



java/j2ee Application Framework

Reference Documentation

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(Work in progress)

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Preface

Developing software applications is hard enough even with good tools and technologies. Implementing applications using platforms which promise everything but turn out to be heavy-weight, hard to control and not very efficient during the development cycle makes it even harder. Spring provides a light-weight solution for building enterprise-ready applications, while still supporting the possibility of using declarative transaction management, remote access to your logic using RMI or webservices, mailing facilities and various options in persisting your data to a database. Spring provides an MVC framework, transparent ways of integrating AOP into your software and a well-structured exception hierarchy including automatic mapping from proprietary exception hierarchies.

Spring could potentially be a one-stop-shop for all your enterprise applications, however, Spring is modular, allowing you to use parts of it, without having to bring in the rest. You can use the bean container, with Struts on top, but you could also choose to just use the Hibernate integration or the JDBC abstraction layer. Spring is non-intrusive, meaning dependencies on the framework are generally none or absolutely minimal, depending on the area of use..

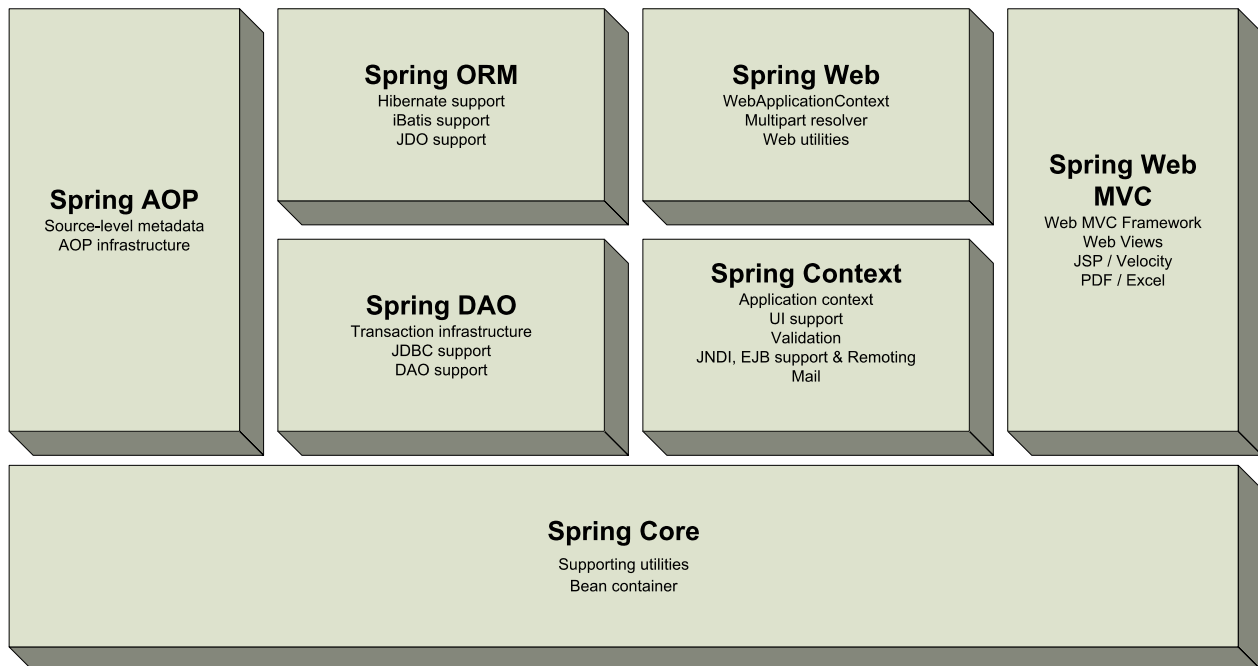
This document provides a reference guide to Spring's features. Since this document is still a work-in-progress, if you have any requests or comments, please post them on the user mailing list or on the forum at the SourceForge project page: <http://www.sf.net/projects/springframework>

Before we go on, a few words of gratitude: Chris Bauer (of the Hibernate team) prepared and adapted the DocBook-XSL software in order to be able to create Hibernate's reference guide, also allowing us to create this one.

Chapter 1. Introduction

1.1. Overview

Spring contains a lot of functionality and features, which are well-organized in seven modules shown in the diagram below. This section discusses each the of modules in turn.



Overview of the the Spring Framework

The *Core* package is the most fundamental part of the framework and provides the Dependency Injection features allowing you to manage bean container functionality. The basic concept here is the *BeanFactory*, which provides a factory pattern removing the need for programmatic singletons and allowing you to decouple the configuration and specification of dependencies from your actual program logic.

On top of the *Core* package sits the *Context* package, providing a way to access beans in a framework-style manner, somewhat resembling a JNDI-registry. The context package inherits its features from the beans package and adds support for text messaging using e.g. resource bundles, event-propagation, resource-loading and transparent creation of contexts by, for example, a servlet container.

The *DAO* package provides a JDBC-abstraction layer that removes the need to do tedious JDBC coding and parsing of database-vendor specific error codes. Also, the JDBC package provides a way to do programmatic as well as declarative transaction management, not only for classes implementing special interfaces, but for *all your POJOs (plain old java objects)*.

The *ORM* package provides integration layers for popular object-relational mapping APIs, including JDO, Hibernate and iBatis. Using the ORM package you can use all those O/R-mappers in combination with all the other features Spring offers, like simple declarative transaction management mentioned before.

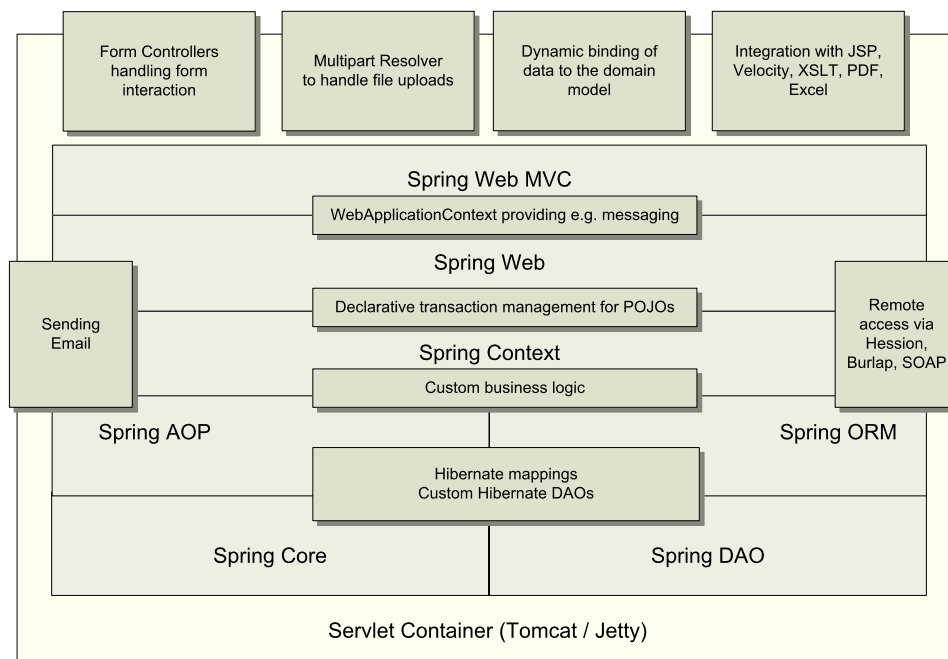
Spring's *AOP* package provides an *AOP Alliance* compliant aspect-oriented programming implementation allowing you to define, for example, method-interceptors and pointcuts to cleanly decouple code implementing functionality that should logically speaking be separated. Using source-level metadata functionality you can incorporate all kinds of behavioral information into your code, a little like .NET attributes.

Spring's *Web* package provides basic web-oriented integration features, such as multipart functionality, initialization of contexts using servlet listeners and a web-oriented application context. When using Spring together with WebWork or Struts, this is the package to integrate with.

Spring's *Web MVC* package provides a Model-View-Controller implementation for web-applications. Spring's MVC implementation is not just any implementation, it provides a clean separation between domain model code and web forms and allows you to use all the other features of the Spring Framework like validation.

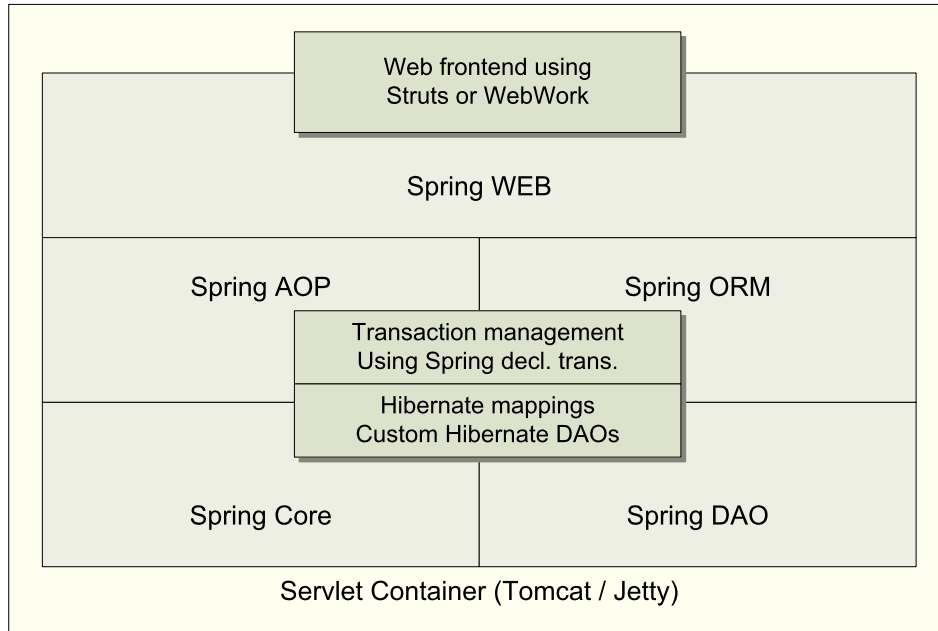
1.2. Usage scenarios

With the building blocks described above you can use Spring in all sorts of scenarios, from applets up to fully-fledged enterprise applications using Spring's transaction management functionality and Web framework.



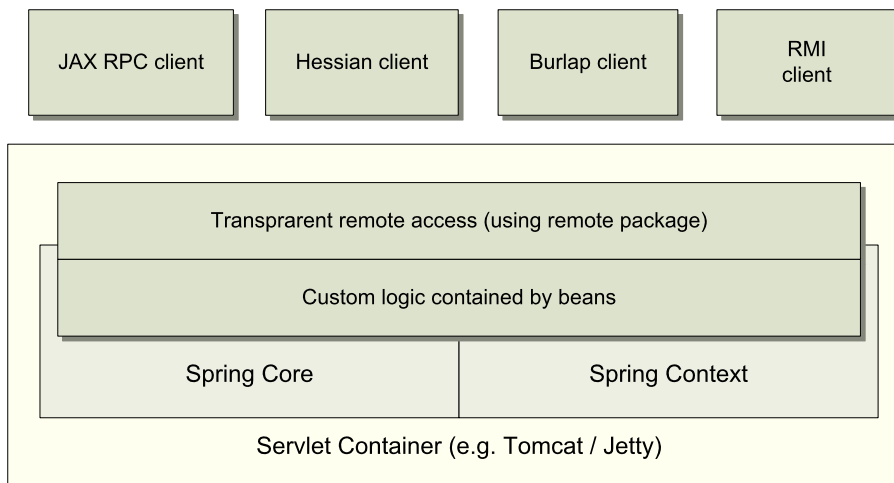
Typical full-fledged Spring web application

A typical web application using most of Spring's features. Using `TransactionProxyFactoryBeans` the web application is fully transactional, just as it would be when using container managed transaction as provided by Enterprise JavaBeans. All your custom business logic can be implemented using simple POJOs, managed by Spring's Dependency Injection container. Additional services such as sending email and validation, independent of the web layer enable you to choose where to execute validation rules. Spring's ORM support is integrated with Hibernate, JDO and iBatis. Using for example `HibernateDaoSupport`, you can re-use your existing Hibernate mappings. Form controllers seamlessly integrate the web-layer with the domain model, removing the need for `ActionForms` or other classes that transform HTTP parameters to values for your domain model.



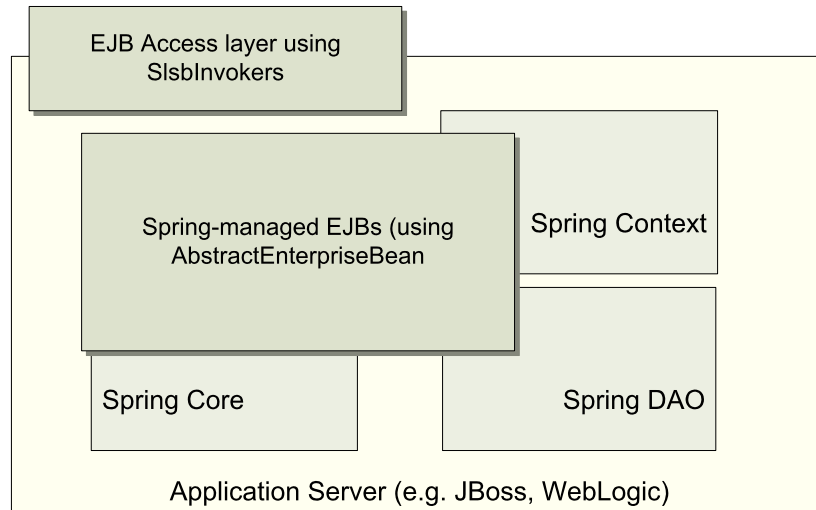
Spring middle-tier using a third-party web framework

Sometimes the current circumstances do not allow you to completely switch to a different framework. Spring does *not* force you to use everything within it; it's not an *all-or-nothing* solution. Existing frontends using WebWork, Struts, Tapestry, or other UI frameworks can be integrated perfectly well with a Spring-based middle-tier, allowing you to use the transaction features that Spring offers. The only thing you need to do is wire up your business logic using an `ApplicationContext` and integrate your Web UI layer using a `WebApplicationContext`.



Remoting usage scenario

When you need to access existing code via webservices, you can use Spring's `Hessian`-, `Burlap`-, `Rmi`- or `JaxRpcProxyFactory` classes. Enabling remote access to existing application is all of a sudden not that hard anymore.



EJBs - Wrapping existing POJOs

Spring also provides an access layer and abstraction layer for Enterprise JavaBeans, enabling you to reuse your existing POJOs and wrap them in Stateless Session Beans, for use in scalable failsafe webapplications, that might need declarative security.

Chapter 2. Background information

2.1. Inversion of Control / Dependency Injection

In early 2004, Martin Fowler asked the readers of his site: when talking about Inversion of Control: *"the question, is what aspect of control are they inverting?"*. After talking about the term Inversion of Control Martin suggests renaming the pattern, or at least giving it a more self-explanatory name, and starts to use the term *Dependency Injection*. His article continues to explain some of the ideas behind Inversion of Control or Dependency Injection. If you need a decent insight: <http://martinfowler.com/articles/injection.html>.

Chapter 3. Beans, BeanFactory and the ApplicationContext

3.1. Introduction

Two of the most elementary and important packages in Spring are the `org.springframework.beans` and `org.springframework.context` packages. Code in these packages provides the basis for Spring's *Inversion of Control* (alternately called *Dependency Injection*) features. The `BeanFactory`

[<http://www.springframework.org/docs/api/org/springframework/beans/factory/BeanFactory.html>]

provides an advanced configuration mechanism capable of managing beans (objects) of any nature, using potentially any kind of storage facility. The `ApplicationContext`

[<http://www.springframework.org/docs/api/org/springframework/context/ApplicationContext.html>] builds on

top of the `BeanFactory` and adds other functionality such as easier integration with Springs AOP features, message resource handling (for use in internationalization), event propagation, declarative mechanisms to create the `ApplicationContext` and optional parent contexts, and application-layer specific contexts such as the `WebApplicationContext`, among other enhancements.

In short, the `BeanFactory` provides the configuration framework and basic functionality, while the `ApplicationContext` adds enhanced capabilities to it, some of them perhaps more J2EE and enterprise-centric. In general, an `ApplicationContext` is a complete superset of a `BeanFactory`, and any description of `BeanFactory` capabilities and behavior should be considered to apply to `ApplicationContexts` as well.

Users are sometimes unsure whether `BeanFactory` or `ApplicationContext` are best suited for use in a particular situation. Normally when building most applications in a J2EE-environment, *the best option is to use the `ApplicationContext`*, since it offers all the features of the `BeanFactory` and adds on to it in terms of features, while also allowing a more declarative approach to use of some functionality, which is generally desirable. The main usage scenario when you might prefer to use the `BeanFactory` is when memory usage is the greatest concern (such as in an applet where every last kilobyte counts), and you don't need all the features of the `ApplicationContext`.

This chapter is roughly divided into two parts, the first part covering the basic principles that apply to both the `BeanFactory` and the `ApplicationContext`. The second part will cover some of the features that only apply to the `ApplicationContext`.

3.2. BeanFactory and BeanDefinitions - the basics

3.2.1. The BeanFactory

The `BeanFactory`

[<http://www.springframework.org/docs/api/org/springframework/beans/factory/BeanFactory.html>]

is the actual *container* which instantiates, configures, and manages a number of beans. These beans typically collaborate with one another, and thus have dependencies between themselves. These dependencies are reflected in the configuration data used by the `BeanFactory` (although some dependencies may not be visible as configuration data, but rather be a function of programmatic interactions between beans at runtime).

A `BeanFactory` is represented by the interface `org.springframework.beans.factory.BeanFactory`, for which there are multiple implementations. The most commonly used simple `BeanFactory` implementation is `org.springframework.beans.factory.xml.XmlBeanFactory`. (This should be qualified with the reminder that

ApplicationContexts are a subclass of BeanFactory, and most users ultimately prefer to use XML variants of ApplicationContext).

Although for most scenarios, almost all user code managed by the BeanFactory does not have to be aware of the BeanFactory, the BeanFactory does have to be instantiated somehow. This can happen via explicit user code such as:

```
InputStream is = new FileInputStream("beans.xml");
XmlBeanFactory factory = new XmlBeanFactory(is);
```

or

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

or

```
ClassPathXmlApplicationContext appContext = new ClassPathXmlApplicationContext(
    new String[] {"applicationContext.xml", "applicationContext-part2.xml"});
// of course, an ApplicationContext is just a BeanFactory
BeanFactory factory = (BeanFactory) appContext;
```

For many usage scenarios, user code will not have to instantiate the BeanFactory, since Spring Framework code will do it. For example, the web layer provides support code to load a Spring ApplicationContext automatically as part of the normal startup process of a J2EE web-app. This declarative process is described here:

While programmatic manipulation of BeanFactories will be described later, the following sections will concentrate on describing the configuration of BeanFactories.

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

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE beans PUBLIC "-//SPRING//DTD BEAN//EN" "http://www.springframework.org/dtd/spring-beans.dtd">

<beans>

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

  ...

</beans>
```

3.2.2. The BeanDefinition

Bean definitions inside an XmlBeanFactory variant contain, among other information, the following details:

- a classname: this is normally the actual implementation class of the bean being described in the bean definition. However, if the bean is to be constructed by calling a static *factory* method instead of using a normal constructor, this will actually be the classname of the factory class.
- bean behavioral configuration elements, which state how the bean should behave in the container (i.e. prototype or singleton, autowiring mode, dependency checking mode, initialization and destruction methods)

- constructor arguments and property values to set in the newly created bean. An example would be the number of connections to use in a bean that manages a connection pool (either specified as a property or as a constructor argument), or the pool size limit.
- other beans a bean needs to do its work, i.e. *collaborators* (also specified as properties or as constructor arguments). These can also be called dependencies.

The concepts listed above directly translate to a set of elements the bean definition consists of. Some of these element groups are listed below, along with a link to further documentation about each of them.

Table 3.1. Bean definition explanation

| Feature | More info |
|--------------------------|--|
| class | Section 3.2.3, “The bean class” |
| id and name | Section 3.2.4, “The bean identifiers (id and name)” |
| singleton or prototype | Section 3.2.5, “To singleton or not to singleton” |
| constructor arguments | Section 3.3.1, “Setting bean properties and collaborators” |
| bean properties | Section 3.3.1, “Setting bean properties and collaborators” |
| autowiring mode | Section 3.3.5, “Autowiring collaborators” |
| dependency checking mode | Section 3.3.6, “Checking for dependencies” |
| initialization method | Section 3.4.1, “Lifecycle interfaces” |
| destruction method | Section 3.4.1, “Lifecycle interfaces” |

Note that a bean definition is represented by the real interface

`org.springframework.beans.factory.config.BeanDefinition`, and its various subinterfaces and implementations. However, it is very unlikely that most user code would ever work with a `BeanDefinition`.

3.2.3. The bean class

The `class` attribute is mandatory and is used for one of two purposes. In the much more common case where the `BeanFactory` itself directly creates the bean by calling its constructor (equivalent to Java code calling *new*), the class attribute specifies the class of the bean to be constructed. In the less common case where the `BeanFactory` calls a static, so-called *factory* method on a class to create the bean, the class attribute specifies the actual class containing the static factory method. (the type of the returned bean from the static factory method may be the same class or another class entirely, it doesn't matter).

3.2.3.1. Bean creation via constructor

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

Additionally, the `BeanFactory` isn't limited to just managing true `JavaBeans`, it is also able to manage virtually *any* class you want it to manage. Most people using Spring prefer to have actual `JavaBeans` (having just a default (no-argument) constructor and appropriate setters and getters modelled after the properties) in the `BeanFactory`, but it's also possible to have more exotic non-bean-style classes in your `BeanFactory`. If, for

example, you need to use a legacy connection pool that absolutely does not adhere to the JavaBean specification, no worries, Spring can manage it as well.

Using the `XmlBeanFactory` you can specify your bean class as follows:

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

The mechanism for supplying (optional) arguments to the constructor, or setting properties of the object instance after it has been constructed, will be described shortly.

3.2.3.2. Bean creation via static factory method

When defining a bean which is to be created using a static factory method, along with the `class` attribute which specifies the class containing the static factory method, another attribute named `factory-method` is needed to specify the name of the factory method itself. Spring expects to be able to call this method (with an optional list of arguments as described later) and get back a live object, which from that point on is treated as if it had been created normally via a constructor. One use for such a bean definition is to call static factories in legacy code.

Following is an example of a bean definition which specifies that the bean is to be created by calling a `factory-method`. Note that the definition does not specify the type (class) of the returned object, only the class containing the factory method. In this example, `createInstance` must be a *static* method.

```
<bean id="exampleBean"
      class="examples.ExampleBean2"
      factory-method="createInstance" />
```

The mechanism for supplying (optional) arguments to the factory method, or setting properties of the object instance after it has been returned from the factory, will be described shortly.

3.2.4. The bean identifiers (`id` and `name`)

Every bean has one or more `ids` (also called identifiers, or names; these terms refer to the same thing). These `ids` must be unique within the `BeanFactory` or `ApplicationContext` the bean is hosted in. A bean will almost always have only one `id`, but if a bean has more than one `id`, the extra ones can essentially be considered aliases.

In an `XmlBeanFactory` (including `ApplicationContext` variants), you use the `id` or `name` attributes to specify the bean `id(s)`, and at least one `id` must be specified in one or both of these attributes. The `id` attribute allows you to specify one `id`, and as it is marked in the XML DTD (definition document) as a real XML element ID attribute, the parser is able to do some extra validation when other elements point back to this one. As such, it is the preferred way to specify a bean `id`. However, the XML spec does limit the characters which are legal in XML IDs. This is usually not really a constraint, but if you have a need to use one of these characters, or want to introduce other aliases to the bean, you may also or instead specify one or more bean `ids` (separated by a comma (,) or semicolon (;) via the `name` attribute.

3.2.5. To singleton or not to singleton

Beans are defined to be deployed in one of two modes: singleton or non-singleton. (The latter is also called a prototype, although the term is used loosely as it doesn't quite fit). When a bean is a singleton, only one *shared* instance of the bean will be managed and all requests for beans with an `id` or `ids` matching that bean definition will result in that one specific bean instance being returned.

The non-singleton, prototype mode of a bean deployment results in the *creation of a new bean instance* every time a request for that specific bean is done. This is ideal for situations where for example each user needs an independent user object or something similar.

Beans are deployed in singleton mode by default, unless you specify otherwise. Keep in mind that by changing the type to non-singleton (prototype), each request for a bean will result in a newly created bean and this might not be what you actually want. So only change the mode to prototype when absolutely necessary.

In the example below, two beans are declared of which one is defined as a singleton, and the other one is a non-singleton (prototype). `exampleBean` is created each and every time a client asks the BeanFactory for this bean, while `yetAnotherExample` is only created once; a reference to the exact same instance is returned on each request for this bean.

```
<bean id="exampleBean"
      class="examples.ExampleBean" singleton="false"/>
<bean name="yetAnotherExample"
      class="examples.ExampleBeanTwo" singleton="true"/>
```

Note: when deploying a bean in the prototype mode, the lifecycle of the bean changes slightly. By definition, Spring can not manage the complete lifecycle of a non-singleton/prototype bean, since after it is created, it is given to the client and the container does not keep track of it at all any longer. You can think of Spring's role when talking about a non-singleton/prototype bean as a replacement for the 'new' operator. Any lifecycle aspects past that point have to be handled by the client. The lifecycle of a bean in the BeanFactory is further described in Section 3.4.1, "Lifecycle interfaces".

3.3. Properties, collaborators, autowiring and dependency checking

3.3.1. Setting bean properties and collaborators

Inversion of Control has already been referred to as *Dependency Injection*. The basic principle is that beans define their dependencies (i.e. the other objects they work with) only through constructor arguments, arguments to a factory method, or properties which are set on the object instance after it has been constructed or returned from a factory method. Then, it is the job of the container to actually *inject* those dependencies when it creates the bean. This is fundamentally the inverse (hence the name Inversion of Control) of the bean instantiating or locating its dependencies on its own using direct construction of classes, or something like the *Service Locator* pattern. While we will not elaborate too much on the advantages of Dependency Injection, it becomes evident upon usage that code gets much cleaner and reaching a higher grade of decoupling is much easier when beans do not look up their dependencies, but are provided with them, and additionally do not even know where the dependencies are located and of what actual type they are.

As touched on in the previous paragraph, Inversion of Control/Dependency Injection exists in two major variants:

- *setter-based* dependency injection is realized by calling setters on your beans after invoking a no-argument constructor or no-argument static factory method to instantiate your bean. Beans defined in the BeanFactory that use setter-based dependency injection are *true JavaBeans*. Spring generally advocates usage of setter-based dependency injection, since a large number of constructor arguments can get unwieldy, especially when some properties are optional.
- *constructor-based* dependency injection is realized by invoking a constructor with a number of arguments, each representing a collaborator or property. Additionally, calling a static factory method with specific

arguments, to construct the bean, can be considered almost equivalent, and the rest of this text will consider arguments to a constructor and arguments to a static factory method similarly. Although Spring generally advocates usage of setter-based dependency injection for most situations, it does fully support the constructor-based approach as well, since you may wish to use it with pre-existing beans which provide only multi-argument constructors, and no setters. Additionally, for simpler beans, some people prefer the constructor approach as a means of ensuring beans can not be constructed in an invalid state.

The `BeanFactory` supports both of these variants for injecting dependencies into beans it manages. (It in fact also supports injecting setter-based dependencies after some dependencies have already been supplied via the constructor approach.) The configuration for the dependencies comes in the form of a `BeanDefinition`, which is used together with `JavaBeans PropertyEditors` to know how to convert properties from one format to another. The actual values being passed around are done in the form of `PropertyValue` objects. However, most users of Spring will not be dealing with these classes directly (i.e. programatically), but rather with an XML definition file which will be converted internally into instances of these classes, and used to load an entire `BeanFactory` or `ApplicationContext`.

Bean dependency resolution generally happens as follows:

1. The `BeanFactory` is created and initialized with a configuration which describes all the beans. Most Spring users use a `BeanFactory` or `ApplicationContext` variant which supports XML format configuration files.
2. Each bean has dependencies expressed in the form of properties, constructor arguments, or arguments to the static-factory method when that is used instead of a normal constructor. These dependencies will be provided to the bean, *when the bean is actually created*.
3. Each property or constructor-arg is either an actual definition of the value to set, or a reference to another bean in the `BeanFactory`. In the case of the `ApplicationContext`, the reference can be to a bean in a parent `ApplicationContext`.
4. Each property or constructor argument which is a value must be able to be converted from whatever format it was specified in, 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. Additionally, when talking about the XML based `BeanFactory` variants (including the `ApplicationContext` variants), these have built-in support for defining Lists, Maps, Sets, and Properties collection types. Additionally, Spring uses `JavaBeans PropertyEditor` definitions to be able to convert string values to other, arbitrary types. (You can provide the `BeanFactory` with your own `PropertyEditor` definitions to be able to convert your own custom types; more information about `PropertyEditors` and how to manually add custom ones, can be found in Section 3.9, “Registering additional custom `PropertyEditors`”). When a bean property is a Java Class type, Spring allows you to specify the value for that property as a string value which is the name of the class, and the `ClassEditor` `PropertyEditor`, which is built-in, will take care of converting that class name to an actual Class instance.
5. It is important to realize that Spring validates the configuration of each bean in the `BeanFactory` when the `BeanFactory` is created, including the validation that properties which are bean references are actually referring to valid beans (i.e. the beans being referred to are also defined in the `BeanFactory`, or in the case of `ApplicationContext`, a parent context). However, the bean properties themselves are not set until the bean *is actually created*. For beans which are singleton and set to be pre-instantiated (such as singleton beans in an `ApplicationContext`), creation happens at the time that the `BeanFactory` is created, but otherwise this is only when the bean is requested. When a bean actually has to be created, this will potentially cause a graph of other beans to be created, as its dependencies and its dependencies' dependencies (and so on) are created and assigned.
6. You can generally trust Spring to do the right thing. It will pick up configuration issues, including references to non-existent beans and circular dependencies, at `BeanFactory` load-time. It will actually set properties and resolve dependencies (i.e. create those dependencies if needed) as late as possible, which is when the bean is actually created. This does mean that a `BeanFactory` which has loaded correctly, can later generate an exception when you request a bean, if there is a problem creating that bean or one of its dependencies. This could happen if the bean throws an exception as a result of a missing or invalid

property, for example. This potentially delayed visibility of some configuration issues is why `ApplicationContext` by default pre-instantiates singleton beans. At the cost of some upfront time and memory to create these beans before they are actually needed, you find out about configuration issues when the `ApplicationContext` is created, not later. If you wish, you can still override this default behavior and set any of these singleton beans to lazy-load (not be preinstantiated).

Some examples:

First, an example of using the `BeanFactory` for setter-based dependency injection. Below is a small part of an `XmlBeanFactory` config file specifying some bean definitions. Following is the code for the actual main bean itself, showing the appropriate setters declared.

```
<bean id="exampleBean" class="examples.ExampleBean">
  <property name="beanOne"><ref bean="anotherExampleBean"/></property>
  <property name="beanTwo"><ref bean="yetAnotherBean"/></property>
  <property name="integerProperty">1</property>
</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;
    }
}
```

As you can see, setters have been declared to match against the properties specified in the XML file. (The properties from the XML file, directly relate to the `PropertyValues` object from the `RootBeanDefinition`)

Now, an example of using the `BeanFactory` for IoC type 3 (constructor-based dependency injection). Below is a snippet from an XML configuration that specifies constructor arguments and the actual bean code, showing the constructor:

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

As you can see, the constructor arguments specified in the bean definition will be used to pass in as arguments to the constructor of the `ExampleBean`.

Now consider a variant of this 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 bean="anotherExampleBean"/></constructor-arg>
  <constructor-arg><ref bean="yetAnotherBean"/></constructor-arg>
  <constructor-arg><value>1</value></constructor-arg>
</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 ExampleBean(AnotherBean anotherBean,
                                           YetAnotherBean yetAnotherBean, int i) {
        ExampleBean eb = new ExampleBean(...);
        // some other operations
        ...
        return eb;
    }
}
```

Note that arguments to the static factory method are supplied via `constructor-arg` elements, exactly the same as if a constructor had actually been used. These arguments are optional. Also, it is important to realize that the type of the class being returned by the factory method does not have to be of the same type as the class which contains the static factory method, although in this example it is.

3.3.2. Bean properties and constructor arguments detailed

As mentioned in the previous section, bean properties and constructor arguments can be defined as either references to other managed beans (collaborators), or values defined inline. The `XmlBeanFactory` supports a number of subelement types within its `property` and `constructor-arg` elements for this purpose.

The `value` element specifies a property or constructor argument as a human-readable string representation. As mentioned in detail previously, JavaBeans PropertyEditors are used to convert these string values from a `java.lang.String` to the actual property or argument type.

```
<beans>
  <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</value>
    </property>
    <property name="url">
      <value>jdbc:mysql://localhost:3306/mydb</value>
    </property>
    <property name="username">
      <value>root</value>
    </property>
  </bean>
</beans>
```

The `null` element is used to handle null values. Spring treats empty arguments for properties and the like as empty Strings. The following XmlBeanFactory configuration:

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

results in the email property being set to "", equivalent to the java code: `exampleBean.setEmail("")`. The special `<null>` element may be used to indicate a null value, so that:

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

is equivalent to the java code: `exampleBean.setEmail(null)`.

The `list`, `set`, `map`, and `props` elements allow properties and arguments of Java type `List`, `Set`, `Map`, and `Properties`, respectively, to be defined and set.

```
<beans>
  ...
  <bean id="moreComplexObject" class="example.ComplexObject">
    <!-- results in a setPeople(java.util.Properties) call -->
    <property name="people">
      <props>
        <prop key="HarryPotter">The magic property</prop>
        <prop key="JerrySeinfeld">The funny property</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="yup an entry">
          <value>just some string</value>
        </entry>
        <entry key="yup a ref">
          <ref bean="myDataSource"</ref>
        </entry>
      </map>
    </property>
    <!-- results in a setSomeSet(java.util.Set) call -->
    <property name="someSet">
      <set>
        <value>just some string</value>
        <ref bean="myDataSource"</ref>
      </set>
    </property>
  </bean>
</beans>
```

Note that the value of a Map entry, or a set value, can also again be any of the elements:

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

A bean element inside the `property` element is used to define a bean value inline, instead of referring to a bean defined elsewhere in the BeanFactory. The inline bean definition does not need to have any id defined.

```
<bean id="outer" class="...">
  <!-- Instead of using a reference to target, just use an inner bean -->
  <property name="target">
```

```
<bean class="com.mycompany.PersonImpl">
  <property name="name"><value>Tony</value></property>
  <property name="age"><value>51</value></property>
</bean>
</property>
</bean>
```

An `idref` element is simply a shorthand and error-proof way to set a property to the String *id* or *name* of another bean in the container.

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

This is exactly equivalent at runtime to the following fragment:

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

The main reason the first form is preferable to the second is that using the `idref` tag will allow Spring to validate at deployment time that the other bean actually exists. In the second variation, the class who's *targetName* property is forced to do its own validation, and that will only happen when that class is actually instantiated by Spring, possibly long after the container is actually deployed.

Additionally, if the bean being referred to is in the same actual XML file, and the bean name is the bean *id*, the *local* attribute may be used, which will allow the XML parser itself to validate the bean name even earlier, at XML document parse time.

```
<property name="targetName">
  <idref local="theTargetBean" />
</property>
```

The `ref` element is the final element allowed inside a `property` definition element. It is used to set the value of the specified property to be a reference to another bean managed by the container, a collaborator, so to speak. As mentioned in a previous section, the referred-to bean is considered to be a dependency of the bean who's property is being set, and will be initialized on demand as needed (if it is a singleton bean it may have already been initialized by the container) before the property is set. All references are ultimately just a reference to another object, but there are 3 variations on how the id/name of the other object may be specified, which determines how scoping and validation is handled.

Specifying the target bean by using the `bean` attribute of the `ref` tag is the most general form, and will allow creating a reference to any bean in the same BeanFactory/ApplicationContext (whether or not in the same XML file), or parent BeanFactory/ApplicationContext. The value of the `bean` 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.

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

Specifying the target bean by using the *local* attribute leverages the ability of the XML parser to validate XML id references within the same file. The value of the *local* attribute must be the same as the *id* attribute of the target bean. The XML parser will issue an error if no matching element is found in the same file. As such, using the local variant is the best choice (in order to know about errors as early as possible) if the target bean is in

the same XML file.

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

Specifying the target bean by using the `parent` attribute allows a reference to be created to a bean which is in a parent BeanFactory (or ApplicationContext) of the current BeanFactory (or ApplicationContext). 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 BeanFactory or ApplicationContext to the current one. The main use of this bean reference variant is when there is a need to wrap an existing bean in a parent context with some sort of proxy (which may have the same name as the parent), and needs the original object so it may wrap it.

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

3.3.3. Method Injection

For most users, the majority of the beans in the container will be singletons. When a singleton bean needs to collaborate with (use) another singleton bean, or a non-singleton bean needs to collaborate with another non-singleton bean, the typical and common approach of handling this dependency by defining one bean to be a property of the other, is quite adequate. There is however a problem when the bean lifecycles are different. Consider a singleton bean A which needs to use a non-singleton (prototype) bean B, perhaps on each method invocation on A. The container will only create the singleton bean A once, and thus only get the opportunity to set its properties once. There is no opportunity for the container to provide bean A with a new instance of bean B every time one is needed.

One solution to this problem is to forgo some inversion of control. Bean A can be aware of the container (as described here) by implementing `BeanFactoryAware`, and use programmatic means (as described here) to ask the container via a `getBean("B")` call for (a new) bean B every time it needs it. This is generally not a desirable solution since the bean code is then aware of and coupled to Spring.

Method Injection, an advanced feature of the BeanFactory, allows this use case to be handled in a clean fashion, along with some other scenarios.

3.3.3.1. Lookup method Injection

Lookup method injection refers to the ability of the container to override abstract or concrete methods on managed beans in the container, to return the result of looking up another named bean in the container. The lookup will typically be of a non-singleton bean as per the scenario described above (although it can also be a singleton). Spring implements this by performing bytecode modification on the client class, using the CGLIB library.

In the client class containing the method to be injected, the method definition must be an abstract (or concrete) definition in this form:

```
protected abstract SingleShotHelper createSingleShotHelper();
```

If the method is not abstract, Spring will simply override the existing implementation. In the `XmlBeanFactory` case, you instruct Spring to inject/override this method to return a particular bean from the container, by using the `lookup-method` element inside the bean definition. For example:

```
<!-- a stateful bean deployed as a prototype (non-singleton) -->
<bean id="singleShotHelper" class="..." singleton="false">
  </bean>
```



```
<!-- myBean uses singleShotHelper -->
<bean id="myBean" class="...">
  <lookup-method name="createSingleShotHelper"
                bean="singleShotHelper" />
  <property>
    ...
  </property>
</bean>
```

The bean identified as *myBean* will call its own method `createSingleShotHelper` whenever it needs a new instance of the *singleShotHelper* bean. It is important to note that the person deploying the beans must be careful to deploy *singleShotHelper* as a non-singleton (if that is actually what is needed). If it is deployed as a singleton (either explicitly, or relying on the default *true* setting for this flag), the same instance of *singleShotHelper* will be returned each time!

Note that lookup method injection can be combined with Constructor Injection (supplying optional constructor arguments to the bean being constructed), and also with Setter Injection (settings properties on the bean being constructed).

3.3.3.2. Arbitrary method replacement

A less commonly 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 (which describes this somewhat advanced feature), until this functionality is actually needed.

In an *XmlBeanFactory*, the `replaced-method` element may be used 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 is needed to provide the new method definition.

```
/** meant to be used to override the existing computeValue
    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 *BeanFactory* deployment definition to deploy the original class and specify the method override would look like:

```
<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">
</bean>
```

One or more contained `arg-type` elements within the `replaced-method` element may be used to indicate the method signature of the method being overridden. Note that the signature for the arguments is actually only needed in the case that the method is actually overloaded and there are multiple variants within the class. For convenience, the type string for an argument may be a substring of the fully qualified type name. For example, all the following would match `java.lang.String`.

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

Since the number of arguments is often enough to distinguish between each possible choice, this shortcut can save a lot of typing, by just using the shortest string which will match an argument.

3.3.4. Using `depends-on`

For most situations, the fact that a bean is a dependency of another is expressed simply by the fact that one bean is set as a property of another. This is typically done with the `ref` element in the `XmlBeanFactory`. In a variation of this, sometimes a bean which is aware of the container is simply given the id of its dependency (using a string value or alternately the `idref` element, which evaluates the same as a string value). The first bean then programmatically asks the container for its dependency. In either case, the dependency is properly initialized before the dependent bean.

For the relatively infrequent situations where dependencies between beans are less direct (for example, when a static initializer in a class needs to be triggered, such as database driver registration), the `depends-on` element may be used to explicitly force one or more beans to be initialized before the bean using this element is initialized.

Following is an example config:

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

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

3.3.5. Autowiring collaborators

A `BeanFactory` is able to *autowire* relationships between collaborating beans. This means it's possible to automatically let Spring resolve collaborators (other beans) for your bean by inspecting the contents of the `BeanFactory`. The autowiring functionality has five modes. Autowiring is specified *per* bean and can thus be enabled for some beans, while other beans won't be autowired. Using autowiring, it is possible to reduce or eliminate the need to specify properties or constructor arguments, saving a significant amount of typing.¹In an `XmlBeanFactory`, the autowire mode for a bean definition is specified by using the `autowire` attribute of the bean element. The following values are allowed.

Table 3.2. Autowiring modes

| Mode | Explanation |
|------|---|
| no | No autowiring at all. Bean references must be defined via a <code>ref</code> element. This is the |

¹See Section 3.3.1, "Setting bean properties and collaborators"

| Mode | Explanation |
|-------------|--|
| | default, and changing this is discouraged for larger deployments, since explicitly specifying collaborators gives greater control and clarity. To some extent, it is a form of documentation about the structure of a system. |
| byName | Autowiring by property name. This option will inspect the BeanFactory and look for a bean named exactly the same as the property which needs to be autowired. For example, if you have a bean definition which is set to autowire by name, and it contains a <i>master</i> property (that is, it has a <i>setMaster(...)</i> method), Spring will look for a bean definition named master, and use it to set the property. |
| byType | Allows a property to be autowired if there is exactly one bean of the property type in the BeanFactory. If there is more than one, a fatal exception is thrown, and this indicates that you may not use <i>byType</i> autowiring for that bean. If there are no matching beans, nothing happens; the property is not set. If this is not desirable, setting the <code>dependency-check="objects"</code> attribute value specifies that an error should be thrown in this case. |
| constructor | This is analogous to <i>byType</i> , but applies to constructor arguments. If there isn't exactly one bean of the constructor argument type in the bean factory, a fatal error is raised. |
| autodetect | Chooses <i>constructor</i> or <i>byType</i> through introspection of the bean class. If a default constructor is found, <i>byType</i> gets applied. |

Note that explicit dependencies, i.e. `property` and `constructor-arg` elements, always override autowiring. Autowire behaviour can be combined with dependency checking, which will be performed after all autowiring has been completed.

Note: as has already been mentioned, for larger applications, it is discouraged to use autowiring because it removes the transparency and the structure from your collaborating classes.

3.3.6. Checking for dependencies

Spring has the ability to try to check for the existence of unresolved dependencies of a bean deployed into the BeanFactory. These are JavaBeans properties of the bean, which do not have actual values set for them in the bean definition, or alternately provided automatically by the autowiring feature.

This feature is sometimes useful when you want to ensure that all properties (or all properties of a certain type) are set on a bean. Of course, in many cases a bean class will have default values for many properties, or some properties do not apply to all usage scenarios, so this feature is of limited use. Dependency checking can also be enabled and disabled per bean, just as with the autowiring functionality. The default is to *not* check dependencies. Dependency checking can be handled in several different modes. In an `XmlBeanFactory`, this is specified via the `dependency-check` attribute in a bean definition, which may have the following values.

Table 3.3. Dependency checking modes

| Mode | Explanation |
|--------|--|
| none | No dependency checking. Properties of the bean which have no value specified for them are simply not set. |
| simple | Dependency checking is performed for primitive types and collections (everything except collaborators, i.e. other beans) |

| Mode | Explanation |
|--------|--|
| object | Dependency checking is performed for collaborators |
| all | Dependency checking is done for collaborators, primitive types and collections |

3.4. Customizing the nature of a bean

3.4.1. Lifecycle interfaces

Spring provides several marker interfaces to change the behavior of your bean in the BeanFactory. They include `InitializingBean` and `DisposableBean`. Implementing these interfaces will result in the BeanFactory calling `afterPropertiesSet()` for the former and `destroy()` for the latter to allow the bean to perform certain actions upon initialization and destruction.

Internally, Spring uses `BeanPostProcessors` to process any marker interfaces it can find and call the appropriate methods. If you need custom features or other lifecycle behavior Spring doesn't offer out-of-the-box, you can implement a `BeanPostProcessor` yourself. More information about this can be found in Section 3.7, “Customizing beans with `BeanPostProcessors`”.

All the different lifecycle marker interfaces are described below. In one of the appendices, you can find diagram that show how Spring manages beans and how those lifecycle features change the nature of your beans and how they are managed.

3.4.1.1. `InitializingBean` / `init`-method

Implementing the `org.springframework.beans.factory.InitializingBean` allows a bean to perform initialization work after all necessary properties on the bean are set by the BeanFactory. The `InitializingBean` interface specifies exactly one method:

```
* Invoked by a BeanFactory after it has set all bean properties supplied
* (and satisfied BeanFactoryAware and ApplicationContextAware).
* <p>This method allows the bean instance to perform initialization only
* possible when all bean properties have been set and to throw an
* exception in the event of misconfiguration.
* @throws Exception in the event of misconfiguration (such
* as failure to set an essential property) or if initialization fails.
*/
void afterPropertiesSet() throws Exception;
```

Note: generally, the use of the `InitializingBean` marker interface can be avoided (and is discouraged since it unnecessarily couples the code to Spring). A bean definition provides support for a generic initialization method to be specified. In the case of the `XmlBeanFactory`, this is done via the `init-method` attribute. For example, the following definition:

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

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

Is exactly the same as:

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

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

but does not couple the code to Spring.

3.4.1.2. DisposableBean / destroy-method

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

```
/**
 * Invoked by a BeanFactory on destruction of a singleton.
 * @throws Exception in case of shutdown errors.
 * Exceptions will get logged but not rethrown to allow
 * other beans to release their resources too.
 */
void destroy() throws Exception;
```

Note: generally, the use of the DisposableBean marker interface can be avoided (and is discouraged since it unnecessarily couples the code to Spring). A bean definition provides support for a generic destroy method to be specified. In the case of the XmlBeanFactory, this is done via the destroy-method attribute. For example, the following definition:

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

public class ExampleBean {
    public void cleanup() {
        // do some destruction work (like closing connection)
    }
}
```

Is exactly the same as:

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

public class AnotherExampleBean implements DisposableBean {
    public void destroy() {
        // do some destruction work
    }
}
```

but does not couple the code to Spring.

Important note: when deploying a bean in the prototype mode, the lifecycle of the bean changes slightly. By definition, Spring can not manage the complete lifecycle of a non-singleton/prototype bean, since after it is created, it is given to the client and the container does not keep track of it at all any longer. You can think of Spring's role when talking about a non-singleton/prototype bean as a replacement for the 'new' operator. Any lifecycle aspects past that point have to be handled by the client. The lifecycle of a bean in the BeanFactory is further described in Section 3.4.1, "Lifecycle interfaces".

3.4.2. Knowing who you are

3.4.2.1. BeanFactoryAware

A class which implements the `org.springframework.beans.factory.BeanFactoryAware` interface is provided with a reference to the BeanFactory that created it, when it is created by that BeanFactory.

```

public interface BeanFactoryAware {
    /**
     * Callback that supplies the owning factory to a bean instance.
     * <p>Invoked after population of normal bean properties but before an init
     * callback like InitializingBean's afterPropertiesSet or a custom init-method.
     * @param beanFactory owning BeanFactory (may not be null).
     * The bean can immediately call methods on the factory.
     * @throws BeansException in case of initialization errors
     * @see BeanInitializationException
     */
    void setBeanFactory(BeanFactory beanFactory) throws BeansException;
}

```

This allows beans to manipulate the BeanFactory that created them programmatically, through the `org.springframework.beans.factory.BeanFactory` interface, or by casting the reference to a known subclass of this which exposes additional functionality. Primarily this would consist of programmatic retrieval of other beans. While there are cases when this capability is useful, it should generally be avoided, since it couples the code to Spring, and does not follow the Inversion of Control style, where collaborators are provided to beans as properties.

3.4.2.2. BeanNameAware

If a bean implements the `org.springframework.beans.factory.BeanNameAware` interface and is deployed in a BeanFactory, the BeanFactory will call the bean through this interface to inform the bean of the *id* it was deployed under. The callback will be Invoked after population of normal bean properties but before an init callback like `InitializingBean`'s *afterPropertiesSet* or a custom init-method.

3.4.3. FactoryBean

The `org.springframework.beans.factory.FactoryBean` interface is to be implemented by objects that *are themselves factories*. The BeanFactory interface provides three method:

- `Object getObject()`: has to return 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()`: has to return *true* if this FactoryBean returns singletons, *false* otherwise
- `Class getObjectType()`: has to return either the object type returned by the `getObject()` method or *null* if the type isn't known in advance

3.5. Child bean definitions

A bean definition potentially contains a large amount of configuration information, including container specific information (i.e. initialization method, static factory method name, etc.) and constructor arguments and property values. A child bean definition is a bean definition which inherits configuration data from a parent definition. It is then able to override some values, or add others, as needed. Using parent and child bean definitions can potentially save a lot of typing. Effectively, this is a form of templating.

When working with a BeanFactory programmatically, child bean definitions are represented by the `ChildBeanDefinition` class. Most users will never work with them on this level, instead configuring bean definitions declaratively in something like the `XmlBeanFactory`. In an `XmlBeanFactory` bean definition, a child bean definition is indicated simply by using the `parent` attribute, specifying the parent bean as the value of this attribute.

```

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

```

```
<bean id="inheritsWithDifferentClass" class="org.springframework.beans.DerivedTestBean"
      parent="inheritedTestBean" init-method="initialize">
  <property name="name"><value>override</value></property>
  <!-- age should inherit value of 1 from parent -->
</bean>
```

A child bean definition will use 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, i.e. it must accept the parent's property values.

A child bean definition will inherit constructor argument values, property values and method overrides from the parent, with the option to add new values. If init method, destroy method and/or static factory method are specified, they will override the corresponding parent settings.

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

In the case that the parent definition does not specify a class:

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

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

The parent bean can not get instantiated on its own; it's just a pure template that serves as parent definition for children. Trying to use such parent beans 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, will result in an error. Similarly, the container's internal *preInstantiateSingletons* method will completely ignore bean definitions which don't have either a parent or class attribute set, since they are not complete.

3.6. Interacting with the BeanFactory

A BeanFactory is essentially nothing more than the interface for an advanced factory capable of maintaining a registry of different beans and their dependencies. The BeanFactory enables you to read bean definitions and access them using the bean factory. When using just the BeanFactory you would create one and read in some bean definitions in the XML format as follows:

```
InputStream is = new FileInputStream("beans.xml");
XmlBeanFactory factory = new XmlBeanFactory(is);
```

Basically that's all there is to it. Using `getBean(String)` you can retrieve instances of your beans. You'll get a reference to the same bean if you defined it as a singleton (the default) or you'll get a new instance each time if you set *singleton* to *false*. The client-side view of the BeanFactory is surprisingly simple. The BeanFactory interface has only five methods for clients to call:

- `boolean containsBean(String)`: returns true if the BeanFactory contains a bean definition that matches the given name
- `Object getBean(String)`: returns an instance of the bean registered under the given name. Depending on how the bean was configured by the BeanFactory configuration, either a singleton and thus shared instance

or a newly created bean will be returned. A `BeansException` will be thrown when either the bean could not be found (in which case it'll be a `NoSuchBeanDefinitionException`), or an exception occurred while instantiating and preparing the bean

- `Object getBean(String, Class)`: returns a bean, registered under the given name. The bean returned will be cast to the given `Class`. If the bean could not be cast, corresponding exceptions will be thrown (`BeanNotOfRequiredTypeException`). Furthermore, all rules of the `getBean(String)` method apply (see above)
- `boolean isSingleton(String)`: determines whether or not the `beanDefinition` registered under the given name is a singleton or a prototype. If the `beanDefinition` corresponding to the given name could not be found, an exception will be thrown (`NoSuchBeanDefinitionException`)
- `String[] getAliases(String)`: Return the aliases for the given bean name, if any were defined in the `BeanDefinition`

3.6.1. Obtaining a `FactoryBean`, not its product

Sometimes there is a need to ask a `BeanFactory` for an actual `FactoryBean` instance itself, not the bean it produces. This may be done by prepending the bean id with `&` when calling the `getBean` method of `BeanFactory` (including `ApplicationContext`). So for a given `FactoryBean` with an id `myBean`, invoking `getBean("myBean")` on the `BeanFactory` will return the product of the `FactoryBean`, but invoking `getBean("&myBean")` will return the `FactoryBean` instance itself.

3.7. Customizing beans with `BeanPostprocessors`

A bean post-processor is a java class which implements the `org.springframework.beans.factory.config.BeanPostProcessor` interface, which consists of two callback methods. When such a class is registered as a post-processor with the `BeanFactory`, for each bean instance that is created by the `BeanFactory`, the post-processor will get a callback from the `BeanFactory` before any initialization methods (*afterPropertiesSet* and any declared `init` method) are called, and also afterwards. The post-processor is free to do what it wishes with the bean, including ignoring the callback completely. A bean post-processor will typically check for marker interfaces, or do something such as wrap a bean with a proxy. Some Spring helper classes are implemented as bean post-processors.

It is important to know that a `BeanFactory` treats bean post-processors slightly differently than an `ApplicationContext`. An `ApplicationContext` will automatically detect any beans which are deployed into it which implement the `BeanPostProcessor` interface, and register them as post-processors, to be then called appropriately by the factory on bean creation. Nothing else needs to be done other than deploying the post-processor in a similar fashion to any other bean. On the other hand, when using plain `BeanFactories`, bean post-processors have to manually be *explicitly* registered, with a code sequence such as the following:

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

// now start using the factory
...
```

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

3.8. Customizing bean factories with BeanFactoryPostprocessors

A bean factory post-processor is a java class which implements the `org.springframework.beans.factory.config.BeanFactoryPostProcessor` interface. It is executed manually (in the case of the BeanFactory) or automatically (in the case of the ApplicationContext) to apply changes of some sort to an entire BeanFactory, after it has been constructed. Spring includes a number of pre-existing bean factory post-processors, such as `PropertyResourceConfigurer` and `PropertyPlaceholderConfigurer`, both described below, and `BeanNameAutoProxyCreator`, very useful for wrapping other beans transactionally or with any other kind of proxy, as described later in this manual. The `BeanFactoryPostProcessor` can be used to add custom editors (as also mentioned in Section 4.3.2, “Built-in PropertyEditors, converting types”).

In a BeanFactory, the process of applying a `BeanFactoryPostProcessor` is manual, and will be similar to this:

```
XmlBeanFactory factory = new XmlBeanFactory(new FileSystemResource("beans.xml"));
// create placeholderconfigurer to 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);
```

An ApplicationContext will detect any beans which are deployed into it which implement the `BeanFactoryPostProcessor` interface, and automatically use them as bean factory post-processors, at the appropriate time. Nothing else needs to be done other than deploying these post-processor in a similar fashion to any other bean.

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

3.8.1. The PropertyPlaceholderConfigurer

The `PropertyPlaceholderConfigurer`, implemented as a bean factory post-processor, is used to externalize some property values from a BeanFactory definition, into another separate file in Java Properties format. This is useful to allow the person deploying an application to customize some key properties (for example database URLs, usernames and passwords), without the complexity or risk of modifying the main XML definition file or files for the BeanFactory.

Consider a fragment from a BeanFactory definition, where a `DataSource` with placeholder values is defined:

In the example below, a `datasource` is defined, and we will configure some properties from an external Properties file. At runtime, we will apply a `PropertyPlaceholderConfigurer` to the BeanFactory which will replace some properties of the `datasource`:

```
<bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource" destroy-method="close">
  <property name="driverClassName"><value>${jdbc.driverClassName}</value></property>
  <property name="url"><value>${jdbc.url}</value></property>
  <property name="username"><value>${jdbc.username}</value></property>
  <property name="password"><value>${jdbc.password}</value></property>
</bean>
```

The actual values come from another file in Properties format:

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

To use this with a BeanFactory, the bean factory post-processor is manually executed on it:

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

Note that ApplicationContexts are able to automatically recognize and apply beans deployed in them which implement BeanFactoryPostProcessor. This means that as described here, applying PropertyPlaceholderConfigurer is much more convenient when using an ApplicationContext. For this reason, it is recommended that users wishing to use this or other bean factory postprocessors use an ApplicationContext instead of a BeanFactory.

The PropertyPlaceholderConfigurer doesn't only look for properties in the Properties file you specify, but also checks against the Java System properties if it cannot find a property you are trying to use. This behavior can be customized by setting the `systemPropertiesMode` property of the configurer. It has three values, one to tell the configurer to always override, one to let it *never* override and one to let it override only if the property cannot be found in the properties file specified. Please consult the JavaDoc for the PropertiesPlaceholderConfigurer for more information.

3.8.2. The PropertyOverrideConfigurer

The PropertyOverrideConfigurer, another bean factory post-processor, is similar to the PropertyPlaceholderConfigurer, but in contrast to 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 factory definition is *not* aware of being overridden, so it is not immediately obvious when looking at the XML definition file that the override configurer is being used. In case that there are multiple PropertyOverrideConfigurers that define different values for the same bean property, the last one will win (due to the overriding mechanism).

Properties file configuration lines are expected to be in the format:

```
beanName.property=value
```

An example properties file could look like:

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

This example file would be usable against a BeanFactory definition which contains a bean in it called *dataSource*, which has *driver* and *url* properties.

3.9. Registering additional custom PropertyEditors

When setting bean properties as a string value, a BeanFactory 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 to be simply 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.

The more convenient mechanism is to use a special bean factory post-processor called `CustomEditorConfigurer`. Although bean factory post-processors can be used semi-manually with `BeanFactories`, this one has a nested property setup, so it is strongly recommended that, as described here, it is used with the `ApplicationContext`, where it may be deployed in similar fashion to any other bean, and automatically detected and applied.

3.10. Introduction to the `ApplicationContext`

While the `beans` package provides basic functionality for managing and manipulating beans, often in a programmatic way, the `context` package adds `ApplicationContext` [<http://www.springframework.org/docs/api/org.springframework.context/ApplicationContext.html>], which enhances `BeanFactory` functionality in a more *framework-oriented style*. Many users will use `ApplicationContext` in a completely declarative fashion, not even having to create it manually, but instead relying on support classes such as `ContextLoader` to automatically start an `ApplicationContext` as part of the normal startup process of a J2EE web-app. Of course, it is still possible to programmatically create an `ApplicationContext`.

The basis for the `context` package is the `ApplicationContext` interface, located in the `org.springframework.context` package. Deriving from the `BeanFactory` interface, it provides all the functionality of `BeanFactory`. To allow working in a more framework-oriented fashion, using layering and hierarchical contexts, the `context` package also provides the following:

- *MessageSource*, providing access to messages in, i18n-style
- *Access to resources*, such as URLs and files
- *Event propagation* to beans implementing the `ApplicationListener` interface
- *Loading of multiple (hierarchical) contexts*, allowing each to be focused on one particular layer, for example the web layer of an application

As the `ApplicationContext` includes all functionality of the `BeanFactory`, it is generally recommended that it be used over the `BeanFactory`, except for a few limited situations such as perhaps in an Applet, where memory consumption might be critical, and a few extra kilobytes might make a difference. The following sections described functionality which `ApplicationContext` adds to basic `BeanFactory` capabilities.

3.11. Added functionality of the `ApplicationContext`

As already stated in the previous section, the `ApplicationContext` has a couple of features that distinguish it from the `BeanFactory`. Let us review them one-by-one.

3.11.1. Using the `MessageSource`

The `ApplicationContext` interface extends an interface called `MessageSource`, and therefore provides messaging (i18n or internationalization) functionality. Together with the `NestingMessageSource`, capable of resolving hierarchical messages, these are the basic interfaces Spring provides to do message resolution. Let's quickly review the methods defined there:

- `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 are used as 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 can not be found, a `NoSuchMessageException` is thrown.
- `String getMessage(MessageSourceResolvable resolvable, Locale locale)`: all properties used in the methods above are also wrapped in a class named `MessageSourceResolvable`, which you can use via this method.

When an `ApplicationContext` gets loaded, it automatically searches for a `MessageSource` bean defined in the context. The bean has to have the name `messageSource`. If such a bean is found, all calls to the methods described above will be delegated to the message source that was found. If no message source was found, the `ApplicationContext` inspects attempts to see if it has a parent containing a bean with the same name. If so, it uses that bean as the `MessageSource`. If it can't find any source for messages, an empty `StaticMessageSource` will be instantiated in order to be able to accept calls to the methods defined above.

Spring currently provides two `MessageSource` implementations. These are the `ResourceBundleMessageSource` and the `StaticMessageSource`. Both implement `NestingMessageSource` in order to do nested messaging. The `StaticMessageSource` is hardly ever used but provides programmatic ways to add messages to the source. The `ResourceBundleMessageSource` is more interesting and is the one we will provide an example for:

```
<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>
```

This assumes you have three resource bundles defined on your classpath called `format`, `exceptions` and `windows`. Using the JDK standard way of resolving messages through `ResourceBundles`, any request to resolve a message will be handled. TODO: SHOW AN EXAMPLE

3.11.2. Propagating events

Event handling in the `ApplicationContext` is provided through the `ApplicationEvent` class and `ApplicationListener` interface. If a bean which implements the `ApplicationListener` interface is deployed into the context, every time an `ApplicationEvent` gets published to the `ApplicationContext`, that bean will be notified. Essentially, this is the standard *Observer* design pattern. Spring provides three standard events:

Table 3.4. Built-in Events

| Event | Explanation |
|-----------------------|--|
| ContextRefreshedEvent | Event published when the ApplicationContext is initialized or refreshed. Initialized here means that all beans are loaded, singletons are pre-instantiated and the ApplicationContext is ready for use |
| ContextClosedEvent | Event published when the ApplicationContext is closed, using the <code>close()</code> method on the ApplicationContext. Closed here means that singletons are destroyed |
| RequestHandledEvent | A web-specific event telling all beans that a HTTP request has been serviced (i.e. this will be published <i>after</i> the request has been finished). Note that this event is only applicable for web applications using Spring's DispatcherServlet |

Implementing custom events can be done as well. Simply call the `publishEvent()` method on the ApplicationContext, specifying a parameter which is an instance of your custom event class implementing ApplicationEvent. Let's look at an example. First, the ApplicationContext:

```
<bean id="emailer" class="example.EmailBean">
  <property name="blackList">
    <list>
      <value>black@list.org</value>
      <value>white@list.org</value>
      <value>john@doe.org</value>
    </list>
  </property>
</bean>

<bean id="blackListListener" class="example.BlackListNotifier">
  <property name="notificationAddress">
    <value>spam@list.org</value>
  </property>
</bean>
```

and then, the actual beans:

```
public class EmailBean implements ApplicationContextAware {

    /** the blacklist */
    private List blackList;

    public void setBlackList(List blackList) {
        this.blackList = blackList;
    }

    public void setApplicationContext(ApplicationContext ctx) {
        this.ctx = ctx;
    }

    public void sendEmail(String address, String text) {
        if (blackList.contains(address)) {
            BlackListEvent evt = new BlackListEvent(address, text);
            ctx.publishEvent(evt);
            return;
        }
        // send email
    }
}

public class BlackListNotifier implements ApplicationListener {

    /** notification address */
    private String notificationAddress;

    public void setNotificationAddress(String notificationAddress) {
        this.notificationAddress = notificationAddress;
    }

    public void onApplicationEvent(ApplicationEvent evt){
        if (evt instanceof BlackListEvent) {

```

```

        // notify appropriate person
    }
}

```

Of course, this particular example could probably be implemented in better ways (perhaps by using AOP features), but it should be sufficient to illustrate the basic event mechanism.

3.11.3. Using resources within Spring

Many applications need to access resources. Resources could include files, but also things like web pages or NNTP newfeeds. Spring provides a clean and transparent way of accessing resources in a protocol independent way. The `ApplicationContext` interface includes a method (`getResource(String)`) to take care of this.

The `Resource` class defines a couple of methods that are shared across all `Resource` implementations:

Table 3.5. Resource functionality

| Method | Explanation |
|-------------------------------|---|
| <code>getInputStream()</code> | Opens an <code>InputStream</code> on the resource and returns it |
| <code>exists()</code> | Checks if the resource exists, returning false if it doesn't |
| <code>isOpen()</code> | Will return true is multiple streams cannot be opened for this resource. This will be false for some resources, but file-based resources for instance, cannot be read multiple times concurrently |
| <code>getDescription()</code> | Returns a description of the resource, often the fully qualified file name or the actual URL |

A couple of `Resource` implementations are provided by Spring. They all need a `String` representing the actual location of the resource. Based upon that `String`, Spring will automatically choose the right `Resource` implementation for you. When asking an `ApplicationContext` for a resource first of all Spring will inspect the resource location you're specifying and look for any prefixes. Depending on the implementation of the `ApplicationContext` more or less `Resource` implementations are available. Resources can best be configured by using the `ResourceEditor` and for example the `XmlBeanFactory`.

3.12. Customized behavior in the ApplicationContext

The `BeanFactory` already offers a number of mechanisms to control the lifecycle of beans deployed in it (such as marker interfaces like `InitializingBean` or `DisposableBean`, their configuration only equivalents such as the `init-method` and `destroy-method` attributes in an `XmlBeanFactory` config, and bean post-processors. In an `ApplicationContext`, all of these still work, but additional mechanisms are added for customizing behaviour of beans and the container.

3.12.1. ApplicationContextAware marker interface

All marker interfaces available with `BeanFactories` still work. The `ApplicationContext` does add one extra marker interface which beans may implement, `org.springframework.context.ApplicationContextAware`. A bean which implements this interface and is deployed into the context will be called back on creation of the

bean, using the interface's `setApplicationContext()` method, and provided with a reference to the context, which may be stored for later interaction with the context.

3.12.2. The `BeanPostProcessor`

Bean post-processors, java classes which implement the `org.springframework.beans.factory.config.BeanPostProcessor` interface, have already been mentioned. It is worth mentioning again here though, that post-processors are much more convenient to use in `ApplicationContexts` than in plain `BeanFactories`. In an `ApplicationContext`, any deployed bean which implements the above marker interface is automatically detected and registered as a bean post-processor, to be called appropriately at creation time for each bean in the factory.

3.12.3. The `BeanFactoryPostProcessor`

Bean factory post-processors, java classes which implement the `org.springframework.beans.factory.config.BeanFactoryPostProcessor` interface, have already been mentioned. It is worth mentioning again here though, that bean factory post-processors are much more convenient to use in `ApplicationContexts` than in plain `BeanFactories`. In an `ApplicationContext`, any deployed bean which implements the above marker interface is automatically detected as a bean factory post-processor, to be called at the appropriate time.

3.12.4. The `PropertyPlaceholderConfigurer`

The `PropertyPlaceholderConfigurer` has already been described, as used with a `BeanFactory`. It is worth mentioning here though, that it is generally more convenient to use it with an `ApplicationContext`, since the context will automatically recognize and apply any bean factory post-processors, such as this one, when they are simply deployed into it like any other bean. There is no need for a manual step to execute it.

```
<!-- property placeholder post-processor -->
<bean id="placeholderConfig"
      class="org.springframework.beans.factory.config.PropertyPlaceholderConfigurer">
  <property name="location"><value>jdbc.properties</value></property>
</bean>
```

3.13. Registering additional custom `PropertyEditors`

As previously mentioned, standard JavaBeans `PropertyEditors` 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 `PropertyEditors` to an `ApplicationContext`.

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

```
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 a real `ExoticType` object.:

```
<bean id="sample" class="example.DependsOnExoticType">
  <property name="type"><value>aNameForExoticType</value></property>
</bean>
```

The `PropertyEditor` could look similar to this:

```
// converts string representation to ExoticType object
public class ExoticTypeEditor extends PropertyEditorSupport {

    private String format;

    public void setFormat(String format) {
        this.format = format;
    }

    public void setAsText(String text) {
        if (format != null && format.equals("upperCase")) {
            text = text.toUpperCase();
        }
        ExoticType type = new ExoticType(text);
        setValue(type);
    }
}
```

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

```
<bean id="customEditorConfigurer"
      class="org.springframework.beans.factory.config.CustomEditorConfigurer">
  <property name="customEditors">
    <map>
      <entry key="example.ExoticType">
        <bean class="example.ExoticTypeEditor">
          <property name="format">
            <value>upperCase</value>
          </property>
        </bean>
      </entry>
    </map>
  </property>
</bean>
```

3.14. Setting a bean property as the result of a method invocation

It is sometimes necessary to set a property on a bean, as the result of a method call on another bean in the container, or a static method call on any arbitrary class. Additionally, it is sometimes necessary to call a static or non-static method just to perform some sort of initialization. For both of these purposes, a helper class called `MethodInvokingFactoryBean` may be used. This is a `FactoryBean` which returns a value which is the result of a static or instance method invocation.

An example (in an XML based `BeanFactory` definition) of a bean definition which uses this class to call a static factory method:

```
<bean id="myClass" class="org.springframework.beans.factory.config.MethodInvokingFactoryBean">
  <property name="staticMethod"><value>com.whatever.MyClassFactory.getInstance</value></property>
</bean>
```

An example of calling a static method then an instance method to get at a Java System property. Somewhat

verbose, but it works.

```
<bean id="sysProps" class="org.springframework.beans.factory.config.MethodInvokingFactoryBean">
  <property name="targetClass"><value>java.lang.System</value></property>
  <property name="targetMethod"><value>getProperties</value></property>
</bean>
<bean id="javaVersion" class="org.springframework.beans.factory.config.MethodInvokingFactoryBean">
  <property name="targetObject"><ref local='sysProps' /></property>
  <property name="targetMethod"><value>getProperty</value></property>
  <property name="arguments">
    <list>
      <value>java.version</value>
    </list>
  </property>
</bean>
```

Note that as it is expected to be used mostly for accessing factory methods, `MethodInvokingFactoryBean` by default operates in a *singleton* fashion. The first request by the container for the factory to produce an object will cause the specified method invocation, whose return value will be cached and returned for the current and subsequent requests. An internal `singleton` property of the factory may be set to `false`, to cause it to invoke the target method each time it is asked for an object.

A static target method may be specified by setting the `targetMethod` property to a `String` representing the static method name, with `targetClass` specifying the `Class` that the static method is defined on. Alternatively, a target instance method may be specified, by setting the `targetObject` property as the target object, and the `targetMethod` property as the name of the method to call on that target object. Arguments for the method invocation may be specified by setting the `args` property.

3.15. Creating an ApplicationContext from a web application

As opposed to the `BeanFactory`, which will often be created programmatically, `ApplicationContexts` can be created declaratively using for example a `ContextLoader`. Of course you can also create `ApplicationContexts` programmatically using one of the `ApplicationContext` implementations. First, let's examine the `ContextLoader` and its implementations.

The `ContextLoader` has two implementations: the `ContextLoaderListener` and the `ContextLoaderServlet`. They both have the same functionality but differ in that the listener cannot be used in `Servlet 2.2` compatible containers. Since the `Servlet 2.4` specification, listeners are required to initialize after startup of a web application. A lot of `2.3` compatible containers already implement this feature. It is up to you as to which one you use, but all things being equal you should probably prefer `ContextLoaderListener`; for more information on compatibility, have a look at the `JavaDoc` for the `ContextLoaderServlet`.

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>

<!-- OR USE THE CONTEXTLOADERSERVLET INSTEAD OF THE LISTENER -->
<servlet>
  <servlet-name>context</servlet-name>
  <servlet-class>org.springframework.web.context.ContextLoaderServlet</servlet-class>
  <load-on-startup>1</load-on-startup>
</servlet>
-->
```

The listener inspects the `contextConfigLocation` parameter. If it doesn't exist, it'll use `/WEB-INF/applicationContext.xml` as a default. When it *does* exist, it'll separate the String using predefined delimiters (comma, semi-colon and space) and use the values as locations where application contexts will be searched for. The `ContextLoaderServlet` can - as said - be used instead of the `ContextLoaderListener`. The servlet will use the `contextConfigLocation` parameter just as the listener does.

3.16. Glue code and the evil singleton

The majority of the code inside an application is best written in a Dependency Injection (Inversion of Control) style, where that code is served out of a `BeanFactory` or `ApplicationContext` container, has its own dependencies supplied by the container when it is created, and is completely unaware of the container. However, for the small glue layers of code that are sometimes needed to tie other code together, there is sometimes a need for singleton (or quasi-singleton) style access to a `BeanFactory` or `ApplicationContext`. For example, third party code may try to construct new objects directly (`Class.forName()` style), without the ability to force it to get these objects out of a `BeanFactory`. If the object constructed by the third party code is just a small stub or proxy, which then uses a singleton style access to a `BeanFactory`/`ApplicationContext` to get a real object to delegate to, then inversion of control has still been achieved for the majority of the code (the object coming out of the `BeanFactory`); thus most code is still unaware of the container or how it is accessed, and remains uncoupled from other code, with all ensuing benefits. EJBs may also use this stub/proxy approach to delegate to a plain java implementation object, coming out of a `BeanFactory`. While the `BeanFactory` ideally does not have to be a singleton, it may be unrealistic in terms of memory usage or initialization times (when using beans in the `BeanFactory` such as a `Hibernate SessionFactory`) for each bean to use its own, non-singleton `BeanFactory`.

As another example, in a complex J2EE apps with multiple layers (i.e. various JAR files, EJBs, and WAR files packaged as an EAR), with each layer having its own `ApplicationContext` definition (effectively forming a hierarchy), the preferred approach when there is only one web-app (WAR) in the top hierarchy is to simply create one composite `ApplicationContext` from the multiple XML definition files from each layer. All the `ApplicationContext` variants may be constructed from multiple definition files in this fashion. However, if there are multiple sibling web-apps at the top of the hierarchy, it is problematic to create an `ApplicationContext` for each web-app which consists of mostly identical bean definitions from lower layers, as there may be issues due to increased memory usage, issues with creating multiple copies of beans which take a long time to initialize (i.e. a `Hibernate SessionFactory`), and possible issues due to side-effects. As an alternative, classes such as

`ContextSingletonBeanFactoryLocator [???]` or `SingletonBeanFactoryLocator`

[<http://www.springframework.org/docs/api/org/springframework/beans/factory/access/SingletonBeanFactoryL>

may be used to demand load multiple hierarchical (i.e. one is a parent of another) `BeanFactories` or `ApplicationContexts` in an effectively singleton fashion, which may then be used as the parents of the web-app `ApplicationContexts`. The result is that bean definitions for lower layers are loaded only as needed, and loaded only once.

3.16.1. Using `SingletonBeanFactoryLocator` and `ContextSingletonBeanFactoryLocator`

You can see a detailed example of using `SingletonBeanFactoryLocator`

[<http://www.springframework.org/docs/api/org/springframework/beans/factory/access/SingletonBeanFactoryL> and `ContextSingletonBeanFactoryLocator [???]` by viewing their respective JavaDocs.

As mentioned in the chapter on EJBs, the Spring convenience base classes for EJBs normally use a non-singleton `BeanFactoryLocator` implementation, which is easily replaced by the use of `SingletonBeanFactoryLocator` and `ContextSingletonBeanFactoryLocator` if there is a need.

Chapter 4. PropertyEditors, data binding, validation and the BeanWrapper

4.1. Introduction

The big question is whether or not validation should be considered *business logic*. There are pros and cons for both answers, and Spring offers a design for validation (and data binding) that does not exclude either one of them. Validation should specifically not be tied to the web tier, should be easily localizable and it should be possible to plug in any validator available. Considering the above, Spring has come up with a `Validator` interface that's both basic and 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 ever have the need to use the `BeanWrapper` directly. Because this is reference documentation however, we felt that some explanation might be right. We're explaining the `BeanWrapper` in this chapter since if you were going to use it at all, you would probably do that when trying to bind data to objects, which is strongly related to the `BeanWrapper`.

Spring uses `PropertyEditors` all over the place. The concept of a `PropertyEditor` is part of the JavaBeans specification. Just as the `BeanWrapper`, it's best to explain the use of `PropertyEditors` in this chapter as well, since it's closely related to the `BeanWrapper` and the `DataBinder`.

4.2. Binding data using the `DataBinder`

The `DataBinder` builds on top of the `BeanWrapper`².

4.3. Bean manipulation and the `BeanWrapper`

The `org.springframework.beans` package adheres to the JavaBeans standard provided by Sun. A JavaBean is simply a class with a default no-argument constructor, which follows a naming conventions where a property named `prop` has a setter `setProp(...)` and a getter `getProp()`. For more information about JavaBeans and the specification, please refer to Sun's website (java.sun.com/products/javabeans) [<http://java.sun.com/products/javabeans/>].

One quite important concept of the beans package is the `BeanWrapper` interface and its corresponding implementation (`BeanWrapperImpl`). As quoted from the JavaDoc, the `BeanWrapper` offers functionality to set and get property values (individually or in bulk), get property descriptors and query the readability and writability of properties. Also, the `BeanWrapper` offers support for nested properties, enabling the setting of properties on subproperties to an unlimited depth. Then, the `BeanWrapper` support 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`.

²See the beans chapter for more information

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.

4.3.1. Setting and getting basic and nested properties

Setting and getting properties is done using the `setProperty(s)` and `getProperty(s)` methods that both come with a couple of overloaded variants. They're all described in more detail in the JavaDoc 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 4.1. Examples of properties

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

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

Note: this part is not 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 float salary;

    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`

```
Company c = new Company();
BeanWrapper bwComp = BeanWrapperImpl(c);
// setting the company name...
bwComp.setPropertyValue("name", "Some Company Inc.");
// ... can also be done like this:
PropertyValue v = new PropertyValue("name", "Some Company Inc.");
bwComp.setPropertyValue(v);

// ok, let's create the director and tie it to the company:
Employee jim = new Employee();
BeanWrapper bwJim = BeanWrapperImpl(jim);
bwJim.setPropertyValue("name", "Jim Stravinsky");
bwComp.setPropertyValue("managingDirector", jim);

// retrieving the salary of the managingDirector through the company
Float salary = (Float)bwComp.getPropertyValue("managingDirector.salary");
```

4.3.2. Built-in PropertyEditors, converting types

Spring heavily uses the concept of `PropertyEditors`. Sometimes it 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, 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` gives it the knowledge of how to convert properties to the desired type. Read more about `PropertyEditors` in the JavaDoc of the `java.beans` package provided by Sun.

A couple of examples where property editing is used in Spring

- *setting properties on beans* is done using `PropertyEditors`. When mentioning `java.lang.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 a `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:

Table 4.2. Built-in PropertyEditors

| Class | Explanation |
|---------------------------|--|
| <code>ClassEditor</code> | Parses Strings representing classes to actual classes and the other way around. When a class is not found, an <code>IllegalArgumentException</code> is thrown |
| <code>FileEditor</code> | Capable of resolving Strings to <code>File</code> -objects |
| <code>LocaleEditor</code> | Capable of resolving Strings to <code>Locale</code> -objects and vice versa (the String format is <code>[language]_[country]_[variant]</code> , which is the same thing the <code>toString()</code> method of <code>Locale</code> provides |

| Class | Explanation |
|--|--|
| <code>PropertiesEditor</code> | Capable of converting Strings (formatted using the format as defined in the Javadoc for the <code>java.lang.Properties</code> class) to <code>Properties</code> -objects |
| <code>StringArrayPropertyEditor</code> | Capable of resolving a comma-delimited list of String to a String-array and vice versa |
| <code>URLEditor</code> | Capable of resolving a String representation of a URL to an actual URL-object |

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 `PropertyEditors` for `Font`, `Color` and all the primitive types.

4.3.3. Other features worth mentioning

Besides the features you've seen in the previous sections there a couple of features that might be interesting to you, though not worth an entire section.

- *determining readability and writability*: using the `isReadable()` and `isWritable()` methods, you can determine whether or not a property is readable or writable
- *retrieving `PropertyDescriptor`s*: using `getPropertyDescriptor(String)` and `getPropertyDescriptors()` you can retrieve objects of type `java.beans.PropertyDescriptor`, that might come in handy sometimes

Chapter 5. Spring AOP: Aspect Oriented Programming with Spring

5.1. Concepts

Aspect-Oriented Programming (AOP) complements OOP by providing another way of thinking about program structure. While OO decomposes applications into a hierarchy of objects, AOP decomposes programs into *aspects* or *concerns*. This enables modularization of concerns such as transaction management that would otherwise cut across multiple objects. (Such concerns are often termed *crosscutting* concerns.)

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

AOP is used in Spring:

- To provide declarative enterprise services, especially as a replacement for EJB declarative services. The most important such service is *declarative transaction management*, which builds on Spring's transaction abstraction.
- To allow users to implement custom aspects, complementing their use of OOP with AOP.

Thus you can view Spring AOP as either an enabling technology that allows Spring to provide declarative transaction management without EJB; or use the full power of the Spring AOP framework to implement custom aspects.

If you are interested only in generic declarative services or other pre-packaged declarative middleware services such as pooling, you don't 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. 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 for which the implementation might otherwise cut across multiple objects. Transaction management is a good example of a crosscutting concern in J2EE applications. Aspects are implemented using Spring as Advisors or interceptors.
- *Joinpoint*: Point during the execution of a program, such as a method invocation or a particular exception being thrown. In Spring AOP, a joinpoint is always method invocation. Spring does not use the term joinpoint prominently; joinpoint information is accessible through methods on the `MethodInvocation` argument passed to interceptors, and is evaluated by implementations of the `org.springframework.aop.Pointcut` interface.
- *Advice*: Action taken by the AOP framework at a particular joinpoint. Different types of advice include "around," "before" and "throws" advice. Advice types are discussed below. Many AOP frameworks, including Spring, model an advice as an *interceptor*, maintaining a chain of interceptors "around" the joinpoint.

- *Pointcut*: A set of joinpoints specifying when an advice should fire. An AOP framework must allow developers to specify pointcuts: for example, using regular expressions.
- *Introduction*: Adding methods or fields to an advised class. Spring allows you to introduce new interfaces to any advised object. For example, you could use an introduction to make any object implement an `IsModified` interface, to simplify caching.
- *Target object*: Object containing the joinpoint. Also referred to as *advised* or *proxied* object.
- *AOP proxy*: Object created by the AOP framework, including advice. In Spring, an AOP proxy will be a JDK dynamic proxy or a CGLIB proxy.
- *Weaving*: Assembling aspects to create an advised object. This can be done at compile time (using the AspectJ compiler, for example), or at runtime. Spring, like other pure Java AOP frameworks, performs weaving at runtime.

Different advice types include:

- *Around advice*: Advice that surrounds a joinpoint such as a method invocation. This is the most powerful kind of advice. Around advices will perform custom behaviour before and after the method invocation. They are responsible for choosing whether to proceed to the joinpoint or to shortcut executing by returning their own return value or throwing an exception.
- *Before advice*: Advice that executes before a joinpoint, but which does not have the ability to prevent execution flow proceeding to the joinpoint (unless it throws an exception).
- *Throws advice*: Advice to be executed if a method throws an exception. Spring provides strongly typed throws advice, so you can write code that catches the exception (and subclasses) you're interested in, without needing to cast from `Throwable` or `Exception`.
- *After returning advice*: Advice to be executed after a joinpoint completes normally: for example, if a method returns without throwing an exception.

Around advice is the most general kind of advice. Most interception-based AOP frameworks, such as Nanning Aspects, provide only around advice.

As Spring, like AspectJ, provides a full range of advice types, we recommend that you use the least powerful advice type that can implement the required behaviour. 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 don't need to invoke the `proceed()` method on the `MethodInvocation` used for around advice, and hence can't fail to invoke it.

The pointcut concept is the key to AOP, distinguishing AOP from older technologies offering interception. Pointcuts enable advice to be targeted independently of the OO hierarchy. For example, an around advice providing declarative transaction management can be applied to a set of methods spanning multiple objects. Thus pointcuts provide the structural element of AOP.

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 J2EE web container or application server.

Spring currently supports interception of method invocations. Field interception is not implemented, although support for field interception could be added without breaking the core Spring AOP APIs.

Field interception arguably violates OO encapsulation. We don't believe it is wise in application development. If you require field interception, consider using AspectJ.

Spring provides classes to represent pointcuts and different advice types. Spring uses the term *advisor* for an object representing an aspect, including both an advice and a pointcut targeting it to specific joinpoints.

Different advice types are `MethodInterceptor` (from the AOP Alliance interception API); and the advice interfaces defined in the `org.springframework.aop` package. All advices must implement the `org.aopalliance.aop.Advice` tag interface. Advices supported out the box are `MethodInterceptor`; `ThrowsAdvice`; `BeforeAdvice`; and `AfterReturningAdvice`. We'll discuss advice types in detail below.

Spring implements the *AOP Alliance* interception interfaces (<http://www.sourceforge.net/projects/aopalliance>). Around advice must implement the AOP Alliance `org.aopalliance.intercept.MethodInterceptor` interface. Implementations of this interface can run in Spring or any other AOP Alliance compliant implementation. Currently JAC implements the AOP Alliance interfaces, and Nanning and Dynaop are likely to in early 2004.

Spring'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, Spring's AOP functionality is normally used in conjunction with a Spring IoC container. AOP advice is specified using normal bean definition syntax (although this allows powerful "autoproxying" capabilities); advice and pointcuts are themselves managed by Spring IoC: a crucial difference from other AOP implementations. There are some things you can't do easily or efficiently with Spring AOP, such as advise very fine-grained objects. AspectJ is probably the best choice in such cases. However, our experience is that Spring AOP provides an excellent solution to most problems in J2EE applications that are amenable to AOP.

Spring AOP will never strive to compete with AspectJ or AspectWerkz to provide a comprehensive AOP solution. We believe that both proxy-based frameworks like Spring and full-blown frameworks such as AspectJ are valuable, and that they are complementary, rather than in competition. Thus a major priority for Spring 1.1 will be seamlessly integrating 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 will not affect the Spring AOP API or the AOP Alliance API; Spring AOP will remain backward-compatible.

5.1.3. AOP Proxies in Spring

Spring defaults to using J2SE *dynamic proxies* for AOP proxies. This enables any interface or set of interfaces to be proxied.

Spring can also use CGLIB proxies. This is necessary to proxy classes, rather than interfaces. CGLIB is used by default if a business object doesn't implement an interface. As it's good practice to *program to interfaces rather than classes*, business objects normally will implement one or more business interfaces.

It is possible to force the use of CGLIB: we'll discuss this below, and explain why you'd want to do this. *Beyond Spring 1.0, Spring may offer additional types of AOP proxy, including wholly generated classes. This won't affect the programming model.*

5.2. Pointcuts in Spring

Let's look at how Spring handles the crucial pointcut concept.

5.2.1. 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.

5.2.2. 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.

5.2.3. 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.

5.2.3.1. 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.

5.2.3.1.1. Regular expression pointcuts

One obvious way to specific static pointcuts is regular expressions. Several AOP frameworks besides Spring make this possible. *org.springframework.aop.support.RegexpMethodPointcut* is a generic regular expression pointcut, using Perl 5 regular expression syntax.

Using this class, you can provide a list of pattern Strings. If any of these is a match, the pointcut will evaluate to true. (So the result is effectively the union of these pointcuts.)

The usage is shown below:

```
<bean id="settersAndAbsquatulatePointcut"
      class="org.springframework.aop.support.RegexpMethodPointcut">
  <property name="patterns">
    <list>
      <value>.*get.*</value>
      <value>.*absquatulate</value>
    </list>
  </property>
</bean>
```

A convenience subclass of *RegexpMethodPointcut*, *RegexpMethodPointcutAdvisor*, allows us to reference an Advice also. (Remember that an Advice can be an interceptor, before advice, throws advice etc.) This simplifies wiring, as the one bean serves as both pointcut and advisor, as shown below:

```
<bean id="settersAndAbsquatulateAdvisor"
      class="org.springframework.aop.support.RegexpMethodPointcutAdvisor">
  <property name="advisor">
    <ref local="beanNameOfAopAllianceInterceptor"/>
  </property>
  <property name="patterns">
    <list>
      <value>.*get.*</value>
      <value>.*absquatulate</value>
    </list>
  </property>
</bean>
```

RegexpMethodPointcutAdvisor can be used with any Advice type.

The *RegexpMethodPointcut* class requires the Jakarta ORO regular expression package.

5.2.3.1.2. 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.

5.2.3.2. 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.

5.2.3.2.1. 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 another pointcut.) A control flow pointcut matches the current call stack. For example, it might fire if the joinpoint 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.



Note

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; in Java 1.3 more than 10.

5.2.4. 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 implemented just one abstract method (although it's possible to override other methods to customize behaviour):

```
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.

5.2.5. Custom pointcuts

Because pointcuts in Spring are Java classes, rather than language features (as in AspectJ) it's possible to declare custom pointcuts, whether static or dynamic. However, there is no support out of the box for the sophisticated pointcut expressions that can be coded in AspectJ syntax. However, custom pointcuts in Spring

can be arbitrarily complex.

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."

5.3. Advice types in Spring

Let's now look at how Spring AOP handles advice.

5.3.1. Advice lifecycles

Spring advices 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.

5.3.2. 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.

5.3.2.1. 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 joinpoint; the AOP proxy; and the arguments to the method. The *invoke()* method should return the invocation's result: the return value of the joinpoint.

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 joinpoint. 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.

5.3.2.2. 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 the return type is `void`. Before advice can insert custom behaviour before the joinpoint 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 methods that return normally:

```
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.

5.3.2.3. Throws advice

Throws advice is invoked after the return of the joinpoint if the joinpoint 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 of form

```
afterThrowing([Method], [args], [target], subclassOfThrowable)
```

Only the last argument is required. Thus there from one to four arguments, depending on whether the advice method is interested in the method and arguments. The following are examples of throws advices.

This advice will be 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 static 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  
    }  
}
```

Throws advice can be used with any pointcut.

5.3.2.4. 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.

5.3.2.5. 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 `InterceptionIntroductionAdvisor`, which has the following methods:

```
public interface InterceptionIntroductionAdvisor extends InterceptionAdvisor {
    ClassFilter getClassFilter();
    IntroductionInterceptor getIntroductionInterceptor();
    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.

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` subclasses `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 joinpoint--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.

5.4. Advisors in Spring

In Spring, an Advisor is a modularization of an aspect. Advisors typically incorporate both an advice and a pointcut.

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 create interceptor chain.

5.5. 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 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.

5.5.1. 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 other 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.

5.5.2. JavaBean properties

Like most `FactoryBean` implementations provided with Spring, `ProxyFactoryBean` is itself a JavaBean. Its properties are used to:

- Specify the target you want to proxy
- Specify whether to use CGLIB

Some key properties are inherited from `org.springframework.aop.framework.ProxyConfig`: the superclass for all AOP proxy factories. These include:

- `proxyTargetClass`: true if we should proxy the target class, rather than its interfaces. If this is true we need to use CGLIB.
- `optimize`: whether to apply aggressive optimization to created proxies. Don't use this setting unless you understand how the relevant AOP proxy handles optimization. This is currently used only for CGLIB proxies; it has no effect with JDK dynamic proxies (the default).
- `frozen`: whether advice changes should be disallowed once the proxy factory has been configured. Default is false.
- `exposeProxy`: whether the current proxy should be exposed in a `ThreadLocal` so that it can be accessed by the target. (It's available via the `MethodInvocation` without the need for a `ThreadLocal`.) If a target needs to obtain the proxy and `exposeProxy` is true, the target can use the `AopContext.currentProxy()` method.
- `aopProxyFactory`: the implementation of `AopProxyFactory` to use. Offers a way of customizing whether to use dynamic proxies, CGLIB or any other proxy strategy. The default implementation will choose dynamic proxies or CGLIB appropriately. There should be no need to use this property; it's intended to allow the addition of new proxy types in Spring 1.1.

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
- `interceptorNames`: `String` array of `Advisor`, `interceptor` or other advice names to apply. Ordering is significant. The names are bean names in the current factory, including bean names from ancestor factories.
- `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. 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.

5.5.3. 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</value></property>
  <property name="age"><value>51</value></property>
</bean>

<bean id="myAdvisor" class="com.mycompany.MyAdvisor">
  <property name="someProperty"><value>Custom string property value</value></property>
</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</value></property>

  <property name="target"><ref local="personTarget" /></property>
  <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 local="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</value></property>
</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</value></property>

  <!-- Use inner bean, not local reference to target -->
  <property name="target">
    <bean class="com.mycompany.PersonImpl">
      <property name="name"><value>Tony</value></property>
      <property name="age"><value>51</value></property>
    </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 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.

5.5.4. 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 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.
- You'll need the CGLIB 2 binaries on your classpath; dynamic proxies are available with the JDK

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.

5.6. Convenient proxy creation

Often we don't need the full power of the `ProxyFactoryBean`, because we're only interested in one aspect: For example, transaction management.

There are a number of convenience factories we can use to create AOP proxies when we want to focus on a specific aspect. These are discussed in other chapters, so we'll just provide a quick survey of some of them here.

5.6.1. TransactionProxyFactoryBean

The **jPetStore** sample application shipped with Spring shows the use of the `TransactionProxyFactoryBean`.

The `TransactionProxyFactoryBean` is a subclass of `ProxyConfig`, so basic configuration is shared with `ProxyFactoryBean`. (See list of `ProxyConfig` properties above.)

The following example from the `jPetStore` illustrates how this works. As with a `ProxyFactoryBean`, there is a target bean definition. Dependencies should be expressed on the proxied factory bean definition ("petStore" here), rather than the target POJO ("petStoreTarget").

The `TransactionProxyFactoryBean` requires a target, and information about "transaction attributes," specifying which methods should be transactional and the required propagation and other settings:

```
<bean id="petStoreTarget" class="org.springframework.samples.jpetestore.domain.logic.PetStoreImpl">
  <property name="accountDao"><ref bean="accountDao"/></property>
  <!-- Other dependencies omitted -->
</bean>

<bean id="petStore"
  class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">
  <property name="transactionManager"><ref bean="transactionManager"/></property>
  <property name="target"><ref local="petStoreTarget"/></property>
  <property name="transactionAttributes">
    <props>
      <prop key="insert*">PROPAGATION_REQUIRED</prop>
      <prop key="update*">PROPAGATION_REQUIRED</prop>
      <prop key="*">PROPAGATION_REQUIRED,readOnly</prop>
    </props>
  </property>
</bean>
```

As with the `ProxyFactoryBean`, we might choose to use an inner bean to set the value of `target` property, instead of a reference to a top-level target bean.

The `TransactionProxyFactoryBean` automatically creates a transaction advisor, including a pointcut based on the transaction attributes, so only transactional methods are advised.

The `TransactionProxyFactoryBean` allows the specification of "pre" and "post" advice, using the `preInterceptors` and `postInterceptors` properties. These take Object arrays of interceptors, other advice or Advisors to place in the interception chain before or after the transaction interceptor. These can be populated using a `<list>` element in XML bean definitions, as follows:

```
<property name="preInterceptors">
  <list>
    <ref local="authorizationInterceptor"/>
    <ref local="notificationBeforeAdvice"/>
  </list>
</property>
<property name="postInterceptors">
  <list>
    <ref local="myAdvisor"/>
  </list>
</property>
```

These properties could be added to the "petStore" bean definition above. A common usage is to combine transactionality with declarative security: a similar approach to that offered by EJB.

Because of the use of actual instance references, rather than bean names as in `ProxyFactoryBean`, pre and post interceptors can be used only for shared-instance advice. Thus they are not useful for stateful advice: for example, in mixins. This is consistent with the `TransactionProxyFactoryBean`'s purpose. It provides a simple way of doing common transaction setup. If you need more complex, customized, AOP, consider using the generic `ProxyFactoryBean`, or an auto proxy creator (see below).

Especially if we view Spring AOP as, in many cases, a replacement for EJB, we find that most advice is fairly generic and uses a shared-instance model. Declarative transaction management and security checks are classic examples.

The `TransactionProxyFactoryBean` depends on a `PlatformTransactionManager` implementation via its `transactionManager` JavaBean property. This allows for pluggable transaction implementation, based on JTA, JDBC or other strategies. This relates to the Spring transaction abstraction, rather than AOP. We'll discuss the transaction infrastructure in the next chapter.

If you're interested only in declarative transaction management, the `TransactionProxyFactoryBean` is a good solution, and simpler than using a `ProxyFactoryBean`.

5.6.2. EJB proxies

Other dedicated proxies create proxies for EJBs, enabling the EJB "business methods" interface to be used directly by calling code. Calling code does not need to perform JNDI lookups or use EJB create methods: A significant improvement in readability and architectural flexibility.

See the chapter on Spring EJB services in this manual for further information.

5.7. 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.addInterceptor(myMethodInterceptor);
factory.addAdvisor(myAdvisor);
MyBusinessInterface tb = (MyBusinessInterface) factory.getProxy();
```

The first step is to construct a 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 interceptors 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`) allowing 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.

5.8. 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, whatever 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 introduction).

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.

5.9. Using the "autoproxy" facility

So far we've considered explicit creation of AOP proxies using a `ProxyFactoryBean` or similar factory bean.

Spring also allows us to use "autoproxy" 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 configuring the auto proxy infrastructure. This allows you just to declare the targets eligible for autoproxying: you don't need to use `ProxyFactoryBean`.

There are two ways to do this:

- Using an autoproxy creator that refers to specific beans in the current context
- A special case of autoproxy creation that deserves to be considered separately; autoproxy creation driven by source-level metadata attributes

5.9.1. Autoproxy bean definitions

The `org.springframework.aop.framework.autoproxy` package provides the following standard autoproxy creators.

5.9.1.1. BeanNameAutoProxyCreator

The `BeanNameAutoProxyCreator` automatically creates AOP proxies for beans with names matching literal values or wildcards.

```
<bean id="jdkBeanNameProxyCreator"
      class="org.springframework.aop.framework.autoproxy.BeanNameAutoProxyCreator">
  <property name="beanNames"><value>jdk*,onlyJdk</value></property>
  <property name="interceptorNames">
    <list>
      <value>myInterceptor</value>
    </list>
  </property>
</bean>
```

As with `ProxyFactoryBean`, there is an `interceptorNames` property rather than a list of interceptor, to allow

correct behaviour 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, and 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.

5.9.1.2. DefaultAdvisorAutoProxyCreator

A more general and extremely powerful auto proxy creator is `DefaultAdvisorAutoProxyCreator`. This will automatically apply eligible advisors in the current context, without the need to include specific bean names in the autoproxy 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 id="autoProxyCreator"
      class="org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreator">
</bean>

<bean id="txAdvisor"
      autowire="constructor"
      class="org.springframework.transaction.interceptor.TransactionAttributeSourceAdvisor">
  <property name="order"><value>1</value></property>
</bean>

<bean id="customAdvisor"
      class="com.mycompany.MyAdvisor">
</bean>

<bean id="businessObject1"
      class="com.mycompany.BusinessObject1">
  <!-- Properties omitted -->
</bean>

<bean id="businessObject2"
      class="com.mycompany.BusinessObject2">
</bean>
```

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; default is unordered.

5.9.1.3. AbstractAdvisorAutoProxyCreator

This is the superclass of `DefaultAdvisorAutoProxyCreator`. You can create your own autoproxies by subclassing this class, in the unlikely event that advisor definitions offer insufficient customization to the behaviour of the framework `DefaultAdvisorAutoProxyCreator`.

5.9.2. Using metadata-driven autoproxies

A particularly important type of autoproxies is driven by metadata. This produces a similar programming model to .NET `ServiceComponents`. Instead of using XML deployment descriptors as in EJB, configuration for transaction management and other enterprise services is held in source-level attributes.

In this case, you use the `DefaultAdvisorAutoProxyCreator`, in combination with Advisors that understand metadata attributes. The metadata specifics are held in the pointcut part of the candidate advisors, rather than in the autoproxies creation class itself.

This is really a special case of the `DefaultAdvisorAutoProxyCreator`, but deserves consideration on its own. (The metadata-aware code is in the pointcuts contained in the advisors, not the AOP framework itself.)

The `/attributes` directory of the `jPetStore` sample application shows the use of attribute-driven autoproxies. In this case, there's no need to use the `TransactionProxyFactoryBean`. Simply defining transactional attributes on business objects is sufficient, because of the use of metadata-aware pointcuts. The bean definitions include the following code, in `/WEB-INF/declarativeServices.xml`. Note that this is generic, and can be used outside the `jPetStore`:

```
<bean id="autoproxies"
      class="org.springframework.aop.framework.autoproxies.DefaultAdvisorAutoProxyCreator">
</bean>

<bean id="transactionAttributeSource"
      class="org.springframework.transaction.interceptor.AttributesTransactionAttributeSource"
      autowire="constructor">
</bean>

<bean id="transactionInterceptor"
      class="org.springframework.transaction.interceptor.TransactionInterceptor"
      autowire="byType">
</bean>

<bean id="transactionAdvisor"
      class="org.springframework.transaction.interceptor.TransactionAttributeSourceAdvisor"
      autowire="constructor">
</bean>

<bean id="attributes"
      class="org.springframework.metadata.commons.CommonsAttributes"
/>
```

The `DefaultAdvisorAutoProxyCreator` bean definition--called "advisor" in this case, but the name is not significant--will pick up all eligible pointcuts in the current application context. In this case, the "transactionAdvisor" bean definition, of type `TransactionAttributeSourceAdvisor`, will apply to classes or methods carrying a transaction attribute. The `TransactionAttributeSourceAdvisor` depends on a `TransactionInterceptor`, via constructor dependency. The example resolves this via autowiring. The `AttributesTransactionAttributeSource` depends on an implementation of the `org.springframework.metadata.Attributes` interface. In this fragment, the "attributes" bean satisfies this, using the Jakarta Commons Attributes API to obtain attribute information. (The application code must have been compiled using the Commons Attributes compilation task.)

The `TransactionInterceptor` defined here depends on a `PlatformTransactionManager` definition, which is not included in this generic file (although it could be) because it will be specific to the application's transaction requirements (typically JTA, as in this example, or Hibernate, JDO or JDBC):

```
<bean id="transactionManager"
      class="org.springframework.transaction.jta.JtaTransactionManager" />
```

If you require only declarative transaction management, using these generic XML definitions will result in Spring automatically proxying all classes or methods with transaction attributes. You won't need to work directly with AOP, and the programming model is similar to that of .NET ServicedComponents.

This mechanism is extensible. It's possible to do autoproxying based on custom attributes. You need to:

- Define your custom attribute.
- Specify an Advisor with the necessary advice, including a pointcut that is triggered by the presence of the custom attribute on a class or method. You may be able to use an existing advice, merely implementing a static pointcut that picks up the custom attribute.

It's possible for such advisors to be unique to each advised class (for example, mixins): they simply need to be defined as prototype, rather than singleton, bean definitions. For example, the `LockMixin` introduction interceptor from the Spring test suite, shown above, could be used in conjunction with an attribute-driven pointcut to target a mixin, as shown here. We use the generic `DefaultPointcutAdvisor`, configured using JavaBean properties:

```
<bean id="lockMixin"
      class="org.springframework.aop.LockMixin"
      singleton="false"
/>

<bean id="lockableAdvisor"
      class="org.springframework.aop.support.DefaultPointcutAdvisor"
      singleton="false"
>
  <property name="pointcut">
    <ref local="myAttributeAwarePointcut" />
  </property>
  <property name="advice">
    <ref local="lockMixin" />
  </property>
</bean>

<bean id="anyBean" class="anyclass" ...
```

If the attribute aware pointcut matches any methods in the `anyBean` or other bean definitions, the mixin will be applied. Note that both `lockMixin` and `lockableAdvisor` definitions are prototypes. The `myAttributeAwarePointcut` pointcut can be a singleton definition, as it doesn't hold state for individual advised objects.

5.10. 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 joinpoint. 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.

5.10.1. 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>

<bean id="swapper"
    class="org.springframework.aop.target.HotSwappableTargetSource">
    <constructor-arg><ref local="initialTarget"/></constructor-arg>
</bean>

<bean id="swappable"
    class="org.springframework.aop.framework.ProxyFactoryBean"
>
    <property name="targetSource">
        <ref local="swapper"/>
    </property>
</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.

5.10.2. 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 Jakarta Commons Pool 1.1, 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.

Sample configuration is shown below:

```
<bean id="businessObjectTarget" class="com.mycompany.MyBusinessObject"
    singleton="false">
    ... properties omitted
</bean>

<bean id="poolTargetSource"
    class="org.springframework.aop.target.CommonsPoolTargetSource">
    <property name="targetBeanName"><value>businessObjectTarget</value></property>
    <property name="maxSize"><value>25</value></property>
</bean>

<bean id="businessObject"
    class="org.springframework.aop.framework.ProxyFactoryBean"
    >
    <property name="targetSource"><ref local="poolTargetSource"/></property>
    <property name="interceptorNames"><value>myInterceptor</value></property>
</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 Javadoc for `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="target"><ref local="poolTargetSource" /></property>
    <property name="targetMethod"><value>getPoolingConfigMixin</value></property>
</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 threadsafe, and instance pooling is problematic if resources are cached.

Simpler pooling is available using autoproxying. It's possible to set the TargetSources used by any autoproxy creator.

5.10.3. 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"><value>businessObjectTarget</value></property>
</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.

5.11. 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 interception around advice, before, throws advice and after returning advice, which are supported out of the box.

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` tag interface.

Please refer to the `org.springframework.aop.framework.adapter` package's Javadocs for further information

5.12. Further reading and resources

I recommend the excellent *AspectJ in Action* by Ramnivas Laddad (Manning, 2003) for an introduction to AOP.

Please refer to the Spring sample applications for further examples of Spring AOP:

- The JPetStore's default configuration illustrates the use of the `TransactionProxyFactoryBean` for declarative transaction management

- The `/attributes` directory of the JPetStore illustrates the use of attribute-driven declarative transaction management

If you are interested in more advanced capabilities of Spring AOP, take a look at the test suite. The test coverage is over 90%, and this illustrates advanced features not discussed in this document.

5.13. Roadmap

Spring AOP, like the rest of Spring, is actively developed. The core API is stable. Like the rest of Spring, the AOP framework is very modular, enabling extension while preserving the fundamental design. Several improvements are planned in the Spring 1.1 timeframe, which will preserve backward compatibility. These include:

- *Performance improvements:* The creation of AOP proxies is handled by a factory via a Strategy interface. Thus we can support additional AopProxy types without impacting user code or the core implementation. Significant performance optimizations for CGLIB proxying are scheduled for the 1.0.3 release, with further optimizations by Spring 1.1 in cases where advice will not change at runtime. This should produce a significant reduction in the overhead of the AOP framework. Note, however, that the overhead of the AOP framework is not an issue in normal usage.
- *More expressive pointcuts:* Spring presently offers an expressive Pointcut interface, but we can add value through adding more Pointcut implementations. We are looking at an integration with AspectJ that will allow AspectJ pointcut expressions to be used in Spring configuration files. And if you wish to contribute a useful Pointcut, please do!

The most significant enhancements are likely to concern integration with AspectJ, which will be done in cooperation with the AspectJ community. We believe that this will provide significant benefits for both Spring and AspectJ users, in the following areas:

- Allowing AspectJ aspects to be configured using Spring IoC. This has the potential to integrate AspectJ aspects into applications where appropriate, in the same way as Spring aspects are integrated into application IoC contexts.
- Allowing the use of AspectJ pointcut expressions within Spring configuration to target Spring advice. This has significant benefits over devising our own pointcut expression language; AspectJ is both well thought out and well documented.

Both these integrations should be available in Spring 1.1.

Chapter 6. AspectJ Integration

6.1. Overview

Spring's proxy-based AOP framework is well suited for handling many generic middleware and application-specific problems. However, there are times when a more powerful AOP solution is required: for example, if we need to add additional fields to a class, or advise fine-grained objects that aren't created by the Spring IoC container.

We recommend the use of AspectJ in such cases. Accordingly, as of version 1.1, Spring provides a powerful integration with AspectJ.

6.2. Configuring AspectJ aspects using Spring IoC

The most important part of the Spring/AspectJ integration allows Spring to configure AspectJ aspects using Dependency Injection. This brings similar benefits to aspects as to objects. For example:

- There is no need for aspects to use ad hoc configuration mechanisms; they can be configured in the same, consistent, approach used for the entire application.
- Aspects can depend on application objects. For example, a security aspect can depend on a security manager, as we'll see in an example shortly.
- It's possible to obtain a reference to an aspect through the relevant Spring context. This can allow for dynamic reconfiguration of the aspect.

AspectJ aspects can expose JavaBean properties for Setter Injection, and even implement Spring lifecycle interfaces such as `BeanFactoryAware`.

Note that AspectJ aspects cannot use Constructor Injection or Method Injection. This limitation is due to the fact that aspects do not have constructors that can be invoked like constructors of objects.

6.2.1. "Singleton" aspects

In most cases, AspectJ aspects are singletons, with one instance per class loader. This single instance is responsible for advising multiple object instances.

A Spring IoC container cannot instantiate an aspect, as aspects don't have callable constructors. But it can obtain a reference to an aspect using the static `aspectOf()` method that AspectJ defines for all aspects, and it can inject dependencies into that aspect.

6.2.1.1. Example

Consider a security aspect, which depends on a security manager. This aspect applies to all changes in the value of the `balance` instance variable in the `Account` class. (We couldn't do this in the same way using Spring AOP.)

The AspectJ code for the aspect (one of the Spring/AspectJ samples), is shown below. Note that the dependency on the `SecurityManager` interface is expressed in a JavaBean property:

```
public aspect BalanceChangeSecurityAspect {
    private SecurityManager securityManager;

    public void setSecurityManager(SecurityManager securityManager) {
        this.securityManager = securityManager;
    }

    private pointcut balanceChanged() :
        set(int Account.balance);

    before() : balanceChanged() {
        this.securityManager.checkAuthorizedToModify();
    }
}
```

We configure this aspect in the same way as an ordinary class. Note that the way in which we set the property reference is identical. Note that we must use the `factory-method` attribute to specify that we want the aspect "created" using the `aspectOf()` static method. In fact, this is *locating*, rather than, *creating*, the aspect, but the Spring container doesn't care:

```
<bean id="securityAspect"
    class="org.springframework.samples.aspectj.bank.BalanceChangeSecurityAspect"
    factory-method="aspectOf"
>
    <property name="securityManager">
        <ref local="securityManager"/>
    </property>
</bean>
```

We don't need to do anything in Spring configuration to target this aspect. It contains the pointcut information in AspectJ code that controls where it applies. Thus it can apply even to objects not managed by the Spring IoC container.

6.2.1.2. Ordering issues

to be completed

6.2.2. Non-singleton aspects

** Complete material on `pertarget` etc.

6.2.3. Gotchas

to be completed

- Singleton issue

6.3. Using AspectJ pointcuts to target Spring advice

In a future release of Spring, we plan to provide the ability for AspectJ pointcut expressions to be used in Spring XML or other bean definition files, to target Spring advice. This will allow some of the power of the AspectJ pointcut model to be applied to Spring's proxy-based AOP framework. This will work in pure Java, and will not require the AspectJ compiler. Only the subset of AspectJ pointcuts relating to method invocation will be usable.

This feature is scheduled for Spring 1.2. It depends on AspectJ enhancements.

This feature replaces our previous plan to create a pointcut expression language for Spring.

6.4. Spring aspects for AspectJ

In a future release of Spring (probably 1.2), we will package some Spring services, such as the declarative transaction management service, as AspectJ aspects. This will enable them to be used by AspectJ users without dependence on the Spring AOP framework--potentially, even without dependence on the Spring IoC container.

This feature is probably of more interest to AspectJ users than Spring users.

Chapter 7. Transaction management

7.1. The Spring transaction abstraction

Spring provides a consistent abstraction for transaction management. This abstraction is one of the most important of Spring's abstractions, and delivers the following benefits:

- Provides a consistent programming model across different transaction APIs such as JTA, JDBC, Hibernate, iBATIS Database Layer and JDO.
- Provides a simpler, easier to use, API for programmatic transaction management than most of these transaction APIs
- Integrates with the Spring data access abstraction
- Supports Spring declarative transaction management

Traditionally, J2EE developers have had two choices for transaction management: to use *global* or *local* transactions. Global transactions are managed by the application server, using JTA. Local transactions are resource-specific: for example, a transaction associated with a JDBC connection. This choice had profound implications. Global transactions provide the ability to work with multiple transactional resources. (It's worth noting that most applications use a single transaction resource) With local transactions, the application server is not involved in transaction management, and cannot help ensure correctness across multiple resources.

Global transactions have a significant downside. Code needs to use JTA: a cumbersome API to use (partly due to its exception model). Furthermore, a JTA `UserTransaction` normally needs to be obtained from JNDI: meaning that we need to use *both* JNDI and JTA to use JTA. Obviously all use of global transactions limits the reusability of application code, as JTA is normally only available in an application server environment.

The preferred way to use global transactions was via EJB *CMT* (*Container Managed Transaction*): a form of **declarative transaction management** (as distinguished from **programmatic transaction management**). EJB CMT removes the need for transaction-related JNDI lookups--although of course the use of EJB itself necessitates the use of JNDI. It removes most--not all--need to write Java code to control transactions. The significant downside is that CMT is (obviously) tied to JTA and an application server environment; and that it's only available if we choose to implement business logic in EJBs, or at least behind a transactional EJB facade. The negatives around EJB in general are so great that this is not an attractive proposition, when there are alternatives for declarative transaction management.

Local transactions may be easier to use, but also have significant disadvantages: They cannot work across multiple transactional resources, and tend to invade the programming model. For example, code that manages transactions using a JDBC connection cannot run within a global JTA transaction.

Spring resolves these problems. It enables application developers to use a consistent programming model *in any environment*. You write your code once, and it can benefit from different transaction management strategies in different environments. Spring provides both declarative and programmatic transaction management. Declarative transaction management is preferred by most users, and recommended in most cases.

With programmatic transaction management developers work with the Spring transaction abstraction, which can run over any underlying transaction infrastructure. With the preferred declarative model developers typically write little or no code related to transaction management, and hence don't depend on Spring's or any other transaction API.

7.2. Transaction strategies

The key to the Spring transaction abstraction is the notion of a *transaction strategy*.

This is captured in the `org.springframework.transaction.PlatformTransactionManager` interface, shown below:

```
public interface PlatformTransactionManager {

    TransactionStatus getTransaction(TransactionDefinition definition)
        throws TransactionException;

    void commit(TransactionStatus status) throws TransactionException;

    void rollback(TransactionStatus status) throws TransactionException;

}
```

This is primarily an SPI interface, although it can be used programmatically. Note that in keeping with Spring's philosophy, this is an *interface*. Thus it can easily be mocked or stubbed if necessary. Nor is it tied to a lookup strategy such as JNDI: `PlatformTransactionManager` implementations are defined like any other object in a Spring IoC container. This benefit alone makes this a worthwhile abstraction even when working with JTA: transactional code can be tested much more easily than if it directly used JTA.

In keeping with Spring's philosophy, `TransactionException` is unchecked. Failures of the transaction infrastructure are almost invariably fatal. In rare cases where application code can recover from them, the application developer can still choose to catch and handle `TransactionException`.

The `getTransaction()` method returns a `TransactionStatus` object, depending on a `TransactionDefinition` parameter. The returned `TransactionStatus` might represent a new or existing transaction (if there was a matching transaction in the current call stack).

As with J2EE transaction contexts, a `TransactionStatus` is associated with a **thread** of execution.

The `TransactionDefinition` interface specifies:

- **Transaction isolation:** The degree of isolation this transaction has from the work of other transactions. For example, can this transaction see uncommitted writes from other transactions?
- **Transaction propagation:** Normally all code executed within a transaction scope will run in that transaction. However, there are several options specifying behaviour if a transactional method is executed when a transaction context already exists: For example, simply running in the existing transaction (the most common case); or suspending the existing transaction and creating a new transaction. Spring offers the transaction propagation options familiar from EJB CMT.
- **Transaction timeout:** How long this transaction may run before timing out (automatically being rolled back by the underlying transaction infrastructure).
- **Read-only status:** A read-only transaction does not modify any data. Read-only transactions can be a useful optimization in some cases (such as when using Hibernate).

These settings reflect standard concepts. If necessary, please refer to a resource discussing transaction isolation levels and other core transaction concepts: Understanding such core concepts is essential to using Spring or any other transaction management solution.

The `TransactionStatus` interface provides a simple way for transactional code to control transaction execution

and query transaction status. The concepts should be familiar, as they are common to all transaction APIs:

```
public interface TransactionStatus {

    boolean isNewTransaction();

    void setRollbackOnly();

    boolean isRollbackOnly();

}
```

However Spring transaction management is used, defining the `PlatformTransactionManager` implementation is essential. In good Spring fashion, this important definition is made using Inversion of Control.

`PlatformTransactionManager` implementations normally require knowledge of the environment in which they work: JDBC, JTA, Hibernate etc.

The following examples from `dataAccessContext-local.xml` from Spring's **jPetStore** sample application show how a local `PlatformTransactionManager` implementation can be defined. This will work with JDBC.

We must define a JDBC `DataSource`, and then use the Spring `DataSourceTransactionManager`, giving it a reference to the `DataSource`.

```
<bean id="dataSource"
    class="org.apache.commons.dbcp.BasicDataSource" destroy-method="close">
    <property name="driverClassName"><value>${jdbc.driverClassName}</value></property>
    <property name="url"><value>${jdbc.url}</value></property>
    <property name="username"><value>${jdbc.username}</value></property>
    <property name="password"><value>${jdbc.password}</value></property>
</bean>
```

The `PlatformTransactionManager` definition will look like this:

```
<bean id="transactionManager"
    class="org.springframework.jdbc.datasource.DataSourceTransactionManager">
    <property name="dataSource"><ref local="dataSource"/></property>
</bean>
```

If we use JTA, as in the `dataAccessContext-jta.xml` file from the same sample application, we need to use a container `DataSource`, obtained via JNDI, and a `JtaTransactionManager` implementation. The `JtaTransactionManager` doesn't need to know about the `DataSource`, or any other specific resources, as it will use the container's global transaction management.

```
<bean id="dataSource" class="org.springframework.jndi.JndiObjectFactoryBean">
    <property name="jndiName"><value>jdbc/jpetstore</value></property>
</bean>

<bean id="transactionManager"
    class="org.springframework.transaction.jta.JtaTransactionManager"/>
```

We can use Hibernate local transactions easily, as shown in the following examples from the Spring **PetClinic** sample application.

In this case, we need to define a `Hibernate LocalSessionFactory`, which application code will use to obtain `Hibernate Sessions`.

The `DataSource` bean definition will be similar to one of the above examples, and is not shown. (If it's a container `DataSource` it should be non-transactional as Spring, rather than the container, will manage transactions.)

The "transactionManager" bean in this case is of class `HibernateTransactionManager`. In the same way as the `DataSourceTransactionManager` needs a reference to the `DataSource`, the `HibernateTransactionManager` needs a reference to the session factory.

```
<bean id="sessionFactory" class="org.springframework.orm.hibernate.LocalSessionFactoryBean">
  <property name="dataSource"><ref local="dataSource"/></property>
  <property name="mappingResources">
    <value>org/springframework/samples/petclinic/hibernate/petclinic.hbm.xml</value>
  </property>
  <property name="hibernateProperties">
    <props>
      <prop key="hibernate.dialect">${hibernate.dialect}</prop>
    </props>
  </property>
</bean>

<bean id="transactionManager"
  class="org.springframework.orm.hibernate.HibernateTransactionManager">
  <property name="sessionFactory"><ref local="sessionFactory"/></property>
</bean>
```

With Hibernate and JTA transactions we could simply use the `JtaTransactionManager` as with JDBC or any other resource strategy.

```
<bean id="transactionManager"
  class="org.springframework.transaction.jta.JtaTransactionManager"/>
```

Note that this is identical to JTA configuration for any resource, as these are global transactions, which can enlist any transactional resource.

In all these cases, application code won't need to change at all. We can change how transactions are managed merely by changing configuration, even if that change means moving from local to global transactions or vice versa.

When not using global transactions, you do need to follow one special coding convention. Fortunately this is very simple. You need to obtain connection or session resources in a special way, to allow the relevant `PlatformTransactionManager` implementation to track connection usage, and apply transaction management as necessary.

For example, if using JDBC, you should not call the `getConnection()` method on a `DataSource`, but must use the Spring `org.springframework.jdbc.datasource.DataSourceUtils` class as follows:

```
Connection conn = DataSourceUtils.getConnection(dataSource);
```

This has the added advantage that any `SQLException` will be wrapped in a Spring `CannotGetJdbcConnectionException`--one of Spring's hierarchy of unchecked `DataAccessExceptions`. This gives you more information than can easily be obtained from the `SQLException`, and ensures portability across databases: even across different persistence technologies.

This will work fine without Spring transaction management, so you can use it whether or not you are using Spring for transaction management.

Of course, once you've used Spring's JDBC support or Hibernate support, you won't want to use `DataSourceUtils` or the other helper classes, because you'll be much happier working via the Spring abstraction than directly with the relevant APIs. For example, if you use the Spring `JdbcTemplate` or `jdbc.object` package to simplify your use of JDBC, correct connection retrieval happens behind the scenes and you won't need to write any special code.

7.3. Programmatic transaction management

Spring provides two means of programmatic transaction management:

- Using the `TransactionTemplate`
- Using a `PlatformTransactionManager` implementation directly

We generally recommend the first approach.

The second approach is similar to using the JTA `UserTransaction` API (although exception handling is less cumbersome).

7.3.1. Using the `TransactionTemplate`

The `TransactionTemplate` adopts the same approach as other Spring *templates* such as `JdbcTemplate` and `HibernateTemplate`. It uses a callback approach, to free application code from the working of acquiring and releasing resources. (No more try/catch/finally.) Like other templates, a `TransactionTemplate` is threadsafe.

Application code that must execute in a transaction context looks like this. Note that the `TransactionCallback` can be used to return a value:

```
Object result = tt.execute(new TransactionCallback() {
    public Object doInTransaction(TransactionStatus status) {
        updateOperation1();
        return resultOfUpdateOperation2();
    }
});
```

If there's no return value, use a `TransactionCallbackWithoutResult` like this:

```
tt.execute(new TransactionCallbackWithoutResult() {
    protected void doInTransactionWithoutResult(TransactionStatus status) {
        updateOperation1();
        updateOperation2();
    }
});
```

Code within the callback can roll the transaction back by calling the `setRollbackOnly()` method on the `TransactionStatus` object.

Application classes wishing to use the `TransactionTemplate` must have access to a `PlatformTransactionManager`: usually exposed as a JavaBean property or as a constructor argument.

It's easy to unit test such classes with a mock or stub `PlatformTransactionManager`. There's no JNDI lookup or static magic here: it's a simple interface. As usual, you can use Spring to simplify your unit testing.

7.3.2. Using the `PlatformTransactionManager`

You can also use the `org.springframework.transaction.PlatformTransactionManager` directly to manage your transaction. Simply pass the implementation of the `PlatformTransactionManager` you're using to your bean via a bean reference. Then, using the `TransactionDefinition` and `TransactionStatus` objects you can initiate transactions, rollback and commit.


```

DefaultTransactionDefinition def = new DefaultTransactionDefinition()
def.setPropagationBehavior(TransactionDefinition.PROPAGATION_REQUIRED);

TransactionStatus status = transactionManager.getTransactionDefinition(def);

try {
    // execute your business logic here
} catch (MyException ex) {
    transactionManager.rollback(status);
    throw ex;
}
transactionManager.commit(status);

```

7.4. Declarative transaction management

Spring also offers declarative transaction management. This is enabled by Spring AOP.

Most Spring users choose declarative transaction management. It is the option with the least impact on application code, and hence is most consistent with the ideals of a non-invasive lightweight container.

It may be helpful to begin by considering EJB CMT and explaining the similarities and differences with Spring declarative transaction management. The basic approach is similar: It's possible to specify transaction behaviour (or lack of it) down to individual methods. It's possible to make a `setRollbackOnly()` call within a transaction context if necessary. The differences are:

- Unlike EJB CMT, which is tied to JTA, Spring declarative transaction management works in any environment. It can work with JDBC, JDO, Hibernate or other transactions under the covers, with configuration changes only.
- Spring enables declarative transaction management to be applied to any POJO, not just special classes such as EJBs.
- Spring offers declarative *rollback rules*: a feature with no EJB equivalent, which we'll discuss below. Rollback can be controlled declaratively, not merely programmatically.
- Spring gives you an opportunity to customize transactional behaviour, using AOP. For example, if you want to insert custom behaviour in the case of transaction rollback, you can. You can also add arbitrary advice, along with the transactional advice. With EJB CMT, you have no way to influence the container's transaction management other than `setRollbackOnly()`.
- Spring does not support propagation of transaction contexts across remote calls, as do high-end application servers. If you need this feature, we recommend that you use EJB. However, don't use this feature lightly. Normally we don't want transactions to span remote calls.

The concept of rollback rules is important: they enable us to specify which exceptions (and throwables) should cause automatic roll back. We specify this declaratively, in configuration, not in Java code. So, while we can still call `setRollbackOnly()` on the `TransactionStatus` object to roll the current transaction back programmatically, most often we can specify a rule that `MyApplicationException` should always result in roll back. This has the significant advantage that business objects don't need to depend on the transaction infrastructure. For example, they typically don't need to import any Spring APIs, transaction or other.

While the EJB default behaviour is for the EJB container to automatically roll back the transaction on a *system exception* (usually a runtime exception), EJB CMT does not roll back the transaction automatically on an *application exception* (checked exception other than `java.rmi.RemoteException`). While the Spring default behaviour for declarative transaction management follows EJB convention (roll back is automatic only on

unchecked exceptions), it's often useful to customize this.

On our benchmarks, the performance of Spring declarative transaction management exceeds that of EJB CMT.

The usual way of setting up transactional proxying in Spring is via the `TransactionProxyFactoryBean`. We need a target object to wrap in a transactional proxy. The target object is normally a POJO bean definition. When we define the `TransactionProxyFactoryBean`, we must supply a reference to the relevant `PlatformTransactionManager`, and **transaction attributes**. Transaction attributes contain the transaction definitions, discussed above.

```
<bean id="petStore"
  class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">
  <property name="transactionManager"><ref bean="transactionManager"/></property>
  <property name="target"><ref bean="petStoreTarget"/></property>
  <property name="transactionAttributes">
    <props>
      <prop key="insert*">PROPAGATION_REQUIRED,-MyCheckedException</prop>
      <prop key="update*">PROPAGATION_REQUIRED</prop>
      <prop key="*">PROPAGATION_REQUIRED,readOnly</prop>
    </props>
  </property>
</bean>
```

The transactional proxy will implement the interfaces of the target: in this case, the bean with id `petStoreTarget`. (Using CGLIB it's possible to transactionally proxy a target class. Set the `proxyTargetClass` property to true for this. It will happen automatically if the target doesn't implement any interfaces. In general, of course, we want to program to interfaces rather than classes.) It's possible (and usually a good idea) to restrict the transactional proxy to proxying only specific target interfaces, using the `proxyInterfaces` property. It's also possible to customize the behaviour of a `TransactionProxyFactoryBean` via several properties inherited from `org.springframework.aop.framework.ProxyConfig`, and shared with all AOP proxy factories.

The `transactionAttributes` here are set using a Properties format defined in the `org.springframework.transaction.interceptor.NameMatchTransactionAttributeSource` class. The mapping from method name, including wildcards, should be fairly intuitive. Note that the value for the `insert*` mapping contains a rollback rule. Adding `-MyCheckedException` here specifies that if the method throws `MyCheckedException` or any subclasses, the transaction will automatically be rolled back. Multiple rollback rules can be specified here, comma-separated. A `-` prefix forces rollback; a `+` prefix specifies commit. (This allows commit even on unchecked exceptions, if you really know what you're doing!)

The `TransactionProxyFactoryBean` allows you to set "pre" and "post" advice, for additional interception behaviour, using the `preInterceptors` and `postInterceptors` properties. Any number of pre and post advices can be set, and their type may be `Advisor` (in which case they can contain a pointcut), `MethodInterceptor` or any advice type supported by the current Spring configuration (such as `ThrowsAdvice`, `AfterReturningAdvice` or `BeforeAdvice`, which are supported by default.) These advices must support a shared-instance model. If you need transactional proxying with advanced AOP features such as stateful mixins, it's normally best to use the generic `org.springframework.aop.framework.ProxyFactoryBean`, rather than the `TransactionProxyFactoryBean` convenience proxy creator.

It's also possible to set up autoproxying: that is, to configure the AOP framework so that classes are automatically proxied without needing individual proxy definitions.

Please see the chapter on AOP for more information and examples.

You don't need to be an AOP expert--or indeed, to know much at all about AOP--to use Spring's declarative transaction management effectively. However, if you do want to become a "power user" of Spring AOP, you will find it easy to combine declarative transaction management with powerful AOP capabilities.

7.4.1. BeanNameAutoProxyCreator, another declarative approach

`TransactionProxyFactoryBean` is very useful, and gives you full control when wrapping objects with a transactional proxy. In the case that you need to wrap a number of beans in an identical fashion (for example, a boilerplate, 'make all methods transactional', using a `BeanFactoryPostProcessor` called `BeanNameAutoProxyCreator` can offer an alternative approach which can end up being significantly less verbose for this simplified use case.

To recap, once the `ApplicationContext` has read its initialization information, it instantiates any beans within it which implement the `BeanPostProcessor` interface, and gives them a chance to post-process all other beans in the `ApplicationContext`. So using this mechanism, a properly configured `BeanNameAutoProxyCreator` can be used to postprocess any other beans in the `ApplicationContext` (recognizing them by name), and wrap them with a transactional proxy. The actual transaction proxy produced is essentially identical to that produced by the use of `TransactionProxyFactoryBean`, so will not be discussed further.

Let us consider a sample configuration:

```
<!-- Transaction Interceptor set up to do PROPAGATION_REQUIRED on all methods -->
<bean id="matchAllWithPropReq"
      class="org.springframework.transaction.interceptor.MatchAlwaysTransactionAttributeSource">
  <property name="transactionAttribute"><value>PROPAGATION_REQUIRED</value></property>
</bean>
<bean id="matchAllTxInterceptor"
      class="org.springframework.transaction.interceptor.TransactionInterceptor">
  <property name="transactionManager"><ref bean="transactionManager"/></property>
  <property name="transactionAttributeSource"><ref bean="matchAllWithPropReq"/></property>
</bean>

<!-- One BeanNameAutoProxyCreator handles all beans where we want all methods to use
      PROPAGATION_REQUIRED -->
<bean id="autoProxyCreator"
      class="org.springframework.aop.framework.autoproxy.BeanNameAutoProxyCreator">
  <property name="interceptorNames">
    <list>
      <idref local="matchAllTxInterceptor"/>
      <idref bean="hibInterceptor"/>
    </list>
  </property>
  <property name="beanNames">
    <list>
      <idref local="core-services-applicationControllerService"/>
      <idref local="core-services-deviceService"/>
      <idref local="core-services-authenticationService"/>
      <idref local="core-services-packagingMessageHandler"/>
      <idref local="core-services-sendEmail"/>
      <idref local="core-services-userService"/>
    </list>
  </property>
</bean>
```

Assuming that we already have a `TransactionManager` instance in our `ApplicationContext`, the first thing we need to do is create a `TransactionInterceptor` instance to use. The `TransactionInterceptor` decides which methods to intercept based on a `TransactionAttributeSource` implementing object passed to it as a property. In this case, we want to handle the very simple case of matching all methods. This is not necessarily the most efficient approach, but it's very quick to set up, because we can use the special pre-defined `MatchAlwaysTransactionAttributeSource`, which simply matches all methods. If we wanted to be more specific, we could use other variants such as `MethodMapTransactionAttributeSource`, `NameMatchTransactionAttributeSource`, or `AttributesTransactionAttributeSource`.

Now that we have the transaction interceptor, we simply feed it to a `BeanNameAutoProxyCreator` instance we define, along with the names of 6 beans in the `ApplicationContext` that we want to wrap in an identical fashion. As you can see, the net result is significantly less verbose than it would have been to wrap 6 beans identically

with `TransactionProxyFactoryBean`. Wrapping a 7th bean would add only one more line of config.

You may notice that we are able to apply multiple interceptors. In this case, we are also applying a `HibernateInterceptor` we have previously defined (bean id=`hibInterceptor`), which will manage Hibernate Sessions for us.

There is one thing to keep in mind, with regards to bean naming, when switching back and forth between the use of `TransactionProxyFactoryBean`, and `BeanNameAutoProxyCreator`. For the former, you normally give the target bean you want to wrap an id similar in form to `myServiceTarget`, and then give the proxy object an id of `myService`; then all users of the wrapped object simply refer to the proxy, i.e. `myService`. (These are just sample naming conventions, the point is that the target object has a different name than the proxy, and both are available from the `ApplicationContext`). However, when using `BeanNameAutoProxyCreator`, you name the target object something like `myService`. Then, when `BeanNameAutoProxyCreator` postprocesses the target object and create the proxy, it causes the proxy to be inserted into the `Application` context under the name of the original bean. From that point on, only the proxy (the wrapped object) is available from the `ApplicationContext`.

7.5. Choosing between programmatic and declarative transaction management

Programmatic transaction management is usually a good idea only if you have a small number of transactional operations. For example, if you have a web application that require transactions only for certain update operations, you may not want to set up transactional proxies using Spring or any other technology. Using the `TransactionTemplate` may be a good approach.

On the other hand, if your applications has numerous transactional operations, declarative transaction management is usually worthwhile. It keeps transaction management out of business logic, and is not difficult to configure in Spring. Using Spring, rather than EJB CMT, the configuration cost of declarative transaction management is greatly reduced.

7.6. Do you need an application server for transaction management?

Spring's transaction management capabilities--and especially its declarative transaction management--significantly changes traditional thinking as to when a J2EE application requires an application server.

In particular, you don't need an application server just to have declarative transactions via EJB. In fact, even if you have an application server with powerful JTA capabilities, you may well decide that Spring declarative transactions offer more power and a much more productive programming model than EJB CMT.

You need an application server's JTA capability only if you need to enlist multiple transactional resources. Many applications don't face this requirement. For example, many high-end applications use a single, highly scalable, database such as Oracle 9i RAC.

Of course you may need other application server capabilities such as JMS and JCA. However, if you need only JTA, you could also consider an open source JTA add-on such as JOTM. (Spring integrates with JOTM out of the box.) However, as of early 2004, high-end application servers provide more robust support for XA transactions.

The most important point is that with Spring *you can choose when to scale your application up to a full-blown*

application server. Gone are the days when the only alternative to using EJB CMT or JTA was to write coding using local transactions such as those on JDBC connections, and face a hefty rework if you ever needed that code to run within global, container-managed transactions. With Spring only configuration needs to change: your code doesn't.

7.7. Common problems

Developers should take care to use the correct *PlatformTransactionManager* implementation for their requirements.

It's important to understand how the Spring transaction abstraction works with JTA global transactions. Used properly, there is no conflict here: Spring merely provides a simplifying, portable abstraction.

If you are using global transactions, you *must* use the Spring `org.springframework.transaction.jta.JtaTransactionManager` for all your for all your transactional operations. Otherwise Spring will attempt to perform local transactions on resources such as container `DataSources`. Such local transactions don't make sense, and a good application server will treat them as errors.

Chapter 8. Source Level Metadata Support

8.1. Source-level metadata

Source-level metadata is the addition of *attributes* or *annotations* to program elements: usually, classes and/or methods.

For example, we might add metadata to a class as follows:

```
/**
 * Normal comments
 * @org.springframework.transaction.interceptor.DefaultTransactionAttribute()
 */
public class PetStoreImpl implements PetStoreFacade, OrderService {
```

We could add metadata to a method as follows:

```
/**
 * Normal comments
 * @org.springframework.transaction.interceptor.RuleBasedTransactionAttribute ( )
 * @org.springframework.transaction.interceptor.RollbackRuleAttribute (Exception.class)
 * @org.springframework.transaction.interceptor.NoRollbackRuleAttribute ("ServletException")
 */
public void echoException(Exception ex) throws Exception {
    ....
}
```

Both these examples use Jakarta Commons Attributes syntax.

Source-level metadata was introduced to the mainstream with the release of Microsoft's .NET platform, which uses source-level attributes to control transactions, pooling and other behaviour.

The value in this approach has been recognized in the J2EE community. For example, it's much less verbose than the traditional XML deployment descriptors exclusively used by EJB. While it is desirable to externalize some things from program source code, some important enterprise settings--notably transaction characteristics--belong in program source. Contrary to the assumptions of the EJB spec, it seldom makes sense to modify the transactional characteristics of a method.

Although metadata attributes are typically used mainly by framework infrastructure to describe the services application classes require, it should also be possible for metadata attributes to be queried at runtime. This is a key distinction from solutions such as XDoclet, which primarily view metadata as a way of generating code such as EJB artefacts.

There are a number of solutions in this space, including:

- **JSR-175:** the standard Java metadata implementation, available in Java 1.5. But we need a solution now and may always want a facade
- **XDoclet:** well-established solution, primarily intended for code generation
- Various **open source attribute implementations**, pending the release of JSR-175, of which Commons Attributes appears to be the most promising. All these require a special pre- or post-compilation step.

8.2. Spring's metadata support

In keeping with its provision of abstractions over important concepts, Spring provides a facade to metadata implementations, in the form of the `org.springframework.metadata.Attributes` interface.

Such a facade adds value for several reasons:

- There is currently no standard metadata solution. Java 1.5 will provide one, but it is still in beta as of Spring 1.0. Furthermore, there will be a need for metadata support in 1.3 and 1.4 applications for at least two years. Spring aims to provide working solutions *now*; waiting for 1.5 is not an option in such an important area.
- Current metadata APIs, such as Commons Attributes (used by Spring 1.0) are hard to test. Spring provides a simple metadata interface that is much easier to mock.
- Even when Java 1.5 provides metadata support at language level, there will still be value in providing such an abstraction:
 - JSR-175 metadata is static. It is associated with a class at compile time, and cannot be changed in a deployed environment. There is a need for hierarchical metadata, providing the ability to override certain attribute values in deployment--for example, in an XML file.
 - JSR-175 metadata is returned through the Java reflection API. This makes it impossible to mock during test time. Spring provides a simple interface to allow this.

Thus Spring will support JSR-175 before Java 1.5 reaches GA, but will continue to offer an attribute abstraction API.

The Spring `Attributes` interface looks like this:

```
public interface Attributes {  
    Collection getAttributes(Class targetClass);  
    Collection getAttributes(Class targetClass, Class filter);  
    Collection getAttributes(Method targetMethod);  
    Collection getAttributes(Method targetMethod, Class filter);  
    Collection getAttributes(Field targetField);  
    Collection getAttributes(Field targetField, Class filter);  
}
```

This is a lowest common denominator interface. JSR-175 offers more capabilities than this, such as attributes on method arguments. As of Spring 1.0, Spring aims to provide the subset of metadata required to provide effective declarative enterprise services a la EJB or .NET. Beyond Spring 1.0, it is likely that Spring will provide further metadata methods.

Note that this interface offers `Object` attributes, like .NET. This distinguishes it from attribute systems such as that of Nanning Aspects and JBoss 4 (as of DR2), which offer only `String` attributes. There is a significant advantage in supporting `Object` attributes. It enables attributes to participate in class hierarchies and enables attributes to react intelligently to their configuration parameters.

In most attribute providers, attribute classes will be configured via constructor arguments or `JavaBean`

properties. Commons Attributes supports both.

As with all Spring abstraction APIs, `Attributes` is an interface. This makes it easy to mock attribute implementations for unit tests.

8.3. Integration with Jakarta Commons Attributes

Presently Spring supports only Jakarta Commons Attributes out of the box, although it is easy to provide implementations of the `org.springframework.metadata.Attributes` interface for other metadata providers.

Commons Attributes 2.0 (<http://jakarta.apache.org/commons/sandbox/attributes/> [<http://jakarta.apache.org/commons/sandbox/attributes/>]) is a capable attributes solution. It supports attribute configuration via constructor arguments and JavaBean properties, which offers better self-documentation in attribute definitions. (Support for JavaBean properties was added at the request of the Spring team.)

We've already seen two examples of Commons Attributes attributes definitions. In general, we will need to express:

- *The name of the attribute class.* This can be an FQN, as shown above. If the relevant attribute class has already been imported, the FQN isn't required. It's also possible to specify "attribute packages" in attribute compiler configuration.
- *Any necessary parameterization,* via constructor arguments or JavaBean properties

Bean properties look as follows:

```
/**
 * @MyAttribute(myBooleanJavaBeanProperty=true)
 */
```

It's possible to combine constructor arguments and JavaBean properties (as in Spring IoC).

Because, unlike Java 1.5 attributes, Commons Attributes is not integrated with the Java language, it is necessary to run a special *attribute compilation* step as part of the build process.

To run Commons Attributes as part of the build process, you will need to do the following.

1. Copy the necessary library Jars to `$ANT_HOME/lib`. Four Jars are required, and all are distributed with Spring:

- The Commons Attributes compiler Jar and API Jar
- `xjavadoc.jar`, from XDoclet
- `commons-collections.jar`, from Jakarta Commons

2. Import the Commons Attributes ant tasks into your project build script, as follows:

```
<taskdef resource="org/apache/commons/attributes/anttasks.properties"/>
```

3. Next, define an attribute compilation task, which will use the Commons Attributes attribute-compiler task to "compile" the attributes in the source. This process results in the generation of additional sources, to a location specified by the `destdir` attribute. Here we show the use of a temporary directory:


```
<target name="compileAttributes" >

  <attribute-compiler
    destdir="${commons.attributes.tempdir}"
  >
    <fileset dir="${src.dir}" includes="**/*.java"/>
  </attribute-compiler>

</target>
```

The compile target that runs Javac over the sources should depend on this attribute compilation task, and must also compile the generated sources, which we output to our destination temporary directory. If there are syntax errors in your attribute definitions, they will normally be caught by the attribute compiler. However, if the attribute definitions are syntactically plausible, but specify invalid types or class names, the compilation of the generated attribute classes may fail. In this case, you can look at the generated classes to establish the cause of the problem.

Commons Attributes also provides Maven support. Please refer to Commons Attributes documentation for further information.

While this attribute compilation process may look complex, in fact it's a one-off cost. Once set up, attribute compilation is incremental, so it doesn't usually noticeably slow the build process. And once the compilation process is set up, you may find that use of attributes as described in this chapter can save you a lot of time in other areas.

If you require attribute indexing support (only currently required by Spring for attribute-targeted web controllers, discussed below), you will need an additional step, which must be performed on a Jar file of your compiled classes. In this, optional, step, Commons Attributes will create an index of all the attributes defined on your sources, for efficient lookup at runtime. This step looks as follows:

```
<attribute-indexer jarFile="myCompiledSources.jar">

  <classpath refid="master-classpath"/>

</attribute-indexer>
```

See the /attributes directory of the Spring jPetStore sample application for an example of this build process. You can take the build script it contains and modify it for your own projects.

If your unit tests depend on attributes, try to express the dependency on the Spring Attributes abstraction, rather than Commons Attributes. Not only is this more portable--for example, your tests will still work if you switch to Java 1.5 attributes in future--it simplifies testing. Commons Attributes is a static API, while Spring provides a metadata interface that you can easily mock.

8.4. Metadata and Spring AOP autoproxying

The most important uses of metadata attributes are in conjunction with Spring AOP. This provides a .NET-like programming model, where declarative services are automatically provided to application objects that declare metadata attributes. Such metadata attributes can be supported out of the box by the framework, as in the case of declarative transaction management, or can be custom.

There is widely held to be a synergy between AOP and metadata attributes.

8.4.1. Fundamentals

This builds on the Spring AOP autoproxy functionality. Configuration might look like this:

```
<bean id="autoproxy"
      class="org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreator">
</bean>

<bean id="transactionAttributeSource"
      class="org.springframework.transaction.interceptor.AttributesTransactionAttributeSource"
      autowire="constructor">
</bean>

<bean id="transactionInterceptor"
      class="org.springframework.transaction.interceptor.TransactionInterceptor"
      autowire="byType">
</bean>

<bean id="transactionAdvisor"
      class="org.springframework.transaction.interceptor.TransactionAttributeSourceAdvisor"
      autowire="constructor" >
</bean>

<bean id="attributes"
      class="org.springframework.metadata.commons.CommonsAttributes"
/>
```

The basic concepts here should be familiar from the discussion of autoproxying in the AOP chapter.

The most important bean definitions are those named **autoproxy** and **transactionAdvisor**. Note that the actual bean names are not important; what matters is their class.

The autoproxy bean definition of class

`org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreator` will automatically advise ("autoproxy") all bean instances in the current factory based on matching Advisor implementations. This class knows nothing about attributes, but relies on Advisors' pointcuts matching. The pointcuts do know about attributes.

Thus we simply need an AOP advisor that will provide declarative transaction management based on attributes.

It's possible to add arbitrary custom Advisor implementations as well, and they will also be evaluated and applied automatically. (You can use Advisors whose pointcuts match on criteria besides attributes in the same autoproxy configuration, if necessary.)

Finally, the `attributes` bean is the Commons Attributes Attributes implementation. Replace with another implementation of `org.springframework.metadata.Attributes` to source attributes from a different source.

8.4.2. Declarative transaction management

The commonest use of source-level attributes is to provide declarative transaction management a la .NET. Once the bean definitions shown above are in place, you can define any number of application objects requiring declarative transactions. Only those classes or methods with transaction attributes will be given transaction advice. You need to do nothing except define the required transaction attributes.

Unlike in .NET, you can specify transaction attributes at either class or method level. Class-level attributes, if specified, will be "inherited" by all methods. Method attributes will wholly override any class-level attributes.

8.4.3. Pooling

Again, as with .NET, you can enable pooling behaviour via class-level attributes. Spring can apply this

behaviour to any POJO. You simply need to specify a pooling attribute, as follows, in the business object to be pooled:

```
/**
 * @@org.springframework.aop.framework.autoproxy.target.PoolingAttribute (10)
 *
 * @author Rod Johnson
 */
public class MyClass {
```

You'll need the usual autoproxy infrastructure configuration. You then need to specify a pooling `TargetSourceCreator`, as follows. Because pooling affects the creation of the target, we can't use a regular advice. Note that pooling will apply even if there are no advisors applicable to the class, if that class has a pooling attribute.

```
<bean id="poolingTargetSourceCreator"
      class="org.springframework.aop.framework.autoproxy.metadata.AttributesPoolingTargetSourceCreator"
      autowire="constructor" >
</bean>
```

The relevant autoproxy bean definition needs to specify a list of "custom target source creators", including the Pooling target source creator. We could modify the example shown above to include this property as follows:

```
<bean id="autoproxy"
      class="org.springframework.aop.framework.autoproxy.DefaultAdvisorAutoProxyCreator">
>
  <property name="customTargetSourceCreators">
    <list>
      <ref local="poolingTargetSourceCreator" />
    </list>
  </property>
</bean>
```

As with the use of metadata in Spring in general, this is a one-off cost: once setup is out of the way, it's very easy to use pooling for additional business objects.

It's arguable that the need for pooling is rare, so there's seldom a need to apply pooling to a large number of business objects. Hence this feature does not appear to be used often.

Please see the Javadoc for the `org.springframework.aop.framework.autoproxy` package for more details. It's possible to use a different pooling implementation than Commons Pool with minimal custom coding.

8.4.4. Custom metadata

We can even go beyond the capabilities of .NET metadata attributes, because of the flexibility of the underlying autoproxying infrastructure.

We can define custom attributes, to provide any kind of declarative behaviour. To do this, you need to:

- Define your custom attribute class
- Define a Spring AOP Advisor with a pointcut that fires on the presence of this custom attribute.
- Add that Advisor as a bean definition to an application context with the generic autoproxy infrastructure in place.

- Add attributes to your POJOs.

There are several potential areas you might want to do this, such as custom declarative security, or possibly caching.

This is a powerful mechanism which can significantly reduce configuration effort in some projects. However, remember that it does rely on AOP under the covers. The more Advisors you have in play, the more complex your runtime configuration will be.

(If you want to see what advice applies to any object, try casting a reference to `org.springframework.aop.framework.Advised`. This will enable you to examine the Advisors.)

8.5. Using attributes to minimize MVC web tier configuration

The other main use of Spring metadata as of 1.0 is to provide an option to simplify Spring MVC web configuration.

Spring MVC offers flexible *handler mappings*: mappings from incoming request to controller (or other handler) instance. Normally handler mappings are configured in the `xxxx-servlet.xml` file for the relevant Spring `DispatcherServlet`.

Holding these mappings in the `DispatcherServlet` configuration file is normally A Good Thing. It provides maximum flexibility. In particular:

- The controller instance is explicitly managed by Spring IoC, through an XML bean definition
- The mapping is external to the controller, so the same controller instance could be given multiple mappings in the same `DispatcherServlet` context or reused in a different configuration.
- Spring MVC is able to support mappings based on any criteria, rather than merely the request URL-to-controller mappings available in most other frameworks.

However, this does mean that for each controller we typically need both a handler mapping (normally in a handler mapping XML bean definition) and an XML mapping for the controller itself.

Spring offers a simpler approach based on source-level attributes, which is an attractive option in simpler scenarios.

The approach described in this section is best suited to relatively simple MVC scenarios. It sacrifices some of the power of Spring MVC, such as the ability to use the same controller with different mappings, and the ability to base mappings on something other than request URL.

In this approach, controllers are marked with one or more class-level metadata attributes, each specifying one URL they should be mapped to.

The following examples show the approach. In each case, we have a controller that depends on a business object of type `Cruncher`. As usual, this dependency will be resolved by Dependency Injection. The `Cruncher` must be available through a bean definition in the relevant `DispatcherServlet` XML file, or a parent context.

We attach an attribute to the controller class specifying the URL that should map to it. We can express the dependency through a JavaBean property or a constructor argument. This dependency must be resolvable by autowiring: that is, there must be exactly one business object of type `Cruncher` available in the context.

```
/**
 * Normal comments here
 * @author Rod Johnson
```

```

* @@org.springframework.web.servlet.handler.metadata.PathMap("/bar.cgi")
*/
public class BarController extends AbstractController {

    private Cruncher cruncher;

    public void setCruncher(Cruncher cruncher) {
        this.cruncher = cruncher;
    }

    protected ModelAndView handleRequestInternal(
        HttpServletRequest arg0, HttpServletResponse arg1)
        throws Exception {
        System.out.println("Bar Crunching c and d =" +
            cruncher.concatenate("c", "d"));
        return new ModelAndView("test");
    }
}

```

For this automapping to work, we need to add the following to the relevant `xxxx-servlet.xml` file, specifying the attributes handler mapping. This special handler mapping can handle any number of controllers with attributes as shown above. The bean id ("commonsAttributesHandlerMapping") is not important. The type is what matters:

```

<bean id="commonsAttributesHandlerMapping"
    class="org.springframework.web.servlet.handler.metadata.CommonsPathMapHandlerMapping"
/>

```

We *do not* currently need an Attributes bean definition, as in the above example, because this class works directly with the Commons Attributes API, not via the Spring metadata abstraction.

We now need no XML configuration for each controller. Controllers are automatically mapped to the specified URL(s). Controllers benefit from IoC, using Spring's autowiring capability. For example, the dependency expressed in the "cruncher" bean property of the simple controller shown above is automatically resolved in the current web application context. Both Setter and Constructor Dependency Injection are available, each with zero configuration.

An example of Constructor Injection, also showing multiple URL paths:

```

/**
 * Normal comments here
 * @author Rod Johnson
 *
 * @@org.springframework.web.servlet.handler.metadata.PathMap("/foo.cgi")
 * @@org.springframework.web.servlet.handler.metadata.PathMap("/baz.cgi")
 */
public class FooController extends AbstractController {

    private Cruncher cruncher;

    public FooController(Cruncher cruncher) {
        this.cruncher = cruncher;
    }

    protected ModelAndView handleRequestInternal(
        HttpServletRequest arg0, HttpServletResponse arg1)
        throws Exception {
        return new ModelAndView("test");
    }
}

```

This approach has the following benefits:

- Significantly reduced volume of configuration. Each time we add a controller we need add *no* XML configuration. As with attribute-driven transaction management, once the basic infrastructure is in place, it is very easy to add more application classes.
- We retain much of the power of Spring IoC to configure controllers.

This approach has the following limitations:

- One-off cost in more complex build process. We need an attribute compilation step and an attribute indexing step. However, once in place, this should not be an issue.
- Currently Commons Attributes only, although support for other attribute providers may be added in future.
- Only "autowiring by type" dependency injection is supported for such controllers. However, this still leaves them far in advance of Struts Actions (with no IoC support from the framework) and, arguably, WebWork Actions (with only rudimentary IoC support) where IoC is concerned.
- Reliance on automagical IoC resolution may be confusing.

Because autowiring by type means there must be exactly one dependency of the specified type, we need to be careful if we use AOP. In the common case using `TransactionProxyFactoryBean`, for example, we end up with *two* implementations of a business interface such as `Cruncher`: the original POJO definition, and the transactional AOP proxy. This won't work, as the owning application context can't resolve the type dependency unambiguously. The solution is to use AOP autoproxying, setting up the autoproxy infrastructure so that there is only one implementation of `Cruncher` defined, and that implementation is automatically advised. Thus this approach works well with attribute-targeted declarative services as described above. As the attributes compilation process must be in place to handle the web controller targeting, this is easy to set up.

Unlike other metadata functionality, there is currently only a Commons Attributes implementation available: `org.springframework.web.servlet.handler.metadata.CommonsPathMapHandlerMapping`. This limitation is due to the fact that not only do we need attribute compilation, we need attribute *indexing*: the ability to ask the attributes API for all classes with the `PathMap` attribute. Indexing is not currently offered on the `org.springframework.metadata.Attributes` abstraction interface, although it may be in future. (If you want to add support for another attributes implementation--which must support indexing--you can easily extend the `AbstractPathMapHandlerMapping` superclass of `CommonsPathMapHandlerMapping`, implementing the two protected abstract methods to use your preferred attributes API.)

Thus we need two additional steps in the build process: attribute compilation and attribute indexing. Use of the attribute indexer task was shown above. Note that Commons Attributes presently requires a Jar file as input to indexing.

If you begin with a handler metadata mapping approach, it is possible to switch at any point to a classic Spring XML mapping approach. So you don't close off this option. For this reason, I find that I often start a web application using metadata mapping.

8.6. Other uses of metadata attributes

Other uses of metadata attributes appear to be growing in popularity. As of March 2004, an attribute-based validation package for Spring is in development. The one-off setup cost of attribute parsing looks more attractive, when the potential for multiple uses is considered.

8.7. Adding support for additional metadata APIs

Should you wish to provide support for another metadata API it is easy to do so.

Simply implement the `org.springframework.metadata.Attributes` interface as a facade for your metadata API. You can then include this object in your bean definitions as shown above.

All framework services that use metadata, such as AOP metadata-driven autoproxying, will then automatically be able to use your new metadata provider.

We expect to add support for Java 1.5 attributes--probably as an add-on to the Spring core--in Q2 2004.

Chapter 9. DAO support

9.1. Introduction

The DAO (Data Access Object) support in Spring is primarily aimed at making it easy to work with data access technologies like JDBC, Hibernate or JDO in a standardized way. This allows you to switch between them fairly easily and it also allows you to code without worrying about catching exceptions that are specific to each technology.

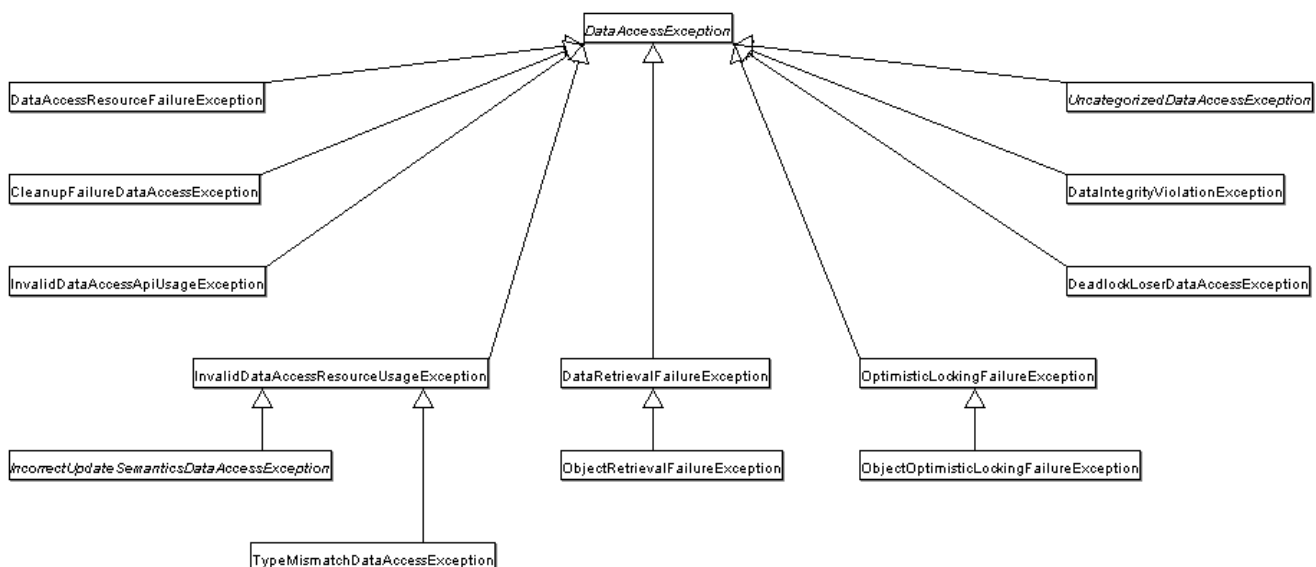
9.2. Consistent Exception Hierarchy

Spring provides a convenient translation from technology specific exceptions like `SQLException` to its own exception hierarchy with the `DataAccessException` as the root exception. These exceptions wrap the original exception so there is never any risk that you would lose any information as to what might have gone wrong.

In addition to JDBC exceptions, Spring can also wrap Hibernate exceptions, converting them from proprietary, checked exceptions, to a set of abstracted runtime exceptions. The same is true for JDO exceptions. This allows you to handle most persistence exceptions, which are non-recoverable, only in the appropriate layers, without annoying boilerplate catches/throws, and exception declarations. You can still trap and handle exceptions anywhere you need to. As we mentioned above, JDBC exceptions (including DB specific dialects) are also converted to the same hierarchy, meaning that you can perform some operations with JDBC within a consistent programming model.

The above is true for the Template versions of the ORM access framework. If you use the Interceptor based classes then the application must care about handling `HibernateExceptions` and `JDOExceptions` itself, preferably via delegating to `SessionFactoryUtils`' `convertHibernateAccessException` or `convertJdoAccessException` methods respectively. These methods convert the exceptions to ones that are compatible with the `org.springframework.dao` exception hierarchy. As `JDOExceptions` are unchecked, they can simply get thrown too, sacrificing generic DAO abstraction in terms of exceptions though.

The exception hierarchy that Spring uses is outlined in the following graph:



9.3. Consistent Abstract Classes for DAO Support

To make it easier to work with a variety of data access technologies like JDBC, JDO and Hibernate in a consistent way, Spring provides a set of abstract DAO classes that you can extend. These abstract classes has methods for setting the data source and any other configuration settings that are specific to the technology you currently are using.

Dao Support classes:

- `JdbcDaoSupport` - super class for JDBC data access objects. Requires a `DataSource` to be set, providing a `JdbcTemplate` based on it to subclasses.
- `HibernateDaoSupport` - super class for Hibernate data access objects. Requires a `SessionFactory` to be set, providing a `HibernateTemplate` based on it to subclasses. Can alternatively be initialized directly via a `HibernateTemplate`, to reuse the latter's settings like `SessionFactory`, flush mode, exception translator, etc.
- `JdoDaoSupport` - super class for JDO data access objects. Requires a `PersistenceManagerFactory` to be set, providing a `JdoTemplate` based on it to subclasses.

Chapter 10. Data Access using JDBC

10.1. Introduction

The JDBC abstraction framework provided by Spring consists of four different packages `core`, `datasource`, `object` and `support`.

The `org.springframework.jdbc.core` package does as its name suggests contain the classes that provide the core functionality. This includes various `SQLExceptionTranslator` and `DataFieldMaxValueIncrementer` implementations as well as a DAO base class for `JdbcTemplate` usage.

The `org.springframework.jdbc.datasource` package contains a utility class for easy `DataSource` access, and various simple `DataSource` implementations that can be used for testing and running unmodified JDBC code outside of a J2EE container. The utility class provides static methods to obtain connections from JNDI and to close connections if necessary. It has support for thread-bound connections, e.g. for use with `DataSourceTransactionManager`.

Next, the `org.springframework.jdbc.object` package contains classes that represent RDBMS queries, updates, and stored procedures as threadsafe, reusable objects. This approach is modelled by JDO, although of course objects returned by queries are “disconnected” from the database. This higher level of JDBC abstraction depends on the lower-level abstraction in the `org.springframework.jdbc.core` package.

Finally the `org.springframework.jdbc.support` package is where you find the `SQLException` translation functionality and some utility classes.

Exceptions thrown during JDBC processing are translated to exceptions defined in the `org.springframework.dao` package. This means that code using the Spring JDBC abstraction layer does not need to implement JDBC or RDBMS-specific error handling. All translated exceptions are unchecked giving you the option of catching the exceptions that you can recover from while allowing other exceptions to be propagated to the caller.

10.2. Using the JDBC Core classes to control basic JDBC processing and error handling

10.2.1. JdbcTemplate

This is the central class in the JDBC core package. It simplifies the use of JDBC since it handles the creation and release of resources. This helps to avoid common errors like forgetting to always close the connection. It executes the core JDBC workflow like statement creation and execution, leaving application code to provide SQL and extract results. This class executes SQL queries, update statements or stored procedure calls, imitating iteration over `ResultSets` and extraction of returned parameter values. It also catches JDBC exceptions and translates them to the generic, more informative, exception hierarchy defined in the `org.springframework.dao` package.

Code using this class only need to implement callback interfaces, giving them a clearly defined contract. The `PreparedStatementCreator` callback interface creates a prepared statement given a `Connection` provided by this class, providing SQL and any necessary parameters. The same is true for the `CallableStatementCreator` interface which creates callable statement. The `RowCallbackHandler` interface extracts values from each row of a `ResultSet`.

This class can be used within a service implementation via direct instantiation with a `DataSource` reference, or get prepared in an application context and given to services as bean reference. Note: The `DataSource` should always be configured as a bean in the application context, in the first case given to the service directly, in the second case to the prepared template. Because this class is parameterizable by the callback interfaces and the `SQLExceptionTranslator` interface, it isn't necessary to subclass it. All SQL issued by this class is logged.

10.2.2. DataSource

In order to work with data from a database, we need to obtain a connection to the database. The way Spring does this is through a `DataSource`. A `DataSource` is part of the JDBC specification and can be seen as a generalized connection factory. It allows a container or a framework to hide connection pooling and transaction management issues from the application code. As a developer, you don't need to know any details about how to connect to the database, that is the responsibility for the administrator that sets up the `datasource`. You will most likely have to fulfil both roles while you are developing and testing your code though, but you will not necessarily have to know how the production data source is configured.

When using Spring's JDBC layer, you can either obtain a data source from JNDI or you can configure your own, using an implementation that is provided in the Spring distribution. The latter comes in handy for unit testing outside of a web container. We will use the `DriverManagerDataSource` implementation for this section but there are several additional implementations that will be covered later on. The `DriverManagerDataSource` works the same way that you probably are used to work when you obtain a JDBC connection. You have to specify the fully qualified class name of the JDBC driver that you are using so that the `DriverManager` can load the driver class. Then you have to provide a url that varies between JDBC drivers. You have to consult the documentation for your driver for the correct value to use here. Finally you must provide a username and a password that will be used to connect to the database. Here is an example of how to configure a

`DriverManagerDataSource`:

```
DriverManagerDataSource dataSource = new DriverManagerDataSource();
dataSource.setDriverClassName( "org.hsqldb.jdbcDriver" );
dataSource.setUrl( "jdbc:hsqldb:hsqldb://localhost:" );
dataSource.setUsername( "sa" );
dataSource.setPassword( "" );
```

10.2.3. SQLExceptionTranslator

`SQLExceptionTranslator` is an interface to be implemented by classes that can translate between `SQLExceptions` and our data access strategy-agnostic `org.springframework.dao.DataAccessException`.

Implementations can be generic (for example, using `SQLState` codes for JDBC) or proprietary (for example, using Oracle error codes) for greater precision.

`SQLErrorCodeSQLExceptionTranslator` is the implementation of `SQLExceptionTranslator` that is used by default. This implementation uses specific vendor codes. More precise than `SQLState` implementation, but vendor specific. The error code translations are based on codes held in a JavaBean type class named `SQLErrorCodes`. This class is created and populated by an `SQLErrorCodesFactory` which as the name suggests is a factory for creating `SQLErrorCodes` based on the contents of a configuration file named "sql-error-codes.xml". This file is populated with vendor codes and based on the `DatabaseProductName` taken from the `DatabaseMetaData`, the codes for the current database are used.

The `SQLErrorCodeSQLExceptionTranslator` applies the following matching rules:

- Try custom translation implemented by any subclass. Note that this class is concrete and is typically used itself, in which case this rule doesn't apply.

- Apply error code matching. Error codes are obtained from the `SQLErrorCodesFactory` by default. This looks up error codes from the classpath and keys into them from the database name from the database metadata.
- Use the fallback translator. `SQLStateSQLExceptionTranslator` is the default fallback translator.

`SQLErrorCodesSQLExceptionTranslator` can be extended the following way:

```
public class MySQLErrorCodesTranslator extends SQLErrorCodesSQLExceptionTranslator {
    protected DataAccessException customTranslate(String task, String sql, SQLException sqlEx) {
        if (sqlEx.getErrorCode() == -12345)
            return new DeadlockLoserDataAccessException(task, sqlEx);
        return null;
    }
}
```

In this example the specific error code '-12345' is translated and any other errors are simply left to be translated by the default translator implementation. To use this custom translator, it is necessary to pass it to the `JdbcTemplate` using the method `setExceptionHandler` and to use this `JdbcTemplate` for all of the data access processing where this translator is needed. Here is an example of how this custom translator can be used:

```
// create a JdbcTemplate and set data source
JdbcTemplate jt = new JdbcTemplate();
jt.setDataSource(dataSource);
// create a custom translator and set the datasource for the default translation lookup
MySQLErrorCodesTranslator tr = new MySQLErrorCodesTranslator();
tr.setDataSource(dataSource);
jt.setExceptionHandler(tr);
// use the JdbcTemplate for this SqlUpdate
SqlUpdate su = new SqlUpdate();
su.setJdbcTemplate(jt);
su.setSql("update orders set shipping_charge = shipping_charge * 1.05");
su.compile();
su.update();
```

The custom translator is passed a data source because we still want the default translation to look up the error codes in `sql-error-codes.xml`.

10.2.4. Executing Statements

To execute an SQL statement, there is very little code needed. All you need is a `DataSource` and a `JdbcTemplate`. Once you have that, you can use a number of convenience methods that are provided with the `JdbcTemplate`. Here is a short example showing what you need to include for a minimal but fully functional class that creates a new table.

```
import javax.sql.DataSource;
import org.springframework.jdbc.core.JdbcTemplate;

public class ExecuteAStatement {
    private JdbcTemplate jt;
    private DataSource dataSource;

    public void doExecute() {
        jt = new JdbcTemplate(dataSource);
        jt.execute("create table mytable (id integer, name varchar(100))");
    }

    public void setDataSource(DataSource dataSource) {
        this.dataSource = dataSource;
    }
}
```

10.2.5. Running Queries

In addition to the execute methods, there is a large number of query methods. Some of these methods are

intended to be used for queries that return a single value. Maybe you want to retrieve a count or a specific value from one row. If that is the case then you can use `queryForInt`, `queryForLong` or `queryForObject`. The latter will convert the returned JDBC Type to the Java class that is passed in as an argument. If the type conversion is invalid, then an `InvalidDataAccessApiUsageException` will be thrown. Here is an example that contains two query methods, one for an `int` and one that queries for a `String`.

```
import javax.sql.DataSource;
import org.springframework.jdbc.core.JdbcTemplate;

public class RunAQuery {
    private JdbcTemplate jt;
    private DataSource dataSource;

    public int getCount() {
        jt = new JdbcTemplate(dataSource);
        int count = jt.queryForInt("select count(*) from mytable");
        return count;
    }

    public String getName() {
        jt = new JdbcTemplate(dataSource);
        String name = (String) jt.queryForObject("select name from mytable", java.lang.String.class);
        return name;
    }

    public void setDataSource(DataSource dataSource) {
        this.dataSource = dataSource;
    }
}
```

In addition to the single results query methods there are several methods that return a `List` with an entry for each row that the query returned. The most generic one is `queryForList` which returns a `List` where each entry is a `Map` with each entry in the map representing the column value for that row. If we add a method to the above example to retrieve a list of all the rows, it would look like this:

```
public List getList() {
    jt = new JdbcTemplate(dataSource);
    List rows = jt.queryForList("select * from mytable");
    return rows;
}
```

The list returned would look something like this: `[{name=Bob, id=1}, {name=Mary, id=2}]`.

10.2.6. Updating the database

There are also a number of update methods that you can use. I will show an example where we update a column for a certain primary key. In this example I am using an SQL statement that has place holders for two parameters. Most of the query and update methods have this functionality. The parameter values are passed in as an array of objects.

```
import javax.sql.DataSource;
import org.springframework.jdbc.core.JdbcTemplate;

public class ExecuteAnUpdate {
    private JdbcTemplate jt;
    private DataSource dataSource;

    public void setName(int id, String name) {
        jt = new JdbcTemplate(dataSource);
        jt.update("update mytable set name = ? where id = ?", new Object[] {name, new Integer(id)});
    }

    public void setDataSource(DataSource dataSource) {
        this.dataSource = dataSource;
    }
}
```

```
}  
}
```

10.3. Controlling how we connect to the database

10.3.1. DataSourceUtils

Helper class that provides static methods to obtain connections from JNDI and close connections if necessary. Has support for thread-bound connections, e.g. for use with `DataSourceTransactionManager`.

Note: The `getDataSourceFromJndi` methods are targeted at applications that do not use a `BeanFactory` resp. an `ApplicationContext`. With the latter, it is preferable to preconfigure your beans or even `JdbcTemplate` instances in the factory: `JndiObjectFactoryBean` can be used to fetch a `DataSource` from JNDI and give the `DataSource` bean reference to other beans. Switching to another `DataSource` is just a matter of configuration then: You can even replace the definition of the `FactoryBean` with a non-JNDI `DataSource`!

10.3.2. SmartDataSource

Interface to be implemented by classes that can provide a connection to a relational database. Extends the `javax.sql.DataSource` interface to allow classes using it to query whether or not the connection should be closed after a given operation. This can sometimes be useful for efficiency, if we know that we want to reuse a connection.

10.3.3. AbstractDataSource

Abstract base class for Spring's `DataSource` implementations, taking care of the "uninteresting" glue. This is the class you would extend if you are writing your own `DataSource` implementation.

10.3.4. SingleConnectionDataSource

Implementation of `SmartDataSource` that wraps a single connection which is not closed after use. Obviously, this is not multi-threading capable.

If client code will call `close` in the assumption of a pooled connection, like when using persistence tools, set `suppressClose` to `true`. This will return a close-suppressing proxy instead of the physical connection. Be aware that you will not be able to cast this to a native Oracle Connection or the like anymore.

This is primarily a test class. For example, it enables easy testing of code outside an application server, in conjunction with a simple JNDI environment. In contrast to `DriverManagerDataSource`, it reuses the same connection all the time, avoiding excessive creation of physical connections.

10.3.5. DriverManagerDataSource

Implementation of `SmartDataSource` that configures a plain old JDBC Driver via bean properties, and returns a new connection every time.

Useful for test or standalone environments outside of a J2EE container, either as a `DataSource` bean in a respective `ApplicationContext`, or in conjunction with a simple JNDI environment. Pool-assuming

`Connection.close()` calls will simply close the connection, so any `DataSource`-aware persistence code should work.

10.3.6. DataSourceTransactionManager

`PlatformTransactionManager` implementation for single JDBC data sources. Binds a JDBC connection from the specified data source to the thread, potentially allowing for one thread connection per data source.

Application code is required to retrieve the JDBC connection via

`DataSourceUtils.getConnection(DataSource)` instead of J2EE's standard `DataSource.getConnection`. This is recommended anyway, as it throws unchecked `org.springframework.dao` exceptions instead of checked `SQLException`. All framework classes like `JdbcTemplate` use this strategy implicitly. If not used with this transaction manager, the lookup strategy behaves exactly like the common one - it can thus be used in any case.

Supports custom isolation levels, and timeouts that get applied as appropriate JDBC statement query timeouts. To support the latter, application code must either use `JdbcTemplate` or call `DataSourceUtils.applyTransactionTimeout` method for each created statement.

This implementation can be used instead of `JtaTransactionManager` in the single resource case, as it does not require the container to support JTA. Switching between both is just a matter of configuration, if you stick to the required connection lookup pattern. Note that JTA does not support custom isolation levels!

10.4. Modeling JDBC operations as Java objects

The `org.springframework.jdbc.object` package contains the classes that allow you to access the database in a more object oriented manner. You can execute queries and get the results back as a list containing business objects with the relational column data mapped to the properties of the business object. You can also execute stored procedures and run update, delete and insert statements.

10.4.1. SqlQuery

Reusable threadsafe object to represent an SQL query. Subclasses must implement the `newResultReader()` method to provide an object that can save the results while iterating over the `ResultSet`. This class is rarely used directly since the `MappingSqlQuery`, that extends this class, provides a much more convenient implementation for mapping rows to Java classes. Other implementations that extend `SqlQuery` are `MappingSqlQueryWithParameters` and `UpdatableSqlQuery`.

10.4.2. MappingSqlQuery

`MappingSqlQuery` is a reusable query in which concrete subclasses must implement the abstract `mapRow(ResultSet, int)` method to convert each row of the JDBC `ResultSet` into an object.

Of all the `SqlQuery` implementations, this is the one used most often and it is also the one that is the easiest to use.

Here is a brief example of a custom query that maps the data from the customer table to a Java object called `Customer`.

```
private class CustomerMappingQuery extends MappingSqlQuery {
    public CustomerMappingQuery(DataSource ds) {
        super(ds, "SELECT id, name FROM customer WHERE id = ?");
        super.declareParameter(new SqlParameter("id", Types.INTEGER));
        compile();
    }
}
```

```

    }
    public Object mapRow(ResultSet rs, int rowNum) throws SQLException {
        Customer cust = new Customer();
        cust.setId((Integer) rs.getObject("id"));
        cust.setName(rs.getString("name"));
        return cust;
    }
}

```

We provide a constructor for this customer query that takes the `DataSource` as the only parameter. In this constructor we call the constructor on the superclass with the `DataSource` and the SQL that should be executed to retrieve the rows for this query. This SQL will be used to create a `PreparedStatement` so it may contain place holders for any parameters to be passed in during execution. Each parameter must be declared using the `declareParameter` method passing in an `SqlParameter`. The `SqlParameter` takes a name and the JDBC type as defined in `java.sql.Types`. After all parameters have been defined we call the `compile` method so the statement can be prepared and later be executed.

Let's take a look at the code where this custom query is instantiated and executed:

```

public Customer getCustomer(Integer id) {
    CustomerMappingQuery custQry = new CustomerMappingQuery(dataSource);
    Object[] parms = new Object[1];
    parms[0] = id;
    List customers = custQry.execute(parms);
    if (customers.size() > 0)
        return (Customer) customers.get(0);
    else
        return null;
}

```

The method in this example retrieves the customer with the id that is passed in as the only parameter. After creating an instance of the `CustomerMappingQuery` class we create an array of objects that will contain all parameters that are passed in. In this case there is only one parameter and it is passed in as an `Integer`. Now we are ready to execute the query using this array of parameters and we get a `List` that contains a `Customer` object for each row that was returned for our query. In this case it will only be one entry if there was a match.

10.4.3. SqlUpdate

`RdbmsOperation` subclass representing a SQL update. Like a query, an update object is reusable. Like all `RdbmsOperation` objects, an update can have parameters and is defined in SQL.

This class provides a number of `update()` methods analogous to the `execute()` methods of query objects.

This class is concrete. Although it can be subclassed (for example to add a custom update method) it can easily be parameterized by setting SQL and declaring parameters.

```

import java.sql.Types;

import javax.sql.DataSource;

import org.springframework.jdbc.core.SqlParameter;
import org.springframework.jdbc.object.SqlUpdate;

public class UpdateCreditRating extends SqlUpdate {
    public UpdateCreditRating(DataSource ds) {
        setDataSource(ds);
        setSql("update customer set credit_rating = ? where id = ?");
        declareParameter(new SqlParameter(Types.NUMERIC));
        declareParameter(new SqlParameter(Types.NUMERIC));
        compile();
    }

    /**

```



```

    * @param id for the Customer to be updated
    * @param rating the new value for credit rating
    * @return number of rows updated
    */
    public int run(int id, int rating) {
        Object[] params =
            new Object[] {
                new Integer(rating),
                new Integer(id)};
        return update(params);
    }
}

```

10.4.4. StoredProcedure

Superclass for object abstractions of RDBMS stored procedures. This class is abstract and its execute methods are protected, preventing use other than through a subclass that offers tighter typing.

The inherited sql property is the name of the stored procedure in the RDBMS. Note that JDBC 3.0 introduces named parameters, although the other features provided by this class are still necessary in JDBC 3.0.

Here is an example of a program that calls a function sysdate() that comes with any Oracle database. To use the stored procedure functionality you have to create a class that extends `StoredProcedure`. There are no input parameters, but there is an output parameter that is declared as a date using the class `SqlOutParameter`. The `execute()` method returns a map with an entry for each declared output parameter using the parameter name as the key.

```

import java.sql.Types;
import java.util.HashMap;
import java.util.Iterator;
import java.util.Map;

import javax.sql.DataSource;

import org.springframework.jdbc.core.SqlOutParameter;
import org.springframework.jdbc.datasource.*;
import org.springframework.jdbc.object.StoredProcedure;

public class TestSP {

    public static void main(String[] args) {

        System.out.println("DB TestSP!");
        TestSP t = new TestSP();
        t.test();
        System.out.println("Done!");

    }

    void test() {
        DriverManagerDataSource ds = new DriverManagerDataSource();
        ds.setDriverClassName("oracle.jdbc.driver.OracleDriver");
        ds.setUrl("jdbc:oracle:thin:@localhost:1521:mydb");
        ds.setUsername("scott");
        ds.setPassword("tiger");

        MyStoredProcedure sproc = new MyStoredProcedure(ds);
        Map res = sproc.execute();
        printMap(res);

    }

    private class MyStoredProcedure extends StoredProcedure {
        public static final String SQL = "sysdate";

        public MyStoredProcedure(DataSource ds) {
            setDataSource(ds);
            setFunction(true);
            setSql(SQL);
            declareParameter(new SqlOutParameter("date", Types.DATE));
        }
    }
}

```

```
        compile();
    }

    public Map execute() {
        Map out = execute(new HashMap());
        return out;
    }

}

private static void printMap(Map r) {
    Iterator i = r.entrySet().iterator();
    while (i.hasNext()) {
        System.out.println((String) i.next().toString());
    }
}
}
```

10.4.5. SqlFunction

SQL "function" wrapper for a query that returns a single row of results. The default behavior is to return an int, but that can be overridden by using the methods with an extra return type parameter. This is similar to using the `queryForXxx` methods of the `JdbcTemplate`. The advantage with `SqlFunction` is that you don't have to create the `JdbcTemplate`, it is done behind the scenes.

This class is intended to use to call SQL functions that return a single result using a query like "select user()" or "select sysdate from dual". It is not intended for calling more complex stored functions or for using a `CallableStatement` to invoke a stored procedure or stored function. Use `StoredProcedure` or `SqlCall` for this type of processing.

This is a concrete class, which there is normally no need to subclass. Code using this package can create an object of this type, declaring SQL and parameters, and then invoke the appropriate run method repeatedly to execute the function. Here is an example of retrieving the count of rows from a table:

```
public int countRows() {
    SqlFunction sf = new SqlFunction(dataSource, "select count(*) from mytable");
    sf.compile();
    return sf.run();
}
```

Chapter 11. Data Access using O/R Mappers

11.1. Introduction

Spring provides integration with Hibernate, JDO, and iBATIS SQL Maps in terms of resource management, DAO implementation support, and transaction strategies. For Hibernate there is first-class support with lots of IoC convenience features, addressing many typical Hibernate integration issues. All of these comply with Spring's generic transaction and DAO exception hierarchies.

Spring's adds significant support when using the O/R mapping layer of your choice to create data-access applications. First of all you should know that once you started using Spring's support for O/R mapping, you don't have to go all the way. No matter to what extent, you're invited to review and leverage the Spring approach, before deciding to take the effort and risk of building a similar infrastructure in-house. Much of the O/R mapping support, no matter what technology you're using may be used in a library style, as everything is designed as a set of reusable JavaBeans. Usage inside an ApplicationContext or BeanFactory does provide additional benefits in terms of ease of configuration and deployment; as such, most examples in this section show configuration inside an ApplicationContext.

Some of the the benefits of using Spring to create your O/R mapping applications include:

- *To avoid vendor lock-in, and allow mix-and-match implementation strategies.* While Hibernate is powerful, flexible, open source and free, it still uses a proprietary API. Furthermore one could argue that iBatis is a bit lightweight, although it's excellent for use in application that don't require complex O/R mapping strategies. Given the choice, it's usually desirable to implement major application functionality using standard or abstracted APIs, in case you need to switch to another implementation for reasons of functionality, performance, or any other concerns. For example, Spring's abstraction of Hibernate Transactions and Exceptions, along with its IoC approach which allow you to easily swap in mapper/DAO objects implementing data-access functionality, make it easy to isolate all Hibernate-specific code in one area of your application, without sacrificing any of the power of Hibernate. Higher level service code dealing with the DAOs has no need to know anything about their implementation. This approach has the additional benefit of making it easy to intentionally implement data-access with a mix-and-match approach (i.e. some data-access performed using Hibernate, and some using JDBC, others using iBatis) in a non-intrusive fashion, potentially providing great benefits in terms of continuing to use legacy code or leveraging the strength of each technology.
- *Ease of testing.* Spring's inversion of control approach makes it easy to swap the implementations and locations of Hibernate session factories, datasources, transaction managers, and mapper object implementations (if needed). This makes it much easier to isolate and test each piece of persistence-related code in isolation.
- *General resource management.* Spring application contexts can handle the location and configuration of Hibernate SessionFactories, JDBC datasources, iBatis SQLMaps configuration objects, and other related resources. This makes these values easy to manage and change. Spring offers efficient, easy and safe handling of Hibernate Sessions. Related code using Hibernate generally needs to use the same Hibernate Session object for efficiency and proper transaction handling. Spring makes it easy to transparently create and bind a session tot he current thread, using either a declarative, AOP method interceptor approach, or by using an explicit, template wrapper class at the Java code level. Thus Spring solves many of the usage issues that repeatedly arise on the Hibernate forums.
- *Exception wrapping.* Spring can wrap exceptions from you O/R mapping tool of choice, converting them

from proprietary, checked exceptions, to a set of abstracted runtime exceptions. This allows you to handle most persistence exceptions, which are non-recoverable, only in the appropriate layers, without annoying boilerplate catches/throws, and exception declarations. You can still trap and handle exceptions anywhere you need to. Remember that JDBC exceptions (including DB specific dialects) are also converted to the same hierarchy, meaning that you can perform some operations with JDBC within a consistent programming model.

- *Integrated transaction management.* Spring allows you to wrap your O/R mapping code with either a declarative, AOP style method interceptor, or an explicit 'template' wrapper class at the Java code level. In either case, transaction semantics are handled for you, and proper transaction handling (rollback, etc.) in case of exceptions is taken care of. As discussed below, you also get the benefit of being able to use and swap various transaction managers, without your Hibernate related code being affected. As an added benefit, JDBC-related code can fully integrate transactionally with the code you use to do O/R mapping. This is useful for handling functionality not implemented in for example Hibernate or iBatis.

11.2. Hibernate

11.2.1.

11.2.2. Resource Management

Typical business applications are often cluttered with repetitive resource management code. Many projects try to invent their own solutions for this issue, sometimes sacrificing proper handling of failures for programming convenience. Spring advocates strikingly simple solutions for proper resource handling: Inversion of control via templating, i.e. infrastructure classes with callback interfaces, or applying AOP interceptors. The infrastructure cares for proper resource handling, and for appropriate conversion of specific API exceptions to an unchecked infrastructure exception hierarchy. Spring introduces a DAO exception hierarchy, applicable to any data access strategy. For direct JDBC, the `JdbcTemplate` class mentioned in a previous section cares for connection handling, and for proper conversion of `SQLException` to the `DataAccessException` hierarchy, including translation of database-specific SQL error codes to meaningful exception classes. It supports both JTA and JDBC transactions, via respective Spring transaction managers. Spring also offers Hibernate and JDO support, consisting of a `HibernateTemplate` / `JdoTemplate` analogous to `JdbcTemplate`, a `HibernateInterceptor` / `JdoInterceptor`, and a `Hibernate` / `JDO` transaction manager. The major goal is to allow for clear application layering, with any data access and transaction technology, and for loose coupling of application objects. No more business object dependencies on the data access or transaction strategy, no more hard-coded resource lookups, no more hard-to-replace singletons, no more custom service registries. One simple and consistent approach to wiring up application objects, keeping them as reusable and free from container dependencies as possible. All the individual data access features are usable on their own but integrate nicely with Spring's application context concept, providing XML-based configuration and cross-referencing of plain JavaBean instances that don't need to be Spring-aware. In a typical Spring app, many important objects are JavaBeans: data access templates, data access objects (that use the templates), transaction managers, business objects (that use the data access objects and transaction managers), web view resolvers, web controllers (that use the business objects), etc.

11.2.3. Resource Definitions in an Application Context

To avoid tying application objects to hard-coded resource lookups, Spring allows you to define resources like a JDBC `DataSource` or a Hibernate `SessionFactory` as beans in an application context. Application objects that

need to access resources just receive references to such pre-defined instances via bean references (the DAO definition in the next section illustrates this). The following excerpt from an XML application context definition shows how to set up a JDBC `DataSource` and a Hibernate `SessionFactory` on top of it:

```
<beans>

  <bean id="myDataSource" class="org.springframework.jndi.JndiObjectFactoryBean">
    <property name="jndiName">
      <value>java:comp/env/jdbc/myds</value>
    </property>
  </bean>

  <bean id="mySessionFactory" class="org.springframework.orm.hibernate.LocalSessionFactoryBean">
    <property name="mappingResources">
      <list>
        <value>product.hbm.xml</value>
      </list>
    </property>
    <property name="hibernateProperties">
      <props>
        <prop key="hibernate.dialect">net.sf.hibernate.dialect.MySQLDialect</prop>
      </props>
    </property>
    <property name="dataSource">
      <ref bean="myDataSource" />
    </property>
  </bean>

  ...

</beans>
```

Note that switching from a JNDI-located `DataSource` to a locally defined one like a Jakarta Commons DBCP `BasicDataSource` is just a matter of configuration:

```
<bean id="myDataSource" class="org.apache.commons.dbcp.BasicDataSource" destroy-method="close">
  <property name="driverClassName">
    <value>org.hsqldb.jdbcDriver</value>
  </property>
  <property name="url">
    <value>jdbc:hsqldb:sql://localhost:9001</value>
  </property>
  <property name="username">
    <value>sa</value>
  </property>
  <property name="password">
    <value></value>
  </property>
</bean>
```

You can also use a JNDI-located `SessionFactory`, but that's typically not necessary outside an EJB context (see the "container resources vs local resources" section for a discussion).

11.2.4. Inversion of Control: Template and Callback

The basic programming model for templating looks as follows, for methods that can be part of any custom data access object or business object. There are no restrictions on the implementation of the surrounding object at all, it just needs to provide a Hibernate `SessionFactory`. It can get the latter from anywhere, but preferably as bean reference from a Spring application context - via a simple `setSessionFactory` bean property setter. The following snippets show a DAO definition in a Spring application context, referencing the above defined `SessionFactory`, and an example for a DAO method implementation.

```
<beans>

  <bean id="myProductDao" class="product.ProductDaoImpl">
    <property name="sessionFactory">
```

```

        <ref bean="mySessionFactory" />
    </property>
</bean>

...

</beans>

```

```

public class ProductDaoImpl implements ProductDao {

    private SessionFactory sessionFactory;

    public void setSessionFactory(SessionFactory sessionFactory) {
        this.sessionFactory = sessionFactory;
    }

    public List loadProductsByCategory(final String category) {
        HibernateTemplate hibernateTemplate =
            new HibernateTemplate(this.sessionFactory);

        return (List) hibernateTemplate.execute(
            new HibernateCallback() {
                public Object doInHibernate(Session session) throws HibernateException {
                    List result = session.find(
                        "from test.Product product where product.category=?",
                        category, Hibernate.STRING);
                    // do some further stuff with the result list
                    return result;
                }
            }
        );
    }
}

```

A callback implementation can effectively be used for any Hibernate data access. `HibernateTemplate` will ensure that `Sessions` are properly opened and closed, and automatically participate in transactions. The template instances are thread-safe and reusable, they can thus be kept as instance variables of the surrounding class. For simple single step actions like a single find, load, `saveOrUpdate`, or delete call, `HibernateTemplate` offers alternative convenience methods that can replace such one line callback implementations. Furthermore, Spring provides a convenient `HibernateDaoSupport` base class that provides a `setSessionFactory` method for receiving a `SessionFactory`, and `getSessionFactory` and `getHibernateTemplate` for use by subclasses. In combination, this allows for very simple DAO implementations for typical requirements:

```

public class ProductDaoImpl extends HibernateDaoSupport implements ProductDao {

    public List loadProductsByCategory(String category) {
        return getHibernateTemplate().find(
            "from test.Product product where product.category=?", category,
            Hibernate.STRING);
    }
}

```

11.2.5. Applying an AOP Interceptor Instead of a Template

An alternative to using a `HibernateTemplate` is Spring's AOP `HibernateInterceptor`, replacing the callback implementation with straight Hibernate code within a delegating try/catch block, and a respective interceptor configuration in the application context. The following snippets show respective DAO, interceptor, and proxy definitions in a Spring application context, and an example for a DAO method implementation.

```

<beans>

...

<bean id="myHibernateInterceptor"
      class="org.springframework.orm.hibernate.HibernateInterceptor">

```

```

        <property name="sessionFactory">
            <ref bean="mySessionFactory" />
        </property>
    </bean>

    <bean id="myProductDaoTarget" class="product.ProductDaoImpl">
        <property name="sessionFactory">
            <ref bean="mySessionFactory" />
        </property>
    </bean>

    <bean id="myProductDao" class="org.springframework.aop.framework.ProxyFactoryBean">
        <property name="proxyInterfaces">
            <value>product.ProductDao</value>
        </property>
        <property name="interceptorNames">
            <list>
                <value>myHibernateInterceptor</value>
                <value>myProductDaoTarget</value>
            </list>
        </property>
    </bean>

    ...
</beans>

```

```

public class ProductDaoImpl extends HibernateDaoSupport implements ProductDao {

    public List loadProductsByCategory(final String category) throws MyException {
        Session session = SessionFactoryUtils.getSession(getSessionFactory(), false);
        try {
            List result = session.find(
                "from test.Product product where product.category=?",
                category, Hibernate.STRING);
            if (result == null) {
                throw new MyException("invalid search result");
            }
            return result;
        }
        catch (HibernateException ex) {
            throw SessionFactoryUtils.convertHibernateAccessException(ex);
        }
    }
}

```

This method will only work with a `HibernateInterceptor` for it, caring for opening a thread-bound `Session` before and closing it after the method call. The "false" flag on `getSession` makes sure that the `Session` must already exist; otherwise `SessionFactoryUtils` would create a new one if none was found. If there is already a `SessionHolder` bound to the thread, e.g. by a `HibernateTransactionManager` transaction, `SessionFactoryUtils` automatically takes part in it in any case. `HibernateTemplate` uses `SessionFactoryUtils` internally - it's all the same infrastructure. The major advantage of `HibernateInterceptor` is that it allows any checked application exception to be thrown within the data access code, while `HibernateTemplate` is restricted to unchecked exceptions within the callback. Note that one can often defer the respective checks and throwing of application exceptions to after the callback, though. The interceptor's major drawback is that it requires special setup in the context. `HibernateTemplate`'s convenience methods offers simpler means for many scenarios.

11.2.6. Programmatic Transaction Demarcation

On top of such lower-level data access services, transactions can be demarcated in a higher level of the application, spanning any number of operations. There are no restrictions on the implementation of the surrounding business object here too, it just needs a `Spring PlatformTransactionManager`. Again, the latter can come from anywhere, but preferably as bean reference via a `setTransactionManager` method - just like the `productDAO` should be set via a `setProductDao` method. The following snippets show a transaction manager

and a business object definition in a Spring application context, and an example for a business method implementation.

```
<beans>

...

<bean id="myTransactionManager"
      class="org.springframework.orm.hibernate.HibernateTransactionManager">
  <property name="sessionFactory">
    <ref bean="mySessionFactory" />
  </property>
</bean>

<bean id="myProductService" class="product.ProductServiceImpl">
  <property name="transactionManager">
    <ref bean="myTransactionManager" />
  </property>
  <property name="productDao">
    <ref bean="myProductDao" />
  </property>
</bean>

</beans>
```

```
public class ProductServiceImpl implements ProductService {

    private PlatformTransactionManager transactionManager;
    private ProductDao productDao;

    public void setTransactionManager(PlatformTransactionManager transactionManager) {
        this.transactionManager = transactionManager;
    }

    public void setProductDao(ProductDao productDao) {
        this.productDao = productDao;
    }

    public void increasePriceOfAllProductsInCategory(final String category) {
        TransactionTemplate transactionTemplate = new TransactionTemplate(this.transactionManager);
        transactionTemplate.setPropagationBehavior(TransactionDefinition.PROPROPAGATION_REQUIRED);
        transactionTemplate.execute(
            new TransactionCallbackWithoutResult() {
                public void doInTransactionWithoutResult(TransactionStatus status) {
                    List productsToChange = productDAO.loadProductsByCategory(category);
                    ...
                }
            }
        );
    }
}
```

11.2.7. Declarative Transaction Demarcation

Alternatively, one can use Spring's AOP TransactionInterceptor, replacing the transaction demarcation code with an interceptor configuration in the application context. This allows you to keep business objects free of repetitive transaction demarcation code in each business method. Furthermore, transaction semantics like propagation behavior and isolation level can be changed in a configuration file and do not affect the business object implementations.

```
<beans>

...

<bean id="myTransactionManager"
      class="org.springframework.orm.hibernate.HibernateTransactionManager">
  <property name="sessionFactory">
    <ref bean="mySessionFactory" />
  </property>
</bean>
```



```

</bean>

<bean id="myTransactionInterceptor"
      class="org.springframework.transaction.interceptor.TransactionInterceptor">
  <property name="transactionManager">
    <ref bean="myTransactionManager"/>
  </property>
  <property name="transactionAttributeSource">
    <value>
      product.ProductService.increasePrice*=PROPAGATION_REQUIRED
      product.ProductService.someOtherBusinessMethod=PROPAGATION_MANDATORY
    </value>
  </property>
</bean>

<bean id="myProductServiceTarget" class="product.ProductServiceImpl">
  <property name="productDao">
    <ref bean="myProductDao"/>
  </property>
</bean>

<bean id="myProductService" class="org.springframework.aop.framework.ProxyFactoryBean">
  <property name="proxyInterfaces">
    <value>product.ProductService</value>
  </property>
  <property name="interceptorNames">
    <list>
      <value>myTransactionInterceptor</value>
      <value>myProductServiceTarget</value>
    </list>
  </property>
</bean>

</beans>

```

```

public class ProductServiceImpl implements ProductService {

    private ProductDao productDao;

    public void setProductDao(ProductDao productDao) {
        this.productDao = productDao;
    }

    public void increasePriceOfAllProductsInCategory(final String category) {
        List productsToChange = this.productDAO.loadProductsByCategory(category);
        ...
    }

    ...
}

```

As with `HibernateInterceptor`, `TransactionInterceptor` allows any checked application exception to be thrown with the callback code, while `TransactionTemplate` is restricted to unchecked exceptions within the callback. `TransactionTemplate` will trigger a rollback in case of an unchecked application exception, or if the transaction has been marked rollback-only by the application (via `TransactionStatus`).

`TransactionInterceptor` behaves the same way by default but allows configurable rollback policies per method. A convenient alternative way of setting up declarative transactions is `TransactionProxyFactoryBean`, particularly if there are no other AOP interceptors involved. `TransactionProxyFactoryBean` combines the proxy definition itself with transaction configuration for a particular target bean. This reduces the configuration effort to one target bean plus one proxy bean. Furthermore, you do not need to specify which interfaces or classes the transactional methods are defined in.

```

<beans>

    ...

    <bean id="myTransactionManager"
          class="org.springframework.orm.hibernate.HibernateTransactionManager">
      <property name="sessionFactory">

```

```

        <ref bean="mySessionFactory" />
    </property>
</bean>

<bean id="myProductServiceTarget" class="product.ProductServiceImpl">
    <property name="productDao">
        <ref bean="myProductDao" />
    </property>
</bean>

<bean id="myProductService"
    class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">
    <property name="transactionManager">
        <ref bean="myTransactionManager" />
    </property>
    <property name="target">
        <ref bean="myProductServiceTarget" />
    </property>
    <property name="transactionAttributes">
        <props>
            <prop key="increasePrice*">PROPAGATION_REQUIRED</prop>
            <prop key="someOtherBusinessMethod">PROPAGATION_MANDATORY</prop>
        </props>
    </property>
</bean>

</beans>

```

11.2.8. Transaction Management Strategies

Both `TransactionTemplate` and `TransactionInterceptor` delegate the actual transaction handling to a `PlatformTransactionManager` instance, which can be a `HibernateTransactionManager` (for a single `Hibernate SessionFactory`, using a `ThreadLocal Session` under the hood) or a `JtaTransactionManager` (delegating to the JTA subsystem of the container) for `Hibernate` applications. You could even use a custom `PlatformTransactionManager` implementation. So switching from native `Hibernate` transaction management to JTA, i.e. when facing distributed transaction requirements for certain deployments of your application, is just a matter of configuration. Simply replace the `Hibernate` transaction manager with Spring's JTA transaction implementation. Both transaction demarcation and data access code will work without changes, as they just use the generic transaction management APIs. For distributed transactions across multiple `Hibernate` session factories, simply combine `JtaTransactionManager` as a transaction strategy with multiple `LocalSessionFactoryBean` definitions. Each of your DAOs then gets one specific `SessionFactory` reference passed into its respective bean property. If all underlying JDBC data sources are transactional container ones, a business object can demarcate transactions across any number of DAOs and any number of session factories without special regard, as long as it is using `JtaTransactionManager` as the strategy.

```

<beans>

    <bean id="myDataSource1" class="org.springframework.jndi.JndiObjectFactoryBean">
        <property name="jndiName">
            <value>java:comp/env/jdbc/myds1</value>
        </property>
    </bean>

    <bean id="myDataSource2" class="org.springframework.jndi.JndiObjectFactoryBean">
        <property name="jndiName">
            <value>java:comp/env/jdbc/myds2</value>
        </property>
    </bean>

    <bean id="mySessionFactory1" class="org.springframework.orm.hibernate.LocalSessionFactoryBean">
        <property name="mappingResources">
            <list>
                <value>product.hbm.xml</value>
            </list>
        </property>
        <property name="hibernateProperties">
            <props>

```

```

        <prop key="hibernate.dialect">net.sf.hibernate.dialect.MySQLDialect</prop>
    </props>
</property>
<property name="dataSource">
    <ref bean="myDataSource1"/>
</property>
</bean>

<bean id="mySessionFactory2" class="org.springframework.orm.hibernate.LocalSessionFactoryBean">
    <property name="mappingResources">
        <list>
            <value>inventory.hbm.xml</value>
        </list>
    </property>
    <property name="hibernateProperties">
        <props>
            <prop key="hibernate.dialect">net.sf.hibernate.dialect.OracleDialect</prop>
        </props>
    </property>
    <property name="dataSource">
        <ref bean="myDataSource2"/>
    </property>
</bean>

<bean id="myTransactionManager"
    class="org.springframework.transaction.jta.JtaTransactionManager"/>

<bean id="myProductDao" class="product.ProductDaoImpl">
    <property name="sessionFactory">
        <ref bean="mySessionFactory1"/>
    </property>
</bean>

<bean id="myInventoryDao" class="product.InventoryDaoImpl">
    <property name="sessionFactory">
        <ref bean="mySessionFactory2"/>
    </property>
</bean>

<bean id="myProductServiceTarget" class="product.ProductServiceImpl">
    <property name="productDao">
        <ref bean="myProductDao"/>
    </property>
    <property name="inventoryDao">
        <ref bean="myInventoryDao"/>
    </property>
</bean>

<bean id="myProductService"
    class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">
    <property name="transactionManager">
        <ref bean="myTransactionManager"/>
    </property>
    <property name="target">
        <ref bean="myProductServiceTarget"/>
    </property>
    <property name="transactionAttributes">
        <props>
            <prop key="increasePrice*">PROPAGATION_REQUIRED</prop>
            <prop key="someOtherBusinessMethod">PROPAGATION_MANDATORY</prop>
        </props>
    </property>
</bean>

</beans>

```

Both `HibernateTransactionManager` and `JtaTransactionManager` allow for proper JVM-level cache handling with Hibernate - without container-specific transaction manager lookup or JCA connector (as long as not using EJB to initiate transactions). Additionally, `HibernateTransactionManager` can export the JDBC Connection used by Hibernate to plain JDBC access code. This allows for high level transaction demarcation with mixed Hibernate/JDBC data access completely without JTA, as long as just accessing one database!

Note, for an alternative approach to using `TransactionProxyFactoryBean` to declaratively demarcate

transactions, please see Section 7.4.1, “BeanNameAutoProxyCreator, another declarative approach”.

11.2.9. Using Spring-managed Application Beans

A Spring application context definition can be loaded with a variety of context implementations, from `FileSystemXmlApplicationContext` and `ClassPathXmlApplicationContext` to `XmlWebApplicationContext`. This allows for reuse of Spring-managed data access and business objects in all kinds of environments. By default, a web app will have its root context defined in “WEB-INF/applicationContext.xml”. In any Spring app, an application context defined in an XML file wires up all the application beans that are involved, from the Hibernate session factory to custom data access and business objects (like the beans above). Most of them do not have to be aware of being managed by the Spring container, not even when collaborating with other beans, as they simply follow JavaBeans conventions. A bean property can either represent a value parameter or a collaborating bean. The following bean definition could be part of a Spring web MVC context that accesses business beans in a root application context.

```
<bean id="myProductList" class="product.ProductListController">
  <property name="productService">
    <ref bean="myProductService"/>
  </property>
</bean>
```

Spring web controllers are provided with all business or data access objects they need via bean references, so there typically isn't any need to do manual bean lookups in the application context. But when using Spring-managed beans with Struts, or within an EJB implementation or even an applet, one is always able to look up a bean manually. Therefore, Spring beans can be leveraged virtually anywhere. One just needs a reference to the application context, be it via a servlet context attribute in the web case, or a manually created instance from a file or class path resource.

```
ApplicationContext context = WebApplicationContextUtils.getWebApplicationContext(servletContext);
ProductService productService = (ProductService) context.getBean("myProductService");
```

```
ApplicationContext context =
    new FileSystemXmlApplicationContext("C:/myContext.xml");
ProductService productService =
    (ProductService) context.getBean("myProductService");
```

```
ApplicationContext context =
    new ClassPathXmlApplicationContext("myContext.xml");
ProductService productService =
    (ProductService) context.getBean("myProductService");
```

11.2.10. Container Resources versus Local Resources

Spring's resource management allows for simple switching between a JNDI SessionFactory and a local one, same for a JNDI DataSource, without having to change a single line of application code. Whether to keep the resource definitions in the container or locally within the application, is mainly a matter of the transaction strategy being used. Compared to a Spring-defined local SessionFactory, a manually registered JNDI SessionFactory does not provide any benefits. If registered via Hibernate's JCA connector, there is the added value of transparently taking part in JTA transactions, especially within EJBs. An important benefit of Spring's transaction support is that it isn't bound to a container at all. Configured to any other strategy than JTA, it will work in a standalone or test environment too. Especially for the typical case of single-database transactions, this is a very lightweight and powerful alternative to JTA. When using local EJB Stateless Session Beans to drive transactions, you depend both on an EJB container and JTA - even if you just access a single database anyway,

and just use SLBs for declarative transactions via CMT. The alternative of using JTA programmatically requires a J2EE environment too. JTA does not just involve container dependencies in terms of JTA itself and of JNDI DataSources. For non-Spring JTA-driven Hibernate transactions, you have to use the Hibernate JCA connector, or extra Hibernate transaction code with JTATransaction being configured, for proper JVM-level caching. Spring-driven transactions can work with a locally defined Hibernate SessionFactory nicely, just like with a local JDBC DataSource - if accessing a single database, of course. Therefore you just have to fall back to Spring's JTA transaction strategy when actually facing distributed transaction requirements. Note that a JCA connector needs container-specific deployment steps, and obviously JCA support in the first place. This is far more hassle than deploying a simple web app with local resource definitions and Spring-driven transactions. And you often need the Enterprise Edition of your container, as e.g. WebLogic Express does not provide JCA. A Spring app with local resources and transactions spanning one single database will work in any J2EE web container (without JTA, JCA, or EJB) - like Tomcat, Resin, or even plain Jetty. Additionally, such a middle tier can be reused in desktop applications or test suites easily. All things considered: If you do not use EJB, stick with local SessionFactory setup and Spring's `HibernateTransactionManager` or `JtaTransactionManager`. You will get all benefits including proper transactional JVM-level caching and distributed transactions, without any container deployment hassle. JNDI registration of a Hibernate SessionFactory via the JCA connector only adds value for use within EJBs.

11.2.11. Skeletons and Samples

For a commented and detailed sample configuration of a J2EE web app with Spring and Hibernate, have a look at the "webapp-typical" skeleton, included in the Spring Framework distribution. It outlines various data source and transaction manager configuration options that are suitable for JDBC and Hibernate apps. It also shows how to configure AOP interceptors, focussing on the transaction interceptor. As of release 1.0 M2, the Petclinic sample in the Spring distribution offers alternative DAO implementations and application context configurations for JDBC and Hibernate. Petclinic can therefore serve as working sample app that illustrates the use of Hibernate in a Spring web app. It also leverages declarative transaction demarcation with different transaction strategies.

11.3. JDO

ToDo

11.4. iBATIS

Through the `org.springframework.orm.ibatis` package, Spring supports iBATIS SqlMaps 1.3.x and 2.0. The iBATIS support much resembles Hibernate support in that it supports the same template style programming and just as with Hibernate, iBatis support works with Spring's exception hierarchy and let's you enjoy the all IoC features Spring has.

11.4.1. Overview and differences between 1.3.x and 2.0

Spring supports both iBATIS SqlMaps 1.3 and 2.0. First let's have a look at the differences between the two.

Table 11.1. iBATIS SqlMaps supporting classes for 1.3 and 2.0

| Feature | 1.3.x | 2.0 |
|--------------------|--------------------------------|--------------------------------------|
| Creation of SqlMap | <code>SqlMapFactoryBean</code> | <code>SqlMapClientFactoryBean</code> |

| Feature | 1.3.x | 2.0 |
|---------------------------------|------------------|------------------------|
| Template-style helper class | SqlMapTemplate | SqlMapClientTemplate |
| Callback to use MappedStatement | SqlMapCallback | SqlMapClientCallback |
| Super class for DAOs | SqlMapDaoSupport | SqlMapClientDaoSupport |

11.4.2. Setting up the SqlMap

Using iBATIS SqlMaps involves creating SqlMap configuration files containing statements and result maps. Spring takes care of loading those using the `SqlMapFactoryBean` Or `SqlMapClientFactoryBean` where the latter is to be used in combination with SqlMaps 2.0.

```
public class Account {
    private String name;
    private String email;

    public String getName() {
        return this.name;
    }

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

    public String getEmail() {
        return this.email;
    }

    public void setEmail(String email) {
        this.email = email;
    }
}
```

Suppose we would want to map this class. We'd have to create the following SqlMap. Using the query, we can later on retrieve users through their email addresses. `Account.xml`:

```
<sql-map name="Account">
    <result-map name="result" class="examples.Account">
        <property name="name" column="NAME" columnIndex="1"/>
        <property name="email" column="EMAIL" columnIndex="2"/>
    </result-map>

    <mapped-statement name="getAccountByEmail" result-map="result">
        select
            ACCOUNT.NAME,
            ACCOUNT.EMAIL
        from ACCOUNT
        where ACCOUNT.EMAIL = #value#
    </mapped-statement>

    <mapped-statement name="insertAccount">
        insert into ACCOUNT (NAME, EMAIL) values (#name#, #email#)
    </mapped-statement>
</sql-map>
```

After having defined the Sql Map, we have to create a configuration file for iBATIS (`sqlmap-config.xml`):

```
<sql-map-config>

    <sql-map resource="example/Account.xml"/>

</sql-map-config>
```

iBATIS loads resources from the classpath so be sure to add the Account.xml file to the classpath somewhere.

Using Spring, we can now very easily set up the SqlMap, using the SqlMapFactoryBean:

```
<bean id="sqlMap" class="org.springframework.orm.ibatis.SqlMapFactoryBean">
    <property name="configLocation"><value>WEB-INF/sqlmap-config.xml</value></property>
</bean>
```

11.4.3. Using SqlMapDaoSupport

The SqlMapDaoSupport class offers a supporting class similar to the HibernateDaoSupport and the JdbcDaoSupport types. Let's implement a DAO:

```
public class SqlMapAccountDao extends SqlMapDaoSupport implements AccountDao {

    public Account getAccount(String email) throws DataAccessException {
        Account acc = new Account();
        acc.setEmail();
        return (Account) getSqlMapTemplate().executeQueryForObject("getAccountByEmail", email);
    }

    public void insertAccount(Account account) throws DataAccessException {
        getSqlMapTemplate().executeUpdate("insertAccount", account);
    }

}
```

As you can see, we're using the SqlMapTemplate to execute the query. Spring has initialized the SqlMap for us using the SqlMapFactoryBean and when setting up the SqlMapAccountDao as follows, you're all set to go:

```
<!-- for more information about using datasource, have a look at the JDBC chapter -->
<bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource" destroy-method="close">
    <property name="driverClassName"><value>${jdbc.driverClassName}</value></property>
    <property name="url"><value>${jdbc.url}</value></property>
    <property name="username"><value>${jdbc.username}</value></property>
    <property name="password"><value>${jdbc.password}</value></property>
</bean>

<bean id="accountDao" class="example.SqlMapAccountDao">
    <property name="dataSource"><ref local="dataSource"/></property>
    <property name="sqlMap"><ref local="sqlMap"/></property>
</bean>
```

11.4.4. Transaction management

It's pretty easy to add declarative transaction management to applications using iBATIS. Basically the only thing you need to do is adding a transaction manager to you application context and declaratively set your transaction boundaries using for example the TransactionProxyFactoryBean. More on this can be found in Chapter 7, *Transaction management*

TODO elaborate!

Chapter 12. Web framework

12.1. Introduction to the web framework

Spring's web framework is designed around a `DispatcherServlet` that dispatches requests to handlers, with configurable handler mappings, view resolution, locale and theme resolution as well support for upload files. The default handler is a very simple Controller interface, just offering a `ModelAndView` `handleRequest(request, response)` method. This can already be used for application controllers, but you will prefer the included implementation hierarchy, consisting of for example `AbstractController`, `AbstractCommandController` and `SimpleFormController`. Application controllers will typically be subclasses of those. Note that you can choose an appropriate base class: If you don't have a form, you don't need a `FormController`. This is a major difference to Struts.

You can take any object as command or form object: There's no need to implement an interface or derive from a base class. Spring's data binding is highly flexible, e.g. it treats type mismatches as validation errors that can be evaluated by the application, not as system errors. So you don't need to duplicate your business objects' properties as Strings in your form objects, just to be able to handle invalid submissions, or to convert the Strings properly. Instead, it's often preferable to bind directly to your business objects. This is another major difference to Struts which is built around required base classes like `Action` and `ActionForm` - for every type of action.

Compared to WebWork, Spring has more differentiated object roles: It supports the notion of a Controller, an optional command or form object, and a model that gets passed to the view. The model will normally include the command or form object but also arbitrary reference data. Instead, a WebWork Action combines all those roles into one single object. WebWork does allow you to use existing business objects as part of your form, but just by making them bean properties of the respective Action class. Finally, the same Action instance that handles the request gets used for evaluation and form population in the view. Thus, reference data needs to be modelled as bean properties of the Action too. These are arguably too many roles in one object.

Regarding views: Spring's view resolution is extremely flexible. A Controller implementation can even write a view directly to the response, returning null as `ModelAndView`. In the normal case, a `ModelAndView` instance consists of a view name and a model Map, containing bean names and corresponding objects (like a command or form, reference data, etc). View name resolution is highly configurable, either via bean names, via a properties file, or via your own `ViewResolver` implementation. The abstract model Map allows for complete abstraction of the view technology, without any hassle: Be it JSP, Velocity, or anything else - every renderer can be integrated directly. The model Map simply gets transformed into an appropriate format, like JSP request attributes or a Velocity template model.

12.1.1. Pluggability of MVC implementation

Many teams will try to leverage their investments in terms of know-how and tools, both for existing projects and for new ones. Concretely, there are not only a large number of books and tools for Struts but also a lot of developers that have experience with it. Thus, if you can live with Struts's architectural flaws, it can still be a viable choice for the web layer. The same applies to WebWork and other web frameworks.

If you don't want to use Spring's web MVC but intend to leverage other solutions that Spring offers, you can integrate the web framework of your choice with Spring easily. Simply start up a Spring root application context via its `ContextLoaderListener`, and access it via its `ServletContext` attribute (or Spring's respective helper method) from within a Struts or WebWork action. Note that there aren't any "plugins" involved, therefore no dedicated integration: From the view of the web layer, you'll simply use Spring as a library, with

the root application context instance as entry point.

All your registered beans and all of Spring's services can be at your fingertips even without Spring's web MVC. Spring doesn't compete with Struts or WebWork in this usage, it just addresses the many areas that the pure web frameworks don't, from bean configuration to data access and transaction handling. So you are able to enrich your application with a Spring middle tier and/or data access tier, even if you just want to use e.g. the transaction abstraction with JDBC or Hibernate.

12.1.2. Features of Spring MVC

If just focusing on the web support, some of the Spring's unique features are:

- Clear separation of roles: controller vs validator vs command object vs form object vs model object, DispatcherServlet vs handler mapping vs view resolver, etc.
- Powerful and straightforward configuration of both framework and application classes as JavaBeans, including easy in-between referencing via an application context, e.g. from web controllers to business objects and validators.
- Adaptability, non-intrusiveness: Use whatever Controller subclass you need (plain, command, form, wizard, multi action, or a custom one) for a given scenario instead of deriving from Action/ActionForm for everything.
- Reusable business code, no need for duplication: You can use existing business objects as command or form objects instead of mirroring them in special ActionForm subclasses.
- Customizable binding and validation: type mismatches as application-level validation errors that keep the offending value, localized date and number binding, etc instead of String-only form objects with manual parsing and conversion to business objects.
- Customizable handler mapping, customizable view resolution: flexible model transfer via name/value Map, handler mapping and view resolution strategies from simple to sophisticated instead of one single way.
- Customizable locale and theme resolution, support for JSPs with and without Spring tag library, support for JSTL, support for Velocity without the need for extra bridges, etc.
- Simple but powerful tag library that avoids HTML generation at any cost, allowing for maximum flexibility in terms of markup code.

12.2. The DispatcherServlet

Spring's web framework is - like many other web frameworks - a request driven web framework, designed around a servlet that dispatches requests to controllers and offers other functionality facilitating the development of webapplications. Spring's DispatcherServlet however, does more than just that. It is completely integrated with the Spring ApplicationContext and allows you to use every other feature Spring has.

Servlets are declared in the `web.xml` of your webapplication, so is the DispatcherServlet. Requests that you want the DispatcherServlet to handle, will have to be mapped, using a url-mapping in the same `web.xml` file.

```
<web-app>
  ...
  <servlet>
    <servlet-name>example</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>
  <servlet-mapping>
    <servlet-name>example</servlet-name>
    <url-pattern>*.form</url-pattern>
  </servlet-mapping>
</web-app>
```

In the example above, all requests ending with `.form` will be handled by the `DispatcherServlet`. Then, the `DispatcherServlet` needs to be configured. As illustrated in Section 3.10, “Introduction to the `ApplicationContext`”, `ApplicationContexts` in Spring can be scoped. In the web framework, each `DispatcherServlet` has its own `WebApplicationContext`, which contains the `DispatcherServlet` configuration beans. The default `BeanFactory` used by the `DispatcherServlet` is the `XmlBeanFactory` and the `DispatcherServlet` will on initialization *look for a file named `[servlet-name]-servlet.xml` in the `WEB-INF` directory of your web application*. The default values used by the `DispatcherServlet` can be modified by using the servlet initialization parameters (see below for more information).

The `WebApplicationContext` is just an ordinary `ApplicationContext` that has some extra features necessary for webapplications. It differs from a normal `ApplicationContext` in that it is capable of resolving themes (see Section 12.7, “Using themes”), and that it knows to which servlet it is associated (by having a link to the `ServletContext`). The `WebApplicationContext` is bound in the `ServletContext`, and using `RequestContextUtils` you can always lookup the `WebApplicationContext` in case you need it.

The Spring `DispatcherServlet` has a couple of special beans it uses, in order to be able to process requests and render the appropriate views. Those beans are included in the Spring framework and (optionally) have to be configured in the `WebApplicationContext`, just as any other bean would have to be configured. Each of those beans, is described in more detail below. Right now, we'll just mention them, just to let you know they exist and to enable us to go on talking about the `DispatcherServlet`. For most of the beans, defaults are provided so you don't have to worry about those.

Table 12.1. Special beans in the `WebApplicationContext`

| Expression | Explanation |
|---------------------------|---|
| handler mapping(s) | (Section 12.4, “Handler mappings”) a list of pre- and postprocessors and controllers that will be executed if they match certain criteria (for instance a matching URL specified with the controller) |
| controller(s) | (Section 12.3, “Controllers”) the beans providing the actual functionality (or at least, access to the functionality) as part of the MVC triad |
| view resolver | (Section 12.5, “Views and resolving them”) capable of resolving view names and needed by the <code>DispatcherServlet</code> to resolves those views with |
| locale resolver | (Section 12.6, “Using locales”) capable of resolves the locale a client is using, in order to be able to offer internationalized views |
| theme resolver | (Section 12.7, “Using themes”) capable of resolving themes your webapplication can use e.g. to offer personalized layouts |
| multipart resolver | (Section 12.8, “Spring's multipart (fileupload) support”) offers functionality to process file uploads from HTML forms |
| handlerexception resolver | (Section 12.9, “Handling exceptions”) offers functionality to map exceptions to views or implement other more complex exception handling code |

When a `DispatcherServlet` is setup for use and a request comes in for that specific `DispatcherServlet` it starts processing it. The list below describes the complete process a request goes through if a `DispatcherServlet` is supposed to handle it:

1. The `WebApplicationContext` is searched for and bound in the request as an attribute in order for controller and other elements in the chain of process to use it. It is bound by default under the key

`DispatcherServlet.WEB_APPLICATION_CONTEXT_ATTRIBUTE`

2. The locale resolver is bound to the request to let elements in the chain resolve the locale to use when processing the request (rendering the view, preparing data, etcetera). If you don't use the resolver, it won't affect anything, so if you don't need locale resolving, just don't bother
3. The theme resolver is bound to the request to let e.g. views determine which theme to use (if you don't needs themes, don't bother, the resolver is just bound and does not affect anything if you don't use it)
4. If a multipart resolver is specified, the request is inspected for multipart and if so, it is wrapped in a `MultipartHttpServletRequest` for further processing by other elements in the chain (more information about multipart handling is provided below)
5. An appropriate handler is searched for. If a handler is found, its execution chain associated to the handler (preprocessors, postprocessors, controllers) will be executed in order to prepare a model
6. If a model is returned, the view is rendered, using the view resolver that has been configured with the `WebApplicationContext`. If no model was returned (which could be the result of a pre- or postprocessor intercepting the request because of for instance security reasons), no view is rendered as well, since the request could already have been fulfilled

Exceptions that might be thrown during processing of the request get picked up by any of the handlerexception resolvers that are declared in the `WebApplicationContext`. Using those exception resolvers you can define custom behavior in case such exceptions get thrown.

The Spring `DispatcherServlet` also has support for returning the *last-modification-date*, as specified by the Servlet API. The process of determining the last modification date for a specific request, is simple. The `DispatcherServlet` will first of all lookup an appropriate handler mapping and test if the handler that matched implements the interface `LastModified` and if so, the value of `long getLastModified(request)` is returned to the client.

You can customize Spring's `DispatcherServlet` by adding context parameters in the `web.xml` file or servlet init parameters. The possibilities are listed below.

Table 12.2. DispatcherServlet initialization parameters

| Parameter | Explanation |
|------------------------------------|--|
| <code>contextClass</code> | Class that implements <code>WebApplicationContext</code> , which will be used to instantiate the context used by this servlet. If this parameter isn't specified, the <code>XmlWebApplicationContext</code> will be used |
| <code>contextConfigLocation</code> | String which is passed to the context instance (specified by <code>contextClass</code>) to indicate where context(s) can be found. The String is potentially split up into multiple strings (using a comma as a delimiter) to support multiple contexts (in case of multiple context locations, of beans that are defined twice, the latest takes precedence) |
| <code>namespace</code> | the namespace of the <code>WebApplicationContext</code> . Defaults to <code>[server-name]-servlet</code> |

12.3. Controllers

The notion of controller is part of the MVC design pattern. Controllers define application behavior, or at least provide users with access to the application behavior. Controllers interpret user input and transform the user input into a sensible model which will be represented to the user by the view. Spring has implemented the notion of a controller in a very abstract way enabling a wide variety of different kinds of controllers to be created. Spring contains `formcontroller`, `commandcontroller`, controllers that execute wizard-style logic and more.

Spring's basis for the controller architecture is the `org.springframework.mvc.Controller` interface, which is listed below.

```
public interface Controller {

    /**
     * Process the request and return a ModelAndView object which the DispatcherServlet
     * will render.
     */
    ModelAndView handleRequest(
        HttpServletRequest request,
        HttpServletResponse response)
        throws Exception;
}
```

As you can see, the Controller interface just states one single method that should be capable of handling a request and return an appropriate model and view. Those three concepts are the basis for the Spring MVC implemente; *ModelAndView* and *Controller*. While the Controller interface is quite abstract, Spring offers a lot of controllers that already contain a lot of functionality you might need. The controller interface just define the most commons functionality offered by every controller: the functionality of handling a request and returning a model and a view.

12.3.1. AbstractController and WebContentGenerator

Of course, just a controller interface isn't enough. To provide a basic infrastructure, all of Spring's Controllers inherit from *AbstractController*, a class offering caching support and for instance the setting of the mimetype.

Table 12.3. Features offered by the *AbstractController*

| Feature | Explanation |
|---------------------------------|---|
| <code>supportedMethods</code> | indicates what methods this controller should accept. Usually this is set to both GET and POST, but you can modify this to reflect the method you want to support. If a request is received with a method that is not supported by the controller, the client will be informed of this (using a <code>ServletException</code>) |
| <code>requiresSession</code> | indicates whether or not this controller requires a session to do its work. This feature is offered to all controllers. If a session is not present when such a controller receives a request, the user is informed using a <code>ServletException</code> |
| <code>synchronizeSession</code> | use this if you want handling by this controller to be synchronized on the user's session. To be more specific, extending controller will override the <code>handleRequestInternal</code> method, which will be synchronized if you specify this variable |
| <code>cacheSeconds</code> | when you want a controller to generate caching directive in the HTTP response, specify a positive integer here. By default it is set to <code>-1</code> so no caching directives will be included |
| <code>useExpiresHeader</code> | tweaking of your controllers specifying the HTTP 1.0 compatible <i>"Expires"</i> header. By default it's set to true, so you won't have to touch it |
| <code>useCacheHeader</code> | tweaking of your controllers specifying the HTTP 1.1 compatible <i>"Cache-Control"</i> header. By default this is set to true so you won't really have to touch it |

AbstractController but to keeps things clear...

When using the `AbstractController` as a baseclass for your controllers (which is *not* recommended since there are a lot of other controller that might already do the job for your) you only have to override the `handleRequestInternal(HttpServletRequest, HttpServletResponse)`-method and implement your logic code and return a `ModelAndView` object there. A short example consisting of a class and a declaration in the `webapplicationcontext`.

```
package samples;

public class SampleController extends AbstractController {

    public ModelAndView handleRequestInternal(
        HttpServletRequest request,
        HttpServletResponse response)
        throws Exception {
        ModelAndView mav = new ModelAndView("foo", new HashMap());
    }
}
```

```
<bean id="sampleController" class="samples.SampleController">
  <property name="cacheSeconds"><value>120</value></property>
</bean>
```

The class above and the declaration in the `webapplicationcontext` is all you need to do besides setting up a handler mapping (see Section 12.4, “Handler mappings”) to get this very simple controller working. This controller will generates caching directives telling the client to cache things for 2 minutes before rechecking. This controller furthermore returns an hard-coded view (hmm, not so nice), named `index` (see Section 12.5, “Views and resolving them” for more information about views).

12.3.2. Other simple controllers

Besides the `AbstractController` - which you could of course extend, although a more concrete controller might offer you more functionality - there are a couple of other simple controllers that might ease the pain of developing simple MVC applications. The `ParameterizableViewController` basically is the same as the one in the example above, except for the fact that you can specify its view name that it'll be returning in the `webapplicationcontext` (ahhh, no need to hard-code the viewname).

The `FileNameViewController` inspects the URL and retrieves the filename of the file request (the filename of `http://www.springframework.org/index.html` is `index`) and uses that as a viewname. Nothing more to it.

12.3.3. The `MultiActionController`

Spring offers a multi-action controller with which you aggregate multiple actions into one controller, grouping functionality together. The multi-action controller lives in a separate package - `org.springframework.web.mvc.multiaction` - and is capable of mapping requests to method names and then invoking the right method name. Using the multi-action controller is especially handy when you're having a lot of commons functionality in one controller, but want to have multiple entry points to the controller to tweak behavior for instance.

Table 12.4. Features offered by the `MultiActionController`

| Feature | Explanation |
|----------|--|
| delegate | there's two usage-scenarios for the <code>MultiActionController</code> . Either you subclass the <code>MultiActionController</code> and specify the methods that will be resolved by the |

| Feature | Explanation |
|--------------------|---|
| | MethodNameResolver on the subclass (in case you don't need this configuration parameter), or you define a delegate object, on which methods resolved by the Resolver will be invoked. If you choose to enter this scenario, you will have to define the delegate using this configuration parameter as a collaborator |
| methodNameResolver | somehow, the MultiActionController will need to resolve the method it has to invoke, based on the request that came in. You can define a resolver that is capable of doing that using this configuration parameter |

Methods defined for a multi-action controller will need to conform to the following signature:

```
// actionName can be replaced by any methodname
ModelAndView actionName(HttpServletRequest, HttpServletResponse);
```

Method overloading is not allowed since it'll confuse the MultiActionController. Furthermore, you can define *exception handlers* capable of handling exception that will be thrown from a method you specify. Exception handler methods need to return a ModelAndView object, just as any other action method and will need to conform to the following signature:

```
// anyMeaningfulName can be replaced by any methodname
ModelAndView anyMeaningfulName(HttpServletRequest, HttpServletResponse, ExceptionClass);
```

The ExceptionClass can be *any* exception, as long as it's a subclass of `java.lang.Exception` or `java.lang.RuntimeException`.

The MethodNameResolver is supposed to resolve method names based on the request coming in. There are three resolver to your disposal, but of course you can implement more of them yourself if you want.

- `ParameterMethodNameResolver` - capable of resolving a request parameter and using that as the method name (`http://www.sf.net/index.view?testParam=testIt` will result in a method `testIt(HttpServletRequest, HttpServletResponse)` being called). Use the `paramName` configuration parameter to tweak the parameter that's inspected)
- `InternalPathMethodNameResolver` - retrieves the filename from the path and uses that as the method name (`http://www.sf.net/testing.view` will result in a method `testing(HttpServletRequest, HttpServletResponse)` being called)
- `PropertiesMethodNameResolver` - uses a user-defined properties object with request URLs mapped to methodnames. When the properties contain `/index/welcome.html=doIt` and a request to `/index/welcome.html` comes in, the `doIt(HttpServletRequest, HttpServletResponse)` method is called. This method name resolver works with the `PathMatcher` (see Section 12.10.1, “A little story about the pathmatcher”) so if the properties contained `/**/*.welcome.html` it would also have worked!

A couple of examples. First of all one showing the `ParameterMethodNameResolver` and the delegate property, which will accept requests to urls with the parameter method included and set to `retrieveIndex`:

```
<bean id="paramResolver" class="org...mvc.multiaction.ParameterMethodNameResolver">
  <property name="paramName"><value>method</value></property>
</bean>

<bean id="paramMultiController" class="org...mvc.multiaction.MultiActionController">
  <property name="methodNameResolver"><ref bean="paramResolver"/></property>
  <property name="delegate"><ref bean="sampleDelegate"/>
</bean>

<bean id="sampleDelegate" class="samples.SampleDelegate"/>

## together with

public class SampleDelegate {
```

```

public ModelAndView retrieveIndex(
    HttpServletRequest req,
    HttpServletResponse resp) {

    return new ModelAndView("index", "date", new Long(System.currentTimeMillis()));
}

```

When using the delegates shown above, we could also use the `PropertiesMethodNameResolver` to match a couple of URLs to the method we defined:

```

<bean id="propsResolver" class="org...mvc.multiaction.PropertiesMethodNameResolver">
    <property name="mappings">
        <props>
            <prop key="/index/welcome.html">retrieveIndex</prop>
            <prop key="/**/notwelcome.html">retrieveIndex</prop>
            <prop key="/*user?.html">retrieveIndex</prop>
        </props>
    </property>
</bean>

<bean id="paramMultiController" class="org...mvc.multiaction.MultiActionController">
    <property name="methodNameResolver"><ref bean="propsResolver"/></property>
    <property name="delegate"><ref bean="sampleDelegate"/>
</bean>

```

12.3.4. CommandControllers

Spring's *CommandControllers* are a fundamental part of the Spring MVC package. Command controllers provide a way to interact with dataobjects and dynamically bind parameters from the `HttpServletRequest` to the dataobject you're specifying. This compares to Struts's actionforms, where in Spring, you don't have to implement any interface or superclass to do databinding. First, let's examine what command controllers are available, just to get a clear picture of what you can do with them:

- `AbstractCommandController` - a command controller you can use to create your own command controller, capable of binding request parameters to a data object you're specifying. This class does not offer form functionality, it does however, offer validation features and lets you specify in the controller itself what to do with the dataobject that has been filled with the parameters from the request.
- `AbstractFormController` - an abstract controller offering form submission support. Using this controller you can model forms and populate them using a dataobject you're retrieving in the controller. After a user has filled the form, the `AbstractFormController` binds the fields, validates and hands the object back to you - the controller - to take appropriate action. Supported features are invalid form submission (resubmission), validation, and the right workflow a form always has. What views you tie to your `AbstractFormController` you decide yourself. Use this controller if you need forms, but don't want to specify what views you're going to show the user in the application context.
- `SimpleFormController` - an even more concrete `FormController` that helps you creating a form with corresponding data object even more. The `SimpleFormController` lets you specify a command object, a viewname for the form, a viewname for page you want to show the user when form submission has succeeded, and more.
- `WizardFormController` - last but not least, a `WizardFormController` allows you to model wizard-style manipulation of dataobjects, which is extremely handy when large dataobjects come in.

12.4. Handler mappings

Using a handler mapping you can map incoming web requests to appropriate handlers. There are some handler mappings you can use, for example the `SimpleUrlHandlerMapping` or the `BeanNameUrlHandlerMapping`, but

let's first examine the general concept of a `HandlerMapping`.

The functionality a basic `HandlerMapping` provides is the delivering of a `HandlerExecutionChain`, first of all containing one handler that matched the incoming request. The second (but optional) element a handler execution chain will contain is a list of handler interceptor that should be applied to the request. When a request comes in, the `DispatcherServlet` will hand it over to the handler mapping to let it inspect the request and come up with an appropriate `HandlerExecutionChain`. When done, the `DispatcherServlet` will execute the handler and interceptors in the chain (if any).

The concept of configurable handler mappings that can optionally contain interceptors (executed before or after the actual handler was executed, or both) is extremely powerful. A lot of supporting functionality can be built-in in custom `HandlerMappings`. Think of a custom handler mapping that chooses a handler not only based on the URL of the request coming in, but also on a specific state of the session associated with the request.

Let's examine the handler mappings that Spring provides.

12.4.1. `BeanNameUrlHandlerMapping`

A very simple, but very powerful handlermapping is the `BeanNameUrlHandlerMapping`, which maps incoming HTTP requests to names of beans, defined in the `webapplicationcontext`. Let's say we want to enable a user to insert an account and we've already provided an appropriate `FormController` (see Section 12.3.4, “CommandControllers” for more information on Command- and `FormControllers`) and a JSP view (or Velocity template) that renders the form. When using the `BeanNameUrlHandlerMapping`, we could map the HTTP request with URL `http://samples.com/editaccount.form` to the appropriate `FormController` as follows:

```
<beans>
  <bean id="handlerMapping"
    class="org.springframework.web.servlet.handler.BeanNameUrlHandlerMapping"/>

  <bean name="/editaccount.form"
    class="org.springframework.web.servlet.mvc.SimpleFormController">
    <property name="formView"><value>account</value></property>
    <property name="successView"><value>account-created</value></property>
    <property name="commandName"><value>Account</value></property>
    <property name="commandClass"><value>samples.Account</value></property>
  </bean>
</beans>
```

All incoming requests for the URL `/editaccount.form` will now be handled by the `FormController` in the source listing above. Of course we have to define a servlet-mapping in `web.xml` as well, to let through all the requests ending with `.form`.

```
<web-app>
  ...
  <servlet>
    <servlet-name>sample</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>

  <!-- Maps the sample dispatcher to /*.form -->
  <servlet-mapping>
    <servlet-name>sample</servlet-name>
    <url-pattern>*.form</url-pattern>
  </servlet-mapping>
  ...
</web-app>
```

NOTE: if you want to use the `BeanNameUrlHandlerMapping`, you don't necessarily have to define it in the `webapplicationcontext` (as indicated above). By default, if no handler mapping can be found in the context, the `DispatcherServlet` creates a `BeanNameUrlHandlerMapping` for you!

12.4.2. SimpleUrlHandlerMapping

Another - and much more powerful handlermapping - is the `SimpleUrlHandlerMapping`. This mapping is configurable in the applicationcontext and has Ant-style pathmatching capabilities (see Section 12.10.1, “A little story about the pathmatcher”). A couple of example will probably makes thing clear enough:

```
<web-app>
  ...
  <servlet>
    <servlet-name>sample</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>

  <!-- Maps the sample dispatcher to /*.form -->
  <servlet-mapping>
    <servlet-name>sample</servlet-name>
    <url-pattern>*.form</url-pattern>
  </servlet-mapping>
  <servlet-mapping>
    <servlet-name>sample</servlet-name>
    <url-pattern>*.html</url-pattern>
  </servlet-mapping>
  ...
</web-app>
```

Allows all requests ending with `.html` and `.form` to be handled by the sample dispatcherservlet.

```
<beans>
  <bean id="handlerMapping"
    class="org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
    <property name="mappings">
      <props>
        <prop key="/*/account.form">editAccountFormController</prop>
        <prop key="/*/editaccount.form">editAccountFormController</prop>
        <prop key="/ex/view*.html">someViewController</prop>
        <prop key="**/help.html">helpController</prop>
      </props>
    </property>
  </bean>

  <bean id="someViewController"
    class="org.springframework.web.servlet.mvc.FilenameViewController"/>

  <bean id="editAccountFormController"
    class="org.springframework.web.servlet.mvc.SimpleFormController">
    <property name="formView"><value>account</value></property>
    <property name="successView"><value>account-created</value></property>
    <property name="commandName"><value>Account</value></property>
    <property name="commandClass"><value>samples.Account</value></property>
  </bean>
</beans>
```

This handlermapping first of all reroutes all requests in all directories for a file named `help.html` to the `someViewController`, which is a `FilenameViewController` (more about that can be found in Section 12.3, “Controllers”). Also, all requests for a resource beginning with `view`, ending with `.html`, in the directory `ex`, will be rerouted to that specific controller. Furthermore, two mappings have been defined that will match with the `editAccountFormController`.

12.4.3. Adding HandlerInterceptors

The handler mapping also has a notion of handler interceptors, that can be extremely useful when you want to apply specific functionality to all requests, for example the checking for a principal or something alike.

Interceptors located in the handler mapping must implement `HandlerInterceptor` from the `org.springframework.web.servlet`-package. This interface defines three methods, one that will be called

before the actual handler will be executed, one that will be called *after* the handler is executed, and one that is called *after the complete request has finished*. Those three methods should provide you with enough flexibility to do all kinds of pre- and post-processing.

The `preHandle` method has a boolean return value. Using this value, you can tweak the behavior of the execution chain. When returning `true`, the handler execution chain will continue, when returning `false`, the `DispatcherServlet` assumes the interceptor itself has taken care of requests (and for instance rendered an appropriate view) and does not continue with executing the other interceptors and the actual handler in the execution chain.

The following example provides an interceptor that intercepts all requests and reroutes the user to a specific page if the time is not between 9 a.m. and 6 p.m.

```
<beans>
  <bean id="handlerMapping"
    class="org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
    <property name="interceptors">
      <list>
        <ref bean="officeHoursInterceptor"/>
      </list>
    </property>
    <property name="mappings">
      <props>
        <prop key="/*.form">editAccountFormController</prop>
        <prop key="/*.view">editAccountFormController</prop>
      </props>
    </property>
  </bean>

  <bean id="officeHoursInterceptor"
    class="samples.TimeBasedAccessInterceptor">
    <property name="openingTime"><value>9</value></property>
    <property name="closingTime"><value>18</value></property>
  </bean>
</beans>
```

```
package samples;

public class TimeBasedAccessInterceptor extends HandlerInterceptorAdapter {

    private int openingTime;
    private int closingTime;
    public void setOpeningTime(int openingTime) {
        this.openingTime = openingTime;
    }
    public void setClosingTime(int closingTime) {
        this.closingTime = closingTime;
    }
    public boolean preHandle(
        HttpServletRequest request,
        HttpServletResponse response,
        Object handler)
        throws Exception {
        Calendar cal = Calendar.getInstance();
        int hour = cal.get(HOUR_OF_DAY);
        if (openingTime <= hour < closingTime) {
            return true;
        } else {
            response.sendRedirect("http://host.com/outsideOfficeHours.html");
            return false;
        }
    }
}
```

Any request coming in, will be intercepted by the `TimeBasedAccessInterceptor`, and if the current time is outside office hours, the user will be redirect to a static html file, saying for instance he can only access the website during office hours.

As you can see, Spring has an adapter to make it easy for you to extend the `HandlerInterceptor`.

12.5. Views and resolving them

No MVC framework for web applications is without a way to address views. Spring provides view resolvers, which enable you to render models in a browser without tying yourself to a specific view technology. Out-of-the-box, Spring enables you to use Java Server Pages, Velocity templates and XSLT views, for example. Chapter 13, *Integrating view technologies* has details of integrating various view technologies.

The two classes which are important to the way Spring handles views are the `ViewResolver` and the `View`. The `View` interface addresses the preparation of the request and hands the request over to one of the view technologies. The `ViewResolver` provides a mapping between view names and actual views.

12.5.1. ViewResolvers

As discussed before, all controllers in the SpringWeb framework, return a `ModelAndView` instance. Views in Spring are addressed by a view name and are resolved by a viewresolver. Spring comes with quite a few view resolvers. We'll list most of them and then provide a couple of examples.

Table 12.5. View resolvers

| ViewResolver | Description |
|---|---|
| <code>AbstractCachingViewResolver</code> | Abstract view resolver taking care of caching views. Lots of views need preparation before they can be used, extending from this viewresolver enables caching of views |
| <code>ResourceBundleViewResolver</code> | Implementation of <code>ViewResolver</code> that uses bean definitions in a <code>ResourceBundle</code> , specified by the bundle basename. The bundle is typically defined in a properties file, located in the classpath |
| <code>UrlBasedViewResolver</code> | Simple implementation of <code>ViewResolver</code> that allows for direct resolution of symbolic view names to URLs, without an explicit mapping definition. This is appropriate if your symbolic names match the names of your view resources in a straightforward manner, without the need for arbitrary mappings |
| <code>InternalResourceViewResolver</code> | Convenience subclass of <code>UrlBasedViewResolver</code> that supports <code>InternalResourceView</code> (i.e. Servlets and JSPs), and subclasses like <code>JstlView</code> and <code>TilesView</code> . The view class for all views generated by this resolver can be specified via <code>setViewClass</code> . See <code>UrlBasedViewResolver</code> 's javadocs for details |
| <code>VelocityViewResolver</code> | Convenience subclass of <code>UrlBasedViewResolver</code> that supports <code>VelocityView</code> (i.e. Velocity templates) and custom subclasses of it |

As an example, when using JSP for a view technology you can use the `UrlBasedViewResolver`. This view resolver translates view names to a URL and hands the request over the `RequestDispatcher` to render the view.

```
<bean id="viewResolver"
      class="org.springframework.web.servlet.view.UrlBasedViewResolver">
  <property name="prefix"><value>/WEB-INF/jsp/</value></property>
  <property name="suffix"><value>.jsp</value></property>
</bean>
```

When returning `test` as a viewname, this view resolver will hand the request over to the `RequestDispatcher`

that'll send the request to `/WEB-INF/jsp/test.jsp`.

When mixing different view technologies in a webapplications, you can use the `ResourceBundleViewResolver`:

```
<bean id="viewResolver"
      class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
  <property name="baseName"><value>views</value></property>
  <property name="defaultParentView"><value>parentView</value></property>
</bean>
```

A note on caching: subclasses of `AbstractCachingViewResolver` cache view instances they've resolved. This greatly improves performance when using certain view technology. It's possible to turn off the cache, by setting the `cache` property to `false`. Furthermore, if you have the requirement to be able to refresh a certain view at runtime (for example when a Velocity template has been modified), you can use the `removeFromCache(String viewName, Locale loc)` method.

12.6. Using locales

Most parts of Spring's architecture support internationalization, just as the Spring web framework does. SpringWEB enables you to automatically resolve messages using the client's locale. This is done with `LocaleResolver` objects.

When a request comes in, the `DispatcherServlet` looks for a locale resolver and if it finds one it tries to use it and set the locale. Using the `RequestContext.getLocale()` method, you can always retrieve the locale that was resolved by the locale resolver.

Besides the automatic locale resolution, you can also attach an interceptor to the handlermapping (see Section 12.4.3, “Adding HandlerInterceptors” for more info on that), to change the locale under specific circumstances, based on a parameter occurring in the request for example.

Locale resolvers and interceptors are all defined in the `org.springframework.web.servlet.i18n` package, and are configured in your application context in the normal way. Here is a selection of the locale resolvers included in Spring.

12.6.1. AcceptHeaderLocaleResolver

This locale resolver inspects the `accept-language` header in the request that was sent by the browser of the client. Usually this header field contains the locale of the client's operating system.

12.6.2. CookieLocaleResolver

This locale resolver inspects a Cookie that might exist on the client, to see if there's a locale specified. If so, it uses that specific locale. Using the properties of this locale resolver, you can specify the name of the cookie, as well as the maximum age.

```
<bean id="localeResolver">
  <property name="cookieName"><value>clientlanguage</value></property>
  <!-- in seconds. If set to -1, the cookie is not persisted (deleted when browser shuts down) -->
  <property name="cookieMaxAge"><value>100000</value></property>
</bean>
```

This is an example of defining a `CookieLocaleResolver`.

Table 12.6. Special beans in the `WebApplicationContext`

| Property | Default | Description |
|--------------|-----------------------|--|
| cookieName | classname + LOCALE | The name of the cookie |
| cookieMaxAge | Integer.MAX_INT | The maximum time a cookie will stay persistent on the client. If -1 is specified, the cookie will not be persisted, at least, only until the client shuts down his or her browser |
| cookiePath | / | Using this parameter, you can limit the visibility of the cookie to a certain part of your site. When cookiePath is specified, the cookie will only be visible to that path, and the paths below |

12.6.3. SessionLocaleResolver

The `SessionLocaleResolver` allows you to retrieve locales from the session that might be associated to the user's request.

12.6.4. LocaleChangeInterceptor

You can build in changing of locales using the `LocaleChangeInterceptor`. This interceptor needs to be added to one of the handler mappings (see Section 12.4, “Handler mappings”) and it will detect a parameter in the request and change the locale (it calls `setLocale()` on the `LocaleResolver` that also exists in the context).

```
<bean id="localeChangeInterceptor"
      class="org.springframework.web.servlet.i18n.LocaleChangeInterceptor">
  <property name="paramName"><value>siteLanguage</value></property>
</bean>

<bean id="localeResolver"
      class="org.springframework.web.servlet.i18n.CookieLocaleResolver"/>

<bean id="urlMapping"
      class="org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
  <property name="interceptors">
    <list>
      <ref local="localeChangeInterceptor"/>
    </list>
  </property>
  <property name="mappings">
    <props>
      <prop key="/**/*.*.view">someController</prop>
    </props>
  </property>
</bean>
```

All calls to all `*.view` resources containing a parameter named `siteLanguage` will now change the locale. So a call to `http://www.sf.net/home.view?siteLanguage=nl` will change the site language to Dutch.

12.7. Using themes

Dummy paragraph

12.8. Spring's multipart (fileupload) support

12.8.1. Introduction

Spring has built-in multipart support to handle fileuploads in webapplications. The design for the multipart support is done with pluggable `MultipartResovler` objects, defined in the `org.springframework.web.multipart` package. Out of the box, Spring provides `MultipartResolver` for use with *Commons FileUpload* (<http://jakarta.apache.org/commons/fileupload>) and *COS FileUpload* (<http://www.servlets.com/cos>). How uploading files is supported will be described in the rest of this chapter.

By default, no multipart handling will be done by Spring, as some developers will want to handle multipart themselves. You'll have to enable it yourself by adding a `multipartresolver` to the webapplication's context. After you've done that, each request will be inspected for a multipart that it might contain. If no such multipart is found, the request will continue as expected. However, if a multipart is found in the request, the `MultipartResolver` that has been declared in your context will resolve. After that, the multipart attribute in your request will be treated as any other attributes.

12.8.2. Using the `MultipartResolver`

The following example shows how to use the `CommonsMultipartResolver`:

```
<bean id="multipartResolver"
      class="org.springframework.web.multipart.commons.CommonsMultipartResolver">

    <!-- one of the properties available; the maximum file size in bytes -->
    <property name="maximumFileSize">
        <value>100000</value>
    </property>
</bean>
```

This is an example using the `CosMultipartResolver`:

```
<bean id="multipartResolver"
      class="org.springframework.web.multipart.cos.CosMultipartResolver">

    <!-- one of the properties available; the maximum file size in bytes -->
    <property name="maximumFileSize">
        <value>100000</value>
    </property>
</bean>
```

Of course you need to stick the appropriate jars in your classpath for the `multipartresolver` to work. In the case of the `CommonsMultipartResolver`, you need to use `commons-fileupload.jar`, while in the case of the `CosMultipartResolver`, use `cos.jar`.

Now that you have seen how to set Spring up to handle multipart requests, let's talk about how to actually use it. When the Spring `DispatcherServlet` detects a Multipart request, it activates the resolver that has been declared in your context and hands over the request. What it basically does is wrap the current `HttpServletRequest` into a `MultipartHttpServletRequest` that has support for multipart. Using the `MultipartHttpServletRequest` you can get information about the multipart contained by this request and actually get the multipart themselves in your controllers.

12.8.3. Handling a fileupload in a form

After the `MultipartResolver` has finished doing its job, the request will be processed like any other. To use it, you create a form with an upload field, then let Spring bind the file on your form. Just as with any other property that's not automatically convertible to a `String` or primitive type, to be able to put binary data in your beans you have to register a custom editor with the `ServletRequestDataBinder`. There are a couple of editors available for handling files and setting the results on a bean. There's a `StringMultipartEditor` capable of converting files to `Strings` (using a user-defined character set) and there's a `ByteArrayMultipartEditor` which

converts files to byte arrays. They function just as the `CustomDateEditor` does.

So, to be able to upload files using a form in a website, declare the resolver, a url mapping to a controller that will process the bean, and the controller itself.

```
<beans>

...

<bean id="multipartResolver"
      class="org.springframework.web.multipart.commons.CommonsMultipartResolver"/>

<bean id="urlMapping" class="org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
  <property name="mappings">
    <props>
      <prop key="/upload.form">fileUploadController</prop>
    </props>
  </property>
</bean>

<bean id="fileUploadController" class="examples.FileUploadController">
  <property name="commandClass"><value>examples.FileUploadBean</value></property>
  <property name="formView"><value>fileuploadform</value></property>
  <property name="successView"><value>confirmation</value></property>
</bean>

</beans>
```

After that, create the controller and the actual bean holding the file property

```
// snippet from FileUploadController
public class FileUploadController extends SimpleFormController {

    protected ModelAndView onSubmit(
        HttpServletRequest request,
        HttpServletResponse response,
        Object command,
        BindException errors)
        throws ServletException, IOException {

        // cast the bean
        FileUploadBean bean = (FileUploadBean)command;

        // let's see if there's content there
        byte[] file = bean.getFile();
        if (file == null) {
            // hmm, that's strange, the user did not upload anything
        }

        // well, let's do nothing with the bean for now and return:
        return super.onSubmit(request, response, command, errors);
    }

    protected void initBinder(
        HttpServletRequest request,
        ServletRequestDataBinder binder)
        throws ServletException {
        // to actually be able to convert Multipart instance to byte[]
        // we have to register a custom editor (in this case the
        // ByteArrayMultipartEditor
        binder.registerCustomEditor(byte[].class, new ByteArrayMultipartFileEditor());
        // now Spring knows how to handle multipart object and convert them
    }
}

// snippet from FileUploadBean
public class FileUploadBean {
    private byte[] file;

    public void setFile(byte[] file) {
        this.file = file;
    }

    public byte[] getFile() {
```

```
        return file;
    }
}
```

As you can see, the `FileUploadBean` has a property typed `byte[]` that holds the file. The controller registers a custom editor to let Spring know how to actually convert the multipart objects the resolver has found to properties specified by the bean. In these examples, nothing is done with the `byte[]` property of the bean itself, but in practice you can do whatever you want (save it in a database, mail it to somebody, etcetera).

But we're still not finished. To actually let the user upload something, we have to create a form:

```
<html>
  <head>
    <title>Upload a file please</title>
  </head>
  <body>
    <h1>Please upload a file</h1>
    <form method="post" action="upload.form" enctype="multipart/form-data">
      <input type="file" name="file"/>
      <input type="submit"/>
    </form>
  </body>
</html>
```

As you can see, we've created a field named after the property of the bean that holds the `byte[]`. Furthermore we've added the encoding attribute which is necessary to let the browser know how to encode the multipart fields (don't forget this!). Right now everything should work.

12.9. Handling exceptions

Spring provides `HandlerExceptionResolvers` to ease the pain of unexpected exceptions occurring while your request is being handled by a controller which matched the request. `HandlerExceptionResolvers` somewhat resemble the exception-mappings you can define in the webapplication descriptor `web.xml`. However, they provide a more flexible to handle exceptions. about what handler was executing when the exception was thrown. Furthermore, a programmatic way of handling exception gives you many more options for how to respond appropriately before the request is forwarded to another URL (the same end result as when using the servlet specific exception mappings).

Besides implementing the `HandlerExceptionResolver`, which is only a matter of implementing the `resolveException(Exception, Handler)` method and returning a `ModelAndView`, you may also use the `SimpleMappingExceptionHandler`. This resolver enables you to take the class name of any exception that might be thrown and map it to a view name. This is functionally equivalent to the exception mapping feature from the servlet api, but it's also possible to implement more fine grained mappings of exception from different handlers.

12.10. Commonly used utilities

12.10.1. A little story about the pathmatcher

ToDo

Chapter 13. Integrating view technologies

13.1. Introduction

One of the areas in which Spring excels is in the separation of view technologies from the rest of the MVC framework. For example, deciding to use Velocity or XSLT in place of an existing JSP is primarily a matter of configuration. This chapter covers the major view technologies that work with Spring and touches briefly on how to add new ones. This chapter assumes you are already familiar with Section 12.5, “Views and resolving them” which covers the basics of how views in general are coupled to the MVC framework.

13.2. Using Spring together with JSP & JSTL

Spring provides a couple of out-of-the-box solutions for JSP and JSTL views (which are the most popular ones, incidentally). Using JSP or JSTL is done using a normal viewresolver defined in the `WebApplicationContext`. Furthermore, of course you need to write some JSPs that will actually render the view. This part describes some of the additional features Spring provides to facilitate JSP development.

13.2.1. View resolvers

Just as with any other view technology you're integrating with Spring, for JSPs you'll need a view resolver that will resolve your views. The most commonly used view resolvers when developing with JSPs are the `InternalResourceViewResolver` and the `ResourceBundleViewResolver`. Both are declared in the `WebApplicationContext`:

```
# The ResourceBundleViewResolver:
<bean id="viewResolver" class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
  <property name="basename"><value>views</value></property>
</bean>

# And a sample properties file is uses (views.properties in WEB-INF/classes):
welcome.class=org.springframework.web.servlet.view.JstlView
welcome.url=/WEB-INF/jsp/welcome.jsp

productList.class=org.springframework.web.servlet.view.JstlView
productList.url=/WEB-INF/jsp/productlist.jsp
```

As you can see, the `ResourceBundleViewResolver` needs a properties file defining the view names mapped to 1) a class and 2) a URL. With a `ResourceBundleViewResolver` you can mix different types of views using only one resolver.

```
<bean id="viewResolver" class="org.springframework.web.servlet.view.InternalResourceViewResolver">
  <property name="viewClass"><value>org.springframework.web.servlet.view.JstlView</value></property>
  <property name="prefix"><value>/WEB-INF/jsp/</value></property>
  <property name="suffix"><value>.jsp</value></property>
</bean>
```

The `InternalResourceBundleViewResolver` can be configured for using JSPs as described above. As a best practice, we strongly encourage placing your JSP files in a directory under the `WEB-INF` directory, so there can be no direct access by clients.

13.2.2. 'Plain-old' JSPs versus JSTL

When using Java Standard Tag Library you must use a special view class, the `JstlView`, as JSTL needs some preparation before things such as the `i18N` features will work.

13.2.3. Additional tags facilitating development

Spring provides data binding of request parameters to command objects as described in earlier chapters. To facilitate the development of JSP pages in combination with those data binding features, Spring provides a few tags that make things even easier. All Spring tags have *html escaping* features to enable or disable escaping of characters.

The tag library descriptor (TLD) is included in the `spring.jar` as well in the distribution itself. More information about the individual tags can be found online:
<http://www.springframework.org/docs/taglib/index.html>.

13.3. Using Tiles

It is possible to integrate Tiles - just as any other view technology - in webapplications using Spring. The following describes in a broad way how to do this.

13.3.1. Dependencies

To be able to use Tiles you have to have a couple of additional dependencies included in your project. The following is the list of dependencies you need.

- `struts version 1.1`
- `commons-beanutils`
- `commons-digester`
- `commons-logging`
- `commons-lang`

The dependencies are all available in the Spring distribution.

13.3.2. How to integrate Tiles

To be able to use Tiles, you have to configure it using files containing definitions (for basic information on definitions and other Tiles concepts, please have a look at <http://jakarta.apache.org/struts>). In Spring this is done using the `TilesConfigurer`. Have a look at the following piece of example `ApplicationContext` configuration:

```
<bean id="tilesConfigurer" class="org.springframework.web.servlet.view.tiles.TilesConfigurer">
  <property name="factoryClass">
    <value>org.apache.struts.tiles.xmlDefinition.I18nFactorySet</value>
  </property>
  <property name="definitions">
    <list>
      <value>/WEB-INF/defs/general.xml</value>
      <value>/WEB-INF/defs/widgets.xml</value>
      <value>/WEB-INF/defs/administrator.xml</value>
      <value>/WEB-INF/defs/customer.xml</value>
      <value>/WEB-INF/defs/templates.xml</value>
    </list>
  </property>
</bean>
```

As you can see, there are five files containing definitions, which are all located in the WEB-INF/defs directory. At initialization of the `WebApplicationContext`, the files will be loaded and the `definitionsFactory` defined by the `factoryClass`-property is initialized. After that has been done, the tiles includes in the definition files can be used as views within your Spring webapplication. To be able to use the views you have to have a `ViewResolver` just as with any other view technology used with Spring. Below you can find two possibilities, the `InternalResourceViewResolver` and the `ResourceBundleViewResolver`.

13.3.2.1. InternalResourceViewResolver

The `InternalResourceViewResolver` instantiates the given `viewClass` for each view it has to resolve.

```
<bean id="viewResolver" class="org.springframework.web.servlet.view.InternalResourceViewResolver">
  <property name="requestContextAttribute"><value>requestContext</value></property>
  <property name="viewClass">
    <value>org.springframework.web.servlet.view.tiles.TilesView</value>
  </property>
</bean>
```

13.3.2.2. ResourceBundleViewResolver

The `ResourceBundleViewResolver` has to be provided with a property file containing viewnames and viewclasses the resolver can use:

```
<bean id="viewResolver" class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
  <property name="basename"><value>views</value></property>
</bean>
```

```
...
welcomeView.class=org.springframework.web.servlet.view.tiles.TilesView
welcomeView.url=welcome (<b>this is the name of a definition</b>)

vetsView.class=org.springframework.web.servlet.view.tiles.TilesView
vetsView.url=vetsView (<b>again, this is the name of a definition</b>)

findOwnersForm.class=org.springframework.web.servlet.view.JstlView
findOwnersForm.url=/WEB-INF/jsp/findOwners.jsp
...
```

As you can see, when using the `ResourceBundleViewResolver`, you can mix view using different view technologies.

13.4. Velocity

Velocity is a view technology developed by the Jakarta Project. More information about Velocity can be found at <http://jakarta.apache.org/velocity>. This section describes how to integrate the Velocity view technology for use with Spring.

13.4.1. Dependencies

There are two dependency that your web application will need to satisfy before working with Velocity, namely that `velocity-1.x.x.jar` and `commons-collections.jar` need to be available. Typically they are included in the `WEB-INF/lib` folder where it is guaranteed to be found by a J2EE server and added to the classpath for your application. It is of course assumed that you already have the `spring.jar` in your `WEB-INF/lib` folder too! The latest stable velocity jar and commons collections jar are supplied with the Spring framework and can be copied from the `/lib/velocity` or `/lib/jakarta-commons` directories. If you make use of Spring's `dateToolAttribute`

or `numberToolAttribute` in your Velocity views, you will also need to include the `velocity-tools-generic-1.x.jar`

13.4.2. Context configuration

The configuration file for your Spring dispatcher servlet (usually `WEB-INF/[servletname]-servlet.xml`) will require a bean definition for the view resolver. We'll also add a bean here to configure the Velocity environment. I've chosen to call my dispatcher 'frontcontroller' so my config file names reflect this. This example uses the convenience `VelocityViewResolver` as it offers the simplest configuration. More flexibility when required can be obtained from different types of view resolution strategy.

The following code examples show the two beans in the simplest configuration. See the JavaDocs for these classes for more information on the various options available.

```
<!-- =====>
<!-- Velocity configurer. -->
<!-- =====>
<!--
This bean sets up the Velocity environment for us based on a root path for templates.
Optionally, a properties file can be specified for more control over the Velocity
environment, but the defaults are pretty sane for file based template loading.
-->
<bean
    id="velocityConfig"
    class="org.springframework.web.servlet.view.velocity.VelocityConfigurer"
    singleton="true">
    <property name="resourceLoaderPath"><value>/WEB-INF/velocity/</value></property>
</bean>

<!-- =====>
<!-- View resolver. Required by web framework. -->
<!-- =====>
<!--
View resolvers can also be configured with ResourceBundles or XML files. If you need
different view resolving based on Locale, you have to use the resource bundle resolver.
-->
<bean
    id="viewResolver"
    class="org.springframework.web.servlet.view.velocity.VelocityViewResolver">
    <property name="cache"><value>true</value></property>
    <property name="prefix"><value></value></property>
    <property name="suffix"><value>.vm</value></property>
</bean>
```

13.4.3. Velocity.properties

This file is completely optional, but if specified, contains the values that are passed to the Velocity runtime in order to configure velocity itself. Only a few properties are actually required, but many more optional properties are available - see the Velocity docs for more information. If you need this file, specify its location on the `VelocityConfigurer` bean definition above.

13.4.3.1. Template Locations

The most important property values concern the location of the Velocity templates themselves. Velocity templates can be loaded from the classpath or the file system and there are pros and cons for both. Loading from the classpath is entirely portable and will work on all target servers, but you may find that the templates clutter your java packages (unless you create a new source tree for them). A further downside of classpath storage is that during development, changing anything in the source tree often causes a refresh of the resource in the `WEB-INF/classes` tree and this in turn may cause your development server to restart the application (hot-deploying of code). This can be irritating. Once most of the development is complete though, you could store the templates in a jar file which would make them available to the application if this were placed in

WEB-INF/lib

13.4.3.2. Example velocity.properties

This example stores velocity templates on the file system somewhere under WEB-INF so that they are not directly available to the client browsers, but don't cause an application restart in development every time you change one. The downside is that the target server may not be able to resolve the path to these files correctly, particularly if the target server doesn't explode WAR modules on the file system. The file method works fine for Tomcat 4.1.x/5.x, WebSphere 4.x and WebSphere 5.x. Your mileage may vary.

```
#
# velocity.properties - example configuration
#

# uncomment the next two lines to load templates from the
# classpath (i.e. WEB-INF/classes)
#resource.loader=class
#class.resource.loader.class=org.apache.velocity.runtime.resource.loader.ClasspathResourceLoader

# comment the next two lines to stop loading templates from the
# file system
resource.loader=file
file.resource.loader.class=org.apache.velocity.runtime.resource.loader.FileResourceLoader

# additional config for file system loader only.. tell Velocity where the root
# directory is for template loading. You can define multiple root directories
# if you wish, I just use the one here. See the text below for a note about
# the ${webapp.root}
file.resource.loader.path=${webapp.root}/WEB-INF/velocity

# caching should be 'true' in production systems, 'false' is a development
# setting only. Change to 'class.resource.loader.cache=false' for classpath
# loading
file.resource.loader.cache=false

# override default logging to direct velocity messages
# to our application log for example. Assumes you have
# defined a log4j.properties file
runtime.log.logsystem.log4j.category=com.mycompany.myapplication
```

13.4.3.3. Web application root marker

The file resource loader configuration above uses a marker to denote the root of the web application on the file system `${webapp.root}`. This marker will be translated into the actual OS-specific path by the Spring code prior to supplying the properties to Velocity. This is what makes the file resource loader non-portable in some servers. The actual name of the marker itself can be changed if you consider it important by defining a different "appRootMarker" for VelocityConfigurer. See the Spring documentation for details on how to do this.

13.4.3.4. Alternative property specifications

Alternatively, you can specify velocity properties directly in the bean definition for the Velocity config bean by replacing the "configLocation" property with the following inline properties.

```
<property name="velocityProperties">
  <props>
    <prop key="resource.loader">file</prop>
    <prop key="file.resource.loader.class">org.apache.velocity.runtime.resource.loader.FileResourceLoader</prop>
    <prop key="file.resource.loader.path">${webapp.root}/WEB-INF/velocity</prop>
    <prop key="file.resource.loader.cache">false</prop>
  </props>
</property>
```

13.4.4. Creating the Velocity templates

Finally, you simply need to create the actual velocity templates. We have defined views that reference two templates, `mainTemplate.vm` and `secondaryTemplate.vm`. Both of these files will live in `WEB-INF/velocity/` as noted in the Velocity config above. If you chose a classpath loader in `velocity.properties`, these files would live in the default package (`WEB-INF/classes`), or in a jar file under `WEB-INF/lib`. Here's what our `/WEB-INF/velocity/firstView.vm` template might look like.

```
## model objects are set in the controller and referenced
## via bean properties or method names. See the Velocity
## docs for info
<html>
  <head><title>$title</title></head>
  <body>
    <h1>This is $title!!</h1>

    Model Value: $model.value
    Model Method Return Value: $model.getReturnVal()

  </body>
</html>
```

Now, when your controllers return a `ModelAndView` with the "firstView" set as the view to render, Velocity should kick in with the above page.

13.4.5. Form handling

Spring provides a tag library for use in JSP's that contains (amongst other things) a `<spring:bind>` tag. This tag primarily enables forms to display the results of failed validations from a `Validator` in the web or business tier. From version 1.1, Spring now has support for the same functionality in both Velocity and FreeMarker.

13.4.5.1. the springBind Velocity macro (VM)

A standard set of Velocity macros are maintained within the `spring.jar` file, so they are always available to a suitably configured application, however they can only be used if your Velocity view sets the bean property `exposeSpringMacroHelpers` to `true`. The same property can be set on `VelocityViewResolver` too if you happen to be using it, in which case all of your views will inherit the value from it. Note that this property is **not required** for any aspect of HTML form handling **except** where you wish to take advantage of the Spring VM's. Below is an example of a `view.properties` file showing correct configuration of such a view

```
personFormV.class=org.springframework.web.servlet.view.velocity.VelocityView
personFormV.url=personForm.vm
personFormV.exposeSpringMacroHelpers=true
```

13.4.5.2. Binding fields in the HTML form

Now, in your html forms (Velocity templates), you can use code similar to the following to display bound values and error messages for each input field in similar fashion to the JSP equivalent.

```
<html>
...
<form action="" method="POST">
  Name:
  #springBind( "command.name" )
  <input type="text" name="{status.expression}" value="{!status.value}" /><br>
  #foreach($error in $status.errorMessages) <b>$error</b> <br> #end
  <br>

  Age:
  #springBind( "command.age" )
```

```



```

`#springBind` requires a 'path' argument which consists of the name of your command object (it will be 'command' unless you changed it in your FormController properties) followed by a period and the name of the field on the command object you wish to bind to. Nested fields can be used too as shown in the example above for the 'Street' field. The `#springBind` macro assumes the default HTML escaping behaviour specified by the ServletContext parameter `defaultHtmlEscape` in `web.xml`

The optional form of the macro called `#springBindEscaped` takes a second argument and explicitly specifies whether HTML escaping should be used in the status error messages or values. Set to true or false as required.

13.5. FreeMarker

FreeMarker [<http://www.freemarker.org>] is a templating language with similar goals to Velocity. FreeMarker has a more powerful language and additional constructs compared to Velocity, but it is correspondingly more complex to learn. Spring aims to abstract much of the configuration complexities away and so when using FreeMarker within your Spring applications, it's very similar to using Velocity. For this reason, much of what is said in the Velocity section above also applies here and it would be worth a read if you haven't already done so.

13.5.1. Dependencies

Your application should include the latest FreeMarker jar file (`freemarker-2.3.jar` at the time of writing) which can always be found in the Spring distribution or from the FreeMarker web site.

13.5.2. Context configuration

A FreeMarker configuration is initialized by adding the following definition to your `*-servlet.xml`. For non web-apps add a `FreeMarkerConfigurationFactoryBean` application context definition file.

```

<!-- freemarker config -->
<bean id="freemarkerConfig" class="org.springframework.web.servlet.view.freemarker.FreeMarkerConfigurer">
  <property name="templateLoaderPath"><value>/WEB-INF/ftl</value></property>
</bean>

```

13.5.3. Form handling

FreeMarker macros are available within `spring.jar` similar to the Velocity macros and all of the same principals apply. See above for details of this. Here's an example view definition making use of the Spring macros in a `FreeMarkerView`

```

personFormF.class=org.springframework.web.servlet.view.freemarker.FreeMarkerView
personFormF.url=personForm.ftl

```

```
personFormF.exposeSpringMacroHelpers=true
```

13.5.3.1. Binding fields in the HTML form

Here's the FreeMarker equivalent of the Velocity example above:

```
<#import "/spring.ftl" as spring />

<html>
...
<form action="" method="POST">
  Name:
  <@spring.bind "command.name" />
  <input type="text" name="${spring.status.expression}" value="${spring.status.value?default("")}" /><br>
  <#list spring.status.errorMessages as error> <b>${error}</b> <br> </#list>
  <br>

  Age:
  <@spring.bind "command.age" />
  <input type="text" name="${spring.status.expression}" value="${spring.status.value}" /><br>
  <#list spring.status.errorMessages as error> <b>${error}</b> <br> </#list>
  <br>

  Street:
  <@spring.bindEscaped "command.address.street", true />
  <input type="text" name="${spring.status.expression}" value="${spring.status.value?default("")}" /><br>
  <#list spring.status.errorMessages as error> <b>${error}</b> <br> </#list>
  <br>

  <input type="submit" value="submit"/>
</form>
...
</html>
```

Note that a critical difference with FreeMarker is that the Spring macros have to be imported into the template under their own namespace. This is done in the first line of the file shown above. The `<@spring.bind>` macro assumes the default HTML escaping behaviour specified by the ServletContext parameter `defaultHtmlEscape` in `web.xml`

There is an optional form of the macro called `<@spring.bindEscaped>` which takes a second argument and explicitly specifies whether HTML escaping should be used in the status error messages or values. Set to `true` or `false` as required.

13.6. XSLT Views

XSLT is a transformation language for XML and is popular as a view technology within web applications. XSLT can be a good choice as a view technology if your application naturally deals with XML, or if your model can easily be converted to XML. The following section shows how to produce an XML document as model data and have it transformed with XSLT in a Spring application.

13.6.1. My First Words

This example is a trivial Spring application that creates a list of words in the Controller and adds them to the model map. The map is returned along with the view name of our XSLT view. See Section 12.3, “Controllers” for details of Spring `Controller`s. The XSLT view will turn the list of words into a simple XML document ready for transformation.

13.6.1.1. Bean definitions

Configuration is standard for a simple Spring application. The dispatcher servlet config file contains a reference to a `ViewResolver`, URL mappings and a single controller bean..

```
<bean id="homeController" class="xslt.HomeController"/>
```

..that implements our word generation 'logic'.

13.6.1.2. Standard MVC controller code

The controller logic is encapsulated in a subclass of `AbstractController`, with the handler method being defined like so..

```
protected ModelAndView handleRequestInternal(
    HttpServletRequest req,
    HttpServletResponse resp)
    throws Exception {

    Map map = new HashMap();
    List wordList = new ArrayList();

    wordList.add("hello");
    wordList.add("world");

    map.put("wordList", wordList);

    return new ModelAndView("home", map);
}
```

So far we've done nothing that's XSLT specific. The model data has been created in the same way as you would for any other Spring MVC application. Depending on the configuration of the application now, that list of words could be rendered by JSP/JSTL by having them added as request attributes, or they could be handled by Velocity by adding the object to the `VelocityContext`. In order to have XSLT render them, they of course have to be converted into an XML document somehow. There are software packages available that will automatically 'domify' an object graph, but within Spring, you have complete flexibility to create the DOM from your model in any way you choose. This prevents the transformation of XML playing too great a part in the structure of your model data which is a danger when using tools to manage the domification process.

13.6.1.3. Convert the model data to XML

In order to create a DOM document from our list of words or any other model data, we subclass `org.springframework.web.servlet.view.xslt.AbstractXsltView`. In doing so, we must implement the abstract method `createDomNode()`. The first parameter passed to this method is our model `Map`. Here's the complete listing of the `HomePage` class in our trivial word application - it uses `JDOM` to build the XML document before converting it to the required `W3C Node`, but this is simply because I find `JDOM` (and `Dom4J`) easier API's to handle than the `W3C API`.

```
package xslt;

// imports omitted for brevity

public class HomePage extends AbstractXsltView {

    protected Node createDomNode(
        Map model, String rootName, HttpServletRequest req, HttpServletResponse res
    ) throws Exception {

        org.jdom.Document doc = new org.jdom.Document();
        Element root = new Element(rootName);
        doc.setRootElement(root);

        List words = (List) model.get("wordList");
        for (Iterator it = words.iterator(); it.hasNext();) {
```

```

        String nextWord = (String) it.next();
        Element e = new Element("word");
        e.setText(nextWord);
        root.addContent(e);
    }

    // convert JDOM doc to a W3C Node and return
    return new DOMOutputter().output( doc );
}
}

```

13.6.1.3.1. Adding stylesheet parameters

A series of parameter name/value pairs can optionally be defined by your subclass which will be added to the transformation object. The parameter names must match those defined in your XSLT template declared with `<xsl:param name="myParam">defaultValue</xsl:param>`. To specify the parameters, override the method `getParameters()` from `AbstractXsltView` and return a `Map` of the name/value pairs. If your parameters need to derive information from the current request, you can (from version 1.1) override the `getParameters(HttpServletRequest request)` method instead.

13.6.1.3.2. Formatting dates and currency

Unlike JSTL and Velocity, XSLT has relatively poor support for locale based currency and date formatting. In recognition of the fact, Spring provides a helper class that you can use from within your `createDomNode()` methods to get such support. See the javadocs for `org.springframework.web.servlet.view.xslt.FormatHelper`

13.6.1.4. Defining the view properties

The `views.properties` file (or equivalent `xml` definition if you're using an XML based view resolver as we did in the Velocity examples above) looks like this for the one-view application that is 'My First Words'..

```

home.class=xslt.HomePage
home.stylesheetLocation=/WEB-INF/xsl/home.xslt
home.root=words

```

Here, you can see how the view is tied in with the `HomePage` class just written which handles the model domification in the first property `'class'`. The `stylesheetLocation` property obviously points to the XSLT file which will handle the XML transformation into HTML for us and the final property `'root'` is the name that will be used as the root of the XML document. This gets passed to the `HomePage` class above in the second parameter to the `createDomNode` method.

13.6.1.5. Document transformation

Finally, we have the XSLT code used for transforming the above document. As highlighted in the `views.properties` file, it is called `home.xslt` and it lives in the war file under `WEB-INF/xsl`.

```

<?xml version="1.0"?>

<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:output method="text/html" omit-xml-declaration="yes"/>

  <xsl:template match="/">
    <html>
      <head><title>Hello!</title></head>
      <body>

        <h1>My First Words</h1>
        <xsl:for-each select="wordList/word">
          <xsl:value-of select="."/><br />

```

```

        </xsl:for-each>

    </body>
</html>
</xsl:template>

</xsl:stylesheet>

```

13.6.2. Summary

A summary of the files discussed and their location in the WAR file is shown in the simplified WAR structure below.

```

ProjectRoot
|
+- WebContent
|
|   +- WEB-INF
|   |
|   |   +- classes
|   |   |
|   |   |   +- xslt
|   |   |   |
|   |   |   |   +- HomePageController.class
|   |   |   |   +- HomePage.class
|   |   |   |
|   |   |   +- views.properties
|   |   |
|   |   +- lib
|   |   |
|   |   |   +- spring.jar
|   |   |
|   |   +- xsl
|   |   |
|   |   |   +- home.xslt
|   |   |
|   +- frontcontroller-servlet.xml

```

You will also need to ensure that an XML parser and an XSLT engine are available on the classpath. JDK 1.4 provides them by default, and most J2EE containers will also make them available by default, but it's a possible source of errors to be aware of.

13.7. Document views (PDF/Excel)

13.7.1. Introduction

Returning an HTML page isn't always the best way for the user to view the model output, and Spring makes it simple to generate a PDF document or an Excel spreadsheet dynamically from the model data. The document is the view and will be streamed from the server with the correct content type to (hopefully) enable the client PC to run their spreadsheet or PDF viewer application in response.

In order to use Excel views, you need to add the 'poi' library to your classpath, and for PDF generation, the iText.jar. Both are included in the main Spring distribution.

13.7.2. Configuration and setup

Document based views are handled in an almost identical fashion to XSLT views, and the following sections build upon the previous one by demonstrating how the same controller used in the XSLT example is invoked to render the same model as both a PDF document and an Excel spreadsheet (which can also be viewed or

manipulated in Open Office).

13.7.2.1. Document view definitions

Firstly, let's amend the `views.properties` file (or xml equivalent) and add a simple view definition for both document types. The entire file now looks like this with the XSLT view shown from earlier..

```
home.class=xslt.HomePage
home.stylesheetLocation=/WEB-INF/xsl/home.xslt
home.root=words

xl.class=excel.HomePage

pdf.class=pdf.HomePage
```

If you want to start with a template spreadsheet to add your model data to, specify the location as the 'url' property in the view definition

13.7.2.2. Controller code

The controller code we'll use remains exactly the same from the XSLT example earlier other than to change the name of the view to use. Of course, you could be clever and have this selected based on a URL parameter or some other logic - proof that Spring really is very good at decoupling the views from the controllers!

13.7.2.3. Subclassing for Excel views

Exactly as we did for the XSLT example, we'll subclass suitable abstract classes in order to implement custom behaviour in generating our output documents. For Excel, this involves writing a subclass of `org.springframework.web.servlet.view.document.AbstractExcelView` and implementing the `buildExcelDocument`

Here's the complete listing for our Excel view which displays the word list from the model map in consecutive rows of the first column of a new spreadsheet..

```
package excel;

// imports omitted for brevity

public class HomePage extends AbstractExcelView {

    protected void buildExcelDocument(
        Map model,
        HSSFWorkbook wb,
        HttpServletRequest req,
        HttpServletResponse resp)
        throws Exception {

        HSSFSheet sheet;
        HSSFRow sheetRow;
        HSSFCell cell;

        // Go to the first sheet
        // getSheetAt: only if wb is created from an existing document
        //sheet = wb.getSheetAt( 0 );
        sheet = wb.createSheet("Spring");
        sheet.setDefaultColumnWidth((short)12);

        // write a text at A1
        cell = getCell( sheet, 0, 0 );
        setText(cell, "Spring-Excel test");

        List words = (List ) model.get("wordList");
        for (int i=0; i < words.size(); i++) {
            cell = getCell( sheet, 2+i, 0 );
            setText(cell, (String) words.get(i));
        }
    }
}
```

```

    }
}

```

If you now amend the controller such that it returns `x1` as the name of the view (`return new ModelAndView("x1", map);`) and run your application again, you should find that the Excel spreadsheet is created and downloaded automagically when you request the same page as before.

13.7.2.4. Subclassing for PDF views

The PDF version of the word list is even simpler. This time, the class extends `org.springframework.web.servlet.view.document.AbstractPdfView` and implements the `buildPdfDocument()` method as follows..

```

package pdf;

// imports omitted for brevity

public class PDFPage extends AbstractPdfView {

    protected void buildPdfDocument(
        Map model,
        Document doc,
        PdfWriter writer,
        HttpServletRequest req,
        HttpServletResponse resp)
        throws Exception {

        List words = (List) model.get("wordList");

        for (int i=0; i<words.size(); i++)
            doc.add( new Paragraph((String) words.get(i)));

    }
}

```

Once again, amend the controller to return the pdf view with a `return new ModelAndView("pdf", map);` and reload the URL in your application. This time a PDF document should appear listing each of the words in the model map.

13.8. Tapestry

Tapestry is a powerful, component-oriented web application framework from Apache's Jakarta project (<http://jakarta.apache.org/tapestry>). While Spring has its own powerful web ui layer, there are a number of unique advantages to building a J2EE application using a combination of Tapestry for the web ui, and the Spring container for the lower layers. This document attempts to detail a few best practices for combining these two frameworks. It is expected that you are relatively familiar with both Tapestry and Spring Framework basics, so they will not be explained here. General introductory documentation for both Tapestry and Spring Framework are available on their respective web sites.

13.8.1. Architecture

A typical layered J2EE application built with Tapestry and Spring will consist of a top UI layer built with Tapestry, and a number of lower layers, hosted out of one or more Spring Application Contexts.

- *User Interface Layer:*
 - concerned with the user interface

- contains some application logic
- provided by Tapestry
- aside from providing UI via Tapestry, code in this layer does its work via objects which implement interfaces from the Service Layer. The actual objects which implement these service layer interfaces are obtained from a Spring Application Context.
- *Service Layer:*
 - application specific 'service' code
 - works with domain objects, and uses the Mapper API to get those domain objects into and out of some sort of repository (database)
 - hosted in one or more Spring contexts
 - code in this layer manipulates objects in the domain model, in an application specific fashion. It does its work via other code in this layer, and via the Mapper API. An object in this layer is given the specific mapper implementations it needs to work with, via the Spring context.
 - since code in this layer is hosted in the Spring context, it may be transactionally wrapped by the Spring context, as opposed to managing its own transactions
- *Domain Model:*
 - domain specific object hierarchy, which deals with data and logic specific to this domain
 - although the domain object hierarchy is built with the idea that it is persisted somehow and makes some general concessions to this (for example, bidirectional relationships), it generally has no knowledge of other layers. As such, it may be tested in isolation, and used with different mapping implementations for production vs. testing.
 - these objects may be standalone, or used in conjunction with a Spring application context to take advantage of some of the benefits of the context, e.g., isolation, inversion of control, different strategy implementations, etc.
- *Data Source Layer:*
 - Mapper API (also called Data Access Objects): an API used to persist the domain model to a repository of some sort (generally a DB, but could be the filesystem, memory, etc.)
 - Mapper API implementations: one or more specific implementations of the Mapper API, for example, a Hibernate-specific mapper, a JDO-specific mapper, JDBC-specific mapper, or a memory mapper.
 - mapper implementations live in one or more Spring Application Contexts. A service layer object is given the mapper objects it needs to work with via the context.
- *Database, filesystem, or other repositories:*
 - objects in the domain model are stored into one or more repositories via one or more mapper implementations
 - a repository may be very simple (e.g. filesystem), or may have its own representation of the data from the domain model (i.e. a schema in a db). It does not know about other layers however.

13.8.2. Implementation

The only real question (which needs to be addressed by this document), is how Tapestry pages get access to service implementations, which are simply beans defined in an instance of the Spring Application Context.

13.8.2.1. Sample application context

Assume we have the following simple Application Context definition, in xml form:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE beans PUBLIC "-//SPRING//DTD BEAN//EN"
    "http://www.springframework.org/dtd/spring-beans.dtd">

<beans>

    <!-- ===== GENERAL DEFINITIONS ===== -->

    <!-- ===== PERSISTENCE DEFINITIONS ===== -->

    <!-- the DataSource -->
    <bean id="dataSource" class="org.springframework.jndi.JndiObjectFactoryBean">
        <property name="jndiName"><value>java:DefaultDS</value></property>
        <property name="resourceRef"><value>false</value></property>
    </bean>

    <!-- define a Hibernate Session factory via a Spring LocalSessionFactoryBean -->
    <bean id="hibSessionFactory"
        class="org.springframework.orm.hibernate.LocalSessionFactoryBean">
        <property name="dataSource"><ref bean="dataSource"/></property>
    </bean>

    <!--
    - Defines a transaction manager for usage in business or data access objects.
    - No special treatment by the context, just a bean instance available as reference
    - for business objects that want to handle transactions, e.g. via TransactionTemplate.
    -->
    <bean id="transactionManager"
        class="org.springframework.transaction.jta.JtaTransactionManager">
    </bean>

    <bean id="mapper"
        class="com.whatever.dataaccess.mapper.hibernate.MapperImpl">
        <property name="sessionFactory"><ref bean="hibSessionFactory"/></property>
    </bean>

    <!-- ===== BUSINESS DEFINITIONS ===== -->

    <!-- AuthenticationService, including tx interceptor -->
    <bean id="authenticationServiceTarget"
        class="com.whatever.services.service.user.AuthenticationServiceImpl">
        <property name="mapper"><ref bean="mapper"/></property>
    </bean>
    <bean id="authenticationService"
        class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">
        <property name="transactionManager"><ref bean="transactionManager"/></property>
        <property name="target"><ref bean="authenticationServiceTarget"/></property>
        <property name="proxyInterfacesOnly"><value>true</value></property>
        <property name="transactionAttributes">
            <props>
                <prop key="*">PROPAGATION_REQUIRED</prop>
            </props>
        </property>
    </bean>

    <!-- UserService, including tx interceptor -->
    <bean id="userServiceTarget"
        class="com.whatever.services.service.user.UserServiceImpl">
        <property name="mapper"><ref bean="mapper"/></property>
    </bean>
    <bean id="userService"
        class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">
        <property name="transactionManager"><ref bean="transactionManager"/></property>
        <property name="target"><ref bean="userServiceTarget"/></property>
        <property name="proxyInterfacesOnly"><value>true</value></property>
```

```

        <property name="transactionAttributes">
            <props>
                <prop key="*">PROPAGATION_REQUIRED</prop>
            </props>
        </property>
    </bean>
</beans>

```

Inside the Tapestry application, we need to load this application context, and allow Tapestry pages to get the `authenticationService` and `userService` beans, which implement the `AuthenticationService` and `UserService` interfaces, respectively.

13.8.2.2. Obtaining beans in Tapestry pages

At this point, the application context is available to a web application by calling Spring's static utility function `WebApplicationContextUtils.getApplicationContext(servletContext)`, where `servletContext` is the standard `ServletContext` from the J2EE Servlet specification. As such, one simple mechanism for a page to get an instance of the `UserService`, for example, would be with code such as:

```

WebApplicationContext appContext = WebApplicationContextUtils.getApplicationContext(
    getRequestCycle().getRequestContext().getServlet().getServletContext());
UserService userService = (UserService) appContext.getBean("userService");
... some code which uses UserService

```

This mechanism does work. It can be made a lot less verbose by encapsulating most of the functionality in a method in the base class for the page or component. However, in some respects it goes against the Inversion of Control approach which Spring encourages, which is being used in other layers of this app, in that ideally you would like the page to not have to ask the context for a specific bean by name, and in fact, the page would ideally not know about the context at all.

Luckily, there is a mechanism to allow this. We rely upon the fact that Tapestry already has a mechanism to declaratively add properties to a page, and it is in fact the preferred approach to manage all properties on a page in this declarative fashion, so that Tapestry can properly manage their lifecycle as part of the page and component lifecycle.

13.8.2.3. Exposing the application context to Tapestry

First we need to make the `ApplicationContext` available to the Tapestry page or Component without having to have the `ServletContext`; this is because at the stage in the page's/component's lifecycle when we need to access the `ApplicationContext`, the `ServletContext` won't be easily available to the page, so we can't use `WebApplicationContextUtils.getApplicationContext(servletContext)` directly. One way is by defining a custom version of the Tapestry `IEngine` which exposes this for us:

```

package com.whatever.web.xportal;
...
import ...
...
public class MyEngine extends org.apache.tapestry.engine.BaseEngine {

    public static final String APPLICATION_CONTEXT_KEY = "appContext";

    /**
     * @see org.apache.tapestry.engine.AbstractEngine#setupForRequest(org.apache.tapestry.request.RequestContext)
     */
    protected void setupForRequest(RequestContext context) {
        super.setupForRequest(context);

        // insert ApplicationContext in global, if not there
        Map global = (Map) getGlobal();
        ApplicationContext ac = (ApplicationContext) global.get(APPLICATION_CONTEXT_KEY);
        if (ac == null) {
            ac = WebApplicationContextUtils.getWebApplicationContext(

```



```

        context.getServlet().getServletContext()
    );
    global.put(APPLICATION_CONTEXT_KEY, ac);
}
}
}

```

This engine class places the Spring Application Context as an attribute called "appContext" in this Tapestry app's 'Global' object. Make sure to register the fact that this special IEngine instance should be used for this Tapestry application, with an entry in the Tapestry application definition file. For example:

```

file: xportal.application:

<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE application PUBLIC
    "-//Apache Software Foundation//Tapestry Specification 3.0//EN"
    "http://jakarta.apache.org/tapestry/dtd/Tapestry_3_0.dtd">
<application
    name="Whatever xPortal"
    engine-class="com.whatever.web.xportal.MyEngine">
</application>

```

13.8.2.4. Component definition files

Now in our page or component definition file (*.page or *.jwc), we simply add property-specification elements to grab the beans we need out of the ApplicationContext, and create page or component properties for them. For example:

```

<property-specification name="userService"
    type="com.whatever.services.service.user.UserService">
    global.appContext.getBean("userService")
</property-specification>
<property-specification name="authenticationService"
    type="com.whatever.services.service.user.AuthenticationService">
    global.appContext.getBean("authenticationService")
</property-specification>

```

The OGNL expression inside the property-specification specifies the initial value for the property, as a bean obtained from the context. The entire page definition might look like this:

```

<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE page-specification PUBLIC
    "-//Apache Software Foundation//Tapestry Specification 3.0//EN"
    "http://jakarta.apache.org/tapestry/dtd/Tapestry_3_0.dtd">

<page-specification class="com.whatever.web.xportal.pages.Login">

    <property-specification name="username" type="java.lang.String"/>
    <property-specification name="password" type="java.lang.String"/>
    <property-specification name="error" type="java.lang.String"/>
    <property-specification name="callback" type="org.apache.tapestry.callback.ICallback" persistent="yes"/>
    <property-specification name="userService"
        type="com.whatever.services.service.user.UserService">
        global.appContext.getBean("userService")
    </property-specification>
    <property-specification name="authenticationService"
        type="com.whatever.services.service.user.AuthenticationService">
        global.appContext.getBean("authenticationService")
    </property-specification>

    <bean name="delegate" class="com.whatever.web.xportal.PortaValidationDelegate"/>

    <bean name="validator" class="org.apache.tapestry.valid.StringValidator" lifecycle="page">
        <set-property name="required" expression="true"/>
        <set-property name="clientScriptingEnabled" expression="true"/>
    </bean>

    <component id="inputUsername" type="ValidField">
        <static-binding name="displayName" value="Username"/>
        <binding name="value" expression="username"/>
    </component>

```

```

        <binding name="validator" expression="beans.validator"/>
    </component>

    <component id="inputPassword" type="ValidField">
        <binding name="value" expression="password"/>
        <binding name="validator" expression="beans.validator"/>
        <static-binding name="displayName" value="Password"/>
        <binding name="hidden" expression="true"/>
    </component>

</page-specification>

```

13.8.2.5. Adding abstract accessors

Now in the Java class definition for the page or component itself, all we need to do is add an abstract getter method for the properties we have defined, to access them. When the page or component is actually loaded by Tapestry, it performs runtime code instrumentation on the classfile to add the properties which have been defined, and hook up the abstract getter methods to the newly created fields. For example:

```

// our UserService implementation; will come from page definition
public abstract UserService getUserService();
// our AuthenticationService implementation; will come from page definition
public abstract AuthenticationService getAuthenticationService();

```

For completeness, the entire Java class, for a login page in this example, might look like this:

```

package com.whatever.web.xportal.pages;

/**
 * Allows the user to login, by providing username and password.
 * After successfully logging in, a cookie is placed on the client browser
 * that provides the default username for future logins (the cookie
 * persists for a week).
 */
public abstract class Login extends BasePage implements ErrorProperty, PageRenderListener {

    /** the key under which the authenticated user object is stored in the visit as */
    public static final String USER_KEY = "user";

    /**
     * The name of a cookie to store on the user's machine that will identify
     * them next time they log in.
     */
    private static final String COOKIE_NAME = Login.class.getName() + ".username";
    private final static int ONE_WEEK = 7 * 24 * 60 * 60;

    // --- attributes

    public abstract String getUsername();
    public abstract void setUsername(String username);

    public abstract String getPassword();
    public abstract void setPassword(String password);

    public abstract ICallback getCallback();
    public abstract void setCallback(ICallback value);

    public abstract UserService getUserService();

    public abstract AuthenticationService getAuthenticationService();

    // --- methods

    protected IValidationDelegate getValidationDelegate() {
        return (IValidationDelegate) getBeans().getBean("delegate");
    }

    protected void setErrorField(String componentId, String message) {
        IFormComponent field = (IFormComponent) getComponent(componentId);
        IValidationDelegate delegate = getValidationDelegate();
        delegate.setFormComponent(field);
        delegate.record(new ValidatorException(message));
    }
}

```

```

}

/**
 * Attempts to login.
 *
 * <p>If the user name is not known, or the password is invalid, then an error
 * message is displayed.
 *
 */
public void attemptLogin(IRequestCycle cycle) {

    String password = getPassword();

    // Do a little extra work to clear out the password.

    setPassword(null);
    IValidationDelegate delegate = getValidationDelegate();

    delegate.setFormComponent((IFormComponent) getComponent("inputPassword"));
    delegate.recordFieldInputValue(null);

    // An error, from a validation field, may already have occurred.

    if (delegate.getHasErrors())
        return;

    try {
        User user = getAuthenticationService().login(getUsername(), getPassword());
        loginUser(user, cycle);
    }
    catch (FailedLoginException ex) {
        this.setError("Login failed: " + ex.getMessage());
        return;
    }
}

/**
 * Sets up the {@link User} as the logged in user, creates
 * a cookie for their username (for subsequent logins),
 * and redirects to the appropriate page, or
 * a specified page).
 *
 */
public void loginUser(User user, IRequestCycle cycle) {

    String username = user.getUsername();

    // Get the visit object; this will likely force the
    // creation of the visit object and an HttpSession.

    Map visit = (Map) getVisit();
    visit.put(USER_KEY, user);

    // After logging in, go to the MyLibrary page, unless otherwise
    // specified.

    ICallback callback = getCallback();

    if (callback == null)
        cycle.activate("Home");
    else
        callback.performCallback(cycle);

    // I've found that failing to set a maximum age and a path means that
    // the browser (IE 5.0 anyway) quietly drops the cookie.

    IEngine engine = getEngine();
    Cookie cookie = new Cookie(COOKIE_NAME, username);
    cookie.setPath(engine.getServletPath());
    cookie.setMaxAge(ONE_WEEK);

    // Record the user's username in a cookie

    cycle.getRequestContext().addCookie(cookie);

    engine.forgetPage(getPageName());
}

```

```
public void pageBeginRender(PageEvent event) {  
    if (getUsername() == null)  
        setUsername(getRequestCycle().getRequestContext().getCookieValue(COOKIE_NAME));  
}  
}
```

13.8.3. Summary

In this example, we've managed to allow service beans defined in the Spring `ApplicationContext` to be provided to the page in a declarative fashion. The page class does not know where the service implementations are coming from, and in fact it is easy to slip in another implementation, for example, during testing. This inversion of control is one of the prime goals and benefits of the Spring Framework, and we have managed to extend it all the way up the J2EE stack in this Tapestry application.

Chapter 14. JMS

14.1. Introduction

Spring provides a JMS abstraction framework that simplifies the use of the JMS API and shields the user from differences between the JMS 1.0.2 and 1.1 APIs.

JMS can be roughly divided into two areas of functionality, production and consumption of messages. In an J2EE environment, the ability to consume messages asynchronously is provided for by `MessageDriven` beans while in a standalone application this is provided for by the creation of `MessageListeners` or `ConnectionConsumers`. The functionality in `JmsTemplate` is focused on producing messages. Future releases of Spring will address asynchronous message consumption in a standalone environment.

The package `org.springframework.jms.core` provides the core functionality for using JMS. It contains JMS template classes that simplify the use of the JMS by handling the creation and release of resources, much like the `JdbcTemplate` does for JDBC. The design principal common to Spring template classes is to provide helper methods to perform common operations and for more sophisticated usage, delegate the essence of the processing task to user implemented callback interfaces. The JMS template follows the same design. The classes offer various convenience methods for the sending of messages, consuming a message synchronously, and exposing the JMS session and message producer to the user.

The package `org.springframework.jms.support` provides `JMSException` translation functionality. The translation converts checked `JMSException` hierarchy to a mirrored hierarchy of unchecked exceptions. If there are any provider specific subclasses of the checked `javax.jms.JMSException`, this exception is wrapped in the unchecked `JmsException`. The package `org.springframework.jms.support.converter` provides a `MessageConverter` abstraction to convert between Java objects and JMS messages. The package `org.springframework.jms.support.destination` provides various strategies for managing JMS destinations, such as providing a service locator for destinations stored in JNDI.

Finally, the package `org.springframework.jms.connection` provides an implementation of the `ConnectionFactory` suitable for use in standalone applications. It also contains an implementation of Spring's `PlatformTransactionManager` for JMS. This allows for integration of JMS as a transactional resource into Spring's transaction management mechanisms.

14.2. Domain unification

There are two major releases of the JMS specification, 1.0.2 and 1.1. JMS 1.0.2 defined two types of messaging domains, point-to-point (Queues) and publish/subscribe (Topics). The 1.0.2 API reflected these two messaging domains by providing a parallel class hierarchy for each domain. Consequentially, a client application was domain specific in the use of the JMS API. JMS 1.1 introduced the concept of domain unification that minimized both the functional differences and client API differences between the two domains. As an example of a functional difference that was removed, if you use a JMS 1.1 provider you can transactionally consume a message from one domain and produce a message on the other using the same `Session`.

The JMS 1.1 specification was released in April 2002 and but only incorporated as part of J2EE 1.4 in November 2003. As a result, most application servers that are currently in use are only required to support JMS 1.0.2.

14.3. JmsTemplate

Two implementations of the `JmsTemplate` are provided. The class `JmsTemplate` uses the JMS 1.1 API and the subclass `JmsTemplate102` uses the JMS 1.0.2 API.

Code that uses the `JmsTemplate` only needs to implement callback interfaces giving them a clearly defined contract. The `MessageCreator` callback interface creates a message given a `Session` provided by the calling code in `JmsTemplate`. In order to allow for more complex usage of the JMS API, the callback `SessionCallback` provides the user with the JMS session and the callback `ProducerCallback` exposes a `Session` and `MessageProducer` pair.

The JMS API exposes two types of send methods, one that takes delivery mode, priority, and time-to-live as quality of service (QOS) parameters and one that takes no QOS parameters and uses default values. Since there are many send methods in `JmsTemplate`, the setting of the QOS parameters has been exposed in the `JmsTemplate` as bean properties to avoid duplication in the number of send methods. Similarly, the timeout value for synchronous receive calls is set using the property `setReceiveTimeout`.

Some JMS providers allow the setting of default QOS values administratively through the configuration of the `ConnectionFactory`. This has the effect that a call to `MessageProducer`'s send method `send(Destination destination, Message message)` will use QOS different default values than those specified in the JMS specification. Therefore, in order to provide consistent management of the QOS values, the `JmsTemplate` must be specifically enabled to use its own QOS values by setting the boolean property `isExplicitQosEnabled` to `true`.

14.3.1. ConnectionFactory

The implementations of the `JmsTemplate` require a reference to a `ConnectionFactory`. The `ConnectionFactory` is part of the JMS specification and serves as the entry point for working with JMS. It is used by the client application as a factory to create connections with the JMS provider and encapsulates various configuration parameters, many of which are vendor specific such as SSL configuration options.

The `ConnectionFactory` interface allows the container or a framework to provide a managed implementation that provides pooling of connection/sessions and participation in declarative transaction management. In order to obtain these features, J2EE containers typically require that you declare a JMS connection factory as a `resource-ref` inside the EJB or servlet deployment descriptors. To ensure the use of these features with the `JmsTemplate`, the client application should ensure that it references the managed implementation of the `ConnectionFactory`.

Spring provides an implementation of the `ConnectionFactory` interface, `SingleConnectionFactory`, that will return the same `Connection` on all `createConnection` calls and ignore calls to `close`. This is useful for testing and standalone environments so that the same connection can be used for multiple `JmsTemplate` calls that may span any number of transactions. `SingleConnectionFactory` takes a reference to a standard `ConnectionFactory` that would typically come from JNDI.

14.3.2. Transaction Management

Spring provides an implementation of the `PlatformTransactionManager` interface for JMS called `JmsTransactionManager` which manages transactions for a single JMS `ConnectionFactory`. This allows JMS applications to leverage the managed transaction features of Spring as described in Chapter 6. The `JmsTransactionManager` binds a `Connection/Session` pair from the specified `ConnectionFactory` to the thread. However, in a J2EE environment the `ConnectionFactory` will pool connections and sessions, so the instances that are bound to the thread depend on the pooling behavior. In a standalone environment, using Spring's

`SingleConnectionFactory` will result in a using a single JMS Connection and each transaction having its own Session. The `JmsTemplate` can also be used with a `JtaTransactionManager` and an XA-capable JMS `ConnectionFactory` for performing distributed transactions.

Reusing code across a managed and unmanaged transactional environment can be confusing when using JMS API to create a Session from a Connection. This is because the JMS API only has only one factory method to create a Session and it requires values for the transaction and acknowledgement modes. In a managed environment, setting these values in the responsibility of the environments transactional infrastructure, so these values are ignored by the vendors wrapper to the JMS Connection. When using the `JmsTemplate` in an unmanaged environment you can specify these values though the use of the properties `SessionTransacted` and `SessionAcknowledgeMode`. When using a `PlatformTransactionManager` with `JmsTemplate`, the template will always be given a transactional JMS Session.

14.3.3. Destination Management

Destinations, like `ConnectionFactories`, are JMS administered objects that can be stored and retrieved in JNDI. When configuring a Spring application context one can use the JNDI factory class `JndiObjectFactoryBean` to perform dependency injection on your object's references to JMS destinations. However, often this strategy is cumbersome if there are a large number of destinations in the application or if there is more advanced destination management provided by the vendor. Examples of such advanced destination management would be the creation of dynamic destination or support for a hierarchical namespace of destinations. The `JmsTemplate` delegates the resolution of a destination name to a JMS destination object to an implementation of the interface `DestinationResolver`. `DynamicDestinationResolver` is the default implementation that accomodates resolving dynamic destinations, while the `JndiDestinationResolver` acts as a service locator for destinations contained in JNDI and optionally falls back to the behavior contained in `DynamicDestinationResolver`.

Quite often the destinations used in a JMS application are only known at runtime and therefore can not be administratively created when the application is deployed. This is often because there is shared application logic between interacting system components that create destinations at runtime according to a well known naming convention. While not explicitly mentioned in the JMS specification, vendors have provided functionality to create destinations at runtime. Dynamic destinations are created with a name defined by the user which differentiates them from temporary destinations and are often not registered in JNDI. The API used to create dynamic destinations varies from provider to provider since the properties associated with the destination are vendor specific. However, a simple implementation choice that is sometimes made by vendors is to disregard the warnings in the JMS specification and to use the `TopicSession` method `createTopic(String topicName)` or the `QueueSession` method `createQueue(String queueName)` to create a new destination with default destination properties. Depending on the vendor implementation, `DynamicDestinationResolver` may then also create a physical destination instead of only resolving one.

The boolean property `PubSubDomain` is used to configure the implementation with knowledge of what JMS domain is being used. By default the value of this property is false, indicating that the point-to-point domain, Queues, will be used. In the 1.0.2 implementation the value of this property determines if the `JmsTemplate`'s send operations will send a message to a Queue or to a Topic. This flag has no effect on send operations for the 1.1 implementation. However, in both implementations, this property determines the behavior of resolving dynamic destination in the implementations of `DestinationResolver`.

You can also configure the `JmsTemplate` with a default destination via the property `DefaultDestination`. The default destination will be used with send and receive operations that do not refer to a specific destination.

14.4. Using the JmsTemplate

To get started using the `JmsTemplate` you need to select either the JMS 1.0.2 implementation `JmsTemplate102` or the JMS 1.1 implementation `JmsTemplate11`. Check your JMS provider to determine what version is supported.

14.4.1. Sending a message

The `JmsTemplate` contains many convenience methods to send a message. There are send methods that specify the destination using a `javax.jms.Destination` object and those that specify the destination using a string for use in a JNDI lookup. The send method that takes no destination argument uses the default destination. Here is an example that sends a message to a queue using the 1.0.2 implementation.

```
import javax.jms.ConnectionFactory;
import javax.jms.JMSEException;
import javax.jms.Message;
import javax.jms.Queue;
import javax.jms.Session;

import org.springframework.jms.core.JmsTemplate;
import org.springframework.jms.core.JmsTemplate102;
import org.springframework.jms.core.MessageCreator;

public class JmsQueueSender {

    private JmsTemplate jt;

    private ConnectionFactory connFactory;

    private Queue queue;

    public void simpleSend() {
        jt = new JmsTemplate102(connFactory, false);
        jt.send(queue, new MessageCreator() {
            public Message createMessage(Session session) throws JMSEException {
                return session.createTextMessage("hello queue world");
            }
        });
    }

    public void setConnectionFactory(ConnectionFactory cf) {
        connFactory = cf;
    }
}
```



```
public void setQueue(Queue q) {  
    queue = q;  
}  
  
}
```

This example uses the `MessageCreator` callback to create a text message from the supplied `Session` object and the `JmsTemplate` is constructed by passing a reference to a `ConnectionFactory` and a boolean specifying the messaging domain. A zero argument constructor and a `setConnectionFactory` method are also provided and can be used for constructing the instance using a `BeanFactory`. The method `simpleSend` modified to send to a topic instead of a queue is shown below

```
public void simpleSend() {  
    jt = new JmsTemplate102(connFactory, true);  
    jt.send(topic, new MessageCreator() {  
        public Message createMessage(Session session) throws JMSException {  
            return session.createTextMessage("hello topic world");  
        }  
    });  
}
```

When configuring the 1.0.2 in an application context it is important to remember setting the value of the boolean property `PubSubDomain` property in order to indicate if you want to send to Queues or Topics.

The method `send(String destinationName, MessageCreator c)` lets you send to a message using the string name of the destination. If these names are registered in JNDI, you should set the `DesinationResolver` property of the template to an instance of `JndiDestinationResolver`.

If you created the `JmsTemplate` and specified a default destination, the `send(MessageCreator c)` sends a message to that destination.

14.4.2. Synchronous Receiving

While JMS is typically associated with asynchronous processing, it is possible to consume messages synchronously. The overloaded `receive` methods provide this functionality. During a synchronous receive the calling thread blocks until a message becomes available. This can be a dangerous operation since the calling thread can potentially be blocked indefinitely. The property `receiveTimeout` specifies how long the receiver should wait before giving up waiting for a message.

14.4.3. Using Message Converters

In order to facilitate the sending of domain model objects via JMS the `JmsTemplate` uses implementations of the

`MessageConverter` interface to convert between Java objects and JMS messages. This allows your application code to concentrate on the business object that is being sent or received via JMS and not with the details of how it is represented as a JMS message. The overloaded methods `convertAndSend` and `receiveAndConvert` in `JmsTemplate` delegate the conversion process to an instance of a `MessageConverter`. The default implementation, `SimpleMessageConverter` supports conversion between `String` and `TextMessage`, `byte[]` and `BytesMessage`, and `java.util.Map` and `MapMessage`. The sandbox currently includes a `MapMessageConverter` which uses reflection to convert between a `JavaBean` and a `MapMessage`. Other popular implementations choices you might implement yourself are `Converters` that an existing XML marshalling packages, such as `JAXB`, `Castor`, `XMLBeans`, or `XStream`, to create a `TextMessage` representing the object.

To accomodate the fine tuning of message properities, headers, and body that can not be encapsulated inside a converter class, the interface `MessagePostProcessor` gives you access to the message after it has been converted, but before it is sent. The example below shows how to modify a message header and a property after a `java.util.Map` is converted to a message.

```
public void sendWithConversion() {
    Map m = new HashMap();
    m.put("Name", "Mark");
    m.put("Age", new Integer(35));
    jt.convertAndSend("testQueue", m, new MessagePostProcessor() {

        public Message postProcessMessage(Message message)
            throws JMSException {
            message.setIntProperty("AccountID", 1234);
            message.setJMSCorrelationID("123-00001");

            return message;
        }
    });
}
```

This results in a message of the form

```
MapMessage={
  Header={
    ... standard headers ...
    CorrelationID={123-00001}
  }
  Properties={
    AccountID={Integer:1234}
  }
  Fields={
```

```
Name={String:Mark}
Age={Integer:35}
}
}
```

14.4.4. SessionCallback and ProducerCallback

While the send operations cover many common usage scenarios, there are cases when you want to perform multiple operations on a JMS Session or MessageProducer. The `SessionCallback` and `ProducerCallback` expose the JMS Session and Session/MessageProducer pair respectfully. The `execute()` methods on `JmsTemplate` execute these callback methods.

Chapter 15. Accessing and implementing EJBs

As a lightweight container, Spring is often considered an EJB replacement. We do believe that for many if not most applications and use cases, Spring as a container, combined with its rich supporting functionality in the area of transactions, ORM and JDBC access, is a better choice than implementing equivalent functionality via an EJB container and EJBs.

However, it is important to note that using Spring does not prevent you from using EJBs. In fact, Spring makes it much easier to access EJBs and implement EJBs and functionality within them. Additionally, using Spring to access services provided by EJBs allows the implementation of those services to later transparently be switched between local EJB, remote EJB, or POJO (plain java object) variants, without the client code client code having to be changed.

In this chapter, we look at how Spring can help you access and implement EJBs. Spring provides particular value when accessing stateless session beans (SLSBs), so we'll begin by discussing this.

15.1. Accessing EJBs

15.1.1. Concepts

To invoke a method on a local or remote stateless session bean, client code must normally perform a JNDI lookup to obtain the (local or remote) EJB Home object, then use a 'create' method call on that object to obtain the actual (local or remote) EJB object. One or more methods are then invoked on the EJB.

To avoid repeated low-level code, many EJB applications use the Service Locator and Business Delegate patterns. These are better than spraying JNDI lookups throughout client code, but their usual implementations have significant disadvantages. For example:

- Typically code using EJBs depends on Service Locator or Business Delegate singletons, making it hard to test
- In the case of the Service Locator pattern used without a Business Delegate, application code still ends up having to invoke the create() method on an EJB home, and deal with the resulting exceptions. Thus it remains tied to the EJB API and the complexity of the EJB programming model.
- Implementing the Business Delegate pattern typically results in significant code duplication, where we have to write numerous methods that simply call the same method on the EJB.

The Spring approach is to allow the creation and use of proxy objects, normally configured inside a Spring ApplicationContext or BeanFactory, which act as codeless business delegates. You do not need to write another Service Locator, another JNDI lookup, or duplicate methods in a hand-coded Business Delegate unless you're adding real value.

15.1.2. Accessing local SLSBs

Assume that we have a web controller that needs to use a local EJB. We'll follow best practice and use the EJB Business Methods Interface pattern, so that the EJB's local interface extends a non EJB-specific business methods interface. Let's call this business methods interface MyComponent.

```
public interface MyComponent {  
    ...  
}
```

```
}
```

(One of the main reasons to the Business Methods Interface pattern is to ensure that synchronization between method signatures in local interface and bean implementation class is automatic. Another reason is that it later makes it much easier for us to switch to a POJO (plain java object) implementation of the service if it makes sense to do so) Of course we'll also need to implement the local home interface and provide a bean implementation class that implements SessionBean and the MyComponent business methods interface. Now the only Java coding we'll need to do to hook up our web tier controller to the EJB implementation is to expose a setter method of type MyComponent on the controller. This will save the reference as an instance variable in the controller:

```
private MyComponent myComponent;

public void setMyComponent(MyComponent myComponent) {
    this.myComponent = myComponent;
}
```

We can subsequently use this instance variable in any business method in the controller. Now assuming we are obtaining our controller object out of a Spring ApplicationContext or BeanFactory, we can in the same context configure a LocalStatelessSessionProxyFactoryBean instance, which will be EJB proxy object. The configuration of the proxy, and setting of the myComponent property of the controller is done with a configuration entry such as:

```
<bean id="myComponent"
      class="org.springframework.ejb.access.LocalStatelessSessionProxyFactoryBean">
    <property name="jndiName"><value>myComponent</value></property>
    <property name="businessInterface"><value>com.mycom.MyComponent</value></property>
</bean>

<bean id="myController" class = "com.mycom.myController">
    <property name="myComponent"><ref bean="myComponent"/></property>
</bean>
```

There's a lot of magic happening behind the scenes, courtesy of the Spring AOP framework, although you aren't forced to work with AOP concepts to enjoy the results. The myComponent bean definition creates a proxy for the EJB, which implements the business method interface. The EJB local home is cached on startup, so there's only a single JNDI lookup. Each time the EJB is invoked, the proxy invokes the create() method on the local EJB and invokes the corresponding business method on the EJB.

The myController bean definition sets the myController property of the controller class to this proxy.

This EJB access mechanism delivers huge simplification of application code: The web tier code (or other EJB client code) has no dependence on the use of EJB. If we want to replace this EJB reference with a POJO or a mock object or other test stub, we could simply change the myComponent bean definition without changing a line of Java code. Additionally, we haven't had to write a single line of JNDI lookup or other EJB plumbing code as part of our application.

Benchmarks and experience in real applications indicate that the performance overhead of this approach (which involves reflective invocation of the target EJB) is minimal, and undetectable in typical use. Remember that we don't want to make fine-grained calls to EJBs anyway, as there's a cost associated with the EJB infrastructure in the application server.

There is one caveat with regards the JNDI lookup. In a bean container, this class is normally best used as a singleton (there simply is no reason to make it a prototype). However, if that bean container pre-instantiates singletons (as do the XML ApplicationContext variants) you may have a problem if the bean container is loaded before the EJB container loads the target EJB. That is because the JNDI lookup will be performed in the

init method of this class and cached, but the EJB will not have been bound at the target location yet. The solution is to not pre-instantiate this factory object, but allow it to be created on first use. In the XML containers, this is controlled via the `lazy-init` attribute.

Although this will not be of interest to the majority of Spring users, those doing programmatic AOP work with EJBs may want to look at `LocalSlsbInvokerInterceptor`.

15.1.3. Accessing remote SLSBs

Accessing remote EJBs is essentially identical to accessing local EJBs, except that the `SimpleRemoteStatelessSessionProxyFactoryBean` is used. Of course, with or without Spring, remote invocation semantics apply; a call to a method on an object in another VM in another computer does sometimes have to be treated differently in terms of usage scenarios and failure handling.

Spring's EJB client support adds one more advantage over the non-Spring approach. Normally it is problematic for EJB client code to be easily switched back and forth between calling EJBs locally or remotely. This is because the remote interface methods must declare that they throw `RemoteException`, and client code must deal with this, while the local interface methods don't. Client code written for local EJBs which needs to be moved to remote EJBs typically has to be modified to add handling for the remote exceptions, and client code written for remote EJBs which needs to be moved to local EJBs, can either stay the same but do a lot of unnecessary handling of remote exceptions, or needs to be modified to remove that code. With the Spring remote EJB proxy, you can instead not declare any thrown `RemoteException` in your Business Method Interface and implementing EJB code, have a remote interface which is identical except that it does throw `RemoteException`, and rely on the proxy to dynamically treat the two interfaces as if they were the same. That is, client code does not have to deal with the checked `RemoteException` class. Any actual `RemoteException` that is thrown during the EJB invocation will be rethrown as the non-checked `RemoteAccessException` class, which is a subclass of `RuntimeException`. The target service can then be switched at will between a local EJB or remote EJB (or even plain Java object) implementation, without the client code knowing or caring. Of course, this is optional; there is nothing stopping you from declaring `RemoteExceptions` in your business interface.

15.2. Using Spring convenience EJB implementation classes

Spring also provides convenience classes to help you implement EJBs. These are designed to encourage the good practice of putting business logic behind EJBs in POJOs, leaving EJBs responsible for transaction demarcation and (optionally) remoting.

To implement a Stateless or Stateful session bean, or Message Driven bean, you derive your implementation class from `AbstractStatelessSessionBean`, `AbstractStatefulSessionBean`, and `AbstractMessageDrivenBean`/`AbstractJmsMessageDrivenBean`, respectively.

Consider an example Stateless Session bean which actually delegates the implementation to a plain Java service object. We have the business interface:

```
public interface MyComponent {
    public void myMethod(...);
    ...
}
```

We have the plain Java implementation object:

```
public class MyComponentImpl implements MyComponent {
    public String myMethod(...) {
        ...
    }
}
```

```

    ...
}

```

And finally the Stateless Session Bean itself:

```

public class MyComponentEJB implements extends AbstractStatelessSessionBean
    implements MyComponent {

    MyComponent _myComp;

    /**
     * Obtain our POJO service object from the BeanFactory/ApplicationContext
     * @see org.springframework.ejb.support.AbstractStatelessSessionBean#onEjbCreate()
     */
    protected void onEjbCreate() throws CreateException {
        _myComp = (MyComponent) getBeanFactory().getBean(
            ServicesConstants.CONTEXT_MYCOMP_ID);
    }

    // for business method, delegate to POJO service impl.
    public String myMethod(...) {
        return _myComp.myMethod(...);
    }
    ...
}

```

The Spring EJB support base classes will by default create and load a `BeanFactory` (or in this case, its `ApplicationContext` subclass) as part of their lifecycle, which is then available to the EJB (for example, as used in the code above to obtain the POJO service object). The loading is done via a strategy object which is a subclass of `BeanFactoryLocator`. The actual implementation of `BeanFactoryLocator` used by default is `ContextJndiBeanFactoryLocator`, which creates the `ApplicationContext` from a resource locations specified as a JNDI environment variable (in the case of the EJB classes, at `java:comp/env/ejb/BeanFactoryPath`). If there is a need to change the `BeanFactory/ApplicationContext` loading strategy, the default `BeanFactoryLocator` implementation used may be overridden by calling the `setBeanFactoryLocator()` method, either in `setSessionContext()`, or in the actual constructor of the EJB. Please see the JavaDocs for more details.

As described in the JavaDocs, Stateful Session beans expecting to be passivated and reactivated as part of their lifecycle, and which use a non-serializable `BeanFactory/ApplicationContext` instance (which is the normal case) will have to manually call `unloadBeanFactory()` and `loadBeanFactory` from `ejbPassivate` and `ejbActivate`, respectively, to unload and reload the `BeanFactory` on passivation and activation, since it can not be saved by the EJB container.

The default usage of `ContextJndiBeanFactoryLocator` to load an `ApplicationContext` for the use of the EJB is adequate for some situations. However, it is problematic when the `ApplicationContext` is loading a number of beans, or the initialization of those beans is time consuming or memory intensive (such as a `Hibernate SessionFactory` initialization, for example), since every EJB will have their own copy. In this case, the user may want to override the default `ContextJndiBeanFactoryLocator` usage and use another `BeanFactoryLocator` variant, such as `ContextSingletonBeanFactoryLocator`, which can load and use a shared `BeanFactory` or `ApplicationContext` to be used by multiple EJBs or other clients. Doing this is relatively simple, by adding code similar to this to the EJB:

```

/**
 * Override default BeanFactoryLocator implementation
 *
 * @see javax.ejb.SessionBean#setSessionContext(javax.ejb.SessionContext)
 */
public void setSessionContext(SessionContext sessionContext) {
    super.setSessionContext(sessionContext);
    setBeanFactoryLocator(ContextSingletonBeanFactoryLocator.getInstance());
    setBeanFactoryLocatorKey(ServicesConstants.PRIMARY_CONTEXT_ID);
}

```

Please see the respective JavaDocs for `BeanFactoryLocator` and `ContextSingletonBeanFactoryLocator` for more information on their usage.

Chapter 16. Remoting and web services using Spring

16.1. Introduction

Spring features integration classes for remoting support using various technologies. The remoting support eases the development of remote-enabled services, implemented by your usual (Spring) POJOs. Currently, Spring supports four remoting technologies:

- *Remote Method Invocation (RMI)*. Through the use of the `RmiProxyFactoryBean` and the `RmiServiceExporter` Spring supports transparent remoting via RMI and invokers.
- *Hessian*. By using the `HessianProxyFactoryBean` and the `HessianServiceExporter` you can transparently expose your services using the lightweight binary HTTP-based protocol provided by Caucho.
- *Burlap*. Burlap is the XML-based alternative for Hessian. Spring provides supporting classes such as `BurlapProxyFactoryBean` and `BurlapServiceExporter`.
- *JAX RPC (TODO)*.

While discussing the remoting capabilities of Spring, we'll use the following domain model and corresponding services:

```
// Account domain object
public class Account implements Serializable{
    private String name;

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

```
// Account service
public interface AccountService {

    public void insertAccount(Account acc);

    public List getAccounts(String name);
}
```

```
// ... and corresponding implement doing nothing at the moment
public class AccountServiceImpl implements AccountService {

    public void insertAccount(Account acc) {
        // do something
    }

    public List getAccounts(String name) {
        // do something
    }
}
```

We will start exposing the service to a remote client by using RMI and talk a bit about the drawbacks of using RMI. We'll then continue to show Hessian and Burlap support.

16.2. Exposing services using RMI

Using Spring's support for RMI you can transparently expose your services through RMI. After having this set up, you basically have a configuration similar to Enterprise JavaBeans, except for the fact that the security features are missing. Security features are provided by HTTP-based protocols like Hessian and Burlap, but note that those use custom serialization which might result in problems when using complex domain models and other object graphs that need to pass over the wire.

16.2.1. Exporting the service using the `RmiServiceExporter`

Using the `RmiServiceExporter` we can expose the interface of our `AccountService` object as RMI object. The interface can be accessed via plain RMI or by using `RmiProxyFactoryBean`. The `RmiServiceExporter` explicitly supports the exposing of any non-RMI services via RMI invokers.

Of course, we first have to set up our service in the Spring BeanFactory:

```
<bean id="accountService" class="example.AccountServiceImpl">
  <!-- any additional properties, maybe a DAO? -->
</bean>
```

Next we'll have to expose our service using the `RmiServiceExporter`:

```
<bean class="org.springframework.remoting.rmi.RmiServiceExporter">
  <!-- does not necessarily have to be the same name as the bean to be exported -->
  <property name="serviceName"><value>AccountService</value></property>
  <property name="service"><ref bean="accountService"/></property>
  <property name="serviceInterface"><value>example.AccountService</value></property>
  <!-- defaults to 1099 -->
  <property name="registryPort"><value>1199</value></property>
</bean>
```

As you can see, we're overriding the port for the RMI registry. Oftentimes, your application server also maintains an RMI registry and it is wise to not interfere with that one. Furthermore, the service name is used to bind the service under. So right now, the service will be bound at `rmi://HOST:1199/AccountService`. We'll use the URL later on to link in the service at the client side.

Note: we've left out one property, i.e. the `servicePort` property, which is 0 by default. This means an anonymous port will be used to communicate with the service. You can specify a different port if you like.

16.2.2. Linking in the service at the client

Our client is a simple object using the `AccountService` to manage accounts:

```
public class SimpleObject {
  private AccountService accountService;
  public void setAccountService(AccountService accountService) {
    this.accountService = accountService;
  }
}
```

To link in the service on the client, we'll create a separate bean factory, containing the simple object and the service linking configuration bits:

```

<bean class="example.SimpleObject">
    <property name="accountService"><ref bean="accountService"/></property>
</bean>

<bean id="accountService" class="org.springframework.remoting.rmi.RmiProxyFactoryBean">
    <property name="serviceUrl"><value>rmi://HOST:1199/AccountService</value></property>
    <property name="serviceInterface"><value>example.AccountService</value></property>
</bean>

```

That's all we need to do to support the remote account service on the client. Spring will transparently create an invoker and remotely enable the account service through the `RmiServiceExporter`. At the client we're linking it in using the `RmiProxyFactoryBean`.

16.3. Using Hessian to remotely call service via HTTP

Hessian offers a binary HTTP-based remoting protocol. It's created by Caucho and more information about Hessian itself can be found at <http://www.caucho.com>.

16.3.1. Wiring up the DispatcherServlet for Hessian

Hessian communicates via HTTP and does so using a custom servlet. Using Spring's `DispatcherServlet` principles, you can easily wire up such a servlet exposing your services. First we'll have to create a new servlet in your application (this an excerpt from `web.xml`):

```

<servlet>
    <servlet-name>remote</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
</servlet>

```

You're probably familiar with Spring's `DispatcherServlet` principles and if so, you know that you'll have to create an application context named `remote-servlet.xml` (after the name of your servlet) in the `WEB-INF` directory. The application context will be used in the next section.

16.3.2. Exposing your beans by using the HessianServiceExporter

In the newly created application context called `remote-servlet.xml` we'll create a `HessianServiceExporter` exporting your services:

```

<bean id="accountService" class="example.AccountServiceImpl">
    <!-- any additional properties, maybe a DAO? -->
</bean>

<bean name="/AccountService" class="org.springframework.remoting.caucho.HessianServiceExporter">
    <property name="service"><ref bean="accountService"/></property>
    <property name="serviceInterface">
        <value>example.AccountService</value>
    </property>
</bean>

```

Now we're ready to link in the service at the client. No handler mapping is specified mapping requests (urls) onto services and that's why the `BeanNameUrlHandlerMapping` will be used, hence the service will be exported at the URL `http://HOST:8080/AccountService`.

16.3.3. Linking in the service on the client

Using the `HessianProxyFactoryBean` we can link in the service at the client. The same principles apply as with the RMI example. We'll create a separate bean factory or application context and mention the following beans where the `SimpleObject` is using the `AccountService` to manage accounts:

```
<bean class="example.SimpleObject">
  <property name="accountService"><ref bean="accountService"/></property>
</bean>

<bean id="accountService" class="org.springframework.remoting.caucho.HessianProxyFactoryBean">
  <property name="serviceUrl"><value>http://remotehost:8080/AccountService</value></property>
  <property name="ServiceInterface"><value>example.AccountService</value></property>
</bean>
```

That's all there is to it.

16.3.4. Using Burlap

We won't discuss Burlap, the XML based equivalent of Hessian, here since it is configured and set up in exactly the same way as the Hessian variant explained above. Just replace the word `Hessian` with `Burlap` and you're all set to go.

16.3.5. Applying security to service exposed through Hessian or Burlap

One of the advantages of Hessian and Burlap is that we can easily apply security. This is because both protocols are HTTP-based. Your normal security mechanism can easily be applied if you're using the `web.xml` security features for example.

```
<bean class="org.springframework.web.servlet.handler.BeanNameUrlHandlerMapping">
  <property name="interceptors">
    <list>
      <ref bean="authorizationInterceptor"/>
    </list>
  </property>
</bean>

<bean id="authorizationInterceptor"
  class="org.springframework.web.servlet.handler.UserRoleAuthorizationInterceptor">
  <property name="authorizedRoles">
    <list>
      <value>administrator</value>
      <value>operator</value>
    </list>
  </property>
</bean>
```

This an example where we explicitly mention the `BeanNameUrlHandlerMapping` and set an interceptor allowing only administrators and operators to call the beans mentioned in this application context.

Note: of course this example doesn't show a flexible kind of security application. For more options as far as security is concerned, have a look at [Acegi Security System for Spring](http://acegisecurity.sourceforge.net) to be found at <http://acegisecurity.sourceforge.net>

16.4. Considerations when choosing a technology

Each and every technology presented here has its drawbacks. This doesn't mean you shouldn't use them. You should however carefully consider you needs, the services your exposing and the beans you'll be sending over the wire when choosing a technology.

When using RMI, it's not possible to access the objects through the HTTP protocol, unless you're tunneling the RMI traffic. RMI is a fairly heavy-weight protocol in that it support full-object serialization which is importing when using a complex data model that needs serializing over the wire. More light-weight protocols like Hessian and/or Burlap might provide significant value when operating in a low-bandwidth environment since they don't support the same full-object serialization. Known problems include the serialization of Hibernate objects in combination with lazily initializing collections. If you have such a data model, consider using RMI instead of Hessian.

Last but not least, EJB has the advantage over RMI in that it supports role-based authentication and authorization. It is possible to get RMI to support this as well, although some custom coding has to be done in order to get it to work. If you're in need of code that supports JAAS-based RMI, please ask the people at the development list. Hessian and Burlap do provide role based authentication. Both protocols are HTTP-based and work using the Spring DispatcherServlet, thus fully support the use of interceptors, etcetera. You've seen an example above.

Chapter 17. Sending Email with Spring mail abstraction layer

17.1. Introduction

Spring provides a higher level of abstraction for sending electronic mail which shields the user from the specifics of underlying mailing system and is responsible for a low level resource handling on behalf of the client.

17.2. Spring mail abstraction structure

The main package of Spring mail abstraction layer is `org.springframework.mail` package. It contains central interface for sending emails called `MailSender` and the *value object* which encapsulates properties of a simple mail such as *from*, *to*, *cc*, *subject*, *text* called `SimpleMailMessage`. This package also contains a hierarchy of checked exceptions which provide a higher level of abstraction over the lower level mail system exceptions with the root exception being `MailException`. Please refer to JavaDocs for more information on mail exception hierarchy.

Spring also provides a subinterface of `MailSender` for specialized *JavaMail* features such as MIME messages, namely `org.springframework.mail.javamail.JavaMailSender`. It also provides a callback interface for preparation of JavaMail MIME messages, namely

`org.springframework.mail.javamail.MimeMessagePreparator`

`MailSender`:

```
public interface MailSender {

    /**
     * Send the given simple mail message.
     * @param simpleMessage message to send
     * @throws MailException in case of message, authentication, or send errors
     */
    public void send(SimpleMailMessage simpleMessage) throws MailException;

    /**
     * Send the given array of simple mail messages in batch.
     * @param simpleMessages messages to send
     * @throws MailException in case of message, authentication, or send errors
     */
    public void send(SimpleMailMessage[] simpleMessages) throws MailException;

}
```

`JavaMailSender`:

```
public interface JavaMailSender extends MailSender {

    /**
     * Create a new JavaMail MimeMessage for the underlying JavaMail Session
     * of this sender. Needs to be called to create MimeMessage instances
     * that can be prepared by the client and passed to send(MimeMessage).
     * @return the new MimeMessage instance
     * @see #send(MimeMessage)
     * @see #send(MimeMessage[])
     */
    public MimeMessage createMimeMessage();

    /**
     * Send the given JavaMail MIME message.
     * The message needs to have been created with createMimeMessage.
     */
}
```

```

    * @param mimeType message to send
    * @throws MailException in case of message, authentication, or send errors
    * @see #createMimeMessage
    */
    public void send(MimeMessage mimeType) throws MailException;

    /**
     * Send the given array of JavaMail MIME messages in batch.
     * The messages need to have been created with createMimeMessage.
     * @param mimeMessages messages to send
     * @throws MailException in case of message, authentication, or send errors
     * @see #createMimeMessage
     */
    public void send(MimeMessage[] mimeMessages) throws MailException;

    /**
     * Send the JavaMail MIME message prepared by the given MimeMessagePreparator.
     * Alternative way to prepare MimeMessage instances, instead of createMimeMessage
     * and send(MimeMessage) calls. Takes care of proper exception conversion.
     * @param mimeTypePreparator the preparator to use
     * @throws MailException in case of message, authentication, or send errors
     */
    public void send(MimeMessagePreparator mimeTypePreparator) throws MailException;

    /**
     * Send the JavaMail MIME messages prepared by the given MimeMessagePreparators.
     * Alternative way to prepare MimeMessage instances, instead of createMimeMessage
     * and send(MimeMessage[]) calls. Takes care of proper exception conversion.
     * @param mimeTypePreparators the preparator to use
     * @throws MailException in case of message, authentication, or send errors
     */
    public void send(MimeMessagePreparator[] mimeTypePreparators) throws MailException;
}

```

MimeMessagePreparator:

```

public interface MimeMessagePreparator {

    /**
     * Prepare the given new MimeMessage instance.
     * @param mimeType the message to prepare
     * @throws MessagingException passing any exceptions thrown by MimeMessage
     * methods through for automatic conversion to the MailException hierarchy
     */
    void prepare(MimeMessage mimeType) throws MessagingException;

}

```

17.3. Using Spring mail abstraction

Let's assume there is a business interface called OrderManager

```

public interface OrderManager {

    void placeOrder(Order order);

}

```

and there is a use case that says that an email message with order number would need to be generated and sent to a customer placing that order. So for this purpose we want to use MailSender and SimpleMailMessage

Please note that as usual, we work with interfaces in the business code and let Spring IoC container take care of wiring of all the collaborators for us.

Here is the implementation of OrderManager

```

import org.springframework.mail.MailException;
import org.springframework.mail.MailSender;
import org.springframework.mail.SimpleMailMessage;

```

```

public class OrderManagerImpl implements OrderManager {

    private MailSender mailSender;
    private SimpleMailMessage message;

    public void setMailSender(MailSender mailSender) {
        this.mailSender = mailSender;
    }

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

    public void placeOrder(Order order) {

        //... * Do the business calculations....
        //... * Call the collaborators to persist the order

        //Create a threadsafe "sandbox" of the message
        SimpleMailMessage msg = new SimpleMailMessage(this.message);
        msg.setTo(order.getCustomer().getEmailAddress());
        msg.setText(
            "Dear "
            + order.getCustomer().getFirstName()
            + order.getCustomer().getLastName()
            + ", thank you for placing order. Your order number is "
            + order.getOrderNumber());

        try{
            mailSender.send(msg);
        }
        catch(MailException ex) {
            //log it and go on
            System.err.println(ex.getMessage());
        }
    }
}

```

Here is what the bean definitions for the code above would look like:

```

<bean id="mailSender"
      class="org.springframework.mail.javamail.JavaMailSenderImpl">
    <property name="host"><value>mail.mycompany.com</value></property>
</bean>

<bean id="mailMessage"
      class="org.springframework.mail.SimpleMailMessage">
    <property name="from"><value>customerservice@mycompany.com</value></property>
    <property name="subject"><value>Your order</value></property>
</bean>

<bean id="orderManager"
      class="com.mycompany.businessapp.support.OrderManagerImpl">
    <property name="mailSender"><ref bean="mailSender"/></property>
    <property name="message"><ref bean="mailMessage"/></property>
</bean>

```

Here is the implementation of OrderManager using MimeMessagePreparator callback interface. Please note that the mailSender property is of type JavaMailSender in this case in order to be able to use JavaMail MimeMessage:

```

import javax.mail.Message;
import javax.mail.MessagingException;
import javax.mail.internet.InternetAddress;
import javax.mail.internet.MimeMessage;

import javax.mail.internet.MimeMessage;
import org.springframework.mail.MailException;
import org.springframework.mail.javamail.JavaMailSender;
import org.springframework.mail.javamail.MimeMessagePreparator;

public class OrderManagerImpl implements OrderManager {
    private JavaMailSender mailSender;

```



```
public void setMailSender(JavaMailSender mailSender) {
    this.mailSender = mailSender;
}

public void placeOrder(final Order order) {

    //... * Do the business calculations...
    //... * Call the collaborators to persist the order

    MimeMessagePreparator preparator = new MimeMessagePreparator() {
        public void prepare(MimeMessage mimeMessage) throws MessagingException {
            mimeMessage.setRecipient(Message.RecipientType.TO,
                new InternetAddress(order.getCustomer().getEmailAddress()));
            mimeMessage.setFrom(new InternetAddress("mail@mycompany.com"));
            mimeMessage.setText(
                "Dear "
                + order.getCustomer().getFirstName()
                + order.getCustomer().getLastName()
                + ", thank you for placing order. Your order number is "
                + order.getOrderNumber());
        }
    };
    try{
        mailSender.send(preparator);
    }
    catch(MailException ex) {
        //log it and go on
        System.err.println(ex.getMessage());
    }
}
```

If you want to use JavaMail MimeMessage to the full power, the `MimeMessagePreparator` is available at your fingertips.

Please note that the mail code is a crosscutting concern and is a perfect candidate for refactoring into a custom SpringAOP advice, which then could easily be applied to `OrderManager` target. Please see the AOP chapter.

17.3.1. Pluggable MailSender implementations

Spring comes with two MailSender implementations out of the box - the JavaMail implementation and the implementation on top of Jason Hunter's *MailMessage* class that's included in <http://servlets.com/cos> (com.oreilly.servlet). Please refer to JavaDocs for more information.

Chapter 18. Scheduling jobs using Quartz or Timer

18.1. Introduction

Spring features integration classes for scheduling support. Currently, Spring supports the Timer, built in in the JDK since 1.3 and the Quartz Scheduler (<http://www.quartzscheduler.org>). Both schedulers are set up using a `FactoryBean` with optional references to Timers respectively Triggers. Furthermore, a convenience class for both the Quartz Scheduler and the Timer is available that allows you to invoke a method on a target object you can specify yourself (analogous to normal `MethodInvokingFactoryBeans`

18.2. Using the OpenSymphony Quartz Scheduler

Quartz uses `Triggers`, `Jobs` and `JobDetail` to realize scheduling of all kinds of jobs. For the basic concepts behind Quartz, have a look at <http://www.opensymphony.com/quartz>. For convenience purposes, Spring offers a couple of classes that simplify usage of Quartz within Spring-based applications.

18.2.1. Using the JobDetailBean

`JobDetail` objects contain all information needed to run a job. Spring provides a so-called `JobDetailBean` that makes the `JobDetail` more of an actual with sensible defaults. Let's have a look at an example:

```
<bean name="exampleJob" class="org.springframework.scheduling.quartz.JobDetailBean">
  <property name="jobClass">
    <value>example.ExampleJob</value>
  </property>
  <property name="jobDataAsMap">
    <map>
      <entry key="timeout"><value>5</value></entry>
    </map>
  </property>
</bean>
```

The job detail bean has all information it needs to run the job (`ExampleJob`). The timeout is specified as the job data map. The job data map is available through the `JobExecutionContext` (passed to you at execution time), but the `JobDetailBean` also maps the properties from the job data map to properties of the actual job. So in this case, if the `ExampleJob` contains a property named `timeout`, the `JobDetailBean` will automatically apply it:

```
package example;

public class ExampleJob extends QuartzJobBean {

    private int timeout;

    /**
     * Setter called after the ExampleJob is instantiated
     * with the value from the JobDetailBean (5)
     */
    public void setTimeout(int timeout) {
        this.timeout = timeout;
    }

    protected void executeInternal(JobExecutionContext ctx)
        throws JobExecutionException {

        // do the actual work

    }
}
```

```
}
```

All additional settings from the job detail bean are by the way available to you as well.

Note: Using the `name` and `group` properties, you can modify in which group the job runs and using what name. By default the name of the job equals the bean name of the job detail bean (in the example above this is `exampleJob`).

18.2.2. Using the `MethodInvokingJobDetailFactoryBean`

Often times, you just need to invoke a method on a specific object. Using the `MethodInvokingJobDetailFactoryBean` you can do exactly this:

```
<bean id="methodInvokingJobDetail"
  class="org.springframework.scheduling.quartz.MethodInvokingJobDetailFactoryBean">
  <property name="targetObject"><ref bean="exampleBusinessObject"/></property>
  <property name="targetMethod"><value>doIt</value></property>
</bean>
```

The above example will result in the `doIt` being called on the `exampleBusinessObject` (see below):

```
public class BusinessObject {

  // properties and collaborators

  public void doIt() {
    // do the actual work
  }
}
```

```
<bean id="exampleBusinessObject" class="examples.ExampleBusinessObject"/>
```

Using the `MethodInvokingJobDetailFactoryBean` you don't need to create one-line jobs that just invoke a method, and you only need to create the actual business object and wire up the detail object.

By default, Quartz Jobs are stateless, resulting in the possibility of jobs interfering with each other. If you specify two triggers for the same `JobDetail`, it might be possible that before the first job has finished, the second one will start. If `JobDetail` objects implement the `Stateful` interface, this won't happen. The second job will not start before the first one has finished. To make jobs resulting from the `MethodInvokingJobDetailFactoryBean` non-concurrent set the `concurrent` flag to `false`.

```
<bean id="methodInvokingJobDetail"
  class="org.springframework.scheduling.quartz.MethodInvokingJobDetailFactoryBean">
  <property name="targetObject"><ref bean="exampleBusinessObject"/></property>
  <property name="targetMethod"><value>doIt</value></property>
</bean>
```

Note: By default, jobs will run in a concurrent fashion.

18.2.3. Wiring up jobs using triggers and the `SchedulerFactoryBean`

We've created job details, jobs and we've reviewed the convenience bean that allows to you invoke a method on a specific object. Of course we still need to schedule the jobs themselves. This is done using triggers and a

`SchedulerFactoryBean`. Several triggers are available within Quartz. Spring offers two subclassed triggers, the `CronTriggerBean` and the `SimpleTriggerBean`.

Triggers need to be scheduled. Spring offers a `SchedulerFactoryBean` exposing properties to set the triggers. The `SchedulerFactoryBean` schedules the actual triggers.

A couple of examples:

```
<bean id="simpleTrigger" class="org.springframework.scheduling.quartz.SimpleTriggerBean">
  <property name="jobDetail">
    <!-- see the example of method invoking job above -->
    <ref bean="methodInvokingJobDetail"/>
  </property>
  <property name="startDelay">
    <!-- 10 seconds -->
    <value>10000</value>
  </property>
  <property name="repeatInterval">
    <!-- repeat every 50 seconds -->
    <value>50000</value>
  </property>
</bean>

<bean id="cronTrigger" class="org.springframework.scheduling.quartz.CronTriggerBean">
  <property name="jobDetail">
    <ref bean="exampleJob"/>
  </property>
  <property name="cronExpression">
    <!-- run every morning at 6 am -->
    <value>0 6 * * 1</value>
  </property>
</bean>
```

Ok, now we've set up two triggers, one running every 50 seconds with a starting delay of 10 seconds and one every morning at 6. To finalize everything we need to set up the `SchedulerFactoryBean`:

```
<bean class="org.springframework.scheduling.quartz.SchedulerFactoryBean">
  <property name="triggers">
    <list>
      <ref local="cronTrigger"/>
      <ref local="simpleTrigger"/>
    </list>
  </property>
</bean>
```

More properties are available for the `SchedulerFactoryBean` for you to set, such as the Calendars used by the job details, properties to customize Quartz with, etcetera. Have a look at the JavaDOC (<http://www.springframework.org/docs/api/org.springframework.scheduling.quartz.SchedulerFactoryBean.html>) for more information.

18.3. Using JDK Timer support

The other way to schedule jobs is using the JDK Timer objects. More information about Timers themselves can be found at <http://java.sun.com/docs/books/tutorial/essential/threads/timer.html>. The concepts discussed above also apply to the Timer support. You can create custom timers or use the timer that invokes methods. Wiring timers has to be done using the `TimerFactoryBean`.

18.3.1. Creating custom timers

Using the `TimerTask` you can create customer timer tasks, similar to Quartz jobs:

```
public class CheckEmailAddresses extends TimerTask {

    private List emailAddresses;

    public void setEmailAddresses(List emailAddresses) {
        this.emailAddresses = emailAddresses;
    }

    public void run() {

        // iterate over all email addresses and archive them

    }
}
```

Wiring it up is simple:

```
<bean id="checkEmail" class="examples.CheckEmailAddress">
    <property name="emailAddresses">
        <list>
            <value>test@springframework.org</value>
            <value>foo@bar.com</value>
            <value>john@doe.net</value>
        </list>
    </property>
</bean>

<bean id="scheduledTask" class="org.springframework.scheduling.timer.ScheduledTimerTask">
    <!-- wait 10 seconds before starting repeated execution -->
    <property name="delay">
        <value>10000</value>
    </property>
    <!-- run every 50 seconds -->
    <property name="period">
        <value>50000</value>
    </property>
    <property name="timerTask">
        <ref local="checkEmail"/>
    </property>
</bean>
```

18.3.2. Using the MethodInvokingTimerTaskFactoryBean

Just as the Quartz support, the Timer support also features a component that allows you to periodically invoke a method:

```
<bean id="methodInvokingTask"
    class="org.springframework.scheduling.timer.MethodInvokingTimerTaskFactoryBean">
    <property name="targetObject"><ref bean="exampleBusinessObject"/></property>
    <property name="targetMethod"><value>doIt</value></property>
</bean>
```

The above example will result in the `doIt` being called on the `exampleBusinessObject` (see below):

```
public class BusinessObject {

    // properties and collaborators

    public void doIt() {
        // do the actual work
    }
}
```

Changing the reference of the above example in which the `ScheduledTimerTask` is mentioned to the `methodInvokingTask` will result in this task to be executed.

18.3.3. Wrapping up: setting up the tasks using the `TimerFactoryBean`

The `TimerFactoryBean` is similar to the `QuartzSchedulerFactoryBean` in that it serves the same purpose: setting up the actual scheduling. The `TimerFactoryBean` sets up an actual `Timer` and schedules the tasks it has references to. You can specify whether or not daemon threads should be used.

```
<bean id="timerFactory" class="org.springframework.scheduling.timer.TimerFactoryBean">
  <property name="scheduledTimerTasks">
    <list>
      <!-- see the example above -->
      <ref local="scheduledTask"/>
    </list>
  </property>
</bean>
```

That's all!

Appendix A. Spring's beans.dtd

```
<?xml version="1.0" encoding="UTF-8"?>

<!--
    Spring XML Beans DTD
    Authors: Rod Johnson, Juergen Hoeller, Alef Arendsen, Colin Sampaleanu

    This defines a simple and consistent way of creating a namespace
    of JavaBeans objects, configured by a Spring BeanFactory, read by
    a DefaultXmlBeanDefinitionReader.

    This document type is used by most Spring functionality, including
    web application contexts, which are based on bean factories.

    Each "bean" element in this document defines a JavaBean.
    Typically the bean class is specified, along with JavaBean properties
    and/or constructor arguments.

    Bean instances can be "singletons" (shared instances) or "prototypes"
    (independent instances). Further scopes are supposed to be built on top
    of the core BeanFactory infrastructure and are therefore not part of it.

    References among beans are supported, i.e. setting a JavaBean property
    or a constructor argument to refer to another bean in the same factory
    (or an ancestor factory).

    As alternative to bean references, "inner bean definitions" can be used.
    Singleton flags of such inner bean definitions are effectively ignored:
    Inner beans are typically anonymous prototypes.

    There is also support for lists, sets, maps, and java.util.Properties
    as bean property types respectively constructor argument types.

    As the format is simple, a DTD is sufficient, and there's no need
    for a schema at this point.

    XML documents that conform to this DTD should declare the following doctype:

    <!DOCTYPE beans PUBLIC "-//SPRING//DTD BEAN//EN"
        "http://www.springframework.org/dtd/spring-beans.dtd">

    $Id: dtd.xml,v 1.5 2004/06/28 19:50:00 colins Exp $
-->

<!--
    Element containing informative text describing the purpose of the enclosing
    element. Always optional.
    Used primarily for user documentation of XML bean definition documents.
-->
<!ELEMENT description (#PCDATA)>

<!--
    The document root.
    At least one bean definition is required.
-->
<!ELEMENT beans (
    description?,
    bean+
)>

<!--
    Default values for all bean definitions. Can be overridden at
    the "bean" level. See those attribute definitions for details.
-->
<!ATTLIST beans default-lazy-init (true | false) "false">
<!ATTLIST beans default-dependency-check (none | objects | simple | all) "none">
<!ATTLIST beans default-autowire (no | byName | byType | constructor | autodetect) "no">

<!--
    Defines a single named bean.
-->
<!ELEMENT bean (
```

```

        description?,
        (constructor-arg | property)*,
        (lookup-method)*,
        (replaced-method)*
    )>

<!--
    Beans can be identified by an id, to enable reference checking.
    There are constraints on a valid XML id: if you want to reference your bean
    in Java code using a name that's illegal as an XML id, use the optional
    "name" attribute. If neither given, the bean class name is used as id.
-->
<!ATTLIST bean id ID #IMPLIED>

<!--
    Optional. Can be used to create one or more aliases illegal in an id.
    Multiple aliases can be separated by any number of spaces or commas.
-->
<!ATTLIST bean name CDATA #IMPLIED>

<!--
    Optionally specify a parent bean definition.

    Will use the bean class of the parent if none specified, but can
    also override it. In the latter case, the child bean class must be
    compatible with the parent, i.e. accept the parent's property values
    and constructor argument values, if any.

    A child bean definition will inherit constructor argument values,
    property values and method overrides from the parent, with the option
    to add new values. If init method, destroy method and/or static factory
    method are specified, they will override the corresponding parent settings.

    The remaining settings will <i>always</i> be taken from the child definition:
    depends on, autowire mode, dependency check, singleton, lazy init.
-->
<!ATTLIST bean parent CDATA #IMPLIED>

<!--
    Each bean definition must specify the fully qualified name of the class,
    except if it pure serves as parent for child bean definitions.
-->
<!ATTLIST bean class CDATA #IMPLIED>

<!--
    Is this bean a "singleton" (one shared instance, which will
    be returned by all calls to getBean() with the id),
    or a "prototype" (independent instance resulting from each call to
    getBean()). Default is singleton.

    Singletons are most commonly used, and are ideal for multi-threaded
    service objects.
-->
<!ATTLIST bean singleton (true | false) "true">

<!--
    If this bean should be lazily initialized.
    If false, it will get instantiated on startup by bean factories
    that perform eager initialization of singletons.
-->
<!ATTLIST bean lazy-init (true | false | default) "default">

<!--
    Optional attribute controlling whether to "autowire" bean properties.
    This is an automagical process in which bean references don't need to be coded
    explicitly in the XML bean definition file, but Spring works out dependencies.

    There are 5 modes:

    1. "no"
    The traditional Spring default. No automagical wiring. Bean references
    must be defined in the XML file via the <ref> element. We recommend this
    in most cases as it makes documentation more explicit.

    2. "byName"
    Autowiring by property name. If a bean of class Cat exposes a dog property,
    Spring will try to set this to the value of the bean "dog" in the current factory.
-->

```


3. "byType"

Autowiring if there is exactly one bean of the property type in the bean factory. If there is more than one, a fatal error is raised, and you can't use byType autowiring for that bean. If there is none, nothing special happens - use dependency-check="objects" to raise an error in that case.

4. "constructor"

Analogous to "byType" for constructor arguments. If there isn't exactly one bean of the constructor argument type in the bean factory, a fatal error is raised.

5. "autodetect"

Chooses "constructor" or "byType" through introspection of the bean class. If a default constructor is found, "byType" gets applied.

The latter two are similar to PicoContainer and make bean factories simple to configure for small namespaces, but doesn't work as well as standard Spring behaviour for bigger applications.

Note that explicit dependencies, i.e. "property" and "constructor-arg" elements, always override autowiring. Autowire behaviour can be combined with dependency checking, which will be performed after all autowiring has been completed.

```
-->
<!ATTLIST bean autowire (no | byName | byType | constructor | autodetect | default) "default">

<!--
    Optional attribute controlling whether to check whether all this
    beans dependencies, expressed in its properties, are satisfied.
    Default is no dependency checking.

    "simple" type dependency checking includes primitives and String
    "object" includes collaborators (other beans in the factory)
    "all" includes both types of dependency checking
-->
<!ATTLIST bean dependency-check (none | objects | simple | all | default) "default">

<!--
    The names of the beans that this bean depends on being initialized.
    The bean factory will guarantee that these beans get initialized before.

    Note that dependencies are normally expressed through bean properties or
    constructor arguments. This property should just be necessary for other kinds
    of dependencies like statics (*ugh*) or database preparation on startup.
-->
<!ATTLIST bean depends-on CDATA #IMPLIED>

<!--
    Optional attribute for the name of the custom initialization method
    to invoke after setting bean properties. The method must have no arguments,
    but may throw any exception.
-->
<!ATTLIST bean init-method CDATA #IMPLIED>

<!--
    Optional attribute for the name of the custom destroy method to invoke
    on bean factory shutdown. The method must have no arguments,
    but may throw any exception. Note: Only invoked on singleton beans!
-->
<!ATTLIST bean destroy-method CDATA #IMPLIED>

<!--
    Optional attribute specifying the name of a static factory method to use
    to create this object. Use constructor-arg elements to specify arguments
    to the factory method, if it takes arguments. Autowiring does not
    apply to factory methods.
    The factory method will be on the class specified by the "class" attribute
    on this bean definition. Often this will be the same class as that of the
    constructed object - for example, when the factory method is used as an
    alternative to a constructor. However, it may be on a different class. In
    that case, the created object will *not* be of the class specified in
    the "class" attribute. This is analogous to FactoryBean behaviour.

    The factory method can have any number of arguments. Autowiring is not supported.
    Use indexed constructor-arg elements in conjunction with the factory-method
    attribute.

    Setter Injection can be used in conjunction with a factory method.
```

```

        Method Injection cannot, as the factory method returns an instance, which
        will be used when the container creates the bean.
-->
<!ATTLIST bean factory-method CDATA #IMPLIED>

<!--
    Bean definitions can specify zero or more constructor arguments.
    They correspond to either a specific index of the constructor argument list
    or are supposed to be matched generically by type.
    This is an alternative to "autowire constructor".
    constructor-arg elements are also used in conjunction with the factory-method
    element to construct beans using static factory methods.
-->
<!ELEMENT constructor-arg (
    description?,
    (bean | ref | idref | list | set | map | props | value | null)
)>

<!--
    The constructor-arg tag can have an optional index attribute,
    to specify the exact index in the constructor argument list. Only needed
    to avoid ambiguities, e.g. in case of 2 arguments of the same type.
-->
<!ATTLIST constructor-arg index CDATA #IMPLIED>

<!--
    The constructor-arg tag can have an optional type attribute,
    to specify the exact type of the constructor argument. Only needed
    to avoid ambiguities, e.g. in case of 2 single argument constructors
    that can both be converted from a String.
-->
<!ATTLIST constructor-arg type CDATA #IMPLIED>

<!--
    Bean definitions can have zero or more properties.
    Property elements correspond to JavaBean setter methods exposed
    by the bean classes. Spring supports primitives, references to other
    beans in the same or related factories, lists, maps and properties.
-->
<!ELEMENT property (
    description?,
    (bean | ref | idref | list | set | map | props | value | null)
)>

<!--
    The property name attribute is the name of the JavaBean property.
    This follows JavaBean conventions: a name of "age" would correspond
    to setAge()/optional getAge() methods.
-->
<!ATTLIST property name CDATA #REQUIRED>

<!--
    A lookup method causes the IoC container to override the given method and return
    the bean with the name given in the bean attribute. This is a form of Method Injection.
    It's particularly useful as an alternative to implementing the BeanFactoryAware
    interface, in order to be able to make getBean() calls for non-singleton instances
    at runtime. In this case, Method Injection is a less invasive alternative.
-->
<!ELEMENT lookup-method EMPTY>

<!--
    Name of a lookup method. This method should take no arguments.
-->
<!ATTLIST lookup-method name CDATA #IMPLIED>

<!--
    Similar to the lookup method mechanism, the replaced-method element is used to control
    IoC container method overriding: Method Injection. This mechanism allows the overriding
    of a method with arbitrary code.
-->
<!ELEMENT replaced-method (
    (arg-type)*
)>

<!--
    Name of the method whose implementation should be replaced by the IoC container.

```

```

        If this method is not overloaded, there's no need to use arg-type subelements.
        If this method is overloaded, arg-type subelements must be used for all
        override definitions for the method.
-->
<!--ATTLIST replaced-method name CDATA #IMPLIED>

<!--
        Bean name of an implementation of the MethodReplacer interface
        in the current or ancestor factories. This may be a singleton or prototype
        bean. If it's a prototype, a new instance will be used for each method replacement.
        Singleton usage is the norm.
-->
<!--ATTLIST replaced-method replacer CDATA #IMPLIED>

<!--
        Subelement of replaced-method identifying an argument for a replaced method
        in the event of method overloading.
-->
<!--ELEMENT arg-type (#PCDATA)>

<!--
        Specification of the type of an overloaded method argument as a String.
        For convenience, this may be a substring of the FQN. E.g. all the
        following would match "java.lang.String":
        - java.lang.String
        - String
        - Str

        As the number of arguments will be checked also, this convenience can often
        be used to save typing
-->
<!--ATTLIST arg-type match CDATA #IMPLIED>

<!--
        Name of the bean in the current or ancestor factories that the lookup method
        should resolve to. Often this bean will be a prototype, in which case the
        lookup method will return a distinct instance on every invocation. This
        is useful for single-threaded objects.
-->
<!--ATTLIST lookup-method bean CDATA #IMPLIED>

<!--
        Defines a reference to another bean in this factory or an external
        factory (parent or included factory).
-->
<!--ELEMENT ref EMPTY>

<!--
        References must specify a name of the target bean.
        The "bean" attribute can reference any name from any bean in the context,
        to be checked at runtime.
        Local references, using the "local" attribute, have to use bean ids;
        they can be checked by this DTD, thus should be preferred for references
        within the same bean factory XML file.
-->
<!--ATTLIST ref bean CDATA #IMPLIED>
<!--ATTLIST ref local IDREF #IMPLIED>
<!--ATTLIST ref parent CDATA #IMPLIED>

<!--
        Defines a string property value, which must also be the id of another
        bean in this factory or an external factory (parent or included factory).
        While a regular 'value' element could instead be used for the same effect,
        using idref in this case allows validation of local bean ids by the xml
        parser, and name completion by helper tools.
-->
<!--ELEMENT idref EMPTY>

<!--
        ID refs must specify a name of the target bean.
        The "bean" attribute can reference any name from any bean in the context,
        potentially to be checked at runtime by bean factory implementations.
        Local references, using the "local" attribute, have to use bean ids;
        they can be checked by this DTD, thus should be preferred for references
        within the same bean factory XML file.

```

```

-->
<!--
  A list can contain multiple inner bean, ref, collection, or value elements.
  Java lists are untyped, pending generics support in Java 1.5,
  although references will be strongly typed.
  A list can also map to an array type. The necessary conversion
  is automatically performed by the BeanFactory.
-->
<!--
  A set can contain multiple inner bean, ref, collection, or value elements.
  Java sets are untyped, pending generics support in Java 1.5,
  although references will be strongly typed.
-->
<!--
  A Spring map is a mapping from a string key to object.
  Maps may be empty.
-->
<!--
  A map entry can be an inner bean, ref, collection, or value.
  The name of the property is given by the "key" attribute.
-->
<!--
  Each map element must specify its key.
-->
  Props elements differ from map elements in that values must be strings.
  Props may be empty.
-->
  Element content is the string value of the property.
  Note that whitespace is trimmed off to avoid unwanted whitespace
  caused by typical XML formatting.
-->
  Each property element must specify its key.
-->
  Contains a string representation of a property value.
  The property may be a string, or may be converted to the
  required type using the JavaBeans PropertyEditor
  machinery. This makes it possible for application developers
  to write custom PropertyEditor implementations that can
  convert strings to objects.

  Note that this is recommended for simple objects only.
  Configure more complex objects by populating JavaBean

```

```
        properties with references to other beans.
-->
<!ELEMENT value (#PCDATA)>

<!--
    Denotes a Java null value. Necessary because an empty "value" tag
    will resolve to an empty String, which will not be resolved to a
    null value unless a special PropertyEditor does so.
-->
<!ELEMENT null (#PCDATA)>
```