



Spring Framework Reference Documentation
WORK IN PROGRESS!!!

Version: 1.0

Table of Contents

Preface	
1. Introduction	
1.1. Overview	1
1.2. Usage scenarios	2
2. Background information	
2.1. Inversion of Control / Dependency Injection	5
3. Beans and the ApplicationContext	
3.1. Introduction	6
3.2. BeanFactory and BeanDefinitions - the basics	6
3.2.1. The BeanDefinition	7
3.2.2. The BeanFactory	7
3.2.3. The bean class	7
3.2.4. The bean identifiers (id and name)	8
3.2.5. To singleton or not to singleton	8
3.3. Properties, dependencies and autowiring	8
3.3.1. Setting beans properties and collaborators	8
3.3.2. Autowiring collaborators	10
3.3.3. Checking for dependencies	11
3.4. Customizing the nature of a bean	11
3.4.1. Lifecycle interfaces	11
3.4.2. Knowing who you are	13
3.4.3. FactoryBean	13
3.5. Interacting with the BeanFactory	13
3.6. Customizing the BeanFactory (advanced stuff)	14
3.6.1. The BeanFactoryPostProcessor	14
3.6.2. The PropertyPlaceholderConfigurer	14
3.7. Lifecycle of a bean in the BeanFactory	15
3.7.1. The basic lifecycle of a bean	15
3.8. BeanFactory structure and implementations (WIP)	17
3.8.1. Structure of the beans package	18
3.8.2. The XmlBeanFactory	18
3.8.3. Bean definitions specified in XML (XmlBeanFactory)	18
3.9. Introduction to the ApplicationContext	20
3.10. Added functionality of the ApplicationContext	20
3.10.1. Using the MessageSource	20
3.10.2. Propagating events	21
3.10.3. Using resources within Spring	22
3.11. Extra marker interfaces and lifecycle features	23
3.12. Customization of the ApplicationContext	23
4. PropertyEditors, data binding, validation and the BeanWrapper	
4.1. Introduction	24
4.2. Binding data using the DataBinder	24
4.3. Bean manipulation and the BeanWrapper	24
4.3.1. Setting and getting basic and nested properties	25
4.3.2. Built-in PropertyEditors, converting types	26
4.3.3. Other features worth mentioning	27
5. Spring AOP: Aspect Oriented Programming with Spring	
5.1. Concepts	28

5.1.1. AOP concepts	28
5.1.2. Spring AOP capabilities	29
5.1.3. AOP Proxies in Spring	30
5.1.4. Quick start	30
5.2. Pointcuts in Spring	31
5.2.1. Concepts	31
5.2.2. Operations on pointcuts	31
5.2.3. Convenience pointcut implementations	32
5.2.4. Pointcut superclasses	33
5.2.5. Custom pointcuts	33
5.3. Advice types in Spring	33
5.3.1. Advice lifecycles	33
5.3.2. Advice types in Spring	34
5.4. Advisors in Spring	37
5.5. Using the ProxyFactoryBean to create AOP proxies	37
5.5.1. Basics	38
5.5.2. JavaBean properties	38
5.5.3. Proxying interfaces	38
5.5.4. Proxying classes	39
5.5.5. Special flags	39
5.6. Convenient proxy creation	40
5.6.1. TransactionProxyFactoryBean	40
5.6.2. EJB proxies	40
5.7. Creating AOP proxies programmatically with the ProxyFactory	41
5.8. Manipulating advised objects	41
5.9. Using the "autoproxy" facility	42
5.9.1. Autoproxy bean definitions	42
5.9.2. Using metadata-driven autoproxying	44
5.10. Using TargetSources	45
5.10.1. Hot swappable target sources	45
5.10.2. Pooling target sources	45
5.10.3. Prototype" target sources	47
5.11. Defining new advice and advisor types	47
5.12. Further reading and resources	47
6. Transaction management	
6.1. The Spring transaction abstraction	48
6.2. Transaction strategies	48
6.3. Programmatic transaction management	48
6.4. Declarative transaction management	48
6.5.	48
7. Source Level Metadata Support	
7.1. Source-level metadata	49
7.2. Spring's metadata support	49
7.3. Integration with Jakarta Commons Attributes	49
7.4. Common uses of metadata attributes	49
7.4.1. Declarative transaction management	49
7.4.2. Pooling	49
7.4.3. Custom metadata	49
7.4.4. Using attributes to minimize MVC web tier configuration	49
8. Data Access using JDBC	
8.1. Introduction	50
8.2. Using the JDBC Core classes to control basic JDBC processing and error handling	50

8.2.1. JdbcTemplate	50
8.2.2. SQLExceptionTranslator	51
8.3. Controlling how we connect to the database	51
8.3.1. DataSourceUtils	51
8.3.2. SmartDataSource	51
8.3.3. AbstractDataSource	51
8.3.4. SingleConnectionDataSource	51
8.3.5. DriverManagerDataSource	51
8.3.6. DataSourceTransactionManager	51
8.4. Modeling JDBC operations as Java objects	51
8.4.1. SqlQuery	52
8.4.2. MappingSqlQuery	52
8.4.3. SqlUpdate	52
8.4.4. StoredProcedure	52
8.4.5. SqlFunction	52
9. Web framework	
9.1. Introduction to the web framework	53
9.1.1. Pluggability of MVC implementation	53
9.1.2. Features of Spring MVC	54
9.2. The DispatcherServlet	54
9.3. Controllers	56
9.3.1. Using the AbstractController and WebContentGenerator	57
9.3.2. Other simple controller	58
9.3.3. The MultiActionController	58
9.3.4. CommandControllers	60
9.4. Handler mappings	61
9.4.1. BeanNameUrlHandlerMapping	61
9.4.2. SimpleUrlHandlerMapping	62
9.4.3. Adding HandlerInterceptors	63
9.5. Views and resolving them	64
9.5.1. ViewResolvers	64
9.6. Using locales	65
9.6.1. AcceptHeaderLocaleResolver	66
9.6.2. CookieLocaleResolver	66
9.6.3. SessionLocaleResolver	66
9.6.4. LocaleChangeInterceptor	66
9.7. Using themes	67
9.8. Spring's multipart (fileupload) support	67
9.8.1. Introduction	67
9.8.2. Using the MultipartResolver	67
9.8.3. Handling a fileupload in a form	68
9.9. Handling exceptions	70
9.10. Commonly used utilities	70
9.10.1. A little story about the pathmatcher	70
10. Integrating view technologies	
10.1. Introduction	71
10.2. Velocity	71
10.2.1. Dependencies	71
10.2.2. Dispatcher Servlet Context	71
10.2.3. Velocity.properties	72
10.2.4. View configuration	73
10.2.5. Creating the Velocity templates	74

10.2.6. Form Handling	74
10.2.7. Summary	76
10.3. XSLT Views	76
10.3.1. My First Words	76
10.3.2. Summary	78
10.4. Document views (PDF/Excel)	79
10.4.1. Introduction	79
10.4.2. Configuration and setup	79
10.5. Tapestry	81
10.5.1. Architecture	81
10.5.2. Implementation	81
10.5.3. Summary	86
10.6. Tiles	87
10.6.1. Configuration	87
10.6.2. Summary	87
11. Accessing and implementing EJBs	
11.1. Accessing EJBs	88
11.1.1. Concepts	88
11.1.2. Accessing local SLSBs	88
11.1.3. Accessing remote SLSBs	88
11.2. Using Spring convenience EJB implementation classes	88
12. Sending Email with Spring mail abstraction layer	
12.1. Introduction	89
12.2. Spring mail abstraction structure	89
12.3. Using Spring mail abstraction	90
12.3.1. Pluggable MailSender implementations	92
A. Spring's beans.dtd	

Preface

Developing applications alone is hard already, implementing applications using platforms that promise everything but turn out to be heavy-weight, hard to control and not very efficient during development cycles makes it even harder. Spring provides a light-weight solution to build enterprise-ready applications, still supporting the possibility of having declarative transaction management, remote access to your logic using RMI or webservices, mailing facilities and a decent way of persisting your data in a database. Spring provides an MVC framework, transparent ways of integrating AOP in your software and a well-structured exception hierarchy for for example JDBC.

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 bothering about 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 you can do without any dependencies on the framework at all, thus not tying yourself in to Spring.

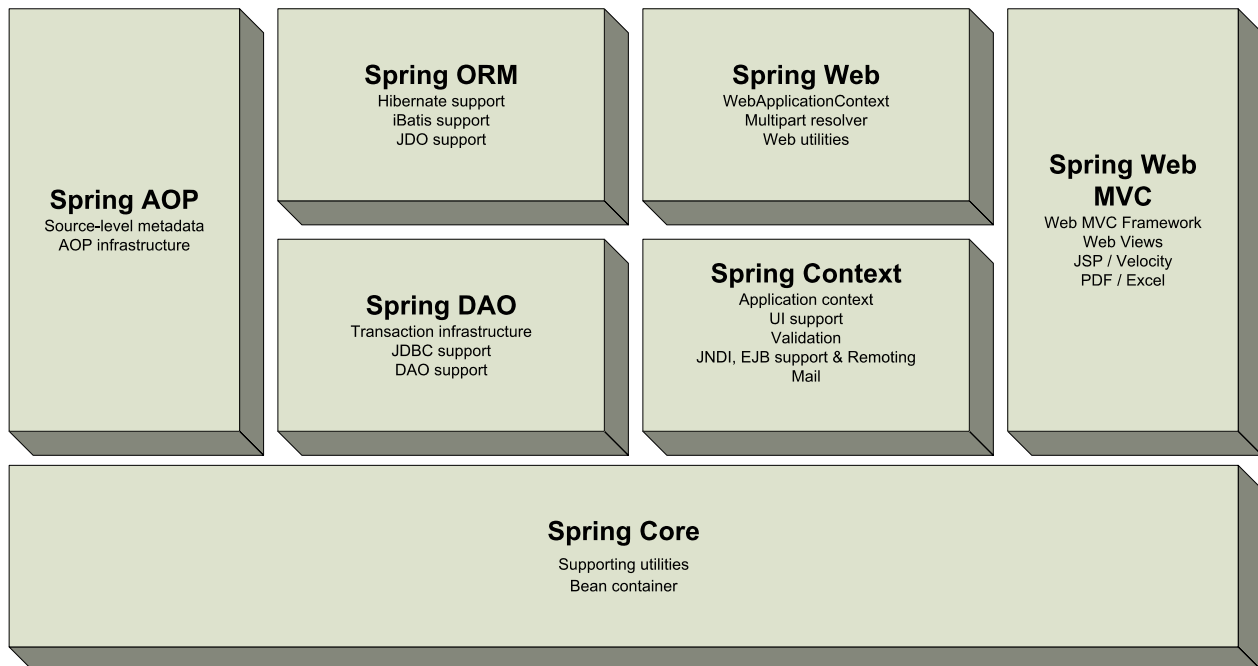
This document provides a reference guide to Spring's features. Since this document is still work-in-progress, you if you have any requests, comments, please post them on the userlist or on the forum at the SourceForge project page: <http://www.sf.net/projects/springframework>

Before we go on a couple some words of gratitude. Chris Bauer (Hibernate) prepared and adapted the Doc-Book-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 of the modules in turn.



Overview of the the Spring Framework

The *beans* package is the most fundamental part of the framework and provides the Dependency Injection features allowing you to manage beans containing 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 logic.

On top of the *beans* 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 messaging, event-propagation, resource-loading and transparent creation of contexts by, for example, a servlet container.

The *JDBC* package provides a JDBC-abstraction layer that removes the need to do tedious JDBC coding and parsing 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*.

The *ORM* package provides integration layers for popular object-relational mappers, 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.

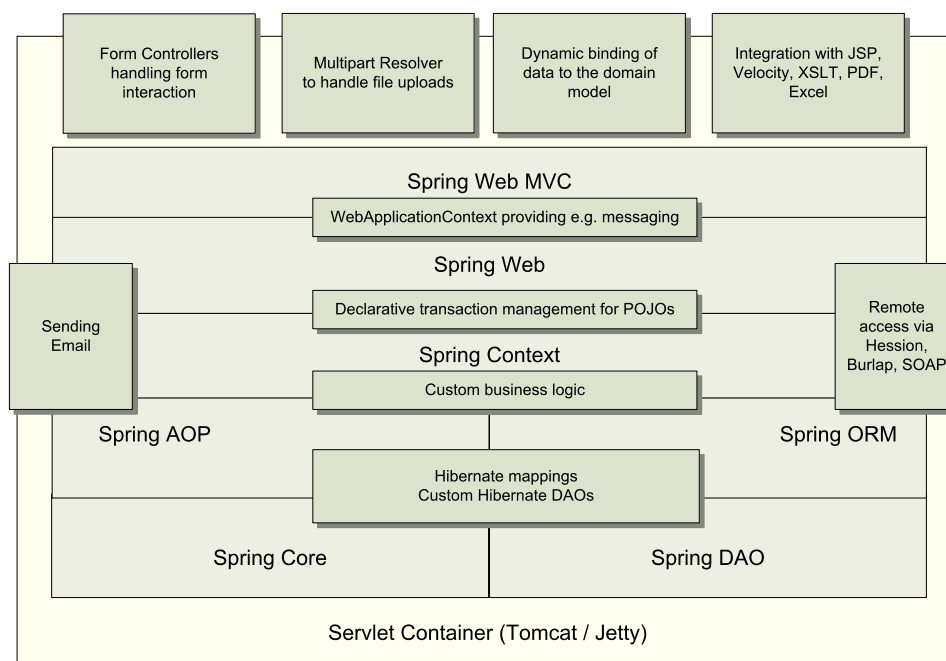
Spring's *AOP* package provides an *Aop Alliance* compliant aspect-oriented programming implementing allowing you to define, for example, method-interceptors and pointcuts to cleanly decouple code implementing functionality that should logically speaking be separated. Using source-level metadata functionality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

Spring's *web* package provides the basic web-oriented integration features, like 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 *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.

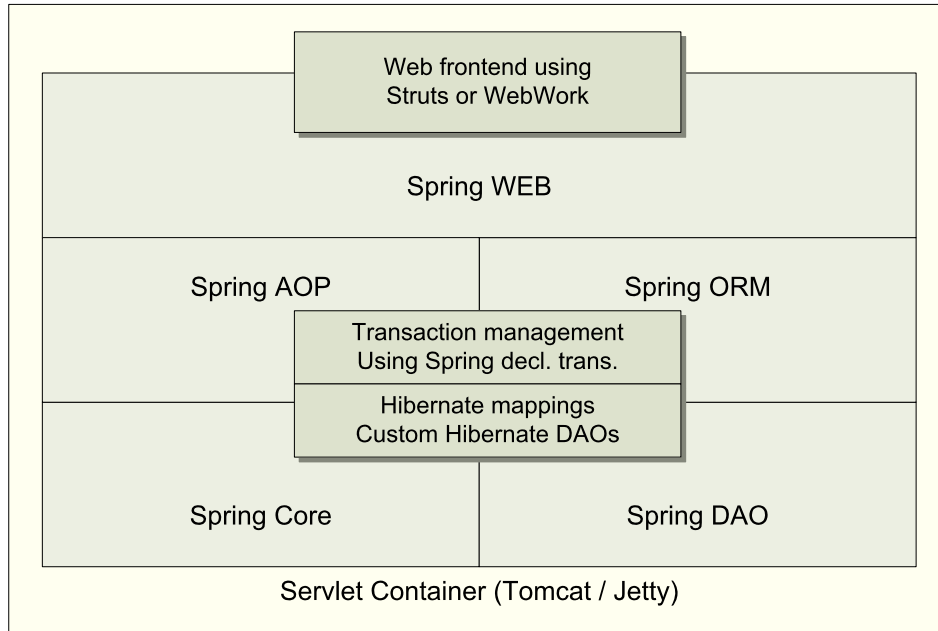
1.2. Usage scenarios

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



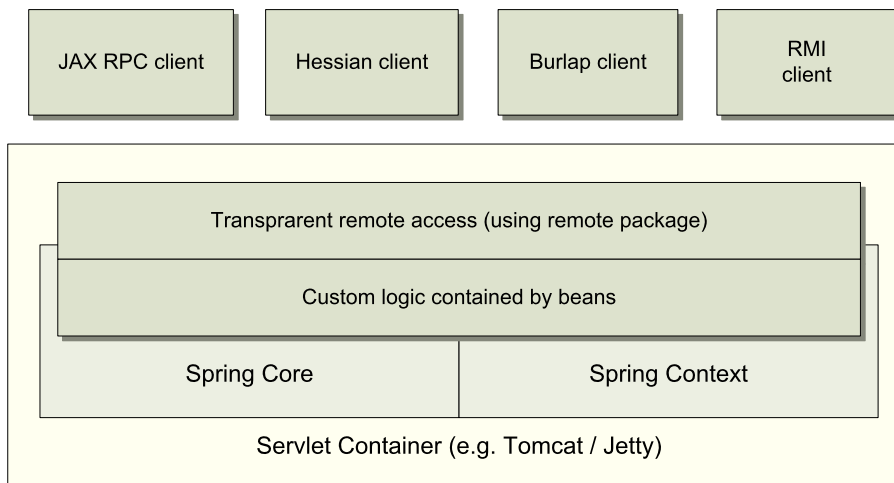
Typical full-fledged Spring web application

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 like 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.



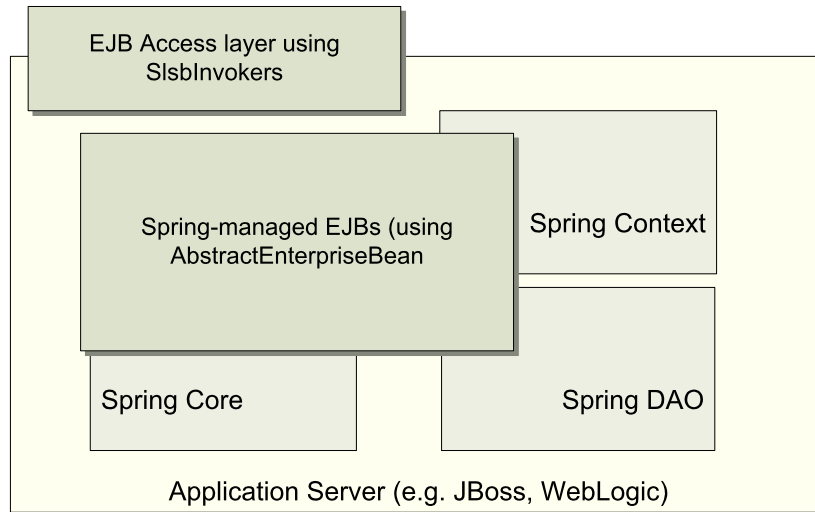
Spring middle-tier using a third-party web framework

Sometimes the situation does not allow you completely switch to a different framework. Spring does not enforce you to use everything, it's not an *all-or-nothing* solution. Existing frontends using WebWork or Struts 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 integrating your Struts frontend 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 provide an access-layer and abstraction-layer for Enterprise JavaBeans, enabling you to reuse your existing POJOs and wrap them in Stateless SessionBeans, 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 and the ApplicationContext

3.1. Introduction

Two of Spring's most elementary and important packages are the `org.springframework.beans` and `org.springframework.context` package. These packages provide the basis for the Spring Inversion of Control features, or Dependency Injection as people more recently call it (see Section 2.1, "Inversion of Control / Dependency Injection" for some resources on that). The `BeanFactory` provides an advanced configuration mechanism capable of managing beans of any kind of nature, using - potentially - any kind of storage facility. The `ApplicationContext` builds on top of the `BeanFactory` and adds other functionality such as integration with Springs AOP features, messaging (using *i18n*), the capability of having contexts inherit from other contexts and defining application-layer specific contexts, such as the `WebApplicationContext`.

In short, the `BeanFactory` provides the configuration framework and allows you to for example avoid the use of singletons, while the `ApplicationContext` adds more enterprise-centric, J2EE functionality to it.

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`.

In order to get you started using the `BeanFactory` and the `ApplicationContext` we'll first introduce you to a couple of basic principles that might be handy to know of when using the `BeanFactory` and the `ApplicationContext`.

- *Bean definition*: the description of a bean managed by the `BeanFactory`. Each `BeanFactory` contains bean definitions each describing the nature of a bean, its properties, the methods that need to be called upon initialization and destruction, whether or not the bean needs to be autowired and more things a like. The `XmlBeanFactory` for example is capable of reading bean definitions from an XML file, where properties, as well as collaborators and lifecycle methods are defined in XML
- *Property editors*: part of the JavaBeans specification by Sun is the concept of `PropertyEditors`. Property editors in Spring are used to convert properties of beans to human-readable String and vice versa. As the PropertyEditor JavaDOC (<http://java.sun.com/j2se/1.4.2/docs/api/>) states, the `getAsText()`-method should return a human-readable String representing the property the editor is (so-called) editing. The `setAsText()`-method should be able to parse the same String and (using the `setValue(Object)`-method) set the resulting value of the property. PropertyEditors are heavily used in Spring, not only by for example the `BeanFactory` to transform the Strings defined in the XML containing beans to properties of those beans, but also by the MVC framework to convert request parameters submitted by a user after filling a form to properties of command objects that might be of some completely different type
- *BeanWrapper*: an special class of which instances wrap a bean, managed `BeanWrappers` for example have features for setting and getting properties from the beans they're wrapping. It's not likely you'll ever have to touch a `BeanWrapper` yourself, but it might be handy to know about them

Note: there has been a lot of confusion about the use of the `ApplicationContext` as opposed to the `BeanFactory`. Basically when building applications in a J2EE-environment you're the better option would be to use the `ApplicationContext`, since it offers a more framework style usage of the Spring Framework and can be initialized using a `ServletContextListener` like the `ContextLoaderListener`.

3.2. BeanFactory and BeanDefinitions - the basics

3.2.1. The BeanDefinition

As already stated in the introduction, bean definitions describe beans managed by a `BeanFactory` Or `ApplicationContext`. Bean definitions contain the following information:

- The beanclass, which is the actual implementation of the bean related to the bean definition
- 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)
- Properties being configuration data for the bean. You could think of the number of connections to use in a bean that manages a connection pool (either specified as properties or as constructor arguments), or the class that should be used to create the connection pool
- Other beans your bean needs to do its work, i.e. *collaborators* (also specified as properties or as constructor arguments)

In the list above, we mentioned the use of constructor arguments, as well as setters. Spring support two types of IoC, i.e. type 2 and type 3. What that means is that you use both constructor arguments to specify your dependencies and properties as well as setters and getters.

The concepts listed above, directly translate to a set of elements the bean definition consists of. These elements are listed below, along with a reference to further documentation about each of them.

Table 3.1. Bean definition explanation

Feature	More info
class	Section 3.2.3, “The bean class”
singleton or prototype	Section 3.2.5, “To singleton or not to singleton”
bean properties	Section 3.3.1, “Setting beans properties and collaborators”
constructor arguments	Section 3.3.1, “Setting beans properties and collaborators”
autowiring mode	Section 3.3.2, “Autowiring collaborators”
dependency checking mode	Section 3.3.3, “Checking for dependencies”
initialization method	Section 3.4.1, “Lifecycle interfaces”
destruction method	Section 3.4.1, “Lifecycle interfaces”

3.2.2. The BeanFactory

The `BeanFactory` is the actual *container* (although we don't like to use the word container too much, since it kind of sounds quite heavy), containing and managing your beans. A `BeanFactory` loads `BeanDefinitions` and - upon request - instantiates one (or possibly more) instances of the bean in question and manages it by calling lifecycle methods.

All of the features described in Section 3.2.1, “The `BeanDefinition`” will be configurable for each of your beans using one of the out-of-the-box `BeanFactory` implementations. In the example below we will use the most popular `BeanFactory` to illustrate the behavior, i.e. the `XmlBeanFactory`. More information on the `XmlBeanFactory` and other implementations can be found further ahead.

3.2.3. The bean class

Of course you need to specify the actual class of your bean, that should be obvious. There's absolutely no special requirements to your bean class, it does not have to implement a special interface to make it Spring compatible. 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 should have a default constructor.

The BeanFactory cannot only manage beans, but is able to manage virtually *any* class you want it to manage. Most people using Spring prefer to have actual beans (having just a default 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're having a legacy connection pool that absolutely does not adhere to the bean 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"/>
```

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

Somehow of course you need to identify your beans. This can be done by a name or an id. The `id` is to be uniquely defined across all beans in a BeanFactory.

3.2.5. To singleton or not to singleton

Beans exist in two types, singletons and prototypes. When a bean is a singleton, only one *shared* instance of the bean will be managed and all requests for instances of that specific instances of bean will result in that one specific bean instance being returned.

The prototype mode of a bean results in *creation of a new bean instance* every time a request for that specific bean is being done. This is ideal for situation where for example each user needs an independent user object or something similar.

Beans exist in singleton mode by default, unless you specify otherwise. Keep in mind that by changing the type to 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 as a prototype. `exampleBean` is created each and every time a client asks the BeanFactory for this bean, while `yetAnotherExample` is only created one, a reference is returned each time a request for this bean is done.

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

3.3. Properties, dependencies and autowiring

3.3.1. Setting beans properties and collaborators

Inversion of Control has already been referred to as *Dependency Injection*. The basic principle is that beans

themselves do not define who or what they're depending on, but instead, let the container do that for them. Also, the container *injects* the actual dependencies, as opposed to the Service Locator pattern, where the beans themselves do a lookup to resolve those dependencies. While not elaborating too much on the advantages of Dependency Injection, it might be obvious that code gets much cleaner and reaching a higher grade of decoupling is much easier when beans themselves do not lookup their dependencies, but also do not even know where the actual dependencies are located and of what actual instance they are.

The BeanFactory is capable of *injecting* dependencies into beans its manages. It does so using the `BeanDefinition` and the `PropertyEditors` that are defined in the Spring Framework. We'll explain that further along using some examples of beans defined in the XML format. For now it might be handy to know that `BeanDefinitions`, collaborators and properties are specified using `PropertyValue`-objects.

The resolving of the dependencies is a little too complex to go in depth here, but the basic procedure is as follows:

1. Checking what the type of the property is (this can be a primitive-like type - like `int` or `String`, a `Collection` - i.e. `Map` or `List`, a `Class` or any other type Spring supports by default. It can also be a collaborator). Collaborators are other beans the BeanFactory must be capable of resolving, in other words, other beans, also defined in the same BeanFactory (or, in case you're using the `ApplicationContext`, possibly in another application context)
2. In case the bean isn't a collaborator that can be resolved from the BeanFactory, Spring uses its built-in (or manually added) `PropertyEditors` to transform the property to the type that was required (when using the XML format to define a bean that contains a setter with a `Class`-parameter, Spring uses the `ClassEditor` (more about `PropertyEditors` and how to manually add custom ones, can be found further ahead, [TODODODODODODO](#) reference!))
3. In the case of collaborators, Spring constructs a reference to the bean that is used later on when the bean is actually instantiated. You can trust Spring here that it sets the actual collaborator at the right moments.

Dependency Injection (or Inversion of Control) exists in two major variants, both of which Spring supports.

- *setter-based* dependency injection is realized by calling setters on your beans after invoking an argumentless constructor to instantiate your bean. Beans defined in the BeanFactory that use setter-based dependency injection are *true JavaBeans*, and not only for the sake of adhering a standard, Spring advocates to use setter-based dependency injection as much as possible
- *constructor-based* dependency injection is realized by invoking a constructor with a number of arguments, each representing a collaborator or property. Though Spring advises to use setter-based dependency injection as much as possible, there might be beans around that just have constructors and that you want to use as well. Therefore we provided the constructor-based approach as well

Some examples:

First, an example of using the BeanFactory for setter-based dependency injection. Below, there's a small part of an XML file specifying bean definition. Also, you can find the actual bean itself, having 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`)

Then, an example of using the `BeanFactory` for IoC type 3 (using constructors). Below you can find a snippet from an XML configuration file that specifies constructor arguments and the actual bean, specifying the constructor

```

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

3.3.2. Autowiring collaborators

Spring has autowire capabilities, which means it's possible to automatically let Spring resolve collaborators (other beans) for you bean by inspecting the `BeanFactory`. The autowiring functionality has four modes. Autowiring is specified *per* bean and can thus be enabled for a couple of beans, while other beans won't be autowired. When using autowiring, there might be no need for specifying properties or constructor arguments¹

Table 3.2. Autowiring modes

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

Mode	Explanation
no	No autowiring at all. This is the default value and it's discouraged to change this for large applications, since specifying your collaborators yourself gives you a feeling of what you're actually doing and is a great way of somewhat documenting the structure of your system
byName	This option will inspect the BeanFactory and look for a bean named exactly the same as the property which needs to be autowired. So in case you have a collaborator on a Bean-Definition Cat which is called dog (so you have a setDog(Dog) method), Spring will look for a BeanDefinition named dog and use this as the collaborator
byType	This option can be found in some other IoC containers as well and gives you the ability to resolve collaborators by type instead of by name. Suppose you have a BeanDefinition with a collaborator typed DataSource, Spring will search the entire bean factory for a bean definition of type DataSource and use it as the collaborator. <i>If 0 (zero) or more than 1 (one) bean definitions of the desired type exist in the BeanFactory, a failure will be reported and you won't be able to use autowiring for that specific bean</i>

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

3.3.3. Checking for dependencies

Spring also offers the capability for checking required dependencies of your beans. This feature might come in handy when certain properties really need to be set and when you can't provide default values (which is an often used approach). Dependency checking can be done in three different ways. Dependency checking can also be enabled and disabled per bean, just as the autowiring functionality. The default is to *not* check dependencies.

Table 3.3. Dependency checking modes

Mode	Explanation
simple	Dependency checking is done for primitive types and collections (this means everything except collaborators)
object	Dependency checking is done for collaborators
all	Dependency checking is done for both collaborators and primitive types and collections

3.4. Customizing the nature of a bean

3.4.1. Lifecycle interfaces

Spring provides a couple of marker interfaces to change the behavior of your bean in the BeanFactory. They include InitializingBean and DisposableBean. Implementing those will result in the BeanFactory calling afterPropertiesSet() for the former and destroy() for the latter to allow you to do things 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 `BeanFactoryPostProcessor` yourself. More information about this can be found in Section 3.6.1, “The `BeanFactoryPostProcessor`”.

All the different lifecycle marker interfaces are described below. In one of the appendices, you can find diagram as to 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`

The `org.springframework.beans.factory.InitializingBean` gives you the ability the do initialization work after all necessary properties on a bean are set by the `BeanFactory`. The `InitializingBean` interface specifies exactly one method:

- `void afterPropertiesSet()`: called after all properties have been set by the beanfactory. This method enables you to do checking to see if all necessary properties have been set correctly, or to perform further initialization work. You can throw *any* exception to indicate misconfiguration, initialization failures, etcetera

Note: generally, the use of the `InitializingBean` can be avoided (and by some people is discouraged). The `beans` package provides support for a generic `init-method`, given to the beandefinition in the beanconfiguration store (may it be XML, properties-files or a database).

```
<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
    }
}
```

3.4.1.2. DisposableBean / `destroy-method`

The `org.springframework.beans.factory.DisposableBean` interface provides you with the ability to get a callback when a beanfactory is destroyed. The `DisposableBean` interface specifies one method:

- `void destroy()`: called on destruction of the beanfactory. This allows you to release any resources you are keeping in this bean (like database connections). You can throw an exception here, however, it will not stop the destruction of the bean factory. It will get logged though.

Note: generally, the use of the `DisposableBean` can be avoided (and by some people is discouraged). The `beans` package provides support for a generic `destroy-method`, given to the beandefinition in the beanconfiguration store (may it be XML, properties-files or a database). For more information about this feature, see the next section)

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

```
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
    }
}
```

3.4.2. Knowing who you are

3.4.2.1. BeanFactoryAware

The `org.springframework.beans.factory.BeanFactoryAware` interface gives you the ability to get a reference to the `BeanFactory` that manages the bean that implements the `BeanFactoryAware` interface. This feature allows for implementing beans to look up their collaborators in the beanfactory. The interface specifies one method:

- `void setBeanFactory(BeanFactory)`: method that will be called *after the initialization methods* (after `PropertiesSet` and the `init`-method).

3.4.2.2. BeanNameAware

The `org.springframework.beans.factory.BeanNameAware` interface gives you the ability to let the `BeanFactory` set the name of the bean on the bean itself. In case you need to know what your name is, implement this interface

- `void setBeanName(String)`: method which will be called to let the bean know what its name is

3.4.3. FactoryBean

The `org.springframework.beans.factory.FactoryBean` is to be implemented 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 this factory providing singleton 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. Interacting with the BeanFactory

Basically the `BeanFactory` is nothing more than an advanced factory capable of maintaining a registry of different components or beans. The `BeanFactory` enables you to read bean definitions and access them using the

bean factory. When just using 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 (which is the default) and 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 four methods for clients to interact with it:

- `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, a singleton and thus shared instance will be returned, or a newly created bean. 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 instantiated 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)`: returns the aliases configured for this bean (TODO: WHAT IS THIS :)

3.6. Customizing the BeanFactory (advanced stuff)

When in need for special behavior for the `BeanFactory` you need to consult the `org.springframework.beans.factory.config`-package, which should provide you all the things you need in such a case. Using the config package you can for instance define a properties file of which the property-entries are used as replacements values in the `BeanFactory`. Also, you can implement custom behavior (like adding custom editors) using the `BeanFactoryPostProcessor`. Each of the features the config-package offers is described below:

3.6.1. The `BeanFactoryPostProcessor`

The `BeanFactoryPostProcessor` is the superclass for all post processors that are capable of applying changes to the `BeanFactory` (or beans in it) after the factory has been initialized. The `BeanFactoryPostProcessor` can be used to add custom editors (as also mentioned in Section 4.3.2, "Built-in PropertyEditors, converting types"). Some out-of-the-box post processors are available, like the `PropertyResourceConfigurer` and the `PropertyPlaceholderConfigurer`, both described below.

3.6.2. The `PropertyPlaceholderConfigurer`

The `PropertyPlaceholderConfigurer` is an excellent solution when you want to externalize a few properties from a file containing bean definitions. Say you want to let the person responsible for deploying applications just fill in database URLs, usernames and passwords. You could of course let him change the XML file containing bean definitions, but that would be risky. Instead, use the `PropertyPlaceholderConfigurer` to - at run-time - replace those properties by values from a properties file.

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>
```

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

```
=
XmlBeanFactory factory = new XmlBeanFactory(new FileInputStream("beans.xml"));
Properties props = new Properties();
props.load(new FileInputStream("jdbc.properties"));
PropertyPlaceholderConfigurer cfg = new PropertyPlaceholderConfigurer(props);
cfg.postProcessBeanFactory(factory);
```

3.7. Lifecycle of a bean in the BeanFactory

This section describes the lifecycle of a bean in the `BeanFactory`, some of the basic characteristics of events happening in the `BeanFactory` as well as the different types of beans.

3.7.1. The basic lifecycle of a bean

The lifecycle of a bean begins with a bean definition, for instance defined in XML or a properties file. The first step is the calling of the default constructor:

1. default constructor

The second step is the initialization process in which you can prepare your bean for use.

2. the autowiring process in which any possible collaborators that can be automatically resolved, will be set (TODO: reference)
3. checking of dependencies, which means that if dependencies are unsatisfied (i.e. they are `null`), an `UnsatisfiedDependencyException` will be thrown. (TODO: reference)
4. property setting, which means that all properties defined with the bean definition in for instance an XML file, will be set on the bean
5. `afterPropertiesSet()` is called. This method is specified by the `InitializingBean`, and thus will only be called if your bean implements this interface (TODO: reference)
6. the extra initialization method will be called that might have been specified with the bean definition (TODO: reference)
7. if your bean is `BeanFactoryAware` the `setBeanFactory()` method will now be called enabling the bean to have access to the `BeanFactory` (TODO: reference)

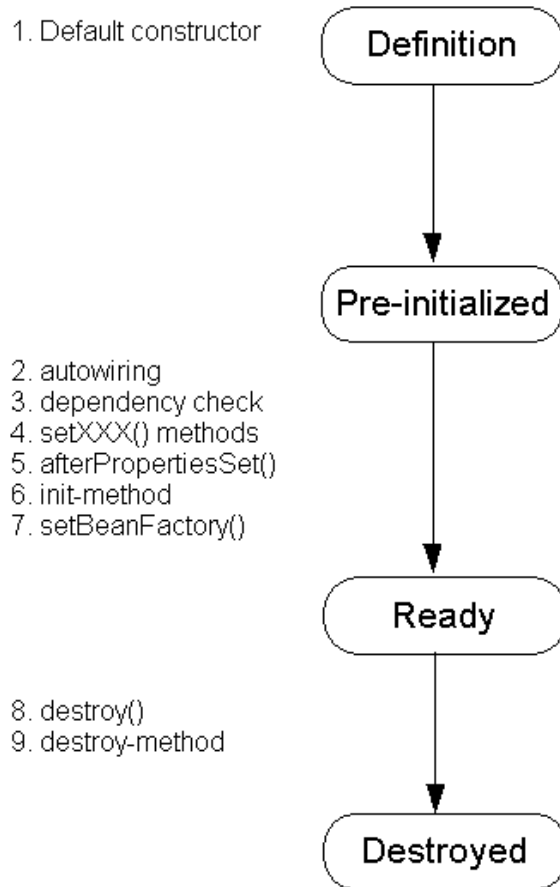
Right now, your bean is ready for use. Calls to `BeanFactory.getBean()` with the name of the bean, will result

in an instance of that bean being returned. Depending on whether or not this bean is a singleton, a shared instance will be returned. More information on consequences for singletons can be found below.

When the `BeanFactory` gets destroyed (for instance when the application server shuts down), the destruction process of the `BeanFactory` will try to destroy all beans that it knows about. The destruction process *will only occur for singleton beans*.

8. If your bean implements `DisposableBean` the `BeanFactory` will call `destroy()`
9. If your bean definition includes a `destroy` method declaration, this method will be called as well

A diagram illustrating the lifecycle of a bean:



3.8. BeanFactory structure and implementations (WIP)

From here on, up till the Context stuff, needs an overhaul.

The `beans` package contains a couple of different implementations. Concrete BeanFactories include the Xml-

BeanFactory which is the most popular format at the moment. However, the `ListableBeanFactory` is also a nice one, which is capable of reading bean definitions from properties files.

3.8.1. Structure of the beans package

Include UML and description here

3.8.2. The `XmlBeanFactory`

The `XmlBeanFactory` is the most often-used implementation of the `BeanFactory` and is capable of reading bean definitions from XML files. XML files need to adhere to the Spring DTD, included in Appendix

A couple of implementations of the `BeanFactory` come out-of-the-box. The `XmlBeanFactory` supports a bean definitions to be specified in XML files and the `ListableBeanFactory` supports bean definitions in the form of properties files. Most people use the `XmlBeanFactory`. However, implementing your own `BeanFactory` that supports bean definition in a database should not be to big an issue. Let's first discuss the `XmlBeanFactory` and the `ListableBeanFactory` and their features.

Basically the two `BeanFactory` implementations Spring comes with provide all the features described above, like specifying the lifecycle methods, specifying whether or not to do autowiring, etcetera. The only way they differ is the way the configuration data (the bean definitions) are stored.

3.8.3. Bean definitions specified in XML (`XmlBeanFactory`)

One of the implementations of the `BeanFactory` is the `XmlBeanFactory` (located in the package `org.springframework.beans.factory.xml`) which offers you the ability to specify bean definition in XML files as the name might have already told you. Spring comes with a DTD to do validation of the XML you're writing to specify beans in order to make things a bit more easy. The DTD is quite well documented so you should find everything you need in there as well. Here we will discuss the format shortly and provide some examples.

The root of a Spring XML bean definition document is a `<beans>` element. The `<beans>` element contains one or more `<bean>` definitions. We normally specify the class and properties of each bean definition. We must also specify the id, which will be the name that we'll use this bean with in our code (see a previous section about clients interacting with the `BeanFactory` for more information. An initialization method as described earlier as well the destruction method can be specified as attributes of the `<bean>` element. The autowiring functionality as well as the de dependency checking can also be specified using attributes of the same element. Furthermore properties and collaborators can be specified using nested `<property>` elements. In the following example, we use a `BasicDataSource` from the Jakarta Commons DBCP project. This class (like many other existing classes) can easily be used in a Spring bean factory, as it offers JavaBean-style configuration. The close method that needs to be called on shutdown can be registered via Spring's "destroy-method" attribute, to avoid the need for `BasicDataSource` to implement any Spring interface (in this case that would be `DisposableBean` mentioned earlier in the section about lifecycle features).

```
<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>
  </bean>
</beans>
```



```

        <property name="username">
            <value>root</value>
        </property>
    </bean>
</beans>

```

Just as an destruction method is specified using the `destroy-method` attribute, we could specify a initialization method using the `init-method` attribute.

To specify properties and collaborators in XML files you have to use nested `<property>` elements. You have already seen the setting of 'primitive' properties in the example about, the setting of collaborators is done using the nested `<ref>` element.

```

<beans>
...
    <bean id="exampleDataAccessObject"
        class="example.ExampleDataAccessObject">
        <!-- results in a setDataSource(BasicDataSource) call -->
        <property name="dataSource">
            <ref bean="myDataSource"/>
        </property>
    </bean>
</beans>

```

As you can see below, we're using the Commons DBCP datasource from the previous example here as a collaborator and we're specifying if using a `<ref bean>` element. References exist in three types that specify whether or not to search the collaborator in the same XML file or in some other XML file (multiple XML files is covered further along):

- `bean`: tries to find the collaborator in either the same XML file or in some other XML file that has also been specified
- `local`: tries to find the collaborator in the current XML file. This attribute is an XML IDREF so it *has* to exist, otherwise validation will fail
- `external`: explicitly states to find the bean in another XML file and does not search in the current XML file

There's a couple of possibilities for specifying more complex properties such as lists, properties object and maps. The following examples show this behavior:

```

<beans>
...
    <bean id="moreComplexObject"
        class="example.ComplexObject">
        <!-- results in a setPeople(java.util.Properties) call -->
        <property name="people">
            <props>
                <prop key="HaaryPotter">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>
    </bean>
</beans>

```

```

        </map>
    </property>
</bean>
</beans>

```

Note that the value of a Map entry can also again be a list or another map.

3.9. Introduction to the ApplicationContext

The `context` package is built on top of the `beans` package which provides basic functionality for managing and manipulating beans, often in a programmatic way. The `ApplicationContext` introduces `BeanFactory` functionality in a more *framework-style* approach. Instead of programmatically loading beans using for example the `XmlBeanFactory` and retrieving them using the `getBean()` method, with the `ApplicationContext` you will be able to let the framework you're working in load your beans using for example the `ContextLoader`.

The basis for the `context` package is the `ApplicationContext` interface, located in the `org.springframework.context` package. First of all it provides all the functionality the `BeanFactory` also provides. To be able to work in a more framework-oriented way, using layering and hierarchical contexts, the `context` package also provides the following:

- *MessageSource*, providing access to messages in, i18n-style
- *Access to resources*, like URLs and files
- *Event propagation* to beans implementing the `ApplicationListener` interface
- *Loading of multiple contexts*, allowing some of them to be focused and used for example only by the web-layer of an application

The `ApplicationContext` includes all the functionality the bean factory has as well. This means you can define beans using the XML format as explained in Section 3.8.2, “The `XmlBeanFactory`” and Appendix A, *Spring's beans.dtd* and retrieve them using their name or id. Also, you will be able to use all of the other features explained in this chapter, such as *autowiring*, *setter-based* or *constructor-based* dependency injection, *dependency checking*, *lifecycle interfaces*, etcetera. All other features the `ApplicationContext` includes are described below, as well as the ways to access an `ApplicationContext`, load beans into an `ApplicationContext` and the ways to customize existing `ApplicationContexts` using special beans defined in them.

3.10. 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.

3.10.1. Using the MessageSource

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

- `String getMessage (String code, Object[] args, String default, Locale loc)`: the basic method to retrieve a message from the `MessageSource`. When no message could be found for the locale specified, the default message is used. Any arguments passed in are used as replacement values, using the `MessageFormat` functionality provided by the JDK

- `String getMessage (String code, Object[] args, Locale loc)`: basically the same as the one above with one difference: the fact that no default message can be specified results in a `NoSuchMessageException` being thrown if the message could not be found
- `String getMessage(MessageSourceResolvable resolvable, Locale locale)`: all properties used in the methods above are also wrapped in a class - the `MessageSourceResolvable`, which you can use in 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 to see if it has a parent containing a similar bean, with a similar 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 provides two `MessageSource` implementation at the moment. These are the `ResourceBundleMessageSource` and the `StaticMessageSource`. Both implement `NestingMessageSource` in order to be able to do nested messaging. The `StaticMessageSource` is hardly ever used and 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.

3.10.2. Propagating events

Eventhandling in the `ApplicationContext` is provided through the `ApplicationEvent` class and `ApplicationListener` interface. When implementing the `ApplicationListener` in one of your beans, everytime an `ApplicationEvent` gets published to the `ApplicationContext`, your bean will be notified, based on the standard Observer design pattern implemented by the `java.util` package. Spring provides three standard events:

Table 3.4. Built-in Events

Event	Explanation
<code>ContextRefreshedEvent</code>	Event published when the <code>ApplicationContext</code> is initialized or refreshed. Initialized here means that all beans are loaded, singletons are pre-instantiated and the <code>ApplicationContext</code> is ready for use
<code>ContextClosedEvent</code>	Event published when the <code>ApplicationContext</code> is closed, using the <code>close()</code> method on the <code>ApplicationContext</code> . Closed here means that all singletons are destroyed

Event	Explanation
RequestHandledEvent	A web-specific event telling all beans that a HTTP request has been serviced (so it'll 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. All you need to do is call the `publishEvent()` method on the `ApplicationContext` and you're done. Let's have a 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, setter omitted for brevity */
    private List 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, setter left out for brevity */
    private String notificationAddress;

    public void onApplicationEvent(ApplicationEvent evt) {
        if (evt instanceof BlackListEvent) {
            // notify appropriate person
        }
    }
}
```

Of course, this behavior could be more cleanly implemented maybe, by using AOP features, but just to illustrate the basic behavior, this should do.

3.10.3. Using resources within Spring

Emphasis: not sure where to cover this, let's leave it for now (so it's not complete yet).

A lot of applications need to access resources. Resources here, might mean files, but also newsfeeds from the Internet or normal webpages. Spring provides a clean and transparent way of accessing resources in a protocol independent way. The ApplicationContext has 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 InputStream 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.

3.11. Extra marker interfaces and lifecycle features

The BeanFactory already offers you some methods to control the lifecycle of your beans (like `InitializingBean` or `init`-method and its counterpart, `DisposableBean` or `destroy`-method). The `context` package builds on top of the BeanFactory so you can use those features in the context package as well. Besides the lifecycle features, the ApplicationContext has one extra marker interface you can add to your beans, the `ApplicationContextAware` interface. This interface will be used to let the bean know about the ApplicationContext it *lives* in, using the `setApplicationContext()` method, that takes an ApplicationContext as an argument.

3.12. Customization of the ApplicationContext

Where the BeanFactory can be customized programmatically using `BeanFactoryPostProcessor`, the ApplicationContext can be customized using special beans, defined in your ApplicationContext

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`.

² See 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 name 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

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, don't mind reading this and go on with reading 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 <code>String</code> to <code>File</code> -objects
<code>LocaleEditor</code>	Capable of resolving Strings to <code>Locale</code> -objects and vice versa (the <code>String</code> 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.

When in need of a custom editor in your `BeanFactory` (i.e. you have some exotic type that you need express as a property in an XML file containing beans), you can use the `BeanFactoryPostProcessor` infrastructure to do this. [TODOOODOOD](#) reference provides more info on how to use the `BeanFactoryPostProcessor`. The following piece of code shows the actual processor that registered a custom editor for use with the `BeanFactory`:

```
public class MyBeanFactoryPostProcessor implements BeanFactoryPostProcessor {
    void postProcessBeanFactory(ConfigurableListableBeanFactory beanFactory) {
        beanFactory.registerCustomEditor(Date.class, new CustomDateEditor());
    }
}
```

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 PropertyDescriptors*: 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's begin by defining some central AOP concepts. These terms are not Spring-specific. Unfortunately, AOP terminology is not particularly intuitive; however, it would be still more confusing for Spring to use 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.
- *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. Some technologies, such as AspectJ, perform weaving at compile time. 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 and JBoss 4 (as or DR2), 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

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. *Field interception arguably violates OO encapsulation. We don't believe that it's 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 and pointcut types are representing in an interface hierarchy in the `org.springframework.aop` package. The following UML class diagram shows the hierarchy:

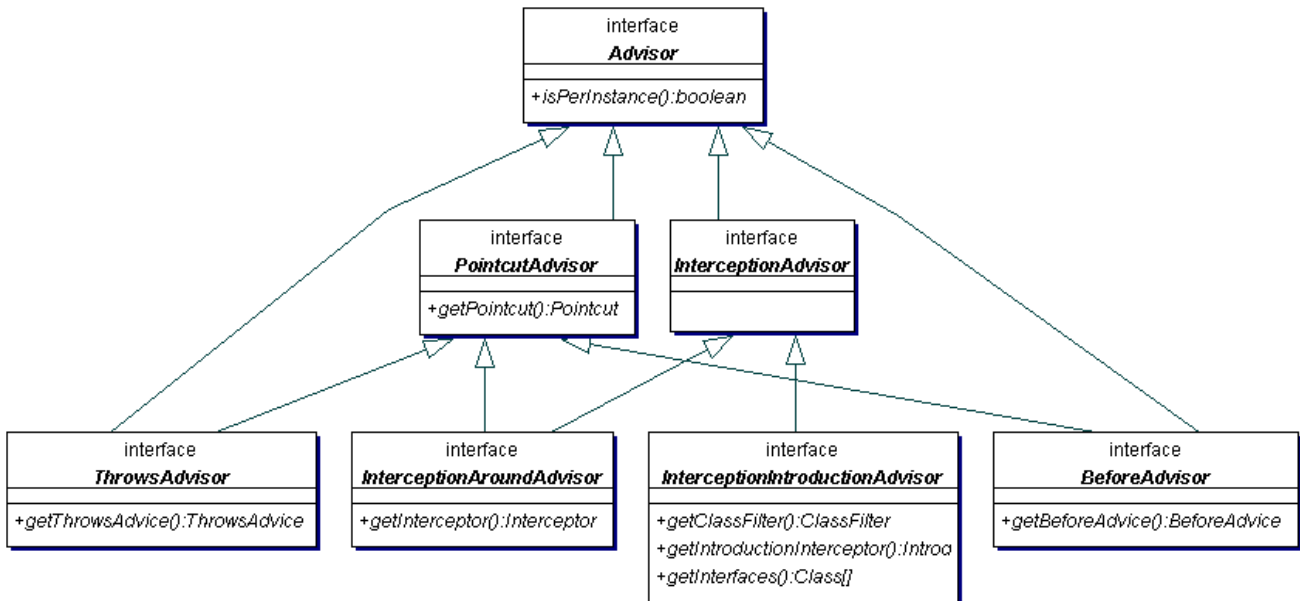


Figure 5.1. Spring Advisor hierarchy

Note how each advisor type has a corresponding advice type: ThrowsAdvisor and ThrowsAdvice; BeforeAdvisor and BeforeAdvice; and InterceptionAroundAdvisor and Interceptor. 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 is likely to in early 2004.

5.1.3. AOP Proxies in Spring

Spring defaults to using JDK *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.

5.1.4. Quick start

If you

Just understand interceptors

Just understand generic advice?

5.2. Pointcuts in Spring

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 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

COMPOSITION

The two operations on pointcuts are *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.

Either of these

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 account of method arguments.

5.2.3.1.1. Regexp

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`, `RegexoMethodPointcutAroundAdvisor`, allows us to reference an interceptor also. This simplifies wiring, as the one bean serves as both pointcut and advisor, as shown below:

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

```
</bean>
```

This creates ****

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.

5.2.3.2.1. Control flow pointcuts

Control flow pointcuts are similar to AspectJ *cflow* pointcuts.



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

These are useful if you intend to implement your own pointcuts.

Because static pointcuts are most useful, you'll probably subclass `StaticMethodMatcherPointcut`

```
class TestStaticPointcut extends StaticMethodMatcherPointcut {
    public boolean matches(Method m, Class targetClass) {
        // return true if custom criteria match
    }
}
```

There is also a superclasses for dynamic pointcuts.

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.

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

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; 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's 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 arguments to the method. The `invoke()` method should return the invocation's result: the return value of the joinpoint.

A simple `MethodInterceptor` 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 interoperably 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 as

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.

interface

```
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 it throws an exception, this will abort further execution of the interceptor chain.

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 can be either one or four arguments, dependent 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.MethodAfterReturningAdvice` interface, shown below:

```
public interface MethodAfterReturningAdvice extends AfterReturningAdvice {

    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 MethodAfterReturningAdvice {
    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 around advice.

After returning

```
public interface IntroductionInterceptor extends MethodInterceptor {

    boolean implementsInterface(Class intf);
}
```

The `invoke()` method inherited from the AOP Alliance `MethodInterceptor` interface must implement the introduction.

Show example

Delegating II

Advice lifecycle

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. Note that this **MAY DIFFER**

5.4. Advisors in Spring

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

For each advice type listed above, there is a corresponding advisor type in the `org.springframework.aop` package. These are, respectively:

- `InterceptionAroundAdvisor`
- `BeforeAdvisor`
- `ThrowsAdvisor`
- `AfterReturningAdvisor`

There is a special advice type to support introductions, `InterceptionIntroductionAdvisor`. This

SHOW implementing an advisor:

****TODO using convenience class**

It is possible to mix advisor and advice types in Spring in the one AOP proxy. For example, you could use an interception around advice, throws advice and before advice in the one proxy configuration: Spring will automatically create the 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

Talk about

5.5.2. JavaBean properties

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

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

**TODO Show UML diagram to show inheritance from `ProxyConfig`?

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.NopInterceptor">
</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>
```

```
</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, and 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 the 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).

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`.

If you want you can force the use of CGLIB in any case, even if you 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.

5.5.5. Special flags

The ProxyConfig class

expose proxy

5.6. Convenient proxy creation

Often we don't need the full power of the ProxyFactoryBean, because we're only interested in one aspect.

There are a number of convenience classes.

These are discussed in other chapters.

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.

The following example from the JPetStore sample application illustrates how this work. 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.jpetsy.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>
```

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

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

NOT DESCENDED FROM PFB

More discussion in next chapter

Hibernate etc?

5.7. Creating AOP proxies programmatically with the Proxy-Factory

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();
Class[] getProxiedInterfaces();
boolean isInterfaceProxied(Class intf);
void addInterceptor(Interceptor interceptor);
void addInterceptor(int pos, Interceptor interceptor);
void addAdvisor(Advisor advisor);
void addAdvisor(int pos, Advisor advisor);
boolean removeInterceptor(Interceptor interceptor);
boolean getProxyTargetClass();
```

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 `InterceptionAroundAdvisor` returning your `MethodInterceptor` and a pointcut that matches all classes and methods.

The `addAdvisor()` methods can be used to add any `Advisor`. Often this will be of type `InterceptionAroundAdvisor`, but it can be generic.

It's possible to add or remove advisors or interceptors 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.)

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 `postProcessor` infrastructure.

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

er

```
<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 interceptors, to allow correct behaviour for prototype advisors.

Named "interceptors" can be advisors or any advice type.

5.9.1.2. AdvisorAutoProxyCreator

A more general auto proxy creator is `AdvisorAutoProxyCreator`. 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.

Using this mechanism involves:

- Specifying an `AdvisorAutoProxyCreator` bean definition
- Specifying any number of Advisors in the same or related contexts.

The `AdvisorAutoProxyCreator` 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 advices 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.

This 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.

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

<bean id="txAdvisor"
      autowire="constructor"
      class="org.springframework.transaction.interceptor.TransactionAttributeSourceTransactionAroundAdvisor">
</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 `AdvisorAutoProxyCreator` 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 `AdvisorAutoProxyCreator` 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 `TransactionAttributeSourceTransactionAroundAdvisor` used in the above example has a high order value, as most other advice will normally want to be run in a transaction context.

5.9.1.3. AbstractAdvisorAutoProxyCreator

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

5.9.2. Using metadata-driven autoproxying

A particularly important type of autoproxying 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 `AdvisorAutoProxyCreator`, 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 autoproxy creation class itself.

This is really a special case of the `AdvisorAutoProxyCreator`, 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 autoproxying. 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="autoproxy"
      class="org.springframework.aop.framework.autoproxy.AdvisorAutoProxyCreator">
</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.TransactionAttributeSourceTransactionAroundAdvisor"
      autowire="constructor">
</bean>

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

The `AdvisorAutoProxyCreator` 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 `TransactionAttributeSourceTransactionAroundAdvisor`, will apply to classes or methods carrying a transaction attribute. The `TransactionAttributeSourceTransactionAroundAdvisor` 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.
- Implement an Advisor with the necessary advice, including a pointcut that is triggered by the presence of the custom attribute on a class or method.

It's possible for such advisors to be unique to each advised class: they simply need to be defined as prototypes, rather than singletons, bean definitions.

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.

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.

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.

CODE EXAMPLE

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 reasonably 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.

Config example

```
<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>businessObject</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 interceptor 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

erer

5.11. Defining new advice and advisor 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.

Please refer to this package's Javadocs for further information.

5.12. Further reading and resources

I recommend *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.

Chapter 6. Transaction management

6.1. The Spring transaction abstraction

Spring provides a consistent abstraction for transaction management. This abstraction 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
- Supports Spring declarative transaction management

Spring provides this consistent model through the PTM

6.2. Transaction strategies

Spring provides

6.3. Programmatic transaction management

6.4. Declarative transaction management

Spring also offers declarative transaction management. This is based on Spring AOP.

Spring declarative transaction management is most similar to EJB CMT.

Chapter 7. Source Level Metadata Support

7.1. Source-level metadata

What metadata is. C# etc.

JSR-175. But we need a solution now and may always want a facade

7.2. Spring's metadata support

In keeping with its provision of abstractions over important concepts, Spring provides a facade to other metadata implementations.

Such a facade adds value because LI- LI- hierarchical

Even when JSR-175 comes, still tied to class

7.3. 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.

7.4. Common uses of metadata attributes

All these uses build on AOP

7.4.1. Declarative transaction management

as in .NET; commonest use

7.4.2. Pooling

Discuss how this works out of the box. Again like .NET

7.4.3. Custom metadata

How easy it is to define custom attribute

7.4.4. Using attributes to minimize MVC web tier configuration

Annotating handlers with PathMap attributes

Chapter 8. Data Access using JDBC

8.1. Introduction

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

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`.

Finally, 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.

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.

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

8.2.1. 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, iterating 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 al-

ways 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.

8.2.2. `SQLExceptionTranslator`

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.

`SQLExceptionCodesSQLExceptionTranslator` 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 `SQLExceptionCodes`. This class is created and populated by an `SQLExceptionCodesFactory` which as the name suggests is a factory for creating `SQLExceptionCodes` 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 `SQLExceptionCodesSQLExceptionTranslator` 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 `SQLExceptionCodesFactory` 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.

8.3. Controlling how we connect to the database

8.3.1. `DataSourceUtils`

8.3.2. `SmartDataSource`

8.3.3. `AbstractDataSource`

8.3.4. `SingleConnectionDataSource`

8.3.5. `DriverManagerDataSource`

8.3.6. `DataSourceTransactionManager`

8.4. Modeling JDBC operations as Java objects

8.4.1. SqlQuery

8.4.2. MappingSqlQuery

8.4.3. SqlUpdate

8.4.4. StoredProcedure

8.4.5. SqlFunction

Chapter 9. Web framework

9.1. 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.

9.1.1. 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' 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 appli-

cation 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.

9.1.2. Features of Spring MVC

If just focussing 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.

9.2. 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 ???, `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 ???), 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 9.1. Special beans in the `WebApplicationContext`

Expression	Explanation
handler mapping(s)	(Section 9.4, “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)	(???) the beans providing the actual functionality (or at least, access to the functionality) as part of the MVC triad
view resolver	(Section 9.5, “Views and resolving them”) capable of resolving view names and needed by the <code>DispatcherServlet</code> to resolves those views with
locale resolver	(Section 9.6, “Using locales”) capable of resolves the locale a client is using, in order to be able to offer internationalized views
theme resolver	(Section 9.7, “Using themes”) capable of resolving themes your webapplication can use e.g. to offer personalized layouts
multipart resolver	(Section 9.8, “Spring's multipart (fileupload) support”) offers functionality to process file uploads from HTML forms
handlerexception resolver	(???) 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 need 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, it 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

Exception 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 the 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 9.2. 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>

9.3. 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 implementation; *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.

9.3.1. Using the `AbstractController` and `WebContentGenerator`

Of course, just a controller interface isn't enough. To provide a basic infrastructure, all Spring's Controller inherit from `AbstractController`, a class offering caching support and for instance the setting of the mimetype.

Table 9.3. 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 "Expires" 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 "Cache-Control" header. By default this is set to true so you won't really have to touch it

the last two properties are actually part of the `WebContentGenerator` which is the superclass of `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 you) you only have to override the `handleRequestInternal(HttpServletRequest request, HttpServletResponse response)`-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 9.4, “Handler mappings”) to get this very simple controller working. This controller will generate 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 9.5, “Views and resolving them” for more information about views).

9.3.2. Other simple controller

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 viewname you

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.

9.3.3. 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 common functionality in one controller, but want to have multiple entry points to the controller to tweak behavior for instance.

Table 9.4. Features offered by the `MultiActionController`

Feature	Explanation
delegate	there's two usage-scenarios for the MultiActionController. Either you subclass the MultiActionController and specify the methods that will be resolved by the 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 ???) so if the properties contained `*/welcom?.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>

```

9.3.4. 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 actionforms, where in Spring, you don't have to implement any interface of superclasses to do databinding. First, let's examine what command controllers available, just to get 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 let's 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 applicationcontext
- `SimpleFormController` - an even more concrete `FormController` that helps you creating a form with corresponding data object even more. The `SimpleFormController` let's you specify a command object, a viewname for the form, a viewname for page you want to show the user when formsubmission has succeeded, and more
- `WizardFormController` - last but not least, a `WizardFormController` allows you to model wizard-style ma-

nipulation of dataobjects, which is extremely handy when large dataobjects come in

9.4. Handler mappings

Using a handler mapping you can map incoming web requests to appropriate handlers. There are some handler mapping 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.

9.4.1. 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 9.3.4, "CommandControllers" for more information on Command- and FormControllers) and an 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!

9.4.2. `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 9.10.1, “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` `dispatcher` `servlet`.

```

<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.FileableViewController"/>

  <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>

```

```

</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 9.3, “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`

9.4.3. 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 postprocessing.

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`.

9.5. Views and resolving them

No MVC framework for web applications without a way to address views. Spring provides view resolvers, which enable you to - without tying yourself to a specific view technology - render models in a browser. Out-of-the-box, Spring enables you to use for example Java Server Pages, Velocity templates and XSLT views. Chapter 10, *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.

9.5.1. 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 a couple of view resolvers. We'll list most of them as provided by the Spring framework and then provide a couple of examples.

Table 9.5. 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 explicit mapping defini-

ViewResolver	Description
	tion. This is appropriate if your symbolic names match the names of your view resources in a straightforward manner, without the need for arbitrary mappings
InternalResourceViewResolver	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
VelocityViewResolver	Convenience subclass of <code>UrlBasedViewResolver</code> that supports <code>VelocityView</code> (i.e. Velocity templates) and custom subclasses of it

When having JSP for a view technology you can use the for example 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>
```

9.6. Using locales

Most parts of Spring's architecture support internalization, just as the Spring web framework does. SpringWEB enables you to automatically resolve messages using the client's locale. This is done through the so-called `LocaleResolver`, that exists in a couple of useful forms. Defining a `localeresolver` is pretty simple, just stick it in your webapplication context and you're done. You have to make a decision where to retrieve the locale from however. There are a couple of `localeresolver` to choose from.

Besides the resolving locales, you can also attach an interceptor to the handlermapping (see Section 9.4.3, "Adding HandlerInterceptors" for more info on that), to change the locale based on for instance a parameter occurring in the request.

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.

Locale resolvers and interceptors are all defined in the `org.springframework.web.servlet.i18n` package.

9.6.1. AcceptHeaderLocaleResolver

This locale resolver inspect 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.

9.6.2. CookieLocaleResolver

This locale resolver inspect 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 9.6. Special beans in the `WebApplicationContext`

Property	Default	Description
<code>cookieName</code>	<code>classname + LOCALE</code>	The name of the cookie
<code>cookieMaxAge</code>	<code>Integer.MAX_INT</code>	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
<code>cookiePath</code>	/	Using this parameter, you can limit the visibility of the cookie to a certain part of your site. When <code>cookiePath</code> is specified, the cookie will only be visible to that path, and the paths below

9.6.3. SessionLocaleResolver

Besides the `CookieLocaleResolver` and the `AcceptHeaderLocaleResolver`, you can also use the `SessionLocaleResolver` to retrieve locales from the session that might be associated to the user's request.

9.6.4. 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 9.4, “Handler mappings”) and it will detect a parameter in the request and changes the locale (call `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.

9.7. Using themes

9.8. Spring's multipart (fileupload) support

9.8.1. Introduction

Spring has built-in multipart support to handle fileuploads in webapplications. The design for the multipart support is done in such a way that pluggable so-called `MultipartResovlers` can be used. Out of the box, Spring provides `MultipartResolver` for use with *Commons FileUpload* and *COS FileUpload*. How uploading files is supported will be described in the rest of this chapter.

As already said, the multipart support is provided through the `MultipartResolver` interface, located in the `org.springframework.web.multipart` package. By default, no multipart handling will be done by Spring. 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. If however, 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.

9.8.2. Using the `MultipartResolver`

To be able to resolve multiparts from a request, you will have to declare a `MultipartResolver`. There's two multipart resolver Spring's comes with. First of all the resolver that works with *Commons FileUpload* (<http://jakarta.apache.org/commons/fileupload>), and secondly, the resolver that uses the O'Reilly COS package (<http://www.servlets.com/cos>). Without a `MultipartResolver` declared in your webapplication context, no detection of multiparts will take place, because some developers might find the need to parse out the multiparts themselves.

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>

```

But you can also use 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 if using one the multipartresolver. In case of the `CommonsMultipartResolver`, you need to use `commons-fileupload.jar`, in case of the `CosMultipartResolver`, use `cos.jar`.

Now that Spring's set 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.

9.8.3. Handling a fileupload in a form

After the `MultipartResolver` has finished doing its jobs, the request will be processed as any other. So in fact, you can create a form, with a form upload field, and let Spring bind the file on your form. Just as with any other property that's not automagically 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's a couple of editors available for handling file and setting the result 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 for instance the `CustomDateEditor`

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 register a custom editor to let Spring know how to actually convert the multipart objects the resolver has found, to properties specified by the bean. Right now, nothing is done with the byte[] and the bean itself, but you can do with it 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 (dont' forget this!). Right now everything should work.

9.9. Handling exceptions

Spring provides so-called `HandlerExceptionResolvers` to ease the pain when unexpected exception might occur while your request is handled by any controller that matched the request. `HandlerExceptionResolvers` somewhat resembles the exception-mappings you can define in the webapplication descriptor `web.xml`. However, they provide a more flexible to handle exceptions. First of all, the `HandlerExceptionResolver` informs you about what handler was execution while the exception was thrown. Furthermore, a programmatic way of handling exception gives you a lot more options to respond appropriately, then in case the request is forwarded to another URL (which is the case 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 can also use the `SimpleMappingExceptionHandler`. This resolver enables you to map the class name of any exception that might be thrown to a view name. With this, you will be do exactly the same the exception mapping feature from the servlet api does, but it's also possible to do more fine grained mappings of exception from different handlers.

9.10. Commonly used utilities

9.10.1. A little story about the pathmatcher

Chapter 10. Integrating view technologies

10.1. Introduction

One of the areas in which Spring excels is its separation of view technologies from the rest of the MVC framework. Deciding to use Velocity or XSLT in place of an existing JSP for example, 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 9.5, “Views and resolving them” which covers the basics of how views in general are coupled to the MVC framework.

10.2. Velocity

Velocity is a view technology developed 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.

10.2.1. Dependencies

There is one dependency that your web application will need to satisfy before working with Velocity, namely that `velocity-1.x.x.jar` needs to be available. Typically this is 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 is supplied with the Spring framework and can be copied from the `/lib/velocity` directory.

10.2.2. Dispatcher Servlet Context

The configuration file for your Spring dispatcher servlet (usually `WEB-INF/[servletname]-servlet.xml`) should already contain 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.

The following code examples show the various configuration files with appropriate comments.

```
<!-- =====>
<!-- View resolver. Required by web framework. -->
<!-- =====>
<!--
View resolvers can be configured with ResourceBundles or XML files. If you need
different view resolving based on Locale, you have to use the resource bundle resolver,
otherwise it makes no difference. I simply prefer to keep the Spring configs and
contexts in XML. See Spring documentation for more info.
-->
<bean id="viewResolver" class="org.springframework.web.servlet.view.XmlViewResolver">
  <property name="cache"><value>true</value></property>
  <property name="location"><value>/WEB-INF/frontcontroller-views.xml</value></property>
</bean>

<!-- =====>
<!-- Velocity configurer. -->
<!-- =====>
<!--
The next bean sets up the Velocity environment for us based on a properties file, the
location of which is supplied here and set on the bean in the normal way. My example shows
that the bean will expect to find our velocity.properties file in the root of the
WEB-INF folder. In fact, since this is the default location, it's not necessary for me
to supply it here. Another possibility would be to specify all of the velocity
properties here in a property set called "velocityProperties" and dispense with the
```

```

actual velocity.properties file altogether.
-->
<bean
  id="velocityConfig"
  class="org.springframework.web.servlet.view.velocity.VelocityConfigurer"
  singleton="true">
  <property name="configLocation"><value>/WEB-INF/velocity.properties</value></property>
</bean>

```

10.2.3. Velocity.properties

This file 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. Here, I'm just demonstrating the bare minimum to get Velocity up and running in your Spring MVC application.

10.2.3.1. Template Locations

The main 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`

10.2.3.2. 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
```

10.2.3.3. 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.

10.2.3.4. 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>
```

10.2.3.5. Default configuration (file resource loaders)

Note that as of Spring version 1.0-m4 you can avoid using a properties file or inline properties to define file system loading of templates by putting the following property in the Velocity config bean which will cause the other values to be figured out.

```
<property name="resourceLoaderPath"><value>/WEB-INF/velocity/</value></property>
```

10.2.4. View configuration

The last step in configuration is to define some views that will be rendered with velocity templates. Views are always defined in a consistent manner in Spring context files. As noted earlier, this example uses an XML file to define view beans, but a properties file (ResourceBundle) can also be used. The name of the view definition file was defined earlier in the ViewResolver bean - part of the `WEB-INF/frontcontroller-servlet.xml` file.

```
<!--
  Views can be hierarchical, here's an example of a parent view that
  simply defines the class to use and sets a default template which
  will normally be overridden in child definitions.
-->
<bean id="parentVelocityView" class="org.springframework.web.servlet.view.velocity.VelocityView">
  <property name="templateName"><value>mainTemplate.vm</value></property>
</bean>

<!--
```

```

- The main view for the home page. Since we don't set a template name, the value
  from the parent is used.
-->
<bean id="welcomeView" parent="parentVelocityView">
  <property name="attributes">
    <props>
      <prop key="title">My Velocity Home Page</prop>
    </props>
  </property>
</bean>

<!--
- Another view - this one defines a different velocity template.
-->
<bean id="secondaryView" parent="parentVelocityView">
  <property name="templateName"><value>secondaryTemplate.vm</value></property>
  <property name="attributes">
    <props>
      <prop key="title">My Velocity Secondary Page</prop>
    </props>
  </property>
</bean>

```

10.2.5. 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.properties` file 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 'secondaryView' might look like (simplified HTML)

```

## $title is set in the view definition file for this view.
<html>
  <head><title>$title</title></head>
  <body>
    <h1>This is $title!!</h1>

    ## model objects are set in the controller and referenced
    ## via bean properties o method names. See the Velocity
    ## docs for info

    Model Value: $model.value
    Model Method Return Value: $model.getReturnVal()

  </body>
</html>

```

Now, when your controllers return a `ModelAndView` with the "secondaryView" set as the view to render, Velocity should kick in with the above page.

10.2.6. 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. This behaviour can be simulated with a Velocity macro and some additional Spring functionality.

10.2.6.1. Validation errors

The error messages that are actually produced from the validation of a form submission can be read from a properties file to make them easily maintainable or internationalised. Spring handles this elegantly in its own

way and you should refer to the MVC tutorial or relevant parts of the javadocs for details on how this works. In order to gain access to the messages, the `RequestContext` object needs to be exposed to your Velocity templates in the `VelocityContext`. Amend your template definition in `views.properties` or `views.xml` file to give a name to this attribute (giving it a name is what causes it to be exposed)

```
<bean id="welcomeView" parent="parentVelocityView">
  <property name="requestContextAttribute"><value>rc</value></property>
  <property name="attributes">
    <props>
      <prop key="title">My Velocity Home Page</prop>
    </props>
  </property>
</bean>
```

The example above is based on our earlier example and sets the `RequestContext` attribute name to be `rc`. All Velocity views that inherit from this parent view will now have an additional object available to them via the reference `$rc`

10.2.6.2. Velocity macro helper

Next, a velocity macro needs to be defined. It makes sense to create this macro in a global macro file since it will be reusable across many Velocity templates (html forms). Refer to the Velocity documentation for more information on creating macros.

The code below should go into the file `VM_global_library.vm` in the root directory of your Velocity template location..

```
##
 * showerror
 *
 * display an error for the field name supplied if one exists
 * in the supplied errors object.
 *
 * param $errors the object obtained from RequestContext.getErrors( "formBeanName" )
 * param $field the field name you want to display errors for (if any)
 *
 *#
#macro( showerror $errors $field )
  #if( $errors )
    #if( $errors.getFieldErrors( $field ) )
      #foreach($err in $errors.getFieldErrors( $field ))
        <span class="fieldErrorText">$rc.getMessage($err)</span><br />
      #end
    #end
  #end
#end
```

10.2.6.3. Associating error messages with the HTML field

Finally, in your html forms, you can use code similar to the following to display bound error messages for each input field.

```
## set the following variable once somewhere at the top of
## the velocity template
#set ($errors=$rc.getErrors("commandBean"))
<html>
...
<form ...>
  <input name="query" value="$!commandBean.query"><br>
  #showerror($errors "query")
```

```

</form>
...
</html>

```

10.2.7. Summary

To summarize, this is the tree structure of files discussed in the example above. Only a partial tree is shown, some required directories are not highlighted here. Incorrect file locations are probably the major reason for velocity views not working, with incorrect properties in the view definitions a close second.

```

ProjectRoot
|
+- WebContent
|
+- WEB-INF
|
| +- lib
| | +- velocity-1.3.1.jar
| | +- spring.jar
|
| +- velocity
| | +- VM_global_library.vm
| | +- mainTemplate.vm
| | +- secondaryTemplate.vm
|
+- frontcontroller-servlet.xml
+- frontcontroller-views.xml
+- velocity.properties

```

10.3. 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.

10.3.1. 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 9.3, “Controllers” for details of Spring `Controller`s. The XSLT view will turn the list of words into a simple XML document ready for transformation.

10.3.1.1. 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'.

10.3.1.2. 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.

10.3.1.3. 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 );
    }
}
```

```
}

```

10.3.1.3.1. 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`

10.3.1.4. 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.

10.3.1.5. 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>

```

10.3.2. 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.

10.4. Document views (PDF/Excel)

10.4.1. 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 the 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.

10.4.2. 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).

10.4.2.1. 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

10.4.2.2. 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!

10.4.2.3. 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 automatically when you request the same page as before.

10.4.2.4. 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.

10.5. Tapestry

Tapestry is a powerful, component-oriented web application framework from Apache's Jakarta project (<http://jakarta.apache.org/tapestry>). Spring Framework is a powerful J2EE application framework which is built around the concept of a lightweight container. 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.

10.5.1. 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.

//TODO Graphic insert

10.5.2. 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.

10.5.2.1. 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="inContainer"><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.

10.5.2.2. Obtaining beans in Tapestry pages

At this point, the application context is available to a web-app by calling Spring's static utility function `WebApplicationContextUtils.getApplicationContext(servletContext)`, where `servletContext` is the standard `ServletContext` from the J2EE Servlet spec. 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 = 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.

10.5.2.3. Exposing the application context to Tapestry

First we need to make the Application Context 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 Application Context, 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"?>
```

```

<!--$Id: views.xml,v 1.4 2004/02/05 23:49:52 davison Exp $-->
<!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>

```

10.5.2.4. 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.PortalValidationDelegate"/>

  <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"/>
    <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>

```

10.5.2.5. 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));
}
}

```

10.5.3. Summary

In this example, we've managed to allow service beans defined in the Spring Application Context 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.

10.6. Tiles

intro

10.6.1. Configuration

config

10.6.2. Summary

summarize files / libs involved

Chapter 11. Accessing and implementing EJBs

As a lightweight container, Spring is often considered an EJB replacement. While we believe that Spring provides a better container for many applications than an EJB container, it's important to note that using Spring does not prevent you from using EJB. In fact, Spring makes it much easier to develop with EJB.

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.

11.1. Accessing EJBs

11.1.1. Concepts

11.1.2. Accessing local SLSBs

11.1.3. Accessing remote SLSBs

11.2. 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.

Chapter 12. Sending Email with Spring mail abstraction layer

12.1. 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.

12.2. 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 mimeMessage message to send
 * @throws MailException in case of message, authentication, or send errors
 * @see #createMimeMessage
 */
public void send(MimeMessage mimeMessage) 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 mimeMessagePreparator the preparator to use
 * @throws MailException in case of message, authentication, or send errors
 */
public void send(MimeMessagePreparator mimeMessagePreparator) 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 mimeMessagePreparators the preparator to use
 * @throws MailException in case of message, authentication, or send errors
 */
public void send(MimeMessagePreparator[] mimeMessagePreparators) throws MailException;
}

```

MimeMessagePreparator:

```

public interface MimeMessagePreparator {

    /**
     * Prepare the given new MimeMessage instance.
     * @param mimeMessage the message to prepare
     * @throws MessagingException passing any exceptions thrown by MimeMessage
     * methods through for automatic conversion to the MailException hierarchy
     */
    void prepare(MimeMessage mimeMessage) throws MessagingException;

}

```

12.3. 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 MimeMes-

sage:

```

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().getEmail()));
                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.

12.3.1. 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.

Appendix A. Spring's beans.dtd

```
<?xml version="1.0" encoding="UTF-8"?>

<!--
    Spring XML BeanFactory DTD.
    Authors: Rod Johnson, Juergen Hoeller

    This defines a simple and consistent way of creating a namespace
    of JavaBeans configured by a Spring XmlBeanFactory.

    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.

    Bean instances can be "singletons" (shared instances) or "prototypes"
    (independent instances).

    References among beans are supported, i.e. setting a JavaBean property
    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 and names of such "inner beans" are always ignored:
    Inner beans are anonymous prototypes.

    There is also support for lists, maps, and java.util.Properties 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 1.1 2004/01/29 23:38:09 aarendsen 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)*
)>

<!--
    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>

<!--
Each bean definition must specify the FQN of the class,
or the name of the parent bean from which the class can be worked out.

Note that a child bean definition that references a parent will just
add respectively override property values and be able to change the
singleton status. It will inherit all of the parent's other parameters
like lazy initialization or autowire settings.
-->
<!ATTLIST bean class CDATA #IMPLIED>
<!ATTLIST bean parent 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>
<!--
    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".
-->
<!ELEMENT constructor-arg (
    description?,
    (bean | ref | idref | list | set | map | props | value)
)>
<!--
    The constructor-arg than 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>
<!--
    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)
)>
<!--
    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>
<!--
    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>

<!--
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,
to be checked at runtime by future Spring 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.
-->
<!ATTLIST idref bean CDATA #IMPLIED>
<!ATTLIST idref local IDREF #IMPLIED>

<!--
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 AbstractBeanFactory.
-->
<!ELEMENT list (
  (bean | ref | idref | list | set | map | props | value)*
)>

<!--
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.
-->
<!ELEMENT set (
  (bean | ref | idref | list | set | map | props | value)*
)>

<!--
A Spring map is a mapping from a string key to object.
Maps may be empty.
-->
<!ELEMENT map (
  (entry)*
)>

<!--
A map entry can be an inner bean, ref, collection, or value.
The name of the property is given by the "key" attribute.
-->
<!ELEMENT entry (
  (bean | ref | idref | list | set | map | props | value)
)>
<!ATTLIST entry key CDATA #REQUIRED>

<!--
Props elements differ from map elements in that values must be strings.
Props may be empty.
-->
<!ELEMENT props (
  (prop)*

```

```
)>

<!--
    Element content is the string value of the property. The "key"
    attribute is the name of the property.
-->
<!ELEMENT prop
    (#PCDATA)
>

<!--
    Each property element must specify the key. The value
    is the element content.
-->
<!ATTLIST prop key CDATA #REQUIRED>

<!--
    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 setting JavaBean
    properties to references to other beans.
-->
<!ELEMENT value (#PCDATA)>
```