the list of interceptors via the interceptorNames property. Note that a CGLIB-based proxy will be created even if the proxyTargetClass property of the ProxyFactoryBean has been set to false. (Obviously this makes no sense, and is best removed from the bean definition because it is at best redundant, and at worst confusing.)

If the target class implements one (or more) interfaces, then the type of proxy that is created depends on the configuration of the ProxyFactoryBean.

If the proxyTargetClass property of the ProxyFactoryBean has been set to true, then a CGLIB-based proxy will be created. This makes sense, and is in keeping with the principle of least surprise. Even if the proxyInterfaces property of the ProxyFactoryBean has been set to one or more fully qualified interface names, the fact that the proxyTargetClass property is set to true will cause CGLIB-based proxying to be in effect.

If the proxyInterfaces property of the ProxyFactoryBean has been set to one or more fully qualified interface names, then a JDK-based proxy will be created. The created proxy will implement all of the interfaces that were specified in the proxyInterfaces property; if the target class happens to implement a whole lot more interfaces than those specified in the proxyInterfaces property, that is all well and good but those additional interfaces will not be implemented by the returned proxy.

If the proxyInterfaces property of the ProxyFactoryBean has not been set, but the target class does implement one (or more) interfaces, then the ProxyFactoryBean will auto-detect the fact that the target class does actually implement at least one interface, and a JDK-based proxy will be created. The interfaces that are actually proxied will be all of the interfaces that the target class implements; in effect, this is the same as simply supplying a list of each and every interface that the target class implements to the proxyInterfaces property. However, it is significantly less work, and less prone to typos.

#### **6.5.4. Proxying interfaces**

Let’s look at a simple example of ProxyFactoryBean in action. This example involves:

* A target bean that will be proxied. This is the "personTarget" bean definition in the example below.
* An Advisor and an Interceptor used to provide advice.
* An AOP proxy bean definition specifying the target object (the personTarget bean) and the interfaces to proxy, along with the advices to apply.

<bean id="personTarget" class="com.mycompany.PersonImpl">

<property name="name" value="Tony"/>

<property name="age" value="51"/>

</bean>

<bean id="myAdvisor" class="com.mycompany.MyAdvisor">

<property name="someProperty" value="Custom string property value"/>

</bean>

<bean id="debugInterceptor" class="org.springframework.aop.interceptor.DebugInterceptor">

</bean>

<bean id="person"

class="org.springframework.aop.framework.ProxyFactoryBean">

<property name="proxyInterfaces" value="com.mycompany.Person"/>

<property name="target" ref="personTarget"/>

<property name="interceptorNames">

<list>

<value>myAdvisor</value>

<value>debugInterceptor</value>

</list>

</property>

</bean>

Note that the interceptorNames property takes a list of String: the bean names of the interceptor or advisors in the current factory. Advisors, interceptors, before, after returning and throws advice objects can be used. The ordering of advisors is significant.

|  |  |
| --- | --- |
|  | You might be wondering why the list doesn’t hold bean references. The reason for this is that if the ProxyFactoryBean’s singleton property is set to false, it must be able to return independent proxy instances. If any of the advisors is itself a prototype, an independent instance would need to be returned, so it’s necessary to be able to obtain an instance of the prototype from the factory; holding a reference isn’t sufficient. |

The "person" bean definition above can be used in place of a Person implementation, as follows:

Person person = (Person) factory.getBean("person");

Other beans in the same IoC context can express a strongly typed dependency on it, as with an ordinary Java object:

<bean id="personUser" class="com.mycompany.PersonUser">

<property name="person"><ref bean="person"/></property>

</bean>

The PersonUser class in this example would expose a property of type Person. As far as it’s concerned, the AOP proxy can be used transparently in place of a "real" person implementation. However, its class would be a dynamic proxy class. It would be possible to cast it to the Advised interface (discussed below).

It’s possible to conceal the distinction between target and proxy using an anonymous inner bean, as follows. Only the ProxyFactoryBean definition is different; the advice is included only for completeness:

<bean id="myAdvisor" class="com.mycompany.MyAdvisor">

<property name="someProperty" value="Custom string property value"/>

</bean>

<bean id="debugInterceptor" class="org.springframework.aop.interceptor.DebugInterceptor"/>

<bean id="person" class="org.springframework.aop.framework.ProxyFactoryBean">

<property name="proxyInterfaces" value="com.mycompany.Person"/>

*<!-- Use inner bean, not local reference to target -->*

<property name="target">

<bean class="com.mycompany.PersonImpl">

<property name="name" value="Tony"/>

<property name="age" value="51"/>

</bean>

</property>

<property name="interceptorNames">

<list>

<value>myAdvisor</value>

<value>debugInterceptor</value>

</list>

</property>

</bean>

This has the advantage that there’s only one object of type Person: useful if we want to prevent users of the application context from obtaining a reference to the un-advised object, or need to avoid any ambiguity with Spring IoC autowiring. There’s also arguably an advantage in that the ProxyFactoryBean definition is self-contained. However, there are times when being able to obtain the un-advised target from the factory might actually be an advantage: for example, in certain test scenarios.

#### **6.5.5. Proxying classes**

What if you need to proxy a class, rather than one or more interfaces?

Imagine that in our example above, there was no Person interface: we needed to advise a class called Person that didn’t implement any business interface. In this case, you can configure Spring to use CGLIB proxying, rather than dynamic proxies. Simply set the proxyTargetClass property on the ProxyFactoryBean above to true. While it’s best to program to interfaces, rather than classes, the ability to advise classes that don’t implement interfaces can be useful when working with legacy code. (In general, Spring isn’t prescriptive. While it makes it easy to apply good practices, it avoids forcing a particular approach.)

If you want to, you can force the use of CGLIB in any case, even if you do have interfaces.

CGLIB proxying works by generating a subclass of the target class at runtime. Spring configures this generated subclass to delegate method calls to the original target: the subclass is used to implement the Decorator pattern, weaving in the advice.

CGLIB proxying should generally be transparent to users. However, there are some issues to consider:

* Final methods can’t be advised, as they can’t be overridden.
* There is no need to add CGLIB to your classpath. As of Spring 3.2, CGLIB is repackaged and included in the spring-core JAR. In other words, CGLIB-based AOP will work "out of the box" just as do JDK dynamic proxies.

There’s little performance difference between CGLIB proxying and dynamic proxies. As of Spring 1.0, dynamic proxies are slightly faster. However, this may change in the future. Performance should not be a decisive consideration in this case.

#### **6.5.6. Using 'global' advisors**

By appending an asterisk to an interceptor name, all advisors with bean names matching the part before the asterisk, will be added to the advisor chain. This can come in handy if you need to add a standard set of 'global' advisors:

<bean id="proxy" class="org.springframework.aop.framework.ProxyFactoryBean">

<property name="target" ref="service"/>

<property name="interceptorNames">

<list>

<value>global\*</value>

</list>

</property>

</bean>

<bean id="global\_debug" class="org.springframework.aop.interceptor.DebugInterceptor"/>

<bean id="global\_performance" class="org.springframework.aop.interceptor.PerformanceMonitorInterceptor"/>

### **6.6. Concise proxy definitions**

Especially when defining transactional proxies, you may end up with many similar proxy definitions. The use of parent and child bean definitions, along with inner bean definitions, can result in much cleaner and more concise proxy definitions.

First a parent, template, bean definition is created for the proxy:

<bean id="txProxyTemplate" abstract="true"

class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">

<property name="transactionManager" ref="transactionManager"/>

<property name="transactionAttributes">

<props>

<prop key="\*">PROPAGATION\_REQUIRED</prop>

</props>

</property>

</bean>

This will never be instantiated itself, so may actually be incomplete. Then each proxy which needs to be created is just a child bean definition, which wraps the target of the proxy as an inner bean definition, since the target will never be used on its own anyway.

<bean id="myService" parent="txProxyTemplate">

<property name="target">

<bean class="org.springframework.samples.MyServiceImpl">

</bean>

</property>

</bean>

It is of course possible to override properties from the parent template, such as in this case, the transaction propagation settings:

<bean id="mySpecialService" parent="txProxyTemplate">

<property name="target">

<bean class="org.springframework.samples.MySpecialServiceImpl">

</bean>

</property>

<property name="transactionAttributes">

<props>

<prop key="get\*">PROPAGATION\_REQUIRED,readOnly</prop>

<prop key="find\*">PROPAGATION\_REQUIRED,readOnly</prop>

<prop key="load\*">PROPAGATION\_REQUIRED,readOnly</prop>

<prop key="store\*">PROPAGATION\_REQUIRED</prop>

</props>

</property>

</bean>

Note that in the example above, we have explicitly marked the parent bean definition as abstract by using the abstract attribute, as described [previously](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-child-bean-definitions), so that it may not actually ever be instantiated. Application contexts (but not simple bean factories) will by default pre-instantiate all singletons. It is therefore 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 try to pre-instantiate it.

### **6.7. Creating AOP proxies programmatically with the ProxyFactory**

It’s easy to create AOP proxies programmatically using Spring. This enables you to use Spring AOP without dependency on Spring IoC.

The following listing shows creation of a proxy for a target object, with one interceptor and one advisor. The interfaces implemented by the target object will automatically be proxied:

ProxyFactory factory = **new** ProxyFactory(myBusinessInterfaceImpl);

factory.addAdvice(myMethodInterceptor);

factory.addAdvisor(myAdvisor);

MyBusinessInterface tb = (MyBusinessInterface) factory.getProxy();

The first step is to construct an object of type org.springframework.aop.framework.ProxyFactory. You can create this with a target object, as in the above example, or specify the interfaces to be proxied in an alternate constructor.

You can add advices (with interceptors as a specialized kind of advice) and/or advisors, and manipulate them for the life of the ProxyFactory. If you add an IntroductionInterceptionAroundAdvisor, you can cause the proxy to implement additional interfaces.

There are also convenience methods on ProxyFactory (inherited from AdvisedSupport) which allow you to add other advice types such as before and throws advice. AdvisedSupport is the superclass of both ProxyFactory and ProxyFactoryBean.

|  |  |
| --- | --- |
|  | Integrating AOP proxy creation with the IoC framework is best practice in most applications. We recommend that you externalize configuration from Java code with AOP, as in general. |

### **6.8. Manipulating advised objects**

However you create AOP proxies, you can manipulate them using the org.springframework.aop.framework.Advised interface. Any AOP proxy can be cast to this interface, whichever other interfaces it implements. This interface includes the following methods:

Advisor**[]** getAdvisors();

**void** addAdvice(Advice advice) **throws** AopConfigException;

**void** addAdvice(**int** pos, Advice advice) **throws** AopConfigException;

**void** addAdvisor(Advisor advisor) **throws** AopConfigException;

**void** addAdvisor(**int** pos, Advisor advisor) **throws** AopConfigException;

**int** indexOf(Advisor advisor);

**boolean** removeAdvisor(Advisor advisor) **throws** AopConfigException;

**void** removeAdvisor(**int** index) **throws** AopConfigException;

**boolean** replaceAdvisor(Advisor a, Advisor b) **throws** AopConfigException;

**boolean** isFrozen();

The getAdvisors() method will return an Advisor for every advisor, interceptor or other advice type that has been added to the factory. If you added an Advisor, the returned advisor at this index will be the object that you added. If you added an interceptor or other advice type, Spring will have wrapped this in an advisor with a pointcut that always returns true. Thus if you added a MethodInterceptor, the advisor returned for this index will be an DefaultPointcutAdvisor returning your MethodInterceptor and a pointcut that matches all classes and methods.

The addAdvisor() methods can be used to add any Advisor. Usually the advisor holding pointcut and advice will be the generic DefaultPointcutAdvisor, which can be used with any advice or pointcut (but not for introductions).

By default, it’s possible to add or remove advisors or interceptors even once a proxy has been created. The only restriction is that it’s impossible to add or remove an introduction advisor, as existing proxies from the factory will not show the interface change. (You can obtain a new proxy from the factory to avoid this problem.)

A simple example of casting an AOP proxy to the Advised interface and examining and manipulating its advice:

Advised advised = (Advised) myObject;

Advisor**[]** advisors = advised.getAdvisors();

**int** oldAdvisorCount = advisors.length;

System.out.println(oldAdvisorCount + " advisors");

*// Add an advice like an interceptor without a pointcut*

*// Will match all proxied methods*

*// Can use for interceptors, before, after returning or throws advice*

advised.addAdvice(**new** DebugInterceptor());

*// Add selective advice using a pointcut*

advised.addAdvisor(**new** DefaultPointcutAdvisor(mySpecialPointcut, myAdvice));

assertEquals("Added two advisors", oldAdvisorCount + 2, advised.getAdvisors().length);

|  |  |
| --- | --- |
|  | It’s questionable whether it’s advisable (no pun intended) to modify advice on a business object in production, although there are no doubt legitimate usage cases. However, it can be very useful in development: for example, in tests. I have sometimes found it very useful to be able to add test code in the form of an interceptor or other advice, getting inside a method invocation I want to test. (For example, the advice can get inside a transaction created for that method: for example, to run SQL to check that a database was correctly updated, before marking the transaction for roll back.) |

Depending on how you created the proxy, you can usually set a frozen flag, in which case the Advised isFrozen() method will return true, and any attempts to modify advice through addition or removal will result in an AopConfigException. The ability to freeze the state of an advised object is useful in some cases, for example, to prevent calling code removing a security interceptor. It may also be used in Spring 1.1 to allow aggressive optimization if runtime advice modification is known not to be required.

### **6.9. Using the "auto-proxy" facility**

So far we’ve considered explicit creation of AOP proxies using a ProxyFactoryBean or similar factory bean.

Spring also allows us to use "auto-proxy" bean definitions, which can automatically proxy selected bean definitions. This is built on Spring "bean post processor" infrastructure, which enables modification of any bean definition as the container loads.

In this model, you set up some special bean definitions in your XML bean definition file to configure the auto proxy infrastructure. This allows you just to declare the targets eligible for auto-proxying: you don’t need to use ProxyFactoryBean.

There are two ways to do this:

* Using an auto-proxy creator that refers to specific beans in the current context.
* A special case of auto-proxy creation that deserves to be considered separately; auto-proxy creation driven by source-level metadata attributes.

#### **6.9.1. Autoproxy bean definitions**

The org.springframework.aop.framework.autoproxy package provides the following standard auto-proxy creators.

##### **BeanNameAutoProxyCreator**

The BeanNameAutoProxyCreator class is a BeanPostProcessor that automatically creates AOP proxies for beans with names matching literal values or wildcards.

<bean class="org.springframework.aop.framework.autoproxy.BeanNameAutoProxyCreator">

<property name="beanNames" value="jdk\*,onlyJdk"/>

<property name="interceptorNames">

<list>

<value>myInterceptor</value>

</list>

</property>

</bean>

As with ProxyFactoryBean, there is an interceptorNames property rather than a list of interceptors, to allow correct behavior for prototype advisors. Named "interceptors" can be advisors or any advice type.

As with auto proxying in general, the main point of using BeanNameAutoProxyCreator is to apply the same configuration consistently to multiple objects, with minimal volume of configuration. It is a popular choice for applying declarative transactions to multiple objects.

Bean definitions whose names match, such as "jdkMyBean" and "onlyJdk" in the above example, are plain old bean definitions with the target class. An AOP proxy will be created automatically by the BeanNameAutoProxyCreator. The same advice will be applied to all matching beans. Note that if advisors are used (rather than the interceptor in the above example), the pointcuts may apply differently to different beans.

##### **DefaultAdvisorAutoProxyCreator**

A more general and extremely powerful auto proxy creator is DefaultAdvisorAutoProxyCreator. This will automagically apply eligible advisors in the current context, without the need to include specific bean names in the auto-proxy advisor’s bean definition. It offers the same merit of consistent configuration and avoidance of duplication as BeanNameAutoProxyCreator.

Using this mechanism involves:

* Specifying a DefaultAdvisorAutoProxyCreator bean definition.
* Specifying any number of Advisors in the same or related contexts. Note that these must be Advisors, not just interceptors or other advices. This is necessary because there must be a pointcut to evaluate, to check the eligibility of each advice to candidate bean definitions.

The DefaultAdvisorAutoProxyCreator will automatically evaluate the pointcut contained in each advisor, to see what (if any) advice it should apply to each business object (such as "businessObject1" and "businessObject2" in the example).

This means that any number of advisors can be applied automatically to each business object. If no pointcut in any of the advisors matches any method in a business object, the object will not be proxied. As bean definitions are added for new business objects, they will automatically be proxied if necessary.

Autoproxying in general has the advantage of making it impossible for callers or dependencies to obtain an un-advised object. Calling getBean("businessObject1") on this ApplicationContext will return an AOP proxy, not the target business object. (The "inner bean" idiom shown earlier also offers this benefit.)

<bean class="org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreator"/>

<bean class="org.springframework.transaction.interceptor.TransactionAttributeSourceAdvisor">

<property name="transactionInterceptor" ref="transactionInterceptor"/>

</bean>

<bean id="customAdvisor" class="com.mycompany.MyAdvisor"/>

<bean id="businessObject1" class="com.mycompany.BusinessObject1">

*<!-- Properties omitted -->*

</bean>

<bean id="businessObject2" class="com.mycompany.BusinessObject2"/>

The DefaultAdvisorAutoProxyCreator is very useful if you want to apply the same advice consistently to many business objects. Once the infrastructure definitions are in place, you can simply add new business objects without including specific proxy configuration. You can also drop in additional aspects very easily - for example, tracing or performance monitoring aspects - with minimal change to configuration.

The DefaultAdvisorAutoProxyCreator offers support for filtering (using a naming convention so that only certain advisors are evaluated, allowing use of multiple, differently configured, AdvisorAutoProxyCreators in the same factory) and ordering. Advisors can implement the org.springframework.core.Ordered interface to ensure correct ordering if this is an issue. The TransactionAttributeSourceAdvisor used in the above example has a configurable order value; the default setting is unordered.

### **6.10. Using TargetSources**

Spring offers the concept of a TargetSource, expressed in the org.springframework.aop.TargetSource interface. This interface is responsible for returning the "target object" implementing the join point. The TargetSource implementation is asked for a target instance each time the AOP proxy handles a method invocation.

Developers using Spring AOP don’t normally need to work directly with TargetSources, but this provides a powerful means of supporting pooling, hot swappable and other sophisticated targets. For example, a pooling TargetSource can return a different target instance for each invocation, using a pool to manage instances.

If you do not specify a TargetSource, a default implementation is used that wraps a local object. The same target is returned for each invocation (as you would expect).

Let’s look at the standard target sources provided with Spring, and how you can use them.

|  |  |
| --- | --- |
|  | When using a custom target source, your target will usually need to be a prototype rather than a singleton bean definition. This allows Spring to create a new target instance when required. |

#### **6.10.1. Hot swappable target sources**

The org.springframework.aop.target.HotSwappableTargetSource exists to allow the target of an AOP proxy to be switched while allowing callers to keep their references to it.

Changing the target source’s target takes effect immediately. The HotSwappableTargetSource is threadsafe.

You can change the target via the swap() method on HotSwappableTargetSource as follows:

HotSwappableTargetSource swapper = (HotSwappableTargetSource) beanFactory.getBean("swapper");

Object oldTarget = swapper.swap(newTarget);

The XML definitions required look as follows:

<bean id="initialTarget" class="mycompany.OldTarget"/>

<bean id="swapper" class="org.springframework.aop.target.HotSwappableTargetSource">

<constructor-arg ref="initialTarget"/>

</bean>

<bean id="swappable" class="org.springframework.aop.framework.ProxyFactoryBean">

<property name="targetSource" ref="swapper"/>

</bean>

The above swap() call changes the target of the swappable bean. Clients who hold a reference to that bean will be unaware of the change, but will immediately start hitting the new target.

Although this example doesn’t add any advice - and it’s not necessary to add advice to use a TargetSource - of course any TargetSource can be used in conjunction with arbitrary advice.

#### **6.10.2. Pooling target sources**

Using a pooling target source provides a similar programming model to stateless session EJBs, in which a pool of identical instances is maintained, with method invocations going to free objects in the pool.

A crucial difference between Spring pooling and SLSB pooling is that Spring pooling can be applied to any POJO. As with Spring in general, this service can be applied in a non-invasive way.

Spring provides out-of-the-box support for Commons Pool 2.2, which provides a fairly efficient pooling implementation. You’ll need the commons-pool Jar on your application’s classpath to use this feature. It’s also possible to subclass org.springframework.aop.target.AbstractPoolingTargetSource to support any other pooling API.

|  |  |
| --- | --- |
|  | Commons Pool 1.5+ is also supported but deprecated as of Spring Framework 4.2. |

Sample configuration is shown below:

<bean id="businessObjectTarget" class="com.mycompany.MyBusinessObject"

scope="prototype">

... properties omitted

</bean>

<bean id="poolTargetSource" class="org.springframework.aop.target.CommonsPool2TargetSource">

<property name="targetBeanName" value="businessObjectTarget"/>

<property name="maxSize" value="25"/>

</bean>

<bean id="businessObject" class="org.springframework.aop.framework.ProxyFactoryBean">

<property name="targetSource" ref="poolTargetSource"/>

<property name="interceptorNames" value="myInterceptor"/>

</bean>

Note that the target object - "businessObjectTarget" in the example - must be a prototype. This allows the PoolingTargetSource implementation to create new instances of the target to grow the pool as necessary. See the javadocs of AbstractPoolingTargetSource and the concrete subclass you wish to use for information about its properties: "maxSize" is the most basic, and always guaranteed to be present.

In this case, "myInterceptor" is the name of an interceptor that would need to be defined in the same IoC context. However, it isn’t necessary to specify interceptors to use pooling. If you want only pooling, and no other advice, don’t set the interceptorNames property at all.

It’s possible to configure Spring so as to be able to cast any pooled object to the org.springframework.aop.target.PoolingConfig interface, which exposes information about the configuration and current size of the pool through an introduction. You’ll need to define an advisor like this:

<bean id="poolConfigAdvisor" class="org.springframework.beans.factory.config.MethodInvokingFactoryBean">

<property name="targetObject" ref="poolTargetSource"/>

<property name="targetMethod" value="getPoolingConfigMixin"/>

</bean>

This advisor is obtained by calling a convenience method on the AbstractPoolingTargetSource class, hence the use of MethodInvokingFactoryBean. This advisor’s name ("poolConfigAdvisor" here) must be in the list of interceptors names in the ProxyFactoryBean exposing the pooled object.

The cast will look as follows:

PoolingConfig conf = (PoolingConfig) beanFactory.getBean("businessObject");

System.out.println("Max pool size is " + conf.getMaxSize());

|  |  |
| --- | --- |
|  | Pooling stateless service objects is not usually necessary. We don’t believe it should be the default choice, as most stateless objects are naturally thread safe, and instance pooling is problematic if resources are cached. |

Simpler pooling is available using auto-proxying. It’s possible to set the TargetSources used by any auto-proxy creator.

#### **6.10.3. Prototype target sources**

Setting up a "prototype" target source is similar to a pooling TargetSource. In this case, a new instance of the target will be created on every method invocation. Although the cost of creating a new object isn’t high in a modern JVM, the cost of wiring up the new object (satisfying its IoC dependencies) may be more expensive. Thus you shouldn’t use this approach without very good reason.

To do this, you could modify the poolTargetSource definition shown above as follows. (I’ve also changed the name, for clarity.)

<bean id="prototypeTargetSource" class="org.springframework.aop.target.PrototypeTargetSource">

<property name="targetBeanName" ref="businessObjectTarget"/>

</bean>

There’s only one property: the name of the target bean. Inheritance is used in the TargetSource implementations to ensure consistent naming. As with the pooling target source, the target bean must be a prototype bean definition.

#### **6.10.4. ThreadLocal target sources**

ThreadLocal target sources are useful if you need an object to be created for each incoming request (per thread that is). The concept of a ThreadLocal provide a JDK-wide facility to transparently store resource alongside a thread. Setting up a ThreadLocalTargetSource is pretty much the same as was explained for the other types of target source:

<bean id="threadlocalTargetSource" class="org.springframework.aop.target.ThreadLocalTargetSource">

<property name="targetBeanName" value="businessObjectTarget"/>

</bean>

|  |  |
| --- | --- |
|  | ThreadLocals come with serious issues (potentially resulting in memory leaks) when incorrectly using them in a multi-threaded and multi-classloader environments. One should always consider wrapping a threadlocal in some other class and never directly use the ThreadLocal itself (except of course in the wrapper class). Also, one should always remember to correctly set and unset (where the latter simply involved a call to ThreadLocal.set(null)) the resource local to the thread. Unsetting should be done in any case since not unsetting it might result in problematic behavior. Spring’s ThreadLocal support does this for you and should always be considered in favor of using ThreadLocals without other proper handling code. |

### **6.11. Defining new Advice types**

Spring AOP is designed to be extensible. While the interception implementation strategy is presently used internally, it is possible to support arbitrary advice types in addition to the out-of-the-box interception around advice, before, throws advice and after returning advice.

The org.springframework.aop.framework.adapter package is an SPI package allowing support for new custom advice types to be added without changing the core framework. The only constraint on a custom Advice type is that it must implement the org.aopalliance.aop.Advice marker interface.

Please refer to the org.springframework.aop.framework.adapter javadocs for further information.

## 7. Null-safety

Although Java does not allow to express null-safety with its type system, Spring Framework now provides following annotations in the org.springframework.lang package to declare nullability of APIs and fields:

* [@NonNull](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/lang/NonNull.html) annotation where specific parameter, return value or field cannot be null (not needed on parameter and return value where @NonNullApi and @NonNullFields apply) .
* [@Nullable](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/lang/Nullable.html) annotation where specific parameter, return value or field can be null.
* [@NonNullApi](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/lang/NonNullApi.html) annotation at package level declares non-null as the default behavior for parameters and return values.
* [@NonNullFields](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/lang/NonNullFields.html) annotation at package level declares non-null as the default behavior for fields.

Spring Framework leverages itself these annotations, but they can also be used in any Spring based Java project to declare null-safe APIs and optionally null-safe fields. Generic type arguments, varargs and array elements nullability are not supported yet, but should be in an upcoming release, see [SPR-15942](https://jira.spring.io/browse/SPR-15942) for up-to-date information. Nullability declaration are expected to be fine-tuned between Spring Framework release, including minor ones. Nullability of types used inside method bodies is outside of the scope of this feature.

|  |  |
| --- | --- |
|  | Libraries like Reactor or Spring Data provide null-safe APIs leveraging this feature. |

### **7.1. Use cases**

In addition to providing an explicit declaration for Spring Framework API nullability, these annotation can be used by IDE (such as IDEA or Eclipse) to provide useful warnings to Java developers related to null-safety in order to avoid NullPointerException at runtime.

They are also used to make Spring API null-safe in Kotlin projects since Kotlin natively supports [null-safety](https://kotlinlang.org/docs/reference/null-safety.html). More details are available in [Kotlin support documentation](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/languages.html#kotlin-null-safety).

### **7.2. JSR 305 meta-annotations**

Spring annotations are meta-annotated with [JSR 305](https://jcp.org/en/jsr/detail?id=305) annotations (a dormant but widely spread JSR). JSR 305 meta-annotations allows tooling vendors like IDEA or Kotlin to provide null-safety support in a generic way, without having to hard-code support for Spring annotations.

It is not necessary nor recommended to add JSR 305 dependency in project classpath to take advantage of Spring null-safe API. Only projects like Spring-based libraries using null-safety annotations in their codebase should add com.google.code.findbugs:jsr305:3.0.2 with compileOnly Gradle configuration or Maven provided scope to avoid compile warnings.

## 8. Data Buffers and Codecs

### **8.1. Introduction**

The DataBuffer interface defines an abstraction over byte buffers. The main reason for introducing it, and not use the standard java.nio.ByteBuffer instead, is Netty. Netty does not use ByteBuffer, but instead offers ByteBuf as an alternative. Spring’s DataBuffer is a simple abstraction over ByteBuf that can also be used on non-Netty platforms (i.e. Servlet 3.1+).

### **8.2. DataBufferFactory**

The DataBufferFactory offers functionality to allocate new data buffers, as well as to wrap existing data. The allocate methods allocate a new data buffer, with a default or given capacity. Though DataBuffer implementation grow and shrink on demand, it is more efficient to give the capacity upfront, if known. The wrap methods decorate an existing ByteBuffer or byte array. Wrapping does not involve allocation: it simply decorates the given data with a DataBuffer implementation.

There are two implementation of DataBufferFactory: the NettyDataBufferFactory which is meant to be used on Netty platforms, such as Reactor Netty. The other implementation, the DefaultDataBufferFactory, is used on other platforms, such as Servlet 3.1+ servers.

### **8.3. The DataBuffer interface**

The DataBuffer interface is similar to ByteBuffer, but offers a number of advantages. Similar to Netty’s ByteBuf, the DataBuffer abstraction offers independent read and write positions. This is different from the JDK’s ByteBuffer, which only exposes one position for both reading and writing, and a separate flip() operation to switch between the two I/O operations. In general, the following invariant holds for the read position, write position, and the capacity:

0 <= read position <= write position <= capacity

When reading bytes from the DataBuffer, the read position is automatically updated in accordance with the amount of data read from the buffer. Similarly, when writing bytes to the DataBuffer, the write position is updated with the amount of data written to the buffer. Also, when writing data, the capacity of a DataBuffer is automatically expanded, just like StringBuilder, ArrayList, and similar types.

Besides the reading and writing functionality mentioned above, the DataBuffer also has methods to view a (slice of a) buffer as ByteBuffer, InputStream, or OutputStream. Additionally, it offers methods to determine the index of a given byte.

There are two implementation of DataBuffer: the NettyDataBuffer which is meant to be used on Netty platforms, such as Reactor Netty. The other implementation, the DefaultDataBuffer, is used on other platforms, such as Servlet 3.1+ servers.

#### **8.3.1. PooledDataBuffer**

The PooledDataBuffer is an extension to DataBuffer that adds methods for reference counting. The retain method increases the reference count by one. The release method decreases the count by one, and releases the buffer’s memory when the count reaches 0. Both of these methods are related to reference counting, a mechanism that is explained below.

Note that DataBufferUtils offers useful utility methods for releasing and retaining pooled data buffers. These methods take a plain DataBuffer as parameter, but only call retain or release if the passed data buffer is an instance of PooledDataBuffer.

##### **Reference Counting**

Reference counting is not a common technique in Java; it is much more common in other programming languages such as Object C and C++. In and of itself, reference counting is not complex: it basically involves tracking the number of references that apply to an object. The reference count of a PooledDataBuffer starts at 1, is incremented by calling retain, and decremented by calling release. As long as the buffer’s reference count is larger than 0 the buffer will not be released. When the number decreases to 0, the instance will be released. In practice, this means that the reserved memory captured by the buffer will be returned back to the memory pool, ready to be used for future allocations.

In general, the last component to access a DataBuffer is responsible for releasing it. Within Spring, there are two sorts of components that release buffers: decoders and transports. Decoders are responsible for transforming a stream of buffers into other types (see [Codecs](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#codecs) below), and transports are responsible for sending buffers across a network boundary, typically as an HTTP message. This means that if you allocate data buffers for the purpose of putting them into an outbound HTTP message (i.e. client-side request or server-side response), they do not have to be released. The other consequence of this rule is that if you allocate data buffers that do not end up in the body, for instance because of a thrown exception, you will have to release them yourself. The following snippet shows a typical DataBuffer usage scenario when dealing with methods that throw exceptions:

DataBufferFactory factory = ...

DataBuffer buffer = factory.allocateBuffer();

**boolean** release = true;

**try** {

writeDataToBuffer(buffer);

putBufferInHttpBody(buffer);

release = false;

}

**finally** {

**if** (release) {

DataBufferUtils.release(buffer);

}

}

**private** **void** writeDataToBuffer(DataBuffer buffer) **throws** IOException {

...

}

|  |  |
| --- | --- |
|  | A new buffer is allocated. |
|  | A boolean flag indicates whether the allocated buffer should be released. |
|  | This example method loads data into the buffer. Note that the method can throw an IOException, and therefore a finally block to release the buffer is required. |
|  | If no exception occurred, we switch the release flag to false as the buffer will now be released as part of sending the HTTP body across the wire. |
|  | If an exception did occur, the flag is still set to true, and the buffer will be released here. |

#### **8.3.2. DataBufferUtils**

DataBufferUtils contains various utility methods that operate on data buffers. It contains methods for reading a Flux of DataBuffer objects from an InputStream or NIO Channel, and methods for writing a data buffer Flux to an OutputStream or Channel. DataBufferUtils also exposes retain and release methods that operate on plain DataBuffer instances (so that casting to a PooledDataBuffer is not required).

Additionally, DataBufferUtils exposes compose, which merges a stream of data buffers into one. For instance, this method can be used to convert the entire HTTP body into a single buffer (and from that, a String, or InputStream). This is particularly useful when dealing with older, blocking APIs. Note, however, that this puts the entire body in memory, and therefore uses more memory than a pure streaming solution would.

### **Codecs**

The org.springframework.core.codec package contains the two main abstractions for converting a stream of bytes into a stream of objects, or vice-versa. The Encoder is a strategy interface that encodes a stream of objects into an output stream of data buffers. The Decoder does the reverse: it turns a stream of data buffers into a stream of objects. Note that a decoder instance needs to consider [reference counting](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#databuffer-reference-counting).

Spring comes with a wide array of default codecs, capable of converting from/to String, ByteBuffer, byte arrays, and also codecs that support marshalling libraries such as JAXB and Jackson (with [Jackson 2.9+ support for non-blocking parsing](https://github.com/FasterXML/jackson-core/issues/57)). Within the context of Spring WebFlux, codecs are used to convert the request body into a @RequestMapping parameter, or to convert the return type into the response body that is sent back to the client. The default codecs are configured in the WebFluxConfigurationSupport class, and can easily be changed by overriding the configureHttpMessageCodecs when inheriting from that class. For more information about using codecs in WebFlux, see [this section](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/web-reactive.html#webflux-codecs).

## 9. Appendix

### **9.1. XML Schemas**

This part of the appendix lists XML schemas related to the core container.

#### **9.1.1. The util schema**

As the name implies, the util tags deal with common, utility configuration issues, such as configuring collections, referencing constants, and suchlike. To use the tags in the util schema, you need to have the following preamble at the top of your Spring XML configuration file; the text in the snippet below references the correct schema so that the tags in the util namespace are available to you.

<?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:util=*"http://www.springframework.org/schema/util"* xsi:schemaLocation="

http://www.springframework.org/schema/beans https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/util https://www.springframework.org/schema/util/spring-util.xsd*"*> *<!-- bean definitions here -->*

</beans>

##### **<util:constant/>**

Before…​

<bean id="..." class="...">

<property name="isolation">

<bean id="java.sql.Connection.TRANSACTION\_SERIALIZABLE"

class="org.springframework.beans.factory.config.FieldRetrievingFactoryBean" />

</property>

</bean>

The above configuration uses a Spring FactoryBean implementation, the FieldRetrievingFactoryBean, to set the value of the isolation property on a bean to the value of the java.sql.Connection.TRANSACTION\_SERIALIZABLE constant. This is all well and good, but it is a tad verbose and (unnecessarily) exposes Spring’s internal plumbing to the end user.

The following XML Schema-based version is more concise and clearly expresses the developer’s intent ('inject this constant value'), and it just reads better.

<bean id="..." class="...">

<property name="isolation">

<util:constant static-field="java.sql.Connection.TRANSACTION\_SERIALIZABLE"/>

</property>

</bean>

###### **Setting a bean property or constructor arg from a field value**

[FieldRetrievingFactoryBean](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/config/FieldRetrievingFactoryBean.html) is a FactoryBean which retrieves a static or non-static field value. It is typically used for retrieving public static final constants, which may then be used to set a property value or constructor arg for another bean.

Find below an example which shows how a static field is exposed, by using the [staticField](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/config/FieldRetrievingFactoryBean.html#setStaticField(java.lang.String)) property:

<bean id="myField"

class="org.springframework.beans.factory.config.FieldRetrievingFactoryBean">

<property name="staticField" value="java.sql.Connection.TRANSACTION\_SERIALIZABLE"/>

</bean>

There is also a convenience usage form where the static field is specified as the bean name:

<bean id="java.sql.Connection.TRANSACTION\_SERIALIZABLE"

class="org.springframework.beans.factory.config.FieldRetrievingFactoryBean"/>

This does mean that there is no longer any choice in what the bean id is (so any other bean that refers to it will also have to use this longer name), but this form is very concise to define, and very convenient to use as an inner bean since the id doesn’t have to be specified for the bean reference:

<bean id="..." class="...">

<property name="isolation">

<bean id="java.sql.Connection.TRANSACTION\_SERIALIZABLE"

class="org.springframework.beans.factory.config.FieldRetrievingFactoryBean" />

</property>

</bean>

It is also possible to access a non-static (instance) field of another bean, as described in the API documentation for the [FieldRetrievingFactoryBean](https://docs.spring.io/spring-framework/docs/5.0.20.RELEASE/javadoc-api/org/springframework/beans/factory/config/FieldRetrievingFactoryBean.html) class.

Injecting enum values into beans as either property or constructor arguments is very easy to do in Spring, in that you don’t actually have to do anything or know anything about the Spring internals (or even about classes such as the FieldRetrievingFactoryBean). Let’s look at an example to see how easy injecting an enum value is; consider this enum:

**package** javax.persistence;

**public** **enum** PersistenceContextType {

TRANSACTION,

EXTENDED

}

Now consider a setter of type PersistenceContextType:

**package** example;

**public** **class** **Client** {

**private** PersistenceContextType persistenceContextType;

**public** **void** setPersistenceContextType(PersistenceContextType type) {

this.persistenceContextType = type;

}

}

1. and the corresponding bean definition:

<bean class="example.Client">

<property name="persistenceContextType" value="TRANSACTION"/>

</bean>

##### **<util:property-path/>**

Before…​

*<!-- target bean to be referenced by name -->*

<bean id="testBean" class="org.springframework.beans.TestBean" scope="prototype">

<property name="age" value="10"/>

<property name="spouse">

<bean class="org.springframework.beans.TestBean">

<property name="age" value="11"/>

</bean>

</property>

</bean>

*<!-- will result in 10, which is the value of property 'age' of bean 'testBean' -->*

<bean id="testBean.age" class="org.springframework.beans.factory.config.PropertyPathFactoryBean"/>

The above configuration uses a Spring FactoryBean implementation, the PropertyPathFactoryBean, to create a bean (of type int) called testBean.age that has a value equal to the age property of the testBean bean.

After…​

*<!-- target bean to be referenced by name -->*

<bean id="testBean" class="org.springframework.beans.TestBean" scope="prototype">

<property name="age" value="10"/>

<property name="spouse">

<bean class="org.springframework.beans.TestBean">

<property name="age" value="11"/>

</bean>

</property>

</bean>

*<!-- will result in 10, which is the value of property 'age' of bean 'testBean' -->*

<util:property-path id="name" path="testBean.age"/>

The value of the path attribute of the <property-path/> tag follows the form beanName.beanProperty.

###### **Using <util:property-path/> to set a bean property or constructor-argument**

PropertyPathFactoryBean is a FactoryBean that evaluates a property path on a given target object. The target object can be specified directly or via a bean name. This value may then be used in another bean definition as a property value or constructor argument.

Here’s an example where a path is used against another bean, by name:

// target bean to be referenced by name

<bean id="person" class="org.springframework.beans.TestBean" scope="prototype">

<property name="age" value="10"/>

<property name="spouse">

<bean class="org.springframework.beans.TestBean">

<property name="age" value="11"/>

</bean>

</property>

</bean>

// will result in 11, which is the value of property 'spouse.age' of bean 'person'

<bean id="theAge"

class="org.springframework.beans.factory.config.PropertyPathFactoryBean">

<property name="targetBeanName" value="person"/>

<property name="propertyPath" value="spouse.age"/>

</bean>

In this example, a path is evaluated against an inner bean:

*<!-- will result in 12, which is the value of property 'age' of the inner bean -->*

<bean id="theAge"

class="org.springframework.beans.factory.config.PropertyPathFactoryBean">

<property name="targetObject">

<bean class="org.springframework.beans.TestBean">

<property name="age" value="12"/>

</bean>

</property>

<property name="propertyPath" value="age"/>

</bean>

There is also a shortcut form, where the bean name is the property path.

*<!-- will result in 10, which is the value of property 'age' of bean 'person' -->*

<bean id="person.age"

class="org.springframework.beans.factory.config.PropertyPathFactoryBean"/>

This form does mean that there is no choice in the name of the bean. Any reference to it will also have to use the same id, which is the path. Of course, if used as an inner bean, there is no need to refer to it at all:

<bean id="..." class="...">

<property name="age">

<bean id="person.age"

class="org.springframework.beans.factory.config.PropertyPathFactoryBean"/>

</property>

</bean>

The result type may be specifically set in the actual definition. This is not necessary for most use cases, but can be of use for some. Please see the Javadocs for more info on this feature.

##### **<util:properties/>**

Before…​

*<!-- creates a java.util.Properties instance with values loaded from the supplied location -->*

<bean id="jdbcConfiguration" class="org.springframework.beans.factory.config.PropertiesFactoryBean">

<property name="location" value="classpath:com/foo/jdbc-production.properties"/>

</bean>

The above configuration uses a Spring FactoryBean implementation, the PropertiesFactoryBean, to instantiate a java.util.Properties instance with values loaded from the supplied [Resource](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#resources) location).

After…​

*<!-- creates a java.util.Properties instance with values loaded from the supplied location -->*

<util:properties id="jdbcConfiguration" location="classpath:com/foo/jdbc-production.properties"/>

##### **<util:list/>**

Before…​

*<!-- creates a java.util.List instance with values loaded from the supplied 'sourceList' -->*

<bean id="emails" class="org.springframework.beans.factory.config.ListFactoryBean">

<property name="sourceList">

<list>

<value>pechorin@hero.org</value>

<value>raskolnikov@slums.org</value>

<value>stavrogin@gov.org</value>

<value>porfiry@gov.org</value>

</list>

</property>

</bean>

The above configuration uses a Spring FactoryBean implementation, the ListFactoryBean, to create a java.util.List instance initialized with values taken from the supplied sourceList.

After…​

*<!-- creates a java.util.List instance with the supplied values -->*

<util:list id="emails">

<value>pechorin@hero.org</value>

<value>raskolnikov@slums.org</value>

<value>stavrogin@gov.org</value>

<value>porfiry@gov.org</value>

</util:list>

You can also explicitly control the exact type of List that will be instantiated and populated via the use of the list-class attribute on the <util:list/> element. For example, if we really need a java.util.LinkedList to be instantiated, we could use the following configuration:

<util:list id="emails" list-class="java.util.LinkedList">

<value>jackshaftoe@vagabond.org</value>

<value>eliza@thinkingmanscrumpet.org</value>

<value>vanhoek@pirate.org</value>

<value>d'Arcachon@nemesis.org</value>

</util:list>

If no list-class attribute is supplied, a List implementation will be chosen by the container.

##### **<util:map/>**

Before…​

*<!-- creates a java.util.Map instance with values loaded from the supplied 'sourceMap' -->*

<bean id="emails" class="org.springframework.beans.factory.config.MapFactoryBean">

<property name="sourceMap">

<map>

<entry key="pechorin" value="pechorin@hero.org"/>

<entry key="raskolnikov" value="raskolnikov@slums.org"/>

<entry key="stavrogin" value="stavrogin@gov.org"/>

<entry key="porfiry" value="porfiry@gov.org"/>

</map>

</property>

</bean>

The above configuration uses a Spring FactoryBean implementation, the MapFactoryBean, to create a java.util.Map instance initialized with key-value pairs taken from the supplied 'sourceMap'.

After…​

*<!-- creates a java.util.Map instance with the supplied key-value pairs -->*

<util:map id="emails">

<entry key="pechorin" value="pechorin@hero.org"/>

<entry key="raskolnikov" value="raskolnikov@slums.org"/>

<entry key="stavrogin" value="stavrogin@gov.org"/>

<entry key="porfiry" value="porfiry@gov.org"/>

</util:map>

You can also explicitly control the exact type of Map that will be instantiated and populated via the use of the 'map-class' attribute on the <util:map/> element. For example, if we really need a java.util.TreeMap to be instantiated, we could use the following configuration:

<util:map id="emails" map-class="java.util.TreeMap">

<entry key="pechorin" value="pechorin@hero.org"/>

<entry key="raskolnikov" value="raskolnikov@slums.org"/>

<entry key="stavrogin" value="stavrogin@gov.org"/>

<entry key="porfiry" value="porfiry@gov.org"/>

</util:map>

If no 'map-class' attribute is supplied, a Map implementation will be chosen by the container.

##### **<util:set/>**

Before…​

*<!-- creates a java.util.Set instance with values loaded from the supplied 'sourceSet' -->*

<bean id="emails" class="org.springframework.beans.factory.config.SetFactoryBean">

<property name="sourceSet">

<set>

<value>pechorin@hero.org</value>

<value>raskolnikov@slums.org</value>

<value>stavrogin@gov.org</value>

<value>porfiry@gov.org</value>

</set>

</property>

</bean>

The above configuration uses a Spring FactoryBean implementation, the SetFactoryBean, to create a java.util.Set instance initialized with values taken from the supplied 'sourceSet'.

After…​

*<!-- creates a java.util.Set instance with the supplied values -->*

<util:set id="emails">

<value>pechorin@hero.org</value>

<value>raskolnikov@slums.org</value>

<value>stavrogin@gov.org</value>

<value>porfiry@gov.org</value>

</util:set>

You can also explicitly control the exact type of Set that will be instantiated and populated via the use of the 'set-class' attribute on the <util:set/> element. For example, if we really need a java.util.TreeSet to be instantiated, we could use the following configuration:

<util:set id="emails" set-class="java.util.TreeSet">

<value>pechorin@hero.org</value>

<value>raskolnikov@slums.org</value>

<value>stavrogin@gov.org</value>

<value>porfiry@gov.org</value>

</util:set>

If no 'set-class' attribute is supplied, a Set implementation will be chosen by the container.

#### **9.1.2. The aop schema**

The aop tags deal with configuring all things AOP in Spring: this includes Spring’s own proxy-based AOP framework and Spring’s integration with the AspectJ AOP framework. These tags are comprehensively covered in the chapter entitled [Aspect Oriented Programming with Spring](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop).

In the interest of completeness, to use the tags in the aop schema, you need to have the following preamble at the top of your Spring XML configuration file; the text in the following snippet references the correct schema so that the tags in the aop namespace are available to you.

<?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 https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/aop https://www.springframework.org/schema/aop/spring-aop.xsd*"*> *<!-- bean definitions here -->*

</beans>

#### **9.1.3. The context schema**

The context tags deal with ApplicationContext configuration that relates to plumbing - that is, not usually beans that are important to an end-user but rather beans that do a lot of grunt work in Spring, such as BeanfactoryPostProcessors. The following snippet references the correct schema so that the tags in the context namespace are available to you.

<?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 https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.springframework.org/schema/context https://www.springframework.org/schema/context/spring-context.xsd*"*> *<!-- bean definitions here -->*

</beans>

##### **<property-placeholder/>**

This element activates the replacement of ${…​} placeholders, resolved against the specified properties file (as a [Spring resource location](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#resources)). This element is a convenience mechanism that sets up a[PropertyPlaceholderConfigurer](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-placeholderconfigurer) for you; if you need more control over the PropertyPlaceholderConfigurer, just define one yourself explicitly.

##### **<annotation-config/>**

Activates the Spring infrastructure for various annotations to be detected in bean classes: Spring’s [@Required](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-required-annotation) and [@Autowired](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-annotation-config), as well as JSR 250’s @PostConstruct, @PreDestroy and @Resource (if available), and JPA’s @PersistenceContext and @PersistenceUnit (if available). Alternatively, you can choose to activate the individual BeanPostProcessors for those annotations explicitly.

|  |  |
| --- | --- |
|  | This element does not activate processing of Spring’s [@Transactional](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/data-access.html#transaction-declarative-annotations) annotation. Use the [<tx:annotation-driven/>](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/data-access.html#tx-decl-explained) element for that purpose. |

##### **<component-scan/>**

This element is detailed in [Annotation-based container configuration](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-annotation-config).

##### **<load-time-weaver/>**

This element is detailed in [Load-time weaving with AspectJ in the Spring Framework](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-aj-ltw).

##### **<spring-configured/>**

This element is detailed in [Using AspectJ to dependency inject domain objects with Spring](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#aop-atconfigurable).

##### **<mbean-export/>**

This element is detailed in [Configuring annotation based MBean export](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/integration.html#jmx-context-mbeanexport).

#### **9.1.4. The beans schema**

Last but not least we have the tags in the beans schema. These are the same tags that have been in Spring since the very dawn of the framework. Examples of the various tags in the beans schema are not shown here because they are quite comprehensively covered in [Dependencies and configuration in detail](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-properties-detailed) (and indeed in that entire [chapter](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans)).

Note that it is possible to add zero or more key / value pairs to <bean/> XML definitions. What, if anything, is done with this extra metadata is totally up to your own custom logic (and so is typically only of use if you are writing your own custom tags as described in the appendix entitled [XML Schema Authoring](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xml-custom)).

Find below an example of the <meta/> tag in the context of a surrounding <bean/> (please note that without any logic to interpret it the metadata is effectively useless as-is).

<?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 https://www.springframework.org/schema/beans/spring-beans.xsd">

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

*<meta* *key*=*"cacheName"* *value*=*"foo"/>*

<property name="name" value="Rick"/>

</bean>

</beans>

In the case of the above example, you would assume that there is some logic that will consume the bean definition and set up some caching infrastructure using the supplied metadata.

### **9.2. XML Schema Authoring**

#### **9.2.1. Introduction**

Since version 2.0, Spring has featured a mechanism for schema-based extensions to the basic Spring XML format for defining and configuring beans. This section is devoted to detailing how you would go about writing your own custom XML bean definition parsers and integrating such parsers into the Spring IoC container.

To facilitate the authoring of configuration files using a schema-aware XML editor, Spring’s extensible XML configuration mechanism is based on XML Schema. If you are not familiar with Spring’s current XML configuration extensions that come with the standard Spring distribution, please first read the appendix entitled[[xsd-config]](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-config).

Creating new XML configuration extensions can be done by following these (relatively) simple steps:

* [Authoring](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-custom-schema) an XML schema to describe your custom element(s).
* [Coding](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-custom-namespacehandler) a custom NamespaceHandler implementation (this is an easy step, don’t worry).
* [Coding](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-custom-parser) one or more BeanDefinitionParser implementations (this is where the real work is done).
* [Registering](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-custom-registration) the above artifacts with Spring (this too is an easy step).

What follows is a description of each of these steps. For the example, we will create an XML extension (a custom XML element) that allows us to configure objects of the type SimpleDateFormat (from the java.text package) in an easy manner. When we are done, we will be able to define bean definitions of type SimpleDateFormat like this:

<myns:dateformat id="dateFormat"

pattern="yyyy-MM-dd HH:mm"

lenient="true"/>

(Don’t worry about the fact that this example is very simple; much more detailed examples follow afterwards. The intent in this first simple example is to walk you through the basic steps involved.)

#### **9.2.2. Authoring the schema**

Creating an XML configuration extension for use with Spring’s IoC container starts with authoring an XML Schema to describe the extension. What follows is the schema we’ll use to configure SimpleDateFormat objects.

*<!-- myns.xsd (inside package org/springframework/samples/xml) -->*

<?xml version="1.0" encoding="UTF-8"?>

<xsd:schema xmlns="http://www.mycompany.com/schema/myns"

xmlns:xsd="http://www.w3.org/2001/XMLSchema"

xmlns:beans="http://www.springframework.org/schema/beans"

targetNamespace="http://www.mycompany.com/schema/myns"

elementFormDefault="qualified"

attributeFormDefault="unqualified">

<xsd:import namespace="http://www.springframework.org/schema/beans"/>

<xsd:element name="dateformat">

<xsd:complexType>

<xsd:complexContent>

<xsd:extension base="beans:identifiedType">

<xsd:attribute name="lenient" type="xsd:boolean"/>

<xsd:attribute name="pattern" type="xsd:string" use="required"/>

</xsd:extension>

</xsd:complexContent>

</xsd:complexType>

</xsd:element>

</xsd:schema>

(The emphasized line contains an extension base for all tags that will be identifiable (meaning they have an id attribute that will be used as the bean identifier in the container). We are able to use this attribute because we imported the Spring-provided 'beans' namespace.)

The above schema will be used to configure SimpleDateFormat objects, directly in an XML application context file using the <myns:dateformat/> element.

<myns:dateformat id="dateFormat"

pattern="yyyy-MM-dd HH:mm"

lenient="true"/>

Note that after we’ve created the infrastructure classes, the above snippet of XML will essentially be exactly the same as the following XML snippet. In other words, we’re just creating a bean in the container, identified by the name 'dateFormat' of type SimpleDateFormat, with a couple of properties set.

<bean id="dateFormat" class="java.text.SimpleDateFormat">

<constructor-arg value="yyyy-HH-dd HH:mm"/>

<property name="lenient" value="true"/>

</bean>

|  |  |
| --- | --- |
|  | The schema-based approach to creating configuration format allows for tight integration with an IDE that has a schema-aware XML editor. Using a properly authored schema, you can use autocompletion to have a user choose between several configuration options defined in the enumeration. |

#### **9.2.3. Coding a NamespaceHandler**

In addition to the schema, we need a NamespaceHandler that will parse all elements of this specific namespace Spring encounters while parsing configuration files. The NamespaceHandler should in our case take care of the parsing of the myns:dateformat element.

The NamespaceHandler interface is pretty simple in that it features just three methods:

* init() - allows for initialization of the NamespaceHandler and will be called by Spring before the handler is used
* BeanDefinition parse(Element, ParserContext) - called when Spring encounters a top-level element (not nested inside a bean definition or a different namespace). This method can register bean definitions itself and/or return a bean definition.
* BeanDefinitionHolder decorate(Node, BeanDefinitionHolder, ParserContext) - called when Spring encounters an attribute or nested element of a different namespace. The decoration of one or more bean definitions is used for example with the [out-of-the-box scopes Spring supports](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-scopes). We’ll start by highlighting a simple example, without using decoration, after which we will show decoration in a somewhat more advanced example.

Although it is perfectly possible to code your own NamespaceHandler for the entire namespace (and hence provide code that parses each and every element in the namespace), it is often the case that each top-level XML element in a Spring XML configuration file results in a single bean definition (as in our case, where a single <myns:dateformat/> element results in a single SimpleDateFormat bean definition). Spring features a number of convenience classes that support this scenario. In this example, we’ll make use the NamespaceHandlerSupport class:

**package** org.springframework.samples.xml;

**import** org.springframework.beans.factory.xml.NamespaceHandlerSupport;

**public** **class** **MyNamespaceHandler** **extends** NamespaceHandlerSupport {

**public** **void** init() {

**registerBeanDefinitionParser("dateformat", new SimpleDateFormatBeanDefinitionParser());**

}

}

The observant reader will notice that there isn’t actually a whole lot of parsing logic in this class. Indeed…​ the NamespaceHandlerSupport class has a built in notion of delegation. It supports the registration of any number of BeanDefinitionParser instances, to which it will delegate to when it needs to parse an element in its namespace. This clean separation of concerns allows a NamespaceHandler to handle the orchestration of the parsing of all of the custom elements in its namespace, while delegating to BeanDefinitionParsers to do the grunt work of the XML parsing; this means that each BeanDefinitionParser will contain just the logic for parsing a single custom element, as we can see in the next step

#### **9.2.4. BeanDefinitionParser**

A BeanDefinitionParser will be used if the NamespaceHandler encounters an XML element of the type that has been mapped to the specific bean definition parser (which is 'dateformat' in this case). In other words, the BeanDefinitionParser is responsible for parsing one distinct top-level XML element defined in the schema. In the parser, we’ll have access to the XML element (and thus its subelements too) so that we can parse our custom XML content, as can be seen in the following example:

**package** org.springframework.samples.xml;

**import** org.springframework.beans.factory.support.BeanDefinitionBuilder;

**import** org.springframework.beans.factory.xml.AbstractSingleBeanDefinitionParser;

**import** org.springframework.util.StringUtils;

**import** org.w3c.dom.Element;

**import** java.text.SimpleDateFormat;

**public** **class** **SimpleDateFormatBeanDefinitionParser** **extends** AbstractSingleBeanDefinitionParser {

**protected** Class getBeanClass(Element element) {

**return** SimpleDateFormat.class;

}

**protected** **void** doParse(Element element, BeanDefinitionBuilder bean) {

*// this will never be null since the schema explicitly requires that a value be supplied*

String pattern = element.getAttribute("pattern");

bean.addConstructorArg(pattern);

*// this however is an optional property*

String lenient = element.getAttribute("lenient");

**if** (StringUtils.hasText(lenient)) {

bean.addPropertyValue("lenient", Boolean.valueOf(lenient));

}

}

}

|  |  |
| --- | --- |
|  | We use the Spring-provided AbstractSingleBeanDefinitionParser to handle a lot of the basic grunt work of creating a single BeanDefinition. |
|  | We supply the AbstractSingleBeanDefinitionParser superclass with the type that our single BeanDefinition will represent. |

In this simple case, this is all that we need to do. The creation of our single BeanDefinition is handled by the AbstractSingleBeanDefinitionParser superclass, as is the extraction and setting of the bean definition’s unique identifier.

#### **9.2.5. Registering the handler and the schema**

The coding is finished! All that remains to be done is to somehow make the Spring XML parsing infrastructure aware of our custom element; we do this by registering our custom namespaceHandler and custom XSD file in two special purpose properties files. These properties files are both placed in a 'META-INF' directory in your application, and can, for example, be distributed alongside your binary classes in a JAR file. The Spring XML parsing infrastructure will automatically pick up your new extension by consuming these special properties files, the formats of which are detailed below.

##### **'META-INF/spring.handlers'**

The properties file called 'spring.handlers' contains a mapping of XML Schema URIs to namespace handler classes. So for our example, we need to write the following:

http\://www.mycompany.com/schema/myns=org.springframework.samples.xml.MyNamespaceHandler

(The ':' character is a valid delimiter in the Java properties format, and so the ':' character in the URI needs to be escaped with a backslash.)

The first part (the key) of the key-value pair is the URI associated with your custom namespace extension, and needs to match exactly the value of the 'targetNamespace' attribute as specified in your custom XSD schema.

##### **'META-INF/spring.schemas'**

The properties file called 'spring.schemas' contains a mapping of XML Schema locations (referred to along with the schema declaration in XML files that use the schema as part of the 'xsi:schemaLocation' attribute) to classpath resources. This file is needed to prevent Spring from absolutely having to use a default EntityResolver that requires Internet access to retrieve the schema file. If you specify the mapping in this properties file, Spring will search for the schema on the classpath (in this case 'myns.xsd' in the 'org.springframework.samples.xml' package):

http\://www.mycompany.com/schema/myns/myns.xsd=org/springframework/samples/xml/myns.xsd

The upshot of this is that you are encouraged to deploy your XSD file(s) right alongside the NamespaceHandler and BeanDefinitionParser classes on the classpath.

#### **9.2.6. Using a custom extension in your Spring XML configuration**

Using a custom extension that you yourself have implemented is no different from using one of the 'custom' extensions that Spring provides straight out of the box. Find below an example of using the custom <dateformat/> element developed in the previous steps in a Spring 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"

xmlns:myns="http://www.mycompany.com/schema/myns"

xsi:schemaLocation="

http://www.springframework.org/schema/beans https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.mycompany.com/schema/myns http://www.mycompany.com/schema/myns/myns.xsd">

*<!-- as a top-level bean -->*

<myns:dateformat id="defaultDateFormat" pattern="yyyy-MM-dd HH:mm" lenient="true"/>

<bean id="jobDetailTemplate" abstract="true">

<property name="dateFormat">

*<!-- as an inner bean -->*

<myns:dateformat pattern="HH:mm MM-dd-yyyy"/>

</property>

</bean>

</beans>

#### **9.2.7. Meatier examples**

Find below some much meatier examples of custom XML extensions.

##### **Nesting custom tags within custom tags**

This example illustrates how you might go about writing the various artifacts required to satisfy a target of the following configuration:

<?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:foo="http://www.foo.com/schema/component"

xsi:schemaLocation="

http://www.springframework.org/schema/beans https://www.springframework.org/schema/beans/spring-beans.xsd

http://www.foo.com/schema/component http://www.foo.com/schema/component/component.xsd">

<foo:component id="bionic-family" name="Bionic-1">

<foo:component name="Mother-1">

<foo:component name="Karate-1"/>

<foo:component name="Sport-1"/>

</foo:component>

<foo:component name="Rock-1"/>

</foo:component>

</beans>

The above configuration actually nests custom extensions within each other. The class that is actually configured by the above <foo:component/> element is the Component class (shown directly below). Notice how the Component class does not expose a setter method for the 'components' property; this makes it hard (or rather impossible) to configure a bean definition for the Component class using setter injection.

**package** com.foo;

**import** java.util.ArrayList;

**import** java.util.List;

**public** **class** **Component** {

**private** String name;

**private** List<Component> components = **new** ArrayList<Component> ();

*// mmm, there is no setter method for the 'components'*

**public** **void** addComponent(Component component) {

this.components.add(component);

}

**public** List<Component> getComponents() {

**return** components;

}

**public** String getName() {

**return** name;

}

**public** **void** setName(String name) {

this.name = name;

}

}

The typical solution to this issue is to create a custom FactoryBean that exposes a setter property for the 'components' property.

**package** com.foo;

**import** org.springframework.beans.factory.FactoryBean;

**import** java.util.List;

**public** **class** **ComponentFactoryBean** **implements** FactoryBean<Component> {

**private** Component parent;

**private** List<Component> children;

**public** **void** setParent(Component parent) {

this.parent = parent;

}

**public** **void** setChildren(List<Component> children) {

this.children = children;

}

**public** Component getObject() **throws** Exception {

**if** (this.children != null && this.children.size() > 0) {

**for** (Component child : children) {

this.parent.addComponent(child);

}

}

**return** this.parent;

}

**public** Class<Component> getObjectType() {

**return** Component.class;

}

**public** **boolean** isSingleton() {

**return** true;

}

}

This is all very well, and does work nicely, but exposes a lot of Spring plumbing to the end user. What we are going to do is write a custom extension that hides away all of this Spring plumbing. If we stick to [the steps described previously](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#xsd-custom-introduction), we’ll start off by creating the XSD schema to define the structure of our custom tag.

<?xml version="1.0" encoding="UTF-8" standalone="no"?>

<xsd:schema xmlns="http://www.foo.com/schema/component"

xmlns:xsd="http://www.w3.org/2001/XMLSchema"

targetNamespace="http://www.foo.com/schema/component"

elementFormDefault="qualified"

attributeFormDefault="unqualified">

<xsd:element name="component">

<xsd:complexType>

<xsd:choice minOccurs="0" maxOccurs="unbounded">

<xsd:element ref="component"/>

</xsd:choice>

<xsd:attribute name="id" type="xsd:ID"/>

<xsd:attribute name="name" use="required" type="xsd:string"/>

</xsd:complexType>

</xsd:element>

</xsd:schema>

We’ll then create a custom NamespaceHandler.

**package** com.foo;

**import** org.springframework.beans.factory.xml.NamespaceHandlerSupport;

**public** **class** **ComponentNamespaceHandler** **extends** NamespaceHandlerSupport {

**public** **void** init() {

registerBeanDefinitionParser("component", **new** ComponentBeanDefinitionParser());

}

}

Next up is the custom BeanDefinitionParser. Remember that what we are creating is a BeanDefinition describing a ComponentFactoryBean.

**package** com.foo;

**import** org.springframework.beans.factory.config.BeanDefinition;

**import** org.springframework.beans.factory.support.AbstractBeanDefinition;

**import** org.springframework.beans.factory.support.BeanDefinitionBuilder;

**import** org.springframework.beans.factory.support.ManagedList;

**import** org.springframework.beans.factory.xml.AbstractBeanDefinitionParser;

**import** org.springframework.beans.factory.xml.ParserContext;

**import** org.springframework.util.xml.DomUtils;

**import** org.w3c.dom.Element;

**import** java.util.List;

**public** **class** **ComponentBeanDefinitionParser** **extends** AbstractBeanDefinitionParser {

**protected** AbstractBeanDefinition parseInternal(Element element, ParserContext parserContext) {

**return** parseComponentElement(element);

}

**private** **static** AbstractBeanDefinition parseComponentElement(Element element) {

BeanDefinitionBuilder factory = BeanDefinitionBuilder.rootBeanDefinition(ComponentFactoryBean.class);

factory.addPropertyValue("parent", parseComponent(element));

List<Element> childElements = DomUtils.getChildElementsByTagName(element, "component");

**if** (childElements != null && childElements.size() > 0) {

parseChildComponents(childElements, factory);

}

**return** factory.getBeanDefinition();

}

**private** **static** BeanDefinition parseComponent(Element element) {

BeanDefinitionBuilder component = BeanDefinitionBuilder.rootBeanDefinition(Component.class);

component.addPropertyValue("name", element.getAttribute("name"));

**return** component.getBeanDefinition();

}

**private** **static** **void** parseChildComponents(List<Element> childElements, BeanDefinitionBuilder factory) {

ManagedList<BeanDefinition> children = **new** ManagedList<BeanDefinition>(childElements.size());

**for** (Element element : childElements) {

children.add(parseComponentElement(element));

}

factory.addPropertyValue("children", children);

}

}

Lastly, the various artifacts need to be registered with the Spring XML infrastructure.

# in 'META-INF/spring.handlers'

http\://www.foo.com/schema/component=com.foo.ComponentNamespaceHandler

# in 'META-INF/spring.schemas'

http\://www.foo.com/schema/component/component.xsd=com/foo/component.xsd

##### **Custom attributes on 'normal' elements**

Writing your own custom parser and the associated artifacts isn’t hard, but sometimes it is not the right thing to do. Consider the scenario where you need to add metadata to already existing bean definitions. In this case you certainly don’t want to have to go off and write your own entire custom extension; rather you just want to add an additional attribute to the existing bean definition element.

By way of another example, let’s say that the service class that you are defining a bean definition for a service object that will (unknown to it) be accessing a clustered [JCache](https://jcp.org/en/jsr/detail?id=107), and you want to ensure that the named JCache instance is eagerly started within the surrounding cluster:

<bean id="checkingAccountService" class="com.foo.DefaultCheckingAccountService"

jcache:cache-name="checking.account">

*<!-- other dependencies here... -->*

</bean>

What we are going to do here is create another BeanDefinition when the 'jcache:cache-name' attribute is parsed; this BeanDefinition will then initialize the named JCache for us. We will also modify the existing BeanDefinition for the 'checkingAccountService' so that it will have a dependency on this new JCache-initializing BeanDefinition.

**package** com.foo;

**public** **class** **JCacheInitializer** {

**private** String name;

**public** JCacheInitializer(String name) {

this.name = name;

}

**public** **void** initialize() {

*// lots of JCache API calls to initialize the named cache...*

}

}

Now onto the custom extension. Firstly, the authoring of the XSD schema describing the custom attribute (quite easy in this case).

<?xml version="1.0" encoding="UTF-8" standalone="no"?>

<xsd:schema xmlns="http://www.foo.com/schema/jcache"

xmlns:xsd="http://www.w3.org/2001/XMLSchema"

targetNamespace="http://www.foo.com/schema/jcache"

elementFormDefault="qualified">

<xsd:attribute name="cache-name" type="xsd:string"/>

</xsd:schema>

Next, the associated NamespaceHandler.

**package** com.foo;

**import** org.springframework.beans.factory.xml.NamespaceHandlerSupport;

**public** **class** **JCacheNamespaceHandler** **extends** NamespaceHandlerSupport {

**public** **void** init() {

super.registerBeanDefinitionDecoratorForAttribute("cache-name",

**new** JCacheInitializingBeanDefinitionDecorator());

}

}

Next, the parser. Note that in this case, because we are going to be parsing an XML attribute, we write a BeanDefinitionDecorator rather than a BeanDefinitionParser.

**package** com.foo;

**import** org.springframework.beans.factory.config.BeanDefinitionHolder;

**import** org.springframework.beans.factory.support.AbstractBeanDefinition;

**import** org.springframework.beans.factory.support.BeanDefinitionBuilder;

**import** org.springframework.beans.factory.xml.BeanDefinitionDecorator;

**import** org.springframework.beans.factory.xml.ParserContext;

**import** org.w3c.dom.Attr;

**import** org.w3c.dom.Node;

**import** java.util.ArrayList;

**import** java.util.Arrays;

**import** java.util.List;

**public** **class** **JCacheInitializingBeanDefinitionDecorator** **implements** BeanDefinitionDecorator {

**private** **static** **final** String**[]** EMPTY\_STRING\_ARRAY = **new** String[0];

**public** BeanDefinitionHolder decorate(Node source, BeanDefinitionHolder holder,

ParserContext ctx) {

String initializerBeanName = registerJCacheInitializer(source, ctx);

createDependencyOnJCacheInitializer(holder, initializerBeanName);

**return** holder;

}

**private** **void** createDependencyOnJCacheInitializer(BeanDefinitionHolder holder,

String initializerBeanName) {

AbstractBeanDefinition definition = ((AbstractBeanDefinition) holder.getBeanDefinition());

String**[]** dependsOn = definition.getDependsOn();

**if** (dependsOn == null) {

dependsOn = **new** String**[]**{initializerBeanName};

} **else** {

List dependencies = **new** ArrayList(Arrays.asList(dependsOn));

dependencies.add(initializerBeanName);

dependsOn = (String**[]**) dependencies.toArray(EMPTY\_STRING\_ARRAY);

}

definition.setDependsOn(dependsOn);

}

**private** String registerJCacheInitializer(Node source, ParserContext ctx) {

String cacheName = ((Attr) source).getValue();

String beanName = cacheName + "-initializer";

**if** (!ctx.getRegistry().containsBeanDefinition(beanName)) {

BeanDefinitionBuilder initializer = BeanDefinitionBuilder.rootBeanDefinition(JCacheInitializer.class);

initializer.addConstructorArg(cacheName);

ctx.getRegistry().registerBeanDefinition(beanName, initializer.getBeanDefinition());

}

**return** beanName;

}

}

Lastly, the various artifacts need to be registered with the Spring XML infrastructure.

# in 'META-INF/spring.handlers'

http\://www.foo.com/schema/jcache=com.foo.JCacheNamespaceHandler

# in 'META-INF/spring.schemas'

http\://www.foo.com/schema/jcache/jcache.xsd=com/foo/jcache.xsd

[**1**](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#_footnoteref_1). See [Inversion of Control](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/overview.html#background-ioc)

[**2**](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#_footnoteref_2). See [Dependency Injection](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#beans-factory-collaborators)

[**3**](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#_footnoteref_3). But see also [FileSystemResource caveats](https://docs.spring.io/spring-framework/docs/5.0.x/spring-framework-reference/core.html#resources-filesystemresource-caveats).

Version 5.0.20.RELEASE  
Last updated 2020-12-09 07:53:35 UTC